SOKKIA

SDR® Level 5

Reference Manual

Part Number 750-1-0073 Rev 1

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Chapter 1 Welcome

Welcome to SDR® software, Sokkia's complete field surveying solution. This introduction will give you a tour of SDR functionality and this reference manual, including:

- A brief introduction to the SDR
- Document conventions
- Technical Support

SDR Level 5 software combines traditional SDR functionality with seamless GPS RTK capabilities on the intuitive Windows CE platform.

SDR software is compatible with the complete range of Sokkia instruments, including total stations, levels, and GPS receivers, and supports many non-Sokkia instruments as well. The SDR increases efficiency of your instrument for traversing, topographic surveys, setting out, and leveling.

The SDR software contains a full range of surveying applications that use electronically transmitted data from various Sokkia instruments to quickly obtain desired results. These applications range from topography, coordinate geometry functions, and roading capabilities. Data collection can be accomplished with topography, resection, positioning and remote elevation. Coordinate geometry functions include Set Out Coords, Lines and Arcs as well as Areas, Intersections and Transformations.

Advanced roading options in the SDR enable you to define horizontal and vertical road alignments, or load the alignments from a computer. You can then set out the road by station and offset,

including catch points. The SDR supports tangents, circular arcs, and spiral curves in the horizontal definition and straight grades and parabolic curves in the vertical definition.

1.1   Document Conventions

The following conventions are used in this manual:

1.1.1   Typefaces

Main Menu .... Indicates menu bar options and functions

| .... This symbol is used to separate menu bar options from menu item selections. For example: **File** | **Save**

Dialog box .... Indicates a small box, opened during interaction with the software, that contains command buttons and options you can select to perform tasks. Dialogs are always shown in title case, bold font. For example, **Save As** dialog box

Fields .... Indicates options or boxes within a dialog box. Fields are always shown in bold font. For example, **File name** dialog box

Tabs .... Indicates pages in a multi-page dialog box. Tabs are always shown in bold font. For example, **General**

List .... Indicates a field, on a dialog box, that expands to offer several options. Lists are always shown in bold font. For example, **Antenna Model** list

<Button> .... Indicates a command button on a dialog box. Buttons are always shown in angled brackets and bold font. For example, **<Close>** button

Prompt.............................. Represents screen prompts and other information displayed on the screen. Prompts are shown in bold, 8pt, palatino font. For example, **Continue** prompt

<Key> .... Indicates a keyboard key, a soft key on the SDR screens, or a key on the SDR keypad that causes an immediate action. Keys are always shown in angled brackets and bold font. For example, **<1>**, **<F1>**, **<ESC>**, **<Y>**

Print .... Represents reports or output to a printer. Print is shown in bold, 8pt, palatino font. For example, Report 1

⊠ **Note:** A note box contains text which explains previous text.

1.1.2   Technical Support

Technical support for this product is available from your distributor. You also may contact one of the Sokkia subsidiaries listed below. Point, Inc. welcomes written communications regarding its products; use the address on the back of the title page of this manual.

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Chapter 2 **Software Overview**

The SDR is designed with you in mind. All options use the standard SDR functionality making surveying simple and efficient.

SDR functionality is designed to make survey data collection and management efficient. It increases productivity of your instrument for topographic surveys, setting out and Cogo operations. It is also a convenient link to Sokkia Software, office-based mapping and design programs, and other software packages.

2.1 Pre-Survey Operations

Successful surveys begin with set up operations. The SDR leads you through each step of the setup process quickly and easily.

2.1.1 Project Management

You can perform a survey with either an Electronic Total Station (ETS) or a GPS/RTK system, or both, using the SDR. Any instrument type selection uses familiar SDR functionality and work flow. The ETS and RTK data reside in the same survey job and can be calibrated to the same coordinate system.

All projects are managed within the context of a job which is stored in the SDR database. Settings are remembered from job to job, so it is unnecessary to set them for each new job. If you are performing an initial traverse operation and then returning for detail pick up, there is no need to switch between jobs.

2.1.2   *Station Setup*

Before taking a reading, you are prompted for a station setup and confirmation of a station and backsight. You can supply coordinates by selecting a point previously observed with a total station or by direct keyboard input. Coordinates or azimuth are required, but they do not need to be known.

2.1.3   *Coordinate Systems*

With the added functionality of selectable coordinate systems, the SDR provides a seamless transition between GPS/RTK and total station operations. You can designate coordinate systems during job creation.

2.1.4   *Instrument Selection*

The SDR works with a variety of total stations, levels, and other instruments. You can change instruments as often as necessary.

The settings established in the ***Instrument Setup*** screen are stored with your job file. Whenever you change instruments, the SDR will store a new instrument record with the new instrument type and associated settings.

2.2   Performing Survey Operations

After the initial setup, you can immediately begin to perform your survey or set out points.

2.2.1   *Taking Readings*

The SDR provides several options to ensure accurate readings. If you are unable to actually set up on the point to be observed, the SDR enables you to perform several different kinds of offsets. To further increase the accuracy of your survey, you can take multiple observations to a point and calculate inherent error and corrected calculations.

2.2.2 Topo

The SDR's ***Topography*** program enables you to collect data on physical elements within an area.The ***Topography*** program can be used for a variety of different surveys including boundary surveys, cadastral (plat) surveys, contour surveys, and two and three dimensional surveys.

2.2.3 Set Out

Setting out can be used for a variety of applications. The SDR can be used before construction to initially set out a design or you can double check locations against a design during and after construction.

2.2.4 Roading

All options needed to survey, define, and set out a road are contained in the SDR's ***Roading*** menu. This feature makes roading quick and efficient using standard SDR workflow - sharing similarities with other SDR options.

2.2.5 COGO

The ***COGO*** menu of the SDR provides several options to perform coordinate geometry calculations, including inverses, areas and intersections. You can use these tools to calculate distances, azimuths and coordinates separately from traditional SDR methods.

2.2.6 Controlling Quality

You have control over the quality of readings by setting survey job tolerances.and by establishing end observation criteria before collecting data. You can automatically end an observation based on the quality of the solution or choose to manually end the observation.

Through the ***Configure Reading*** screen, you have the advantage of setting work standards from job to job. The system will remember the parameters set during a previous survey.

2.2.7   Full Functionality

The SDR delivers multiple options in a single package. With more memory (1 MB NVM), the SDR can handle nearly any survey operation under any condition.

2.2.8   Leveling

Digital or manual levels can be used with the SDR to perform differential leveling. By using the *Leveling* option to collect accurate elevations, you can improve the accuracy of your survey jobs. Elevations recorded from the *Leveling* option can be used to correct existing data in the SDR database.

2.3   Post-Survey Operations

Your collected data is ready for immediate transfer to a desktop computer or a printer.

2.3.1   File Format

Data is stored in the industry-standard SDR file format. You can export files directly to any software package that recognizes SDR files.

2.3.2   Output

You can also choose to send SDR jobs to Sokkia's ProLINK desktop software. With ProLINK's Conversion Definition Manager, you can import, convert, edit, reduce, and export a variety of raw data formats. ProLINK's functionality as an intelligent editor for survey data is enhanced by the ability to convert to and from a wide range of file formats.

Chapter 3   **GPS**

The GPS Status screens are available to review current conditions and information about the RTK solution.

The status screens provide information such as RMS and DOP values, satellite position and usage, differential and RTK signals and both rover and base positions, including rover navigation information. These screens enable you to easily determine if conditions and quality are sufficient for the particular observation.

Five status screens are available, which are selected via the softkeys at the bottom of each screen. The last status screen viewed will display when the status screens are initially accessed. The five status screens are:

- current position
- azimuth/elevation
- geometry
- differential
- satellite use

3.1   Current Position

The *Current Position* screen, accessed through the **GPS Status** menu, provides positional information about the rover receiver. From this screen, you can also access positional information about the base receiver.

3.1.1   Rover receiver

Initially, the *Current Position* screen displays the current coordinates, speed, and direction of the rover receiver.

If a plane projection record has not been written by initiating the first GStn setup in the current job, then Lat/Long values will display. Otherwise the current position is based on the determined vector added to the last GStn and transformed based on the most recent calibration.

3.1.2   Base receiver

The *GPS Stn Position* screen displays the coordinates of the current GPS station.

North.............................. The current northing value of the base receiver's position in the calibrated coordinate system.

East .... The current easting value of the base receiver's position in the calibrated coordinate system.

Elev................................. The current elevation value of the base receiver's position in the calibrated coordinate system.

⊠ **Note:** If a plane projection record has not been written by initiating the first GStn setup in the current job, then Lat/Long values will display. Otherwise the base position is based on the coordinates to the initial GStn setup.

3.2   Azimuth and Elevation

The *Az/El* screen shows satellites tracked by both the base and the rover receivers, indicating those satellites common to both receivers. It also provides information on the azimuth and elevation of the satellite, as well as the signal to noise ratio of the L1 frequency.

Sat................................... This field displays the tracked satellite's PRN.

Az .... This field displays the azimuth value of the indicated satellite.

El.....................................This field displays the elevation value of the indicated satellite.

N1 ....This field displays the Signal to Noise ratio for the L1 frequency.

Rcv.................................This field indicates, in some receivers, which receiver(s) is tracking this satellite. The available options are as follows:

> **B**-Base

> **R**-Rover

> **C**-Common.

> ⊠ **Note:** The Az/El/N1 values are based on the rover receiver; if a satellite is tracked by the base receiver only, then the values are blank.

3.3   Geometry

The *Geometry* screen displays information related to the quality of the GPS signal being received. You will find the following fields in the *Geometry* screen:

PDOP ....This field displays a value for the three dimensional Positional Dilution of Precision.

HDOP ....This field displays a value of the two-dimensional Horizontal Dilution of Precision.

VDOP ....This field displays a value for the elevation Vertical Dilution of Precision.

HRMS (m)......................This field displays a HRMS value from receiver for the residuals of the horizontal component.

VRMS (m)......................This field displays a VRMS value from receiver for the residual of the vertical component.

3DRMS (m).................... This field displays a total RMS value from receiver for the residual of all the components (three-dimensional).

3.4   Differential Message Information

The *Differential* screens display information about the differential message sent from the base receiver to the rover receiver.

Com sats .... This field displays the number of satellites common to both the current rover and base receivers.

Amb status .... The ambiguity status of the current solution from the rover receiver. The options are **Fixed** or **Float**.

The following are receiver specific:

BPS age (s) .... This field displays the time interval for broadcasting the base positional information.

BPS warn .... This field displays the base position signal's from the base receiver. The messages displays as follows:

        No refcoord = base station coordinates contain all zeros

        No ref ant = antenna offsets were not entered in the base receiver

        No ref raw = raw position was not computed at base

        Bad ref pos = computed raw position differs from the entered base coordinates by 500 meters or more

        No ref L2 = L2 measurements are not available at base

DBEN latency................ This field displays the time interval for a message from the base receiver to the rover receiver.

3.5   Satellite Use

The *Satellite Usage* screen displays the health and status of each of the satellites in column format.

The satellites' PRN are displayed with a leading character that indicates which receiver(s) are tracking the satellite and a trailing character which indicates the health of the satellite.

The leading character in the column indicates the following:

B, R, and C are receiver specific.

B....................................... base

R....................................... rover

C....................................... common

⊠   **Note**: If no leading character displays, then the satellite is not tracked by either receiver.

Chapter 4

Setting up the Instrument

The SDR can work with multiple total stations, levels, GPS receivers, and other instruments. You can change instruments as often as necessary.

4.1 Instrument Setup

Settings established in the *Instrument Setup* screen will be stored within your job file. Whenever you change instruments, the SDR will store a new instrument record with the new instrument type and associated settings.

The instrument type you select will affect the information fields pertaining to that instrument type. The instrument types you may choose from are Total Station, Level, and GPS RTK.

4.1.1 Total Station Setup

If you select **Total Stn** from the **Type** menu in the *Instrument Setup* screen, the following information fields appear:

Type................................. This text field addresses the type of instrument you are setting up.

Model............................. This field provides the model of instrument based on the selected type; the information is stored as part of the instrument record.

EDM desc...................... This field is used to log EDM descriptions.

EDM S/N........................ A six digit numeric field for the EDM serial number. It is transmitted as part of the instrument record.

Mount............................ In this field you may choose a type of EDM mounting method. Your choices are:

Not applic-EDM and theodolite are coaxial

Standards-EDM is standard mounted on the theodolite case

Telescope-EDM is mounted on the theodolite telescope and consequently moves as the vertical angle changes

V.obs............................... The **vertical observation** field allows you to select a method to measure a vertical angle.

Zenith-Angles are measured with the upward vertical representing 0 degrees

Horiz -Angles are measured with the horizontal representing 0 degrees

P.C. mm.......................... The prism constant (in millimeters) is the optical distance from the plumb line to the reflexive surface of the prism. Apply the prism constant in either the SDR L5 or the instrument, but not both..The screen allows you to specify the receiver and where the GPS raw data should be stored.

4.1.2   *Level Setup*

The SDR L5 can work in conjunction with a variety of levels. You can specify the model and specific settings for your level.

Type................................ This text field addresses the type of instrument you are setting up. Select from **Total Stn** and **Level**.

Model............................. This field provides the model of instrument based on the selected type; the information is stored as part of the instrument record.

Level Desc...................... Enter the type of level you are using; this information is stored as part of the instrument record for documentation.

Level S/N....................... Enter the serial number of the level; this information is stored as part of the instrument record for documentation.

Stadia .... Select the stadia value, **1:100** or **1:300**, when entering 3-wire readings using the **Manual** instrument setting.

4.1.3   GPS RTK Setup

If you select **GPS RTK** from the *Type* menu in the *Instrument Setup* screen, the following information fields will appear:

Type............................... This text field addresses the type of instrument you are setting up.

Model............................ This field provides the model of instrument based on the selected type; the information is stored as part of the instrument record.

Recvr mode................... The receiver mode identifies which receiver is currently connected and being set up. The options are Base and Rover.

Description................... This field displays a description of the transformation type selected in the Transformation field.

Serial no .... This field displays the automatic number assigned to your project.

In the *GPS RTK Instrument Setup* screen you must also set up your antenna and radio. At the bottom of the screen you will see the following softkeys: **Ant** and **Radio**.

These features will be described in detail in the next two sections.

4.1.3.1 Antenna Settings

When you set up a GPS RTK instrument, you will have to choose your antenna settings. The following options will be available to you:

Antenna type................. This field identifies the antenna type to be used. The options are **User** and several predefined types.

Ant meas method .... This field allows selection of the measurement method for antenna height, which is to be directly input. The options are **Vertical** or **Slant**.

Vertical offset (mm) ..... The vertical offset is the measurement from the antenna mount to the phase center of the antenna in millimeters. This field is editable if the **Antenna type** field is set to **User**.

Radius (mm).................. This radius of the antenna is entered in millimeters. This field displays only if **Ant meas method** is set to **Slant** and is editable if **Antenna type** field is set to **User**.

4.1.3.2 Radio Settings

You can establish or change some radio and receiver settings from your SDR by using the <**RADIO**> softkey in the *Instrument Setup* screen. No special connections are needed. However, before establishing radio controls you will need to disconnect and then reconnect the radio's power supply.

4.1.4 Setting up a level

The SDR can work in conjunction with a variety of levels. You can specify the model and specific settings for your level. The fields display the following information:

Type................................ This field identifies the type of instrument and subsequent type of measurement the SDR should expect. Select from **Total Stn** and **Level**.

Model............................. This field provides the model of instrument based on the selected type; the information is stored as part of the instrument record.

⊠ **Note**: If you are using a level instrument that is not listed, select the **Manual** option. For more information on specific instruments and associated settings, see Appendix B, *Instrument settings.*

⊠ **Note:** Selecting a particular instrument will automatically select the appropriate communications parameters for use with that instrument. The communications parameters cannot be changed (not even by the communications setup option in the *Comms* menu). See Appendix B for setting your instrument to be compatible with the SDR.

Level Desc...................... Enter the type of level you are using; this information is stored as part of the instrument record for descriptive purposes alone.

Level S/N....................... Enter the serial number of the level; this information is stored as part of the instrument record for documentation.

Stadia .... Select the stadia value, **1:100** or **1:300**, when entering 3-wire readings using the **Manual** instrument setting.

4.2   Configure Reading Parameters

The Configure Reading parameters enable you to select settings and preferences that apply to observations taken in the field. These parameters are used in operations such as topography, setting out, and roading.

The instrument type determines the information fields you will see on the *Configure Reading* screen. Your choices are **None**, **Total Station**, **Level**, and **GPS RTK**. Each of these features are explained below.

4.2.1   None Setup

Type................................ This text field addresses the type of instrument you are setting up.

Code list active.............. When this field is set to **Yes**, any code field will use the feature code list for quick entry of codes. When this field is set to **No**, use normal entry of alphanumeric data in the code field.

Info Blocks.................... This field will split your note records into specific fields that contain different types of data. For more information, see 4.2.5, *Info blocks*, Pg 4-12.

Code Fields On? .... If this option is selected, your codes will be split into subfields. For more information, see 4.2.6, *Code fields*, Pg 4-12.

4.2.2   Total Station Setup

Type................................ This text field addresses the type of instrument you are setting up.

Topo View stored.......... This field controls the view in which observations are initially displayed using the topography program. Your options are **OBS** (raw observation view), **MC** (measured and corrected view), **RED** (reduced view), **POS** (position view).

Combine F1/F2.............. When this field is selected **Yes**, the topography program prompts you for two observations, one from each face of the instrument.

 # dist rdgs....................... This field controls how many distance observations are made during each observational sighting. Enter a value between 0 and 9.

Code list active.............. When this field is set to **Yes**, any code field will use the feature code list for quick entry of codes. When this field is set to **No**, use normal entry of alphanumeric data in the code field.

Info Blocks.................... This field will split your note records into specific fields that contain different types of data. For more information, see 4.2.5, *Info blocks*, Pg 4-12.

Code Fields On? .... If this option is selected, your codes will be split into subfields. For more information, see 4.2.6, *Code fields*, Pg 4-12.

Recip Calc .... Choose whether to perform reciprocal calculation. The options are **Prompted**, **Always**, and **Never**.

4.2.3 Level Setup

Type................................. This text field addresses the type of instrument you are setting up.

Manual Method............ This selection field can be toggled between 1-wire and 3-wire. Select 1-wire if you are reading only the center cross hairs. Choose 3-wire if you are recording top, center, and bottom cross hairs.

Code list active.............. When this field is set to **Yes**, any code field will use the feature code list for quick entry of codes. When this field is set to **No**, use normal entry of alphanumeric data in the code field.

Info Blocks..................... This field will split your note records into specific fields that contain different types of data. For more information, see 4.2.5, *Info blocks*, Pg 4-12.

Code Fields On? .... If this option is selected, your codes will be split into subfields. For more information, see 4.2.6, *Code fields*, Pg 4-12.

4.2.4 GPS RTK Setup

Type................................. This text field addresses the type of instrument you are setting up.

GPS view stored .... The GPS observations are stored in the indicated view. Choices: GOBS, GRED, GPOS or POS.

Epoch rate (s)................. This field allows you to enter the rate at which measurement epochs on the receiver are taken. An epoch is a point in time based on the rate in seconds set in this field. Each observation is a number of epochs.

End obsvn...................... The observation will end when the specified conditions are met. The selection in this field will affect the observation in the *Taking Reading* screens. The options are **Epoch, Time, RMS,** and **Manual**.

# of epochs..................... This field establishes the criteria to complete an observation. The name of this field and the values entered are dependent on the entry in the *End obsvn* field (**Epoch**, **Time**, **RMS**, or **Manual**).

Accept float sol .... This field determines if a warning is displayed when attempting to read while in a float solution and whether the end observation criteria includes the requirement of a fixed solution. Select **Yes** or **No** in this field to accept or reject the float solution.

Elev mask...................... Values from 0° to 90°can be entered to exclude satellites below the rover receiver's elevation mask from being used in the observation.

Dynamics .... This field defines changes in velocity during observations. The setting filters out measurements that do not fit expected motion. Select an option best suited to movement (aircraft, vehicle, etc.) expected during the survey. For more information, see 4.2.4.2, *Reading dynamics*, Pg 4-11.

Amb fix mode .... Select from 1 through 8.

Fast Solution .... The **Fast Solution** option will produce calculated estimates to your next point when you are in motion during a survey. This can be used when continuous readings are necessary when navigating between points in set out routines. Select **Yes (default)** or **No** in this field (Available on some receivers).

Code list active.............. When this field is set to **Yes**, any code field will use the feature code list for quick entry of codes. When this field is set to **No**, use normal entry of alphanumeric data in the code field.

Info Blocks..................... This field will split your note records into specific fields that contain different types of data. see 4.2.5, *Info blocks*, Pg 4-12..

Code Fields On? .... If this option is selected, your codes will be split into subfields. For more information, see 4.2.6, *Code fields*, Pg 4-12.

Beep on epoch............... This field will split your note records into specific fields that contain different types of data.

S-O Points...................... This field determines the format of information when setting out functionality for roading alignments. The options are **Azimuth** (default) and **Deltas**.

S-O Align...................... Select the type of information displayed when setting out functionality for roading alignments and defined lines in **COGO** functions. The options are **Azmth/Dist**, **Deltas**, **Sta/Direction** and **Sta/Offset** (default).

Cont record rate .... This field determines how often (in seconds) a position is stored during continuous reading.

Dist exclusion .... A position will not be stored based on the continuous reading setting if the point is within the specified distance of the previous point.

Cont reading.................. This field determines the data collection method of observations. **Yes** - Continuous Reading. **No** - Single reading. For more information, see 4.2.4.1, *Reading type*, Pg 4-10.

4.2.4.1   Reading type

⊠ **Note:** For **GPS/RTK,** receiver settings located in *Configure Reading* will not be applied unless a receiver is connected and a job is open when the screen is accepted.

Two methods are available to collect GPS/RTK data with the SDR:

Single observations ..... select **NO**.

Continue readings........ select **YES**. Use this method to collect continuous observations by specifying time and distance parameters.

⊠ **Note**: Data is always stored internally in raw form. The current
view can be changed at any time using data view. ***Topo view
stored*** merely defines the initial view when the record is stored in
the database.

4.2.4.2   Reading dynamics

Receiver dynamics on the SDR can be set based on your operating
environment, via the **Dynamics** field in the ***Configure Reading***
screen. Your selection in this field affects the reacquisition of GPS
signals if one or more satellite signals are lost during a survey.

Reaquisition times for the six options in the **Dynamics** field are:

- Static
- QuasiStatic
- Walking (default)
- Automobile
- Aircraft
- Ship

Use the default setting **Walking** to optimize reaquisition times. The
reaquisition time is the amount of time it takes the receiver to
recapture a GPS signal. If the allotted time interval (established by the
Dynamic field setting) is exceeded, the search procedure for GPS
signals will be reset by the receiver. The receiver uses the last valid
signal as a starting point.

Receivers follow a given list of "states" when attempting to acquire
GPS signals. Once lock on a satellite is established, the receiver can
lose the GPS signal for brief periods without having to begin
acquisition over again. If a signal is lost for a time less than what is set
in the **Dynamic** field, the receiver does not have to return to the
beginning of the satellite search procedure.

4.2.5   Info blocks

The **Info Block** field of the *Configure Reading* screen allows you to collect information about survey points using Wild's Info Block style of data entry. It should not be confused with the more powerful attribute definition capability of the SDR's feature code list.

Use this field to create notes in seperate information blocks. Specify the number of extra fields that you want to fill in. The first field is called the **code**; subsequent fields are called "Info 1," "Info 2" etc., up to the specified number of information blocks. The maximum number of blocks is five.

The code and each info. block are allocated eight characters each and are combined in a single note record. You may choose to use alpha or numeric keys (do this when setting up feature codes).

4.2.6   Code fields

You can collect feature code information using the Zeiss style of code entry with the **Code fields** option in the *Configure Reading* screen. This option splits codes into subfields. Enter the number of subfields. The maximum is seven. When you specify a number of code fields greater than one, you can specify the size of each field.

The SDR suggests possible default values for the sizes of the fields. The total size of all the subfields must be less than or equal to 16 characters; this number includes a space between each subfield.

⊠   **Note**: Generally if you are using code fields, disable feature code lists.

4.2.7   Establish tolerances

The SDR checks the current status and observations for consistency within specified tolerances. You can set tolerances for various satellite conditions and RTK solution parameters. If any of these tolerances are exceeded, the SDR will provide a warning message describing the offending parameter.

These tolerances, in conjunction with ***Configure Reading*** settings gives you control over the quality of data associated with observations. Use specified tolerances to warn you when data being observed fails to meet your specified standards or tolerances.

From the ***Tolerance*** screen, you must choose the type of instrument you are using in the **Type** field. Information on screen will vary according to instrument type. Your choices are **None**, **Total Stn**, **Level**, and **GPS RTK**.

⊠ **Note**: Tolerances can be accepted without being connected to a receiver.

4.2.7.1   None Setup

If you select **None** from the **Type** field, no tolerances will be displayed.

4.2.7.2   Total Station/Level Setup

Type................................. This text field addresses the type of instrument you are setting up.

Tol H.obs........................ The field displays the horizontal distance measurement.

Tol V.obs......................... This field displays the vertical distance measurement.

Edm tol (mm) .... SDM fixed tolerance in millimeters specifies the SDM error that is independent of the length of line measured.

Edm tol (ppm) .... (parts per million) Specifies the EDM error that is proportional to the length of the line measured.

Stn Pos............................ This field specifies the station point name. If you enter a name known to the SDR, it fills in the coordinate fields with the point's coordinates; otherwise it sets the coordinate fields to **Null**.

4.2.7.3   GPS RTK Setup

Type................................ This text field addresses the type of instrument you are setting up.

3DRMS (m).................... The RMS (root mean square) of observation residuals indicates the divergence of observed values. Enter the 3DRMS value in meters.

HRMS (m)...................... Enter horizontal RMS value in meters.

VRMS (m)...................... Enter vertical RMS value in meters.

Com sat........................... This field indicates the number of satellites required to be in common between the base and rover receivers. The warning will indicate if the number of satellites is equal to or less than number provided.

PDOP .... The Position Dilution of Precision is related to the volume of the geometric figure whose convergent point is the receiver and whose sides are defined by the vectors from the receiver to each of the satellites being tracked. Enter the value for three-dimensional coordinate precision.

HDOP .... Enter a value of the two-dimensional Horizontal Dilution of Precision.

VDOP .... Enter a value for the elevation Vertical Dilution of Precision.

Radio link warn............ This field, if set to **Yes**, provides a warning if the radio link is lost. The options are **Yes** and **No**.

No RTK warn .... This field, if set to **Yes**, provides a warning if no RTK solution is available. The options are **Yes** and **No**.

Memory (kB) .... This field provides information on remaining instrument memory in kilobytes.

Rcvr batt (%).................. This field provides your remaining battery power by percent.

4.3   Units

The SDR can use different measurement units in different work environments. Units can be changed at any time without invalidating stored data.

The Units available in the Unit Settings are listed as they appear on screen:

Angle .... Angle units apply to all horizontal and vertical angle measurements and azimuths. Units can be **degrees**, **quadrant bearings**, **gons**, or **mils**. The SDR assumes horizontal angles and azimuths are always measured turning to the right. Selecting quadrant bearing units only affects the display of bearings (30° displays as N30°E); the underlying units are still degrees.

Dist................................ Distance units can be **meters**, (**International**) **feet**, or **US feet**. The unit chosen applies to all distances, lengths and coordinates. The conversion factor used is 1 International foot = 1.000002 US feet = 0.3048 meters. For distances in land surveying, the difference between the International foot and the U.S. Survey foot is less significant than the error inherent in EDM instruments. However, take this factor into account in certain situations such as using state plane coordinate system values.

Pressure .... Pressure units apply to the atmospheric pressure values. Units can be millimeters of mercury (**mm Hg**), inches of mercury (**Inch Hg**) or **millibars**. Conversion factors used are 1 Inch Hg = 25.4 mm Hg and 1,000 mbar = 750 mm Hg.

Temp .... Temperature units apply to the atmospheric temperature values. Units can be **degrees Fahrenheit** or **degrees Celsius** (Centigrade). The conversion formula used is °C = (°F - 32)/1.8.

Coord .... Coordinate units do not refer to the coordinate values, but to the order in which they are displayed. Your choices are **N-E-Elev** (north, east elevation) or **E-N-Elv** (east, north elevation).

Other grades .... This grade unit will be applied to all crossfall occurrences including the definition of the actual templates in ROADING (with the exception of the sideslope grades as discussed below). The options are: **Ratio** (1:10) or **Percent** (10%).

Sideslope grade .... The sideslope is the crossfall which joins the edge of a roading template and the existing terrain at a catch point. It can be set independently of other grades with this unit. Options: **Ratio** (:) or **Percent** (%).

Sta..ing .... This field controls how stationing values are displayed. The options are **10+00**, **1+000** and **1000**.

Decimals Shown .... This field controls how many decimal places are shown. The options are **2**, **3**, and **4**. The number will be rounded at the specified decimal place.

Zero azimuth .... This field determines which direction is used to define the zero azimuth. The options are **north** (default) and **south**.

Speed .... This field determines the speed at which the receiver is moving. The options are **KPH**, **MPH** and **knots**.

⊠ **Note:** The conversion factors are 90° = 100 gons and 90° = 1,600 mils.

4.4 Communications

In the **Communications** tab choose the format of your data. Your choices are:

SDR .... Communicate your information to an external device.

Printed .... Print your information.

Plotted .... Plot your information.

After you have chosen the format of your data, you can send, receive, and set up communication with your instrument of choice. You also can modify your selected format in the *Options* screen. These choices are available to you at the bottom of your Windows CE screen.

4.4.1 Options

In the Communications *Options* screen you may choose what elements in your project you want to view or output. Your choices listed below may be set to **YES** (view or send) or **NO** (not view, not send). The options will change depending upon the data format you choose.

4.4.1.1 Options menu for SDR, Z-Bin, and Printed

Current view .... Your Current view

OBS view .... Observation view

MC view .... Measure corrected observation view

RED view .... Reduced view

POS view .... Positional view

GOBS view .... GPS observation view

GRED view .... Reduced GPS view

GPOS view .... GPS position uncalibrated/uncorrected view

WGS84 LLH view .... View coordinates in latitude and longitude height

Local Datum View .... View local datum in latitude and longitude height

Send all as LELEV .... Send all as level record (point defined only by elevation)

Send GPS as POS .... Send GPS record as a positional view

Send all as POS .... Send all as a positional view

Send partial job .... Send a partial job

4.4.1.2   Options menu for Plotted

Plotter .... Plotter time

Paper .... Paper size

Planform .... Vertical, horizontal, or 3-D planform

Linework .... Draw lines between points

Point Annotation options:

Pt num .... Point number

Pt code .... Point code

Pt elev .... Point elevation

Pt an DP .... Point annotation decimal places (for height annotations).

Pt an size .... Point annotation size

Pt an pen .... Point annotation pen

Pt an orient .... Point annotation orient

Start code .... Select this code to be the line start code

Close code .... Select this code to be the line end code

4.4.2 Com Setup

In the *Com Setup* screen you can find out what type of communication your SDR L5 will allow. All data formats have access to the *Com Setup* screen. Your Com choices are listed below:

Port .... The SDR port the serial cable is plugged into. Your choices are COM1 (top) and COM2 (bottom).

Modem .... If you are using a modem, set this field to **Yes**.

Baud rate .... Rate of data exchange between instruments in bits per second. Available baud rates are **300**, **600**, **1200**, **2400**, **4800**, **19200**, and **38400**.

Word length .... Set word length. You may have up to eight characters per field.

Parity .... The type of parity bit added to each character during sending. It also refers to the parity bit that is checked when a character is received. Your options are **Not set**, **Odd**, and **Even**.

Stop bit .... The number of stop bits transmitted after each character. Your options are **1** and **2**.

Output delay .... This is designed primarily to give support for serial printers with little or no buffering. When this field is non-zero, it causes any output to pause for the number of milliseconds specified before sending each byte.

File .... Storage container

4.5   Job Deletion

In the **Job Deletion** screen you may choose what elements in your project you want to delete. When this option is selected, the following softkeys will appear on screen: <**Select jobs**>, <**Select roads**>, <**Select templates**>, and <**Select all data**>.

You can open up all files in your SDR to delete by choosing <**Select all data**> or select specific file types by choosing one of the other options. When the files appear on screen you can set them to **YES** (delete) or leave them as **NO** (do not delete).

4.6   Calculator

The SDR L5 calculator eliminates the need to carry a separate calculator in the field. Using the SDR database, you can transfer values from the database to the calculator, perform calculations and transfer the results directly back to the database. The SDR calculator works similarly to a HP (Hewlett-Packard) calculator, making many functions easy and intuitive. Refer to the *SDR Level 5 User Guide* for more information.

4.7   Feature Code List

You can add, delete, edit, or view feature codes on the *Default List* screen.

In the *Add* screen, you can name your code, join your code to a list, and list attributes. If you add attributes, you need to specify the type of attribute you are using. The choices are **Alpha** and **Numeric**.

In the *Feature Code List* screen, you can add, delete, and edit the lists as well as view the statistics of the selected list. If you choose to view the statistics, you will see the following list of statistics:

ID...................................... This field displays the name of the feature code list.

File Size (k).................... This field displays the size of the feature code list in kilobytes.

Recs Used...................... This field displays how many records occur in the feature code list.

Date................................ The date the feature code list was created.

Time .... The time the feature code list was created.

Sort Type .... This field displays the sorting option.

For more information about Feature Code, see Chapter 14, *Feature Codes and Attributes*, Pg 14-1.

4.8   Language

In this screen, select your desired language from the **LNG** files stored on the SDR.

Chapter 5   Taking a Reading

In this chapter we will determine the observation period and take an offset reading. Topography observations vary depending on the device used in taking the observation (total station or GPS receiver).

5.1   Determining the Observation Period

The observation period is the period of time when the antenna is stationary over a feature of interest and is collecting data. Data collection is initiated by taking a reading after the observation period is set in the *Configure Reading* screen.

You can specify that the SDR automatically ends the observation period based on a specified number of epochs, time, or 3DRMS value. You can always manually end the observation regardless of the specified criteria.

The following table describes the observation period values available

Table 1: Observation Period Values

End Obsvn Type	Observation value	Criteria to end observation
Single reading		
Epoch	Epochs left	The number of epochs counted from the specified end observation value to zero
Time	Time left	The time has elapsed from the specified end observation value to zero
3DRMS	3DRMS	The 3DRMS values falls below the specified end observation value.
Manual	N/A	Pressing the **<STOP>** softkey
Continuous reading		
N/A	Continuous Record Rate	The time has elapsed from the value specified in the **Cont Record Rate** field
	Distance Exclusion	The distance from the last continuous reading is less than the value specified in Dist Exclusion

5.2   Assessing Quality Observations

The SDR displays a RMS range in the GOBS record in the 3DRMS field to indicate the quality of an observation. The SDR displays five value ranges for RMS values:

- 0.000 – 0.025 (highest accuracy)
- 0.026 – 0.050
- 0.051 – 0.100
- 0.101 – 0.250
- 0.251 or more (lowest accuracy)

Chapter 6   Calculating Unknown Stations

In this chapter we will calculate unknown stations utilizing Total Stations with resections and inaccessible stations. We will also identify unknown stations with Professional Positioning.

When performing several common operations, you will need to establish a station as the base for subsequent observations. Any time the instrument is moved to a new location, the SDR will prompt you to establish a new station.

Stations are not required to be known locations. However, you may need to calculate an unknown station's location in the field. The SDR needs accurate station coordinates for some options, including coordinate geometry, transformations, roading, and set out. You do not need to calculate an unknown station for general surveying options, such as topography, remote elevation, or building face survey.

If your survey contains some known positions, the SDR can calculate the position of an unknown point. Depending on the version of SDR software installed, one of the two methods will be available. Both options use known data to compute unknown locations. The two options vary in the mathematical processes used to derive the coordinates.

Resection........................ This method uses least squares adjustment techniques to determine the coordinates of an unknown point. For more information, see 6.1, *Resection Calculation*, Pg 6-2..

Positioning .... The Professional Positioning method uses a balanced least absolute value estimation and mathematical techniques to determine the coordinates of an unknown point and any observational errors. For more information, see 6.2, *Professional Positioning*, Pg 6-4..

Both Resection and Professional Positioning use the same technique to observe multiple observations as the Set Collection option.

You can calculate multiple unknown stations by repeating the Resection or Professional Positioning process for each station. The SDR will store the calculation results in the database, for use in determining future stations, observed coordinates, or calculating coordinate geometry functions.

6.1   Resection Calculation

The Resection program calculates the coordinates of an unknown station by observing a number of known positions from the unknown point. The SDR performs a least squares reduction so all data is used and redundant data generates better statistical results. Using the Resection option requires at least one of the following:

- two observations with horizontal and vertical angles, including at least one slope distance

- three observations with horizontal angles

In the following sections we will describe resection in further detail.

6.1.1   Perform a resection

The SDR calculates a preliminary X-Y position from the minimum required data. It uses this result as the basis of a least squares reduction involving all the data. This process terminates when the change in both the X and Y coordinates is less than 0.001 meters from

one iteration to the next. The iterative process also terminates if convergence does not occur within nine iterations because the reduction is not stable.

When performing a resection calculation, be sure the geometry of the observations produces a stable result. For example, in a two distance resection the result will be unstable if the angle between the observations is close to 180°. Similarly, with a three point resection, an unreliable result will occur if the three points and the instrument station lie on a circle.

Once the X, Y coordinates of the resection station are computed, the observed vertical angles (and target heights) from the station to known points are averaged to produce the elevation of the station.

6.1.2   Review existing sets

Before you select **Calculate resection**, you can use this option to view the data collected. If you find a set with errors, mark it "BAD" so it will not be used in calculations. An asterisk denotes a bad set.

You can repeatedly review the observations and perform the resection calculation to see the effect of excluding a set.

6.1.3   Calculate resection

The **Calculate resection** option calculates the coordinates of the station point. If redundant data exists, a least squares calculation is performed.

During calculation, the screen displays a **Processing data message** and indicates the current iteration. When calculations are complete, the SDR displays a station record containing the calculated coordinates.

You can change the code and store the record here. If you press <**Enter**>, the SDR stores a series of notes that show the differences between the expected and actual observation values for each point. For example, if the SDR calculates station coordinates of 100, 300, the

SDR calculates the inverse from the station to each observed point. The notes show the difference between the calculated inverse and the actual observations.

If you are not satisfied with the resection coordinates produced, you can collect more sets to recalculate coordinates.

6.1.4   *Eccentric station setup*

If a desired station location is inaccessible, you can perform an eccentric station setup using resection to calculate the coordinates. An eccentric station is essentially an offset with multiple observations. When positioned on an arbitrary point near your desired station location, the SDR can observe distance and angle measurements using several known points to compute the inaccessible station.

6.2   Professional Positioning

Professional Positioning (PROFPOS) determines the unknown position coordinates by way of two alternate adjustment procedures: **LS** (Least Squares) and **BLAVE** (Balanced Least Absolute Value Estimation). The LS procedure is used in typical resection calculations. The BLAVE procedure allows for the detection of outlying observation errors, or blunders, minimizing the leverage effect. The results of both adjustment procedures are available within PROFPOS.

The coordinates for the unknown station are found by observing a number of known positions from the unknown station. PROFPOS automatically calculates the approximate coordinates and executes the adjustment computations. Statistical methods within the BLAVE procedure minimize, and in most cases, eliminate the adverse affect of outlying observations on the calculated position. Once the results are given, the user is able to trace any errors, such as wrong target point, point displacement or incorrect measurement.

6.2.1 Calculate Station Position

To calculate the station position you must configure your station parameters. The collection parameters are available to you through the options menu in the **Confirm Stn** field.

The **Calculate position** option calculates the coordinates of the station point. Calculations are performed for both adjustment procedures.

Method .... This field indicates the sets collection method:

> **Direction**-observing several points using the same instrument orientation.

> **Repetition**-observing a single angle between two points several times using different instrument orientations.

Data .... This field controls which observational measurements will be collected together. The options are as follows:

> **HVD**-all measurements are collected in each set of obervations.

> **H,VD**-The horizontal angles are collected during one observation. The vertical angle and distance are collected on the next observation.

> **H,V,D**-the horizontal angle, vertical angle, and slope distance are collected in separate observations.

Number H Sets .... This field controls how many sets of horizontal angles are collected.

⊠ **Note**: In the case where the data being collected is HVD, the Number H Sets is also the number of sets of vertical angles. This number is independent of whether both faces are being observed.

Number of V Sets......... This field appears only if the data being collected is **H,VD** or **H,V,D**; this field indicates how many sets of vertical angles are collected.

 # dist rdgs...................... This field controls how many distance observations are made during each observational sighting. Enter a value between 0 and 9.

⊠ **Note**: The SDR will initiate multiple distance reads only for Sokkia surveying instruments.

Face order...................... This field controls the switching between <F1> and <F2> during the collection of single or multiple sets. Select from the following options: F1 only, F2 only, F1F2/F1F2, F1F2/F2F1, F2F1/F2F1, F2F1/F1F2.

Some selections show two sets, separated by a sleash, indicating that both faces will be used. For example, F1F2/F2F1 specifies that, in the first set, observations will be made to points in the set beginning with Face 1 and then Face 2 of your instrument, and in the second set, you will reverse the same points beginning with Face 2 and then Face 1 of the instrument.

If you wish to observe only one set, taking first Face 1 then Face 2, you should choose either F1F2/F1F2 or F1F2/F2F1. Since you are only collecting one set, ignore the second set specification.

Obs order .... This field specifies the order in which the SDR prompts you to observe points when collecting individual sets.

Unprompted.................. The SDR will not prompt you at all and observations may be made in any order.

123...123........................... The SDR prompts for the second face of a set in exactly the same order as it prompted the first face. For example, if you select **123...123...** and pre-enter points A, B, C, and D, you are prompted to observe points in the following order:

A,F1>B,F1>C,F1>D,F1>A,F2>B,F2>C,F2> D,F2.

123..321........................... The SDR prompts for the second face of a set to be prompted in reverse order:

A,F1>B,F1>C,F1>D,F1>D,F2>C,F2>B,F2> A,F2.

Return sight.................. This field specifies whether you wish to sight again on the first observed point in a set when the end of the set is reached. For example, if points 1,2, and 3 are observed and a return sight is selected, then the physical observations made would be 1,2,3,1. Any error found in the return sighting is distributed between the other observations.

This field displays only when the set collection method is **direction**.

Preenter points.............. This field determines if you enter a list of points that you will observe, prior to observing any points in the set. The SDR will use the list's order, in conjunction with the **Obs order** field, to prompt you for the next point to observe.

If this field is **Yes**, the SDR allows you to enter a list of points that you will observe, prior to obvserving any points in the set.

If this field is set to **No**, you will not be asked for the point names prior to observing the points. The SDR will, however, intelligently guess which point

you are observing based on the observations taken, and assist you by supplying the point name, code and target height, if required. The feature is active only for sets collected by direction.

Recip Calc .... Choose whether to perform reciprocal calculation. The options are **Prompted**, **Always**, or **Never**.

⊠   **Note**: A note record is entered in the database when a reciprocal calculation is performed. The first note is placed above the **STN** and states **Vert Recip Calc refined Stn ### Elev.** The second note is placed above the BKB record and states **Recip Calc used Stns #### & ####.**

Once you have collected your data and sighted your instrument correctly, you will have the option to calculate your resection, collect more sets, or review your existing sets.

Calculate resection .... This option calculates the station by performing a least squares adjustment. For more information, see 6.1.3, *Calculate resection*, Pg 6-3..

Collect more sets .... Select this option to collect more observation sets.

Review existing sets .... Select this option to review the collected observation sets. For more information, see 6.1.2, *Review existing sets*, Pg 6-3..

You may also change which adjustment procedure's calculated position is displays on the initial results screen. Your options are **BLAVE** and **Least Squares**.

BLAVE .... This option performs a BLAVE adjustment. For more information , see 6.2.4.2, *BLAVE Technique*, Pg 6-13..

Least Squares .... This option calculates the unknown station using a least squares adjustment. For more information see 6.2.4.1, *Least Squares*, Pg 6-13..

Once the calculations are complete, a station record contains the calculated coordinates of the configured adjustment procedure.

6.2.2 Adjustment procedure results

To see your calculation results, go to the *Results* screen. In this screen you can see the position, correction, and adjustment comparisons between the **BLAVE** and **LS** adjustment procedure.

Position .... compares the coordinates calculated by both adjustment procedures.

General Statistics .... provides general information about the points which were observed.

Corrections .... gives the bearing and distance corrections which were applied by each adjustment procedure. The BLAVE corrections will indicate certain observations with an asterisk next to the appropriate bearing or distance. The asterisk indicates that the corresponding correction exceeds the a prior standard error of the observation (observation tolerances as set in the *Tolerance* screen) multiplied by ten.

Adjustments .... shows the subsequent adjustments made to the coordinates of the initial position. Adjustments for both procedures are given as well as the initial coordinates.

6.2.3 Advanced LS details

The *Details* screen lists the advanced least squares statistical data. You may choose to view the least squares numerical accuracy, advanced status, and advanced results.

6.2.3.1   Numerical Accuracy

Within the ***Numerical Accuracy*** screen you can view the Ansermet data.

The Ansermet data reveals information about the observations. An Ansermet of zero indicates there is no real redundancy in the adjustment. A separate warning screen is displayed prior to the display of the calculated position coordinates to warn the user of this situation. In the case of no redundancy (Ansermet = 0.0), error detection is not possible and all corrections become zero.

A typical Ansermet will be an integer value greater than zero. If an Ansermet is equal to 1, corrections are given, but error detection is not theoretically possible. The same redundancy warning is displayed. If the Ansermet is not an integer value, it is an indication that computing problems were encountered in the adjustment.

6.2.3.2   Advanced statistics and results

The ***Advanced LS Stats*** screen and the ***Advanced LS Results*** screen are intended to give an understanding of the least squares results. Since the **BLAVE** procedure statistically detects errors and distributes the partial redundancies, these screens are intended as additional tools to interpret results.

The ***Advanced LS Stats*** screen gives the reduced bearing and distance as well as the standard error bearing and distance for the observed points. Each point can be shown by paging up and down.

The ***Advanced LS Stats*** screen gives the partial redundancies, **RED Brng** and **RED Dist**, which range in value from 0.0 to 1.0. A large value (close to 1.0) has a minimal impact on the LS adjustment while a small value has a greater affect. Summing of these values leads to the degree of freedom. Equal numerical values for RED indicates equal distribution of the partial redundancies and therefore an ideal LS target point constellation. The **Std Err Brng** and **Dist** are a test for errors within a single point adjustment derived from LS statistics.

An error ellipse can be calculated to indicate the major and minor axis (A and B) of the ellipse related to the target point coordinate system. The azimuth (T) indicates the bearing of the major axis. The information is useful for location accuracy properties. Ideally, the error ellipse becomes a circle when the major and minor axis are equal (A = B).

You can store the station record as well as a note stating which adjustment method was used to determine the coordinates. You may also change which adjustment method's results will be displayed in the station record screen.

To change the configured adjustment procedure, use the left and right arrow buttons to toggle between **BLAVE** and **Least Squares**.

The least square point standard deviation, multiplied by two, is compared to a user-supplied tolerance in the **Functions** menu under *Tolerances*. If it exceeds it, the Stn pos is determined as "BAD" to indicate further investigation of the results may be necessary.

The BLAVE results uses **LS vs. BLAVE** as seen on previous screens. That user-supplied tolerance as described above is applied to the horizontal distance between the determined station position of both adjustment procedures (multiplied by two). If it is exceeded, **LS vs. BLAVE** is marked "BAD." It informs the user when the results of the two procedures deviate from each other. For more information about **LS vs. BLAVE**, see 6.2.6.4, *LS vs. BLAVE*, Pg 6-17.

Your feature codes can be altered.

For more information about **BLAVE**, see 6.2.4.2, *BLAVE Technique*, Pg 6-13. For more information about Least Squares, see 6.2.4.1, *Least Squares*, Pg 6-13.

6.2.3.3   Collect more sets

If you are not satisfied with the positioning coordinates produced, you can collect more sets with which to recalculate coordinates by selecting the **Collect more sets** option.

6.2.3.4   Review existing sets

You can use the **Review existing sets** option to view the data collected. If you find a set with errors, mark it "BAD" so it will not be used in calculations. An asterisk denotes a bad set.

You can repeatedly review the observations and perform the position calculation to see the effect of excluding a set.

6.2.4   Professional Positioning input

Two separate adjustment procedures are available within professional positioning:

- Least Squares (LS).
- Balanced Least Absolute Value Estimation (BLAVE).

The LS and BLAVE procedures differ in their initial estimation technique.

Determining an unknown position requires a minimum of either of the following:

- two observations with horizontal and vertical angles, including at least one slope distance
- three observations with horizontal angles

The SDR estimates an initial X-Y position from the minimum required data. It uses this result as the basis of a least squares reduction involving all the data. This is an iterative process that terminates when the change in both the X and Y coordinates is less than 0.001 meters from one iteration to the next. The iterative process also terminates if convergence does not occur within five iterations because the reduction is not stable. An error message is displayed.

6.2.4.1   Least Squares

The LS procedure uses weighted averages of the observations to estimate an initial X-Y position. An observational error, or blunder, is thereby given unbounded influence to the estimation result. For more information about blunders, see 6.2.6.5, *Blunder detection*, Pg 6-17.

6.2.4.2   BLAVE Technique

The BLAVE estimation technique allows for detection of errors. It also provides useful estimation data by balancing the observations, allowing detection of gross error by statistical means. Blunders then have minimal influence on the initial estimation. The estimation is then used in the iterative process. For more information about blunders, see 6.2.6.5, *Blunder detection*, Pg 6-17.

The threshold of error detection for a BLAVE computation is dependent on the number of observations introduced. The equation is as follows:

number of blundered observation components = (number of observation components - 3) ∕ 2 where an observation component is a full bearing or a distance.

For example, three full readings (two components each) and a bearing (single component) allows for (7 - 3) ∕ 2 = 2 blundered components. In determining your unknown station, introducing more observations than necessary will yield higher accuracy of the position, better checks on plausibility and improved error detection.

Although BLAVE is not as prone to geometric limitations as the least squares procedure, it is good practice to ensure that the geometry of the observations produces a stable result. For example, avoid your target points forming a straight line with the unknown station lying close to that line. Similarly, unreliable results will occur if the target points and the unknown station lie on a circle.

6.2.5   Professional Positioning error/warning messages

Error messages and warnings are given to the user if any situations arise for which a BLAVE and/or an LS adjustment procedure can not be computed. Additionally, warning messages are displayed if the computations could potentially suffer due to the data supplied. The following are the errors and warning messages given by Professional Positioning with an explanation and possible solutions.

Message:

Computation of position not successful.

Solution:

Add more target points. Too few target points were included from which to compute the unknown station position. Additional, non-identical target points should be added.

Message:

Limitation of target points exceeded.

Solution:

The maximum number of target points has been exceeded. Computation of unknown station position will still be computed if possible.

Message:

Unable to determine a unique position.

Solution:

Adjust target point constellation. A unique position is not possible due to lack of observation data to target points in existing constellation. Full observations should be taken if possible, or additional target points should be added.

Message:

Unable to determine approximate values.

Solution:

Adjust target point constellation. The existing target point constellation possess unstable geometry or contains an incomplete combination of bearings and/or distances which may give erroneous results. The target point constellation should be supplemented with additional observations.

Message:

Results may suffer from rounding errors.

Solution:

Adjust target point constellation. Rounding errors occurred within the Linear Programming algorithms. Numerical results may not be sufficient.

Message:

Maximum iterations reached.

Solution:

The predefined maximum number of steps for the balancing computation has been reached. The resulting balancing factors were introduced to the BLAVE adjustment computation.

Message:

Observations not balanced.

Solution:

The balancing procedure was not possible. A Least Absolute Value Estimation (BLAVE) was executed instead of the BLAVE.

Message:

Ansermet < 2 No Redundancy caution.

Solution:

The least squares ansermet is less than two.

6.2.6   Professional Positioning results

The following qualifying indicators exist to guide the user toward understanding Professional Positioning results:

6.2.6.1   Least Squares statistical data

This can be used to determine, independently, the validity of the Least Squares result. This can be particularly helpful in the event that the LS and BLAVE results do not coincide. For more information about Least Squares, see 6.2.4.1, *Least Squares*, Pg 6-13..

6.2.6.2   Ansermet < 2 No Redundancy caution

The determination for this warning message is the least squares ansermet. When the ansermet is equal to zero, there is no real redundancy in the adjustment. Error detection is not possible and all corrections become zero. If the ansermet is 1, error detection is not theoretically possible, but some corrections are made. It can be an indication to the user that a particular situation could produce unreliable results. In the case of ansermet = 0 or the case of ansermet = 1 with a blunder detected, it should be verified that the geometry of the target point constellation is stable.

6.2.6.3 Stn pos

A particular least squares statistic, the standard deviation, is used to determine a **Stn pos** as good or bad. The standard deviation, times two, is compared to a user-supplied tolerance in the **Func** menu under *Tolerances*. If it exceeds it, the **Stn pos** is determined as "bad". This is meant to be an indicator to the user that the LS standard point deviation is large prompting further investigation of the results.

6.2.6.4 LS vs. BLAVE

The standard deviation, times two, is compared to a user-supplied tolerance in the **Func** menu under *Tolerances*. This tolerance is applied to the horizontal distance between the determined unknown station position of both adjustment procedures (times two). It informs the user when the results of the two procedures deviate from each other. This would be expected in the presence of blunders which typically, and incorrectly, alter a Least Squares position.

6.2.6.5 Blunder detection

Because blunders have an adverse affect on Least Squares adjustments and are helpful in explaining the status of other indicators, it is important for the user to be made aware of their presence. A target point observation, bearing or distance, is marked as a blunder if the corresponding correction exceeds the apriori standard error of the observation multiplied by ten. The apriori standard error of the observation are the observation tolerances set in the Tolerance screen in the **Func** menu.

Chapter 7   Coordinate Systems

A coordinate system is a reference frame used to designate a position. The SDR supports three types of coordinate systems - local assumed grid, projected grid, and ellipsoidal. The SDR enables you to select a reference frame and a coordinate system.

This chapter describes the following:

- WGS84
- SDR requirements
- types of coordinate systems
- GPS/RTK Reduction process
- transformations

7.1   The World Geodetic System 1984

The reference frame for GPS is the World Geodetic System 1984 (WGS84), which defines the Earth with a single geodetic or ellipsoidal coordinate system. This reference frame can be described as a "best fit" to the Earth's mean sea level. Since the reference system for GPS is WGS84, high quality geocentric coordinates can be provided automatically by your GPS receiver.

The origin of the WGS84 system is the Earth's center of mass. The Cartesian X axis lies in a plane at the equator and passes through the Greenwich meridian and the Cartesian Z axis passes through the North pole. The Cartesian Y axis lies perpendicular to the X axis and Z axis, forming a right-handed coordinate system.

Longitude is determined by angle measurement in the plane of the equator between the meridian through the point and meridian through Greenwich. Height is determined as distance of the point above or below the ellipsoid, measured along the normal.

7.2　SDR Requirements

All points collected with the SDR during a survey must have an associated coordinate - a linear or angular value describing a point's position relative to a specific reference frame. The SDR enables you to define and use different coordinate systems, thereby transforming WGS84 survey data to your specifications.

Because the SDR can store ETS and RTK survey data in the same job, certain survey parameters must be set when you create a new job. Some of these parameters cannot be changed after selection. Therefore, it is important to evaluate your particular survey situation prior to job creation.

7.3　Types of Coordinate Systems

The SDR supports three types of coordinate systems:

- Local Assumed Grid Coordinates
- Projected Grid Coordinates
- Ellipsoidal Coordinates

7.3.1　Local Assumed Grid Coordinates

A large number of surveys require the use of a rectangular coordinate system. These systems, which are the traditional method of using coordinate systems with a SDR survey, consider the surface of the Earth as a plane. With regards to horizontal distances and directions a

level line is considered as mathematically straight, the plumb line is considered perpendicular to the level line and the same direction at all points with all angles being plane angles.
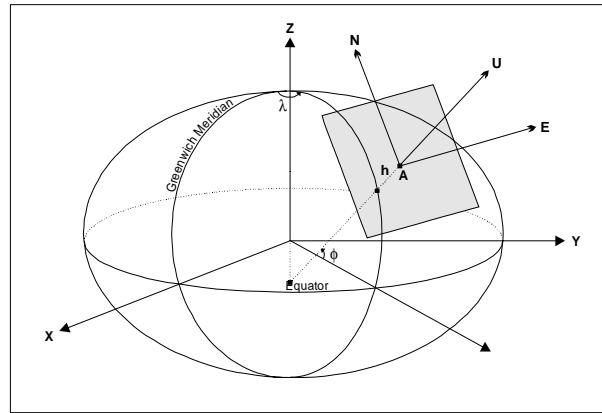
Figure 7-1: Relationship among Cartesian, geographic, and plane coordinates.

If you selected **No** in the **Select XFM** field when you set up your job, you are using local assumed grid coordinates. This is the traditional SDR method of determining position. Both RTK and ETS data can be used with this coordinate system. If both devices are used, you should perform a calibration to minimize error. However, calibrations do not apply to ETS data. Any ETS data is assumed to be in the destination coordinate system. However, you can use a Helmert transformation after your survey if you have not set up ETS data in the destination system.

7.3.1.1 Rules for working with Local Assumed Coordinates

When working with local assumed grid coordinates, observe the following rules when collecting data:

RTK

• Connectivity is required among GStns. Each new GStn must be observed from a previous GStn.

7.3.1.2   Rules for working with Projected Grid Coordinates

When working with projected-grid coordinates, observe the following rules and conditions when collecting data:

RTK

- Connectivity among GStns is required if your selection is **Unknown** in the **GPS Coord System** field. Each new GStn must be observed from a previous GStn.
- Plane curvature corrections are not utilized.
- Atmospheric corrections are allowed only when using a total station.
- Sea level or curvature corrections will not be applied.

ETS

- Connectivity is required among all Stns if your selection is **Unknown** in the **GPS Coord System** field.
- Inverses will be calculated on the projected-grid.
- Atmospheric corrections will be applied to ETS data only.

Sea level, curvature and refraction corrections will not be applied.

> ⊠ **Note:** When using ETS with an unknown start at the initial Stn, latitude, longitude, and height values should be known to better than 32 meters.

7.3.2   Ellipsoidal Coordinates

The Earth can best be approximated as an oblate spheroid of revolution. Mathematically, it is expressed as an ellipsoid with the axis at the equator greater than the axis through the poles. An ellipsoid is best described as an ellipse rotated about its minor axis.

An ellipsoid can be made to describe the Earth using two parameters:

- semi-major axis
- flattening

Historically, most mapping authorities adopted ellipsoids which best define the size and shape of a particular region of use. Because of this, there are large differences among ellipsoids used throughout the world.
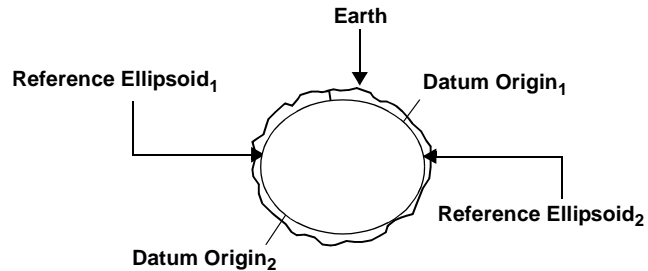
Figure 7-2: Reference ellipsoids

An ellipsoid defines the size and shape of a reference system (or datum). A datum is defined by an ellipsoid fixed in space (with origin) and a defined orientation. In the last few decades, mapping agencies have adopted geocentric datums.

Positions can also be described in terms of latitude, longitude and height.

The latitude is defined as the angle between a normal to the ellipsoid at a point and the plane of the equator. Longitude is measured in the plane of the equator between the meridian through the point and the Greenwich meridian.

Latitude values start at zero at the equator and increase to 90° at the North Pole; decrease to -90° at the South Pole. Longitude values start at zero at the prime meridian at Greenwich and increase to the east, typically normalized between -180 (west) and +180 (east) degrees.
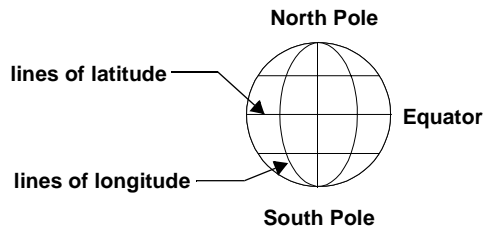
Figure 7-3: Latitude and longitude

The height is based on the surface of the ellipsoid. This is not to be confused with orthometric heights, which are based on a surface, called the geoid, which approximates mean sea level.

The geoid is an equal potential surface approximating mean sea level. In most cases, it is used as a height datum. Values referenced to the geoid indicate the direction water will flow.

The difference between the height of a point above the geoid and the height above the spheroid is called geoid undulation or geoid-spheroid separation. This geoid undulation will vary from point to point as the shape of the geoid is affected by gravity and mass distributions beneath the Earth's surface.

Ellipsoidal coordinates (latitude, longitude, and height) can be used to describe the position of a point relative to the curved surface of an ellipsoid.

h = ellipsoidal height
H = orthometric height
N = Geoidal height
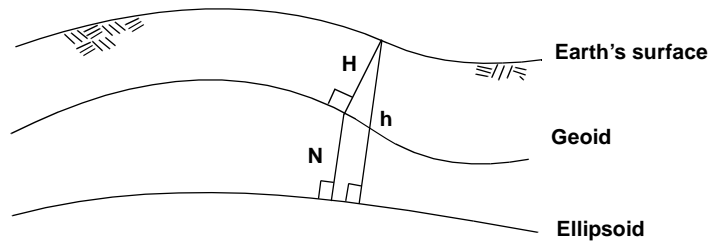
Figure 7-4: Geoidal undulation

If the option selected in the **Zone** field of the *Create Job* screen is a ellipsoidal coordinate system, follow the instructions and rules in this section.

7.3.2.1   Keying in values

To use ellipsoidal coordinate systems, all Latitude and Longitude values must be keyed in. If you have selected Unknown in the **GPS Coord System** field, when you created your job, ellipsoidal coordinates cannot be used.

⊠ **Note:** All values keyed in, when using ellipsoidal coordinate systems, must be entered as degrees, minutes, and seconds.

Because ellipsoidal coordinates systems require known keyed in values, you must select **Known** during job creation. Calibrations are not applicable to ellipsoidal coordinate systems.

The option to choose a known or unknown start is enabled when you select **YES** in the **Select XFM** field when creating a job.

7.3.2.2 Rules for working with ellipsoidal coordinate systems

When working with ellipsoidal coordinates, observe the following rules and conditions when collecting data:

RTK

- Connectivity is not required between each GStn.
- Calibrations are not applied.
- Atmospheric corrections are not applied.
- Sea level or curvature corrections are not applied.
- Stake out operations can not be performed.
- Ellipsoidal coordinates are used for topography only.
- Coordinate Geometry is not available when using ellipsoidal coordinate systems.

ETS

- Connectivity is not required between each Stn.
- Atmospheric corrections may be applied.
- Sea level or curvature and refraction corrections are not applied.
- Stake out operations cannot be performed when using ellipsoidal coordinate systems.
- Ellipsoidal coordinates are used for topography only.
- Coordinate geometry is not available.

7.4 GPS/RTK Reduction Process

When working with coordinate systems during an RTK survey, it is helpful to understand how the SDR produces a solution.

The initial reading from the GPS station (GStn), is first reduced from it's WGS84 Latitude, Longitude, and Height to a vector formed between the location of the base receiver and the rover receiver. This vector is then transformed to a local plane using the initial GStn as the origin.

The vector is stored in the SDR database, as a raw observation, similar to ETS observations. The database record is composed of the horizontal angle, vertical angle, and slope distance.

Also similar to ETS surveys, you can view collected data in varying states (GOBS, GRED, GPOS, and POS). The reduction process takes place from one state to the next. The actual reduction of your data will be determined by settings established when you created the job.

Reduction view options

The SDR view options will vary depending on what instrumentation (GPS/RTK, Total Station, or both) you are using and whether or not you have selected a transformation.

7.5 Understanding Transformations

The use of any of the various coordinate systems requires a transformation of the data from one coordinate system to another. The transformation of one type of coordinate system to a coordinate system of the same type is defined as a **datum transformation** (ellipsoidal to ellipsoidal) or a **plane transformation** (rectangular to rectangular). A transformation between two different coordinate system types (ellipsoidal to rectangular) is defined as a coordinate transformation that usually contains some variation of a **map projection**.

The SDR provides two categories of mathematical processes to accomplish transformations:

Datum Transformation .... ellipsoidal to ellipsoidal

Projection .... ellipsoidal to rectangular

The entire transformation from one coordinate system to another may require a combination of the two processes described above.
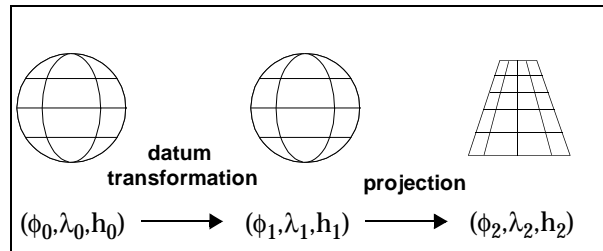
Figure 7-5: Typical transformation

A typical transformation, will start with the WGS84 coordinate system. It may require a datum transformation to get to the destination ellipsoidal coordinate system. A coordinate transformation (projection) may then be required to project the ellipsoidal coordinates onto a planar surface.

7.5.1   *Datum transformation*

Datum transformations describe the specific datum transformation from one ellipsoidal coordinate system to another ellipsoidal coordinate system.

A datum transformation will convert one set of coordinates (ϕ_0,λ_0,h_0) into a different set of coordinates (ϕ_1,λ_1,h_1), or graphically.

This process can be performed in several different ways. In actuality, a coordinate transformation and possibly a 3D transformation are performed. In this way an ellipsoidal coordinate can be converted to a Cartesian (rectangular) coordinate system where its datum origin point can be directly related to the new ellipsoid's datum origin point.

The transferred Cartesian coordinate can then be converted to an ellipsoidal coordinate using the new ellipsoid definition.

The translated Cartesian coordinate system can then be converted to an ellipsoid using the new ellipsoid definition.

The SDR performs the conversion by first converting (ϕ_0, λ_0, h_0) into a *Cartesian coordinate* (x_0, y_0, z_0). The ellipsoid definitions, represented by e_0 and e_1, consist of the semi-major axis and flattening on which (ϕ_0, λ_0, h_0) and (ϕ_1, λ_1, h_1) are based.

Once a Cartesian coordinate is derived, a 3D transformation can optionally be applied to convert from (x_0, y_0, z_0) to (x_1, y_1, z_1). This transformation is described by ¶, whose seven parameters are translations along three Cartesian axes, rotations about the three Cartesian axes, and a scale factor. With the new Cartesian coordinate (x_1, y_1, z_1), a conversion is made to the destination ellipsoid to arrive at (ϕ_1, λ_1, h_1).

If the 3D transformation is omitted, it changes the size and shape of the reference ellipsoid.

7.5.1.1   Available datum transformations

The five types of datum transformations provided from least to most general, are:

Datum And Ellipsoid .. is the simplest type of datum transformation; it allows a conversion between ellipsoids.

Datum Shift .... allows conversion between ellipsoids that have different origins.

Datum Shift Rotate ...... can convert further between ellipsoids whose Cartesian systems are rotated with respect to each other.

Shift Rotate Scale .... the most general type of datum transformation, is similar to DatumShiftRotate, but also provides a scale factor for converting between the Cartesian coordinate systems.

User Datum .... is equivalent to the DatumShiftRotateScale, but the ellipsoid parameters are provided by the user.

The most general datum transformation (DatumShift-RotateScale) could always be used, eliminating the need for the first three datum transformation types. To define a transformation that is equivalent, the scale is set to 1-0 and rotating and translation are set to 0-0. This causes no change to the original coordinates. The primary reason for the first three, more restrictive, types is to reduce the amount of information required to convert between ellipsoids.

7.5.2   Rule for STN /GSTN and projection records

The SDR handles observation data differently depending on your selected coordinate systems and whether or not you are working with known or unknown starting positions.

Selecting **Unknown** in **GPS Coord System** requires all Stns and GStns to have connectivity. This connectivity (or homogeneity) requires all points to be connected by observations. A selection of **Known** allows the use of disjointed Stns and Gstns.

⊠ **Note:** Careful planning is necessary when setting transformation parameters. The selection of **Known** or **Unknown** determines the Stn/GStn connectivity requirements for your job.

7.6   Coordinate Systems

A coordinate system is a reference frame used to designate a position. The type of coordinate system you use is determined when you create a new job. The SDR supports local assumed grid coordinates, projected grid coordinates and ellipsoidal coordinates.

Coordinate systems are assigned to survey jobs. Each time you create a new job with the SDR, you can select a transformation file for that job. Your selection determines what type of coordinate system will be used.

⊠ **Note**: When creating a new job, you must decide whether or not a local assumed grid or projected grid/ellipsoidal coordinate system will be used. Selecting **NO** in the **Select XFM** field will enable local assumed grid coordinates. Selecting **YES** enables either projected-grid or ellipsoidal coordinates. Once selected, this option cannot be changed for a particular job. Selecting **YES**, you must know whether or not the coordinate system you choose in the **Zone** field in the *Create Job* screen is projected grid or ellipsoidal.

The **Select XFM** field determines whether coordinate systems will be applied during the survey process. The following fields will display when the field is set to **YES**:

Transformation .... Select the type of transformation to be used on the job in this field.

Description .... This field displays a description of the transformation type selected in the Transformation field.

GPS Coord system .... Selecting Unknown requires all Stns and GStns to have connectivity. This connectivity (or homogeneity) requires all points to be connected by observations. A selection of Known allows the use of disjointed Stns and Gstns.

Select the local zone to which the transformation will be applied.

⊠ **Note**: Careful planning is necessary when setting transformation parameters. The selection of Known or Unknown determines the Stn/GStn connectivity requirements for your job.

7.6.1   Connection requirements

When multiple Stns and GStns are used, you must have connectivity - the ability to trace each subsequent Stn/GStn back to the original Stn/GStn by using the SDR's OBS or GOBS view. This is necessary to

calculate and apply calibration corrections to produce a reduced coordinate. To ensure accurate observations, each Stn or GStn has to be observed from a previous Stn or GStn.

The option to enable a known or unknown start is determined when you select **YES** in the **Select XFM** field when creating a job.

When working without connectivity (when you select **Known** in the **GPS Coord System** field), you are not required to maintain connectivity among Stns or GStns.

Before creating a new job, you must decide whether or not a local assumed grid or projected grid/ellipsoidal coordinate system will be used.

If you are using an unknown starting point, only a single point calibration may be utilized when using Projected Grid Coordinate systems.

7.7   Transferring (XFM) files

Transformation files are transferred to the SDR from a personal computer. Transformation files can be added to the SDR by using the following two methods:

Permanent Installation will load transformation (XFM) files to the SDR's non-volatile memory (NVM).

Temporary Installation enables you to send an XFM file directly from Sokkia software packages to the SDR. This process works similar to transferring a job.

For information and procedures on installing transformation files, see the ***SDR User Guide***.

Chapter 8   Calibrations

A calibration allows all GPS records in the current coordinate system to be translated, rotated and scaled to match a known coordinate system. Calibration is used to minimize error when using assumed coordinates. The calibration can be performed multiple times, at any time before, during, or after a survey. This chapter will address the following:

- Calibrating local coordinates
- Calibrations with projected grid coordinates
- Populating the calibration list with points
- Reviewing the calibrated parameters

In order to use calibrations, your must have an observed point. The same point ID must also have a POS record loaded or created via keyboard input.

All ETS station values must be in the destination coordinate system if you are using ETS before calibration. As an alternative, you can take readings with an ETS instrument after a calibration is performed.

8.1   Calibrate Local Assumed Grid Coordinates

At some time during the survey, you observe one or more points with coordinates which are known in the target system. The known coordinate values can be provided via keyboard input or from an ETS survey in the same SDR job (or control job). Horizontal and vertical calibrations can be performed together or separately. The SDR has three calibration options.

Horizontal/Vertical....... This option performs both a horizontal and a vertical calibration. For more information, see 8.1.3, *Vertical/Horizontal Calibration*, Pg 8-3.

Horizontal..................... This option performs a horizontal calibration. For more information, see 8.1.1, *Horizontal Calibration*, Pg 8-2.

Vertical........................... This option performs a vertical calibration. For more information, see 8.1.2, *Vertical Calibration*, Pg 8-2.

8.1.1   Horizontal Calibration

The horizontal calibration calculation is based upon a two-dimensional conformal transformation. Four transformation parameters are available: one scale factor which is constant in all directions, a rotation in the horizontal plane about the vertical axis and two translations, one in east and one in north. During the calibration procedure, least squares techniques are used to estimate the four parameters when more than two points are used. A maximum of eight points can be simultaneously used to estimate the four transformation parameters. If only one point is used, the scale and rotation parameters are ignored and the result is a translation in both the east and north directions.

8.1.2   Vertical Calibration

The vertical calibration calculation is based upon a three parameter linear plane model which estimates the difference between the GPS observed height datum and mean sea level based on the selected coordinate system. The three parameters are the slope of the plane in the east direction, the slope of the plane in the north direction and a constant translation applied to all points. If one point is used in the calibration process, the slope parameters are ignored and only a translation is used. If two points are used, the calibration routine reports an error as a minimum of three points are required to define the plane. If more than three points are used, least squares techniques are used to estimate the three plane parameters. A maximum of eight points can be used during the calibration process.

8.1.3 Vertical/Horizontal Calibration

For GPS/RTK surveys, calibrations are performed to allow a survey to be based on some known vertical datum and local horizontal coordinate system. However, this information does not have to be known at the time of survey and the GStn does not have to be set up on a previously known position. The coordinates of the GStn are calculated upon calibration.

⊠ **Note:** Calibration corrections cannot be applied to data collected via total station. To maintain a consistent coordinate system, any total station data collected should be set up in the destination coordinate system. All applicable settings must be established when creating a job. These settings include scale factor, curvature and refraction (if plane curvature correction is applied).

8.2 Calibration with Projected-Grid Coordinates

When using projected-grid coordinates, calibrations are limited to a single horizontal or vertical point.

Unlike local assumed grid coordinate calibrations, which translate, rotate and scale all GPS records in the current coordinate system to match a known coordinate system, projected-grid calibrations solve to produce translation values of a single coordinate - the initial Stn/GStn.

8.3 Calibration with the SDR

Once you decide upon a coordinate system, local assumed grid or projected-grid, use the SDR's **GPS Coord System** option to do the calibration.

⊠ **Note:** The calibration being performed is associated with the current job. If a job is not currently selected, you will be prompted to select one before proceeding with the calibration. Local Projected Coordinate systems are enabled by selecting

<**NO**> from the available transformations in the **Select XFM** field in the *Create Job* screen. Once Local Coordinates are selected, you can not select another coordinate system for a particular job.

Your calibration options available are listed below:

- populate the calibration list
- delete/add points in the calibration list
- view calibration results
- view horizontal/vertical calibration parameters
- view horizontal/vertical residuals

8.3.1   Populate the Calibration List

After selecting the calibration type, the SDR generates a list of available points for the calibration. The points in this list are used to calculate the translation, rotation, and scale values for calibration. You can edit the calibration point list by adding or removing points. The SDR can use up to eight points to calculate a calibration.

A separate calibration list is generated for horizontal and vertical calibrations. Depending on the selected calibration, the SDR requires a number of points with specific observations. Your choices are:

Hz/Vt.............................. One point or three or more points are required for this calibration. Points must have Northing, Easting and Elevation coordinate values.

Horz .... One or more points required for this calibration. Points must have at least Northing and Easting coordinate values.

Vertical........................... One point or three or more points required (two points are not valid) for this calibration. If a single point is used, it must have at least Elevation coordinate values. If three or more points are used, Northing, Easting and Elevation coordinate values are required.

You can add points to the calibration list using two methods: adding a single point or adding a range of points. You can remove points from the calibration list at any time. You may want to add a range of points and then remove specific points.

8.3.2   Delete Points from the Calibration List

The point will be deleted from the list and from the subsequent calibration calculations.

8.3.3   Add Points to the Calibration List

As points are added, the SDR initiates a search for GPS records and non-GPS POS records with the same point ID.

- If the point ID is a GPS record only, a warning will display and the point will not be added to the list.
- If the point ID is a non-GPS record only, a warning will display and the point will not be added to the list.
- If the point ID does not exist in the database, a warning will display.

⊠ **Note:** The known coordinate values can be added using the **Keyboard Input** option.

A warning will display if an entered point does not possess adequate coordinate values.

While adding points to your list, you will have to enter a range or point names to your list. After you have specified the range, using any or all of the selection methods provided, the SDR adds all points meeting the conditions to the list. You will see the following text fields on the *Range* screen:

Point range.................... The first selection method is a simple numeric range of points from the point name specified in the **From** field to the point name specified in the **To pt** field (inclusive). Any point names in the range that do not already exist are ignored.

Distance range .... If a distance value is entered into the **Radius** field, only points within that distance (radius) from the current GStn will be included in the list.

Code .... A code can be specified in the **Cd** field; only points with a matching code will be included in the list.

8.3.4   Calibration Results

After the points are selected and the calibration is performed, the calculated values and residuals are displayed for review.

The last value displayed is the RMS (root mean square) of the adjustment residuals. If you performed a Horizontal/Vertical calibration, the parameters are shown separately.

For information about specific parameters in each screen, see the following sections.

8.3.5   Horizontal Calibration Parameters

Horizontal calibrations fit local RTK plane coordinates to a locally known horizontal plane. You can view the north and east transitions on the *Horiz Parameter* screen. You will see the following fields:

Trans.N .... The north shift parameter moves the GPS origin north to coincide with the locally-defined coordinate system.

Trans.E .... The east shift parameter moves the GPS origin east to coincide with the locally-defined coordinate system.

Rotation .... This is a rotation in the horizontal plane about the vertical axis (rotation of the azimuth), which moves the GPS north axis to coincide with the local system's north axis.

Scale .... The scale factor is a uniform scale in all directions that relates the GPS coordinate system to the local defined system.

RMS .... The root mean square of the least squares calibration procedure.

8.3.6   Horizontal Residuals

Horizontal residuals display corrections necessary to produce mathematical closure for an observation. Individual point residuals depict the amount of error in each calibrated point. The magnitude of this residual value will help you determine whether a point should be utilized in the calibration or investigated further. Common problems resulting in error can include poor observation, incorrect keyed in values, and error in the known position.

8.3.7   Vertical Calibration Parameters

Vertical calibrations account for undulating effects in the Earth's surface, variation in control values, and any error contained in collected observations. Parameters for the vertical calibration are displayed on the *Vertical Parameters* screen. You will see the following fields:

Const Adj .... This field displays the constant height shift for all points based on the difference.

Slope N........................... This field indicates the slope along the north axis, which indicates how the geoid changes in the easterly direction. Since it is a slope (or ratio), it has no units.

Slope E........................... This field indicates the slope along the east axis, which indicates how the geoid changes in the northerly direction. Since it is a slope (or ratio), it has no units.

RMS .... The root mean square of the least squares calibration procedure.

⊠ **Note:** When surveying in known areas of drastically changing geoidal undulations, special attention should be given to vertical calibration. The calibration process can only determine slope in two directions and will not compute anomaly deviations. By using a geoid model, determining the extent of the project area, and interpolating undulations, you can calculate the slope due to geoidal undulation and reduce possible errors. Examples of areas in which changing undulations can occur include mountain foothills or river and stream areas.

8.3.8   *Vertical Residuals*

Vertical residuals display corrections necessary to produce mathematical closure for an observation. Individual point residuals depict the amount of error in each calibrated point. The magnitude of this residual value will help you determine whether a point should be utilized in the calibration or investigated further.

⊠ **Note:** Common problems resulting in error can include poor observation, incorrect keyed in values, and error in the known position.

Chapter 9   Traverse Adjustment

The traverse adjustment option calculates error in an observed traverse route and enables you to adjust the traverse route to minimize error. The SDR assists you in adjusting the traverse in the field, where you can immediately note and correct errors instead of waiting to adjust the traverse in the office. This chapter covers:

- calculating and adjusting a traverse
- collection methods of traverse adjustment.

The SDR has three separate methods of adjusting a traverse:

- coordinate adjustment
- angular adjustment
- elevation adjustment

⊠ **Note:** It may be beneficial to calculate the adjustment using all three methods and then use the results that best fit your survey.

When you adjust the traverse and store results, all observations using the selected stations will also be adjusted. You do not have to have observations in the same order as they were observed. At least one station must be a known location to perform a traverse adjustment.

9.1   Calculate and Adjust Traverse

Using the **Traverse Adjustment** option, you can calculate and adjust a traverse. You may want to calculate the adjustment using different methods and then use the results that best fit your survey.

If a point ID is edited, the SDR discards the route and searches for a new traverse route starting from the newly entered point ID. If you choose to edit a traverse route, you will see the ***Traverse Orientation*** screen. The following fields are viewed:

Stn .... This field displays the starting traverse point ID.

BS pt .... Enter the backsight point ID.

Azimuth .... Enter the backsight azimuth.

Stn .... Enter the ending traverse point ID.

FS pt .... Enter the closing foresight point ID.

Azimuth .... Enter the closing foresight point ID

The following rules apply to the specification of **BS** and **FS** azimuths:

- Neither a **BS** or **FS** azimuth is compulsory. However, if you do not have both, an angular close is not done (the ∆ang result field will be null). It will not be possible to carry out an angular adjustment.
- Enter the azimuths directly or enter point names. The SDR calculates azimuths for you.
- A **FS** azimuth may not be specified unless there is a **BS** azimuth.

⊠ **Note**: If insufficient data existed to calculate the distance closure (for example, any leg of the traverse without distance information), the SDR reports only an angular closure.

The SDR will calculate the precision of the traverse and display your results. You will see the following calculated values fields:

D.ang .... Angular closure error.

D.Dist .... Horizontal closure distance.

Precision .... Precision of the traverse as a ratio of the total horizontal distance traversed to the closure distance.

D.North .... Closure distances for the north coordinates.

D.East .... Closure distances for the east coordinates.

D.Elev .... Closure distances for the elevation coordinates.

⊠ **Note**: In the computation of the traverse closure, and in any subsequent traverse adjustment, the observations in both directions for any traverse leg are averaged to give the best values for the traverse leg. This also applies to observed vertical angles where a slope distance has not actually been measured in one direction; the average of the vertical angles in both directions are used in the computations.

To specify the methods of coordinate, angular, and elevation adjustment, go to the *Adjustment Options* screen. Your options are listed below.

Method .... Select the **Compass** or **Transit** coordinate adjustment method.

Angular .... Select **Weighted**, **Linear**, or **None**.

Elev .... Select **Weighted**, **Linear**, or **None**.

Report angle adjust ...... Select **Yes** or **No** to specify whether or not to display the updated closure and traverse precision details after the angular adjustment, but before the coordinate adjustment. The displayed angular closure after the angular adjustment is always zero.

As the SDR uses the latest point coordinates in its calculations, the adjusted traverse points will be used for calculations.

Coordinates for sideshots from an adjusted traverse station are updated automatically by the coordinate shift applied to the traverse station coordinates.

⊠ **Note**: While the sideshot point coordinates are updated automatically by the coordinate shift applied to the adjusted traverse station, any slight change in orientation at the traverse station due to an angular adjustment is not applied.

9.1.1 Coordinate Adjustment

The *Adjustment Options* screen enables you to select the angular adjustment via the **Method** field.

Two coordinate adjustment methods are available: **Compass** (or Bowditch) rule and **Transit** rule. Both of these methods distribute the latitude and longitude, or northing and easting, coordinate error throughout the traverse lines.

9.1.2 Angular Adjustment

The *Adjustment Options* screen enables you to select the angular adjustment via the **Angular** field. Three angular adjustment options are available:

Weighted .... Any angular closure is distributed among the angles of the traverse route based on the sum of the inverses of the forward and back traverse line lengths at each angle. The backsight and foresight lines are considered to have infinite lengths for the purposes of this weighting computation.

$$\angle adjustment = \frac{\dfrac{1}{todist} + \dfrac{1}{fromdist}}{\sum\left(\dfrac{1}{todist} + \dfrac{1}{fromdist}\right)} \times \angle closure$$

Linear .... Any angular closure is distributed evenly among the angles of the traverse route.

None .... No angular adjustment is carried out.

9.1.3   Elevation Adjustment

If you wish to adjust the elevation values, select an option in the **Elev** field of the *Adjustment Options* screen. Three elevation adjustment options are available:

Weighted .... Any closure in the elevations is distributed in proportion to the length of the traverse line leading to the point (like the Compass rule used in the coordinate adjustment).

Linear .... Any closure in the elevations is distributed evenly in each leg of the traverse route.

None .... No elevation adjustment is carried out.

9.2   Traverse Collection Methods

A traverse is an operation in which you collect points to create a relationship between points in a survey. Collecting a traverse is an extension of taking a reading. First, you establish a station and take multiple readings to desired points. You can then form a traverse by selecting one of the observed points as your next station. The SDR then creates relationships between known stations and observed points.

⌧ **Note**: You do not have to establish a station on a known location. The SDR can calculate an unknown station as long as there is at least one known location in your survey.

Most surveys performed with the SDR are a type of traverse, a collection of linked stations. You can "close" a traverse route by sighting your original station as the last observation in a survey. By closing the traverse route, you will improve the accuracy of the traverse.

Depending on the accuracy desired, the SDR can collect a traverse route two separate ways:

- Traverse with Topography
- Traverse with Set Collection

Using the Topography option, you can observe a point, move and set up on the observed point, observe another point, and continue until the entire traverse route has been observed. Traditionally, the starting point of a traverse route is a known location, although it is not necessary.

If your survey requires a greater accuracy than traditional topography, you can use the Set Collection option to collect multiple observations to a single point. These observations are then averaged and used to adjust the traverse. While Set Collection can take a longer time to observe a traverse route, the accuracy may be desirable. When observing sets, the SDR provides a structured method for observing the Face 1 or Face 2 observations. The resulting sets of observations can be used either for traverse calculations or resection calculations.

Detailed traverse data collected with Topography can be combined with Set Collection data for precise traverse collection. All the combined data can then be adjusted with the Traverse Adjustment program.

9.2.1   Traverse with Topography

Using the Topography option, you can collect individual traverse points along a traverse route. When collecting the traverse route, each station setup must be on a previously observed point. The SDR uses the previous OBS record to calculate the next STN record. This method creates a relationship between the points used to calculate and subsequently adjust the traverse route for greater accuracy.

Face1 and Face2 observations can be collected, but only one combination of these readings is used for producing an OBS MC record. OBS MC records are used to calculate the next station that will be occupied.

9.2.2 *Traverse with Set Collection*

You can collect multiple observations to individual traverse points using the **Set Collection** option. By collecting multiple observations to the points in your traverse route, the SDR can compute positions with greater accuracy. Each set of observations is computed and averaged to generate point coordinates, reducing the amount of inherent error in observations. Set collection may be entirely "free-form" or may be completely driven through a pre-entered set of parameters and points.

While collecting your set of observations you may want to adjust your set collection options. The nine field settings on these screens determine how the SDR does set collection. The following fields are available to you:

Method .... This field indicates the sets collection method:

> **Direction** — observing several points using the same instrument orientation.

> **Repetition** — observing a single angle between two points several times using different instrument orientations.

Data .... This field controls which observational measurements will be collected together. The options are as follows:

> **HVD** — All measurements are collected in each set of observations.

> **H,VD** — The horizontal angles are collected during one observation. The vertical angle and distance are collected on the next observation.

> **H,V,D** — The horizontal angle, vertical angle, and slope distance are collected in separate observations.

Where: **H** = horizontal angle, **V** = vertical angle, and **D** = slope distance

H sets .... This field controls how many sets of horizontal angles are collected.

⊠ **Note**: In the case where the data being collected is **HVD**, the **Number of H sets** is also the number of sets of vertical angles. This number is independent of whether both faces are being observed. For example, if the number **of** H sets is three and only **F1** is being observed, three physical rounds of observations are required. If both **F1** and **F2** are observed, six physical rounds of observations are required (one for each face for each set).

V sets .... This field appears only if the data being collected is **H,VD** or **H,V, D;** this field indicates how many sets of vertical angles are collected.

 # dist rdgs .... This field controls how many distance observations are made during each observational sighting. Enter a value between 0 and 9.

⊠ **Note**: The SDR will initiate multiple distance reads only for Sokkia surveying instruments.

Face order .... This field controls the switching between F1 and F2 during the collection of single as well as multiple sets. Select from the following options:

F1 only	**F1F2/F1F2**	**F2F1/F2F1**
F2 only	**F1F2/F2F1**	**F2F1/F1F2**

Some selections show two sets, separated by a slash, indicating that both faces will be used. For example, F1F2 ⁄ F2F1 specifies that, in the first set, observations will be

made to points in the set beginning with Face 1 and then Face 2 of your instrument, and in the second set, you will reobserve the same points beginning with Face 2 and then Face 1 of the instrument.

If you wish to observe only one set, taking first Face 1 then Face 2, you should choose either F1F2/F1F2 or F1F2/F2F1. (Since you are only collecting one set, ignore the second set specification.)

Obs order .... This field specifies the order in which the SDR prompts you to observe points when collecting individual sets. For more information, see 9.2.2.3, *Example of viewing collected sets*, Pg 9-14.

Unprompted .... The SDR will not prompt you at all and observations may be made in any order.

123...123 .... The SDR prompts you for the second face of a set in exactly the same order as it prompted the first face. For example, if you select **123...123...** and pre-enter points A, B, C, and D, you are prompted to observe points in the following order:

A,F1→B,F1→C,F1→D,F1→
A,F2→B,F2→C,F2→D,F2

123...321 .... The SDR prompts you for the second face of a set be prompted in reverse order:

A,F1→B,F1→C,F1→D,F1→
D,F2→C,F2→B,F2→A,F2

Return sight .... This field specifies whether you wish to sight again on the first observed point in a set when the end of the set is reached. For example, if points 1, 2 and 3 are observed and a return sight is selected, then the physical observations made would be 1, 2,

3, 1. Any error found in the return sighting is distributed between the other observations.

This field displays only when the set collection method is **direction**.

Preenter points.............. This field determines if you enter a list of points that you will observe, prior to observing any points in the set. The SDR will use the list's order, in conjunction with the **Obs order** field, to prompt you for the next point to observe.

If this field is **Yes**, the SDR allows you to enter a list of points that you will observe, prior to observing any points in the set.

If this field is set to **No**, you will not be asked for the point names prior to observing the points. The SDR will, however, intelligently guess which point you are observing based on the observations taken, and assist you by supplying the point name, code and target height, if required. This feature is active only for sets collected by direction.

Recip Calc .... Choose whether to perform reciprocal calculation. The options are **Prompted**, **Always** or **Never**.

⊠ **Note**: A Note record is entered in the database when a reciprocal calculation is performed. The first note is placed above the **Stn** and states **Vert Recip Calc refined Stn ### Elev**. The second note is placed above the BKB record and states **Recip Calc used Stns #### & ####**.

The set number in the top right of the screen is the current count of sets observed from the station you are set up on. If you have requested point prompting, the **To pt** field shows you the point name to observe.

The SDR fills in the data fields (**H.obs, V.obs,** and **Dist**) when the values are available from the instrument.

If the **Obs order** field is **Unprompted**, the code, point name and target height are filled automatically if you have observed this point before. The SDR determines whether the points are the same by checking to see if the new OBS distance is within 15 cm (<6") of the previous OBS distance. If this test passes, the SDR compares the horizontal angle of the two observations to see whether they are within a certain tolerance. This tolerance is calculated based upon the distance of the observation; the longer the distance, the smaller the allowed tolerance. The angular tolerance is calculated to yield approximately 15 cm arc distance. If the horizontal test also passes, a similar angular test is performed on the vertical angle.

9.2.2.1 View collected sets

You can review the collected sets while you are collecting the data or after you have finished set collection.

View and **Set review** options display point information. The **Set review** option displays the points within their corresponding set. This is a structured method to review sets in the same manner in which they were collected, allowing you to "traverse" the data. This option also gives averages and deviations and can give you a comprehensive view of your collected data.

The **Set review** option provides several ways of displaying data with softkeys. The initial *Set review* screen shows the first set associated with the selected station. You can navigate the Set review information using the available softkeys. Several different views of the collected data is available in this screen.

Highlighting a specific observation and pressing <**Enter**> twice displays the point's raw observation data in the *SETS-POINTS-FACES* screen. Several other data screens can be accessed via softkeys from within this view.

You can access any of the Set review screens from any point within Set review. This figure illustrates the abstract structure of the Set review option.
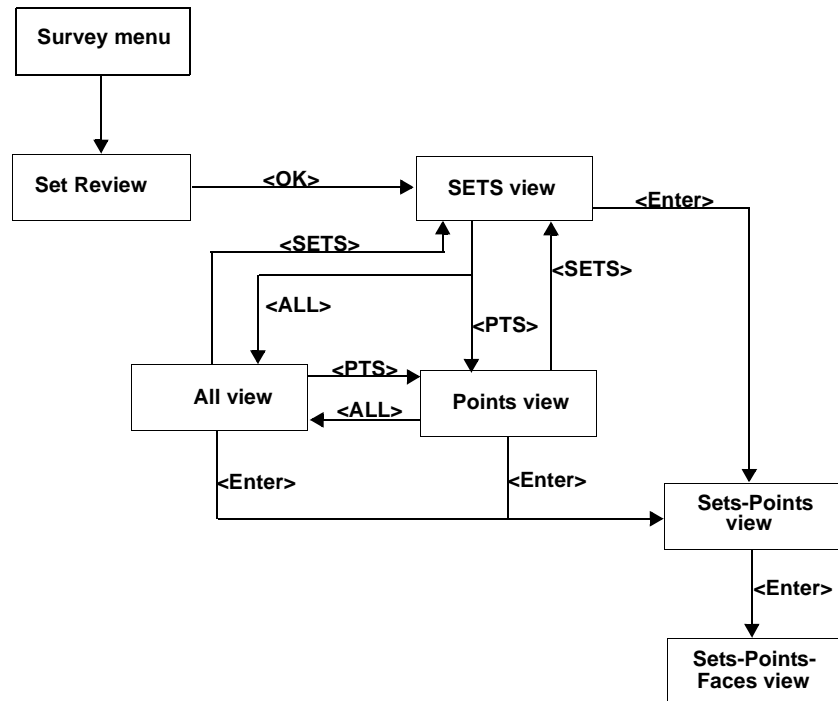

Figure 9-1: Set Review Option

SETS level....................The initial Set review screen indicates all of the points observed during the collection of set number 1 from the station to its left.

ALL level.......................This displays general information about the collected sets, including the number of sets, the station point ID and the collected points.

POINTS level................This displays specific information about a point. Also, this level displays the average of all observations made to a point from

each set in the station. For more information, see 9.2.2.2, *POINTS level*, Pg 9-13.

SETS-POINTS level..... This displays all the observations to a point in a specific set. The fields in this level display the following information:

Third and fourth line-list the horizontal angles of each observation made to B in Set 1.

Fifth line-the average (represented as an **F1** observation) of the horizontal observations made to the point B in Set 1.

Sixth line-the maximum difference between the average and the individual horizontal observations.

Seventh line-the difference between the average from the fifth line and the average over all sets (Sets 1 and 2).

It should be emphasized that return sights are displayed independently of initial sights to the reference point.

SETS-POINTS-FACES This displays the raw observation data about a highlighted point.

9.2.2.2 POINTS level

When horizontal angles for several different sets display, the horizontal angle in each set is adjusted so the angles may be compared. (Each set may have been oriented differently at the time it was collected — different backsight circle readings).

The first set is treated as a reference set. For each subsequent set n, the first observation to a point *P* (with non-null horizontal angle) that also appears in the reference set is found.

The two horizontal angles are compared; if they lie within a tolerance *T* of each other, the difference is assumed to be observational inaccuracy, and set n is not realigned. If the two horizontal angles differ by more than *T*, the two sets are considered to be oriented differently. Set *n* is realigned by subtracting the difference between the angles from each horizontal angle in set *n*. Now the angles can be compared with the observations in the reference set.

The first non-null horizontal angle of the reference set is converted to an azimuth for display, and all other horizontal angles are reoriented accordingly.

An out-of-tolerance observation (with reference to the global **H. Obs, V. Obs**, and **EDM** tolerances) is displayed with an asterisk (*).

⊠ **Note**: Angles are averaged within their sets before averages between sets are computed; observations are not weighted individually.

9.2.2.3   Example of viewing collected sets

As a means of explaining this abstract structure, the following two sets, collected using the SDR, will be used.
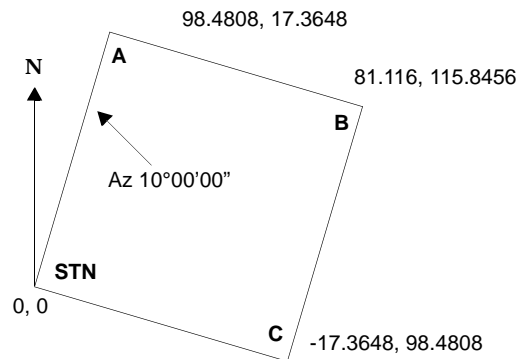

Figure 9-2: Example of Collecting Sets

The first set is a "perfect" representation of the layout of the points A, B, C with respect to **STN**, while the second set contains inaccuracies for the purposes of illustrating the **Set review** mechanism to its fullest. On the following page is an example of the information you will see printed on screen.

Set S.Dist	Face	H.ang V.ang
Set 1	Face 1	
STN	A	0°0'00"90°00'00"
100.000		
STN	B	45°00'00"
90°00'00"	141.420	
STN	C	90°00'00"
90°00'00"	100.000	

After you have collected face 1, the SDR displays this prompt:

Set S.Dist	Face	H.ang V.ang
Set 1,	Face 2	
STN	C	270°00'00"
270°00'00"	100.000	
STN	B	225°00'00"
270°00'00"	141.420	
STN	A	180°00'00"
270°00'00"	100.000	

Upon completion of this set, select **Review sets** from the three available options:

Using <**OPTNS**>, change **Face order** to **F1** only.

Set S.Dist	Face	H.ang V.ang
Set 2, Face 1(Only)		
STN	A	60°00'30"
90°00'30"	100.020	
STN	B	105°00'20"
90°00'20"	141.410	

9.2.3   *Special cases*

Although the preceding discussion has not presented every possible display for the two example sets, it illustrates most of the cases. Special cases are noted here.

9.2.3.1   Return to collect more points

If you wish to return to a previous station to collect more points, the points collected during previous Sets need to be included in the additional Set(s). The traverse adjustment looks at the last station record for a point and considers it the most current information for the point. If the additional data does not include the back sight and next station in the traverse route, the route cannot be found. If the data is not included, a no existing fore sight (observation) message is displayed when the adjustment is attempted.

9.2.3.2   Collecting topography data with set collection

When collecting topography data with set collection data, the information contained in the sets must be included in the topography station record for the traverse route to be valid.

If the traverse is adjusted before the topography shots are collected, the **POS AJ** records produced will be used when these stations are occupied in the Topography routine.

If the topography is to be collected at the same set up as the traverse then collect the traverse data in the Set Collection routine first.

When the data for the traverse is complete within the Set Collection routine the SDR will prompt to collect more sets, review sets or change stations. Press the <**ESC**> key to return to the **SURV** menu and select Topography. Accept the station and back sight displayed to collect topography data.

9.2.3.3   Tolerances exceeded

Tolerances are only checked between the Face1 and Face2 readings within the Set. Tolerances are not checked on the back sight.

Within Topography if data is collected concerning a point that already exists a message is displayed, delta values are displayed and options for overwriting, renaming, check are available. If the Face1 and Face2 option is used and the tolerances are exceeded between the

two readings the user is notified of the error and prompted to continue or not. When taking a back sight within Topography the tolerances are checked and messages displayed if exceeded.

9.2.3.4 Duplicate points

When collecting sets, the SDR does not provide a duplicate point message. You can use the database view option to check if a point exists.

9.2.3.5 Return sights

When collecting sets, you often make an observation to the reference object (typically the back sight) at the beginning and end of each set. The second observation in each pair is the return sight. The return sight permits you to distribute any return error (the difference in horizontal angle between the two reference observations) over the entire set, thus removing errors due to inaccuracies in the circle.

When you review a set containing a return sight, the horizontal angles have been adjusted for return error (before any other adjustment of the set takes place). The return sight appears as a separate entry in the hierarchy. For example, a set containing observations to points A, B, C and D, followed by a return sight to A, displays the **POINTS** level like this:

$$A\leftarrow \: \rightarrow B\leftarrow \: \rightarrow C\leftarrow \: \rightarrow D\leftarrow \: \rightarrow A_1$$

A_1 denotes the return sight.

All levels of the **Set review** hierarchy have return error distributed, with the exception of the lowest raw observation level. For more information about **POINTS**, see 9.2.2.2, *POINTS level*, Pg 9-13.

9.2.3.6 GOOD and BAD sets

The SDR permits you to mark a set as "BAD" if it contains inaccurate data or incorrect point identifier(s). Whenever an averaged set (of MC records) is produced, "BAD" sets are omitted from the averaging process. An averaged set is produced:

- Each time a set collection session is completed
- Each time a set is marked "BAD"
- Each time a "BAD" set is marked "GOOD"

The **Set review** mechanism permits the general reviewing of collected sets, with particular emphasis on the identification of sets that contain erroneous or out-of-tolerance observations. A "BAD" set is displayed with an asterisk.

Once a set is marked "BAD", it is no longer included in any averaging calculations. Averages, standard deviations, and so on, that appears in the **POINTS** and **SETS-POINTS** levels of the **Set review** hierarchy do not take "BAD" sets into account. Basic information for "BAD" sets still appears, including the differences between "BAD" sets and the new averages. For more information about **POINTS** and **SETS-POINTS**, see 9.2.2.1, *View collected sets*, Pg 9-11.

You can mark a set that you suspect of interfering with the averages as "BAD" and then examine how the averages change. If you determine that the suspected set does not change the averages by an inordinate amount, change it back to "GOOD."

⊠ **Note**: If you change the marking of any sets, a new series of averaged **MCs** is output to the database at the end of the **Set review** session.

⊠ **Note**: A set that has been obtained from comms input is available for further set collection, set review, or resection.

9.2.3.7 Collimation correction

Collimation correction is applied to every level above the lowest ("raw observation") level in the **Set review** hierarchy. All angles have collimation correction applied except in the **SETS**-**POINTS**-**FACES** level. For more information about **SETS**-**POINTS**-**FACES**, see 9.2.2.1, *View collected sets,* Pg 9-11.

Chapter 10   **Defining Roads**

This chapter will address string roads, alignment roads, and roading basics.

The roading program is not intended for road design, although this can be done. Road design typically originates from one of two sources: an office-based computer design program or a plotted design already on paper.

If you are using a computer-based design, send it to the SDR using a communication program. If you are using a paper-plotted design, you can manually enter elements like horizontal and vertical definitions, cross-sections, templates, super elevation and widening that define your road.

The SDR can handle two types of road definition. Each of these types of roads can be defined using specific elements. You can combine alignment roads with templates.

- string road
- alignment road

You may want to review the examples detailed at the end of this chapter for assistance and ideas on completing a roading job.

⊠ **Note**: You can transfer road design to the SDR using the Communications option.

10.1 String Roads

The string road type is intended to make it easy to use the output of many computerized road design programs. Because they allow roads to be defined in terms of strings that do not necessarily have a mathematical relationship to the centerline, templates cannot be used to describe the design. Instead, points at intervals along each string in the design are written as **RPOS** records to an SDR road file. The string name can be written to the **RPOS** code field.

When a string road is sent to the SDR, you can set out the design in terms of stationing (chainage), offset and string name. This works similar to an alignment road. However, you can only set out those discrete points in the road definition. You cannot interpolate between them. You can also set out a horizontal offset to the centerline if desired.

A string road definition sent from a road design package will consist of a series of coordinates only. Azimuths, distances or point numbers will not be associated with the coordinates. You can add points to this definition or create your own definition by selecting points in the current job already surveyed with the SDR.

You may want to define a string road as a preliminary procedure when developing a road. String roads require less information and are easier to change than alignment roads. However, you cannot apply template elements, superelevation or widening to a string road. String road definitions are limited to defining the centerline only.

10.1.1   Define the string road

A string road is composed solely of **RPOS** records, each containing the position of a discrete point, described as both coordinates and station (chainage) and offset.

⊠ **Note:** Once the road type has been defined as string or alignment, it cannot be changed. If the type has already been defined, the associated definition screen will display.

You will see the following fields in the *String Road definition* screen:

Pt.....................................This field indicates the current road station point ID.

Sta..ing............................This field indicates the current stationing value.

Offset..............................This field indicates the offset value.

N ....Enter the north coordinate value.

E......................................Enter the east coordinate value.

El.....................................Enter the elevation of the current point.

Code................................This field indicates a descriptive code.

10.2 Alignment Roads

An alignment road is composed of the horizontal and vertical element definitions, cross-sections, templates, super elevation and widening. These elements can be entered manually or uploaded from a computer system. By using Alignment Roads, you can create extremely specific road definitions. While string roads will only allow the RPOS records used to define the road to be set out, alignment roads allow any part of the road to be set out whether it be a defined or a calculated position.

⊠   **Note:** Once the road type has been defined as string or alignment, it cannot be changed.

You can define your road using one of the four available roading elements:

Define horizontal.........This option allows you to enter a variety of horizontal elements to your alignment road definition. For more information, see 10.2.1, *Define the horizontal road alignment*, Pg 10-5.

Define vertical .... This option allows you to enter a variety of vertical elements to your alignment road definition. For more information, see 10.2.2, *Define the vertical alignment road*, Pg 10-10.

Define Xsection .... This option allows you to use a roading template instead of defining individual elements. For more information, see 10.2.3, *Define cross sections*, Pg 10-12.

Define super................. This option allows you to specify superelevation and widening to your road definition. For more information, see 10.2.4, *Apply superelevation and widening*, Pg 10-12.

⊠ **Note**: You can add roading elements in any order. However, once you start to add vertical or horizontal elements, you need to finish adding those components before switching to another option. For example, if you are defining the horizontal part of your road first, finish the horizontal definition before starting the vertical definition. If a point entered exists in the current job, the SDR will import the coordinates of the point into the road definition.
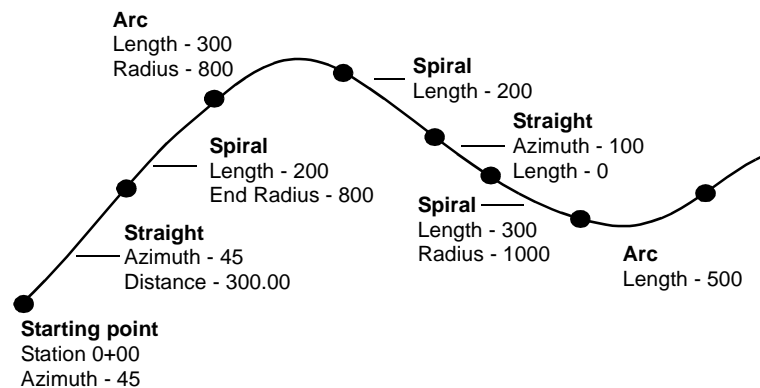
Arc
Length - 300
Radius - 800

Spiral
Length - 200

Straight
Azimuth - 100
Length - 0

Spiral
Length - 200
End Radius - 800

Spiral
Length - 300
Radius - 1000

Straight
Azimuth - 45
Distance - 300.00

Arc
Length - 500

Starting point
Station 0+00
Azimuth - 45

Figure 8-1: Road centerline design - horizontal elements

⊠ **Note:** Compound Curves must be two simple curves separated by a zero-length straight. If an option starts with **Replace**, it means that part of the road definition already exists. If you select **Replace**, you are asked to confirm the replacement.

The vertical design does not have to start or finish at the same station as the horizontal design. For example, the horizontal alignment might start at a station of 100 and the VIP at a station of 90.
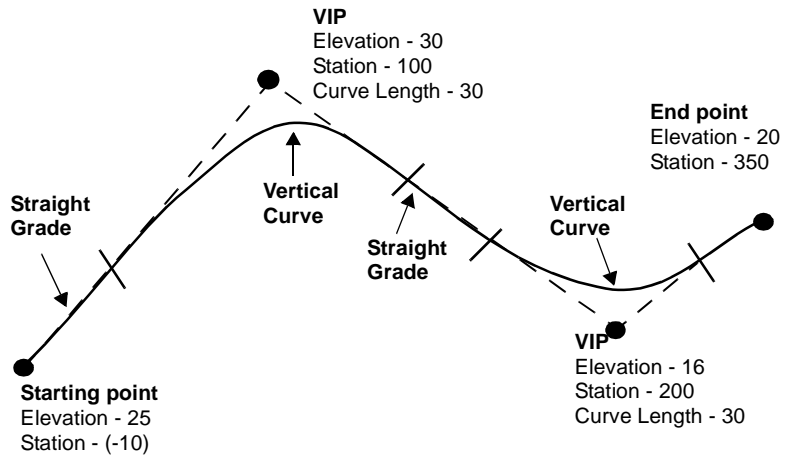

Figure 8-2: Road design - vertical elements

⊠ **Note**: When defining your road, each point must be relative to either the last point in the definition or the centerline of the road. A point can be vertically above or below the previous point. For a coordinated road, specify either the coordinates or the station and offset of the station point.

10.2.1   *Define the horizontal road alignment*

You can define the start of a horizontal alignment using methods such as existing point coordinates, or station and azimuth.

⊠ **Note**: The point name is not stored in the road definition. Only the coordinates are stored because the road is independent of all survey jobs; it cannot contain any job-specific point names.

If you enter a **To pt**, the SDR assumes that you want to use the **To pt** as part of your alignment; it takes you directly to the entry of a horizontal point element. If you do not want to include the point as part of the alignment, the SDR displays the menu of horizontal elements.

10.2.1.1   Add horizontal elements

Once the start point of the horizontal alignment has been defined, you will see a menu listing the four possible horizontal elements, the station (chainage) and coordinates of the end of the last element defined. (If the road is uncoordinated, then the **Horz Point** option is not available, and the coordinates are not displayed).

Also displayed for your information are the coordinates, if known, and the station at the end point of the last element defined. Each element is described in the following sections. A horizontal alignment consists of any number of these elements linked together in any order.

10.2.1.2   Horizontal straight

The *Horz straight* screen enables you to define a straight, horizontal section of your road. Specify the starting stationing for the element, azimuth, and distance for the element in this screen.

Sta..ing............................ The station (chainage) is displayed at the start of the straight section.

Azimuth .... This field displays the direction of the straight. It defaults to the azimuth at the end of the previous element. If the straight is the first element in the alignment, it defaults to the starting azimuth of the centerline. Generally, you will not need to

change this value. It is acceptable to do so, but the alignment will not be smooth; a sudden change of direction will occur.

Distance.......................... This field displays the length of the straight section.

10.2.1.3   Horizontal arc

Define an arc within your road definition in the ***Horz arc by rad.len*** screen. Specify the starting stationing, the azimuth, direction and radius or length for the arc section.

Stationing .... The station (chainage) at the start of the arc.

Azimuth .... The azimuth at the end of the previous element, which is used as the azimuth for the start of the arc.

Direction .... Left or right hand curve.

Radius............................ Radius of the arc.

Length............................ Length of the arc.

Instead of specifying the arc by length and radius, you can change to different definition methods. These methods are radius and subtended angle or length and subtended angle.

⊠ **Note**: The SDR always stores arcs internally as radius and arc length. If you use an alternate definition method, the SDR converts it to an equivalent arc defined by radius and arc length. A note record is generated in the definition to remind you of the original definition. For example, if you define an arc using angle and arc length, the SDR stores a definition showing radius and arc length with a note showing the subtended angle that you specified:

HORZ ARC	Sta.ing 82.000	Dist 210.760
Radius 300.000		
NOTE RO	Angle 265'08"	

10.2.1.4 Horizontal spiral

The *Horz spiral* screen enables you to define a spiral or spiral section within your road definition. Specify the starting stationing, the azimuth, direction, radius and length.

Sta..ing............................ Station (chainage) at the start of the spiral.

Azimuth .... Azimuth at the end of the previous element, which is used as the azimuth for the start of the spiral.

Direction .... Left or right hand curve.

Radius............................. Smallest radius of the spiral.

Length............................. Length of the spiral.

⊠ **Note:** If a spiral element follows a horizontal straight or point, it is assumed to be an entry spiral, with an initial infinite radius that gradually decreases. If the spiral follows an arc, it is assumed to be an exit spiral, with its radius starting at the specified value and gradually increasing. A spiral following another spiral is opposite of the spiral it follows (a spiral following an entry spiral is an exit spiral, and vice versa).

10.2.1.5   Horizontal point

A horizontal point element is similar to a horizontal straight element, except that it is defined by the coordinate where the element ends rather than as a continuation of the previous element. Horizontal point records are meaningful only in a coordinated road definition.

The *Horz point* screen displays the following fields:

Sta..ing............................ (*information only*) The station (chainage) at the end of the previous element.

Azimuth .... (*information only*) Azimuth at the end of the previous element.

You can enter a point's coordinates in one of three ways:

- Enter the point's coordinate values in the **North** and **East** fields. A point name is not stored with the definition since the road definition is independent of any survey job.

- Enter a point name to transfer its coordinates into the **North** and **East** fields.

- Enter an unknown point to create a new position record using the standard keyboard input method.

⊠ **Note**: If you enter a point that creates a line not tangential to the previous element in the alignment, the SDR displays a confirmation message.

10.2.1.6   Delete horizontal elements

To edit or replace an element from the middle of a road definition, you will need to delete all elements back to the element you are replacing. Road elements must start with the previous elements end stationing. (If the road is uncoordinated, the **Horz Point** option is not available, and the coordinates are not displayed).

10.2.2   *Define the vertical alignment road*

Define the vertical alignment in a similar manner to the horizontal alignment. Vertical alignment roads differ from horizontal alignment roads in two ways:

- Only two element types exist for vertical alignment: parabolic curves and circular curves. These elements are joined by straight lines of constant grade.

- Vertical Curves are defined by the points of intersection of the tangents of each curve rather than as a continuation of the previous element.

The defined vertical curves are linked by the straight tangent lines. The vertical curves can be end-to-end without a straight grade connecting them. Note that curves may have zero length, which effectively gives you a vertical point.

10.2.2.1   Define a vertical alignment

To set out the vertical components of a road, you need to establish a vertical alignment. You will see the following fields in the *Define Vertical* screen:

Sta..ing............................ Define the point by specifying the station (chainage) to relate the vertical alignment to the horizontal alignment

Start................................ Enter a point name in the **Start** field; the point elevation value will display in the **Elev** field. (The point name itself is not actually stored in the vertical definition since the information and survey job are independent).

El...................................... Enter the point elevation in the **Elev** field.

When you have entered in your data, you will be prompted to enter the following information:

Parabolic VC .... Define the vertical intersection point **(VIP)** and length for a parabolic curve in this screen. The direction of the curve is determined by the relative position of the previous and following **VIPs**.

Circular VC .... Define the vertical intersection point (**VIP**) and radius for a circular curve in this screen. The direction of the curve is determined by the relative position of the previous and following **VIPs**.

End vert algmnt .... This option will end the vertical alignment definition.

⊠ **Note**: The horizontal and vertical alignments do not have to start at the same station.

You can define the intersection point in two ways:

• Enter values in the **Stationing** and **Elev** fields.

• Enter a point in the **Pt** field, and the elevation appears in the **Elev** field.

⊠ **Note:** If you enter an unknown point name, create a position (POS) record using the standard keyboard input method.

10.2.2.2   Straight grades

The length of a vertical curve can be zero, which results in two straight grades meeting at the vertical intersection point. If you want to set out a straight grade in isolation from other geometry, define a road containing start and end points, but no vertical curves.

10.2.3   *Define cross sections*

Templates are defined independently of the road so you can use a single template to define the cross-section of more than one road. The road cross-section definition specifies which template to use on the left of the centerline and which to use on the right. The template can be changed at different stations (chainage) along the road.
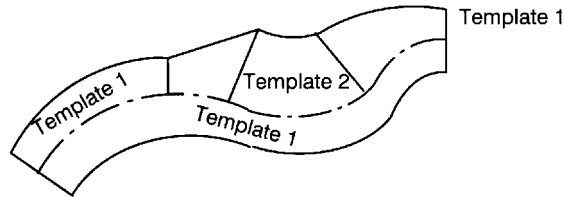

Figure 8-3: Horizontal overview

The *Define Xsection* screen enables you to define a template for the right or left side of the road (or both). Specify the starting stationing and the desired templates. The following fields are shown:

Sta..ing............................This field indicates the station (chainage) at the start of the cross section definition.

Left template ....This field indicates the name of the template to be inserted on the left side of the centerline.

Right template ....This field indicates the name of the template to be inserted on the right side of the centerline.

For more information about Templates, see 10.7, *Working with Templates*, Pg 10-19.

10.2.4   *Apply superelevation and widening*

You can add superelevation or widening to your template. You may need to add superelevation and widening to account for curves or other special road features. Superelevation and widening are applicable only to alignment roads.

⊠ **Note:** A road template must be set up to allow superelevation and widening before these options can be applied.

In the *Define Super* screen you will see the following fields:

Start stn .... The starting station (chainage) of this application.

End stn .... The end station for this application.

Once you have accepted this information you will be prompted to fill in the following fields:

Sta..ing .... The station to which these values are applied.

L super .... The superelevation to apply to the template on the left side of the road. Highlighting the *L super* field will display three softkeys:

      <HORIZ> — applies horizontal superelevation to the left side of the road

      <|:> — converts a superelevation value to a ratio format (1:300)

      <%> — converts the superelevation value to a percentage

R super .... This field specifies the superelevation to apply to the template on the right side of the road. Highlighting the **R super** field displays the same three softkeys presented for the **L super** field:

      <HORIZ> — applies horizontal superelevation to the right side of the road

      <|:> — converts a superelevation value to a ratio format (1:300)

      <%> — converts the superelevation value to a percentage

L widen...........................This field specifies the amount of widening to add on to the elements of the template on the left hand side of the road.

R widen..........................This field specifies the amount of widening to add on to the elements of the template on the right hand side of the road.

Pivot...............................This field specifies whether the center, left or right part on the cross-section is to be held at constant elevation during the application of superelevation and widening.

DEFINE SUPER	Start stn 7.000 End stn 367.760
APPLY SUPER	Sta.ing 7.000 L super%-3.000 R super%-3.000 L widen 0.000 R widen 0.000 Pivot Center
APPLY SUPER	Sta.ing 32.000 L super R super L widen 0.000 R widen 0.000 Pivot Center
APPLY SUPER	Sta.ing 57.000 L super%-3.000 R super L widen R widen Pivot Center
APPLY SUPER	Sta.ing 82.000 L super%-6.000 R super%6.000 L widen 5.000 R widen 10.000 Pivot Center
APPLY SUPER	Sta.ing 292.760 L super%-6.000 R super%6.000 L widen 5.000 R widen 10.000 Pivot Center
APPLY SUPER	Sta.ing 317.760 L super%-3.000 R super L widen R widen Pivot Center
APPLY SUPER	Sta..ing 342.760 L super R super L widen 0.000 R widen 0.000 Pivot Center
APPLY SUPER	Sta.ing 367.760 L super%-3.000 R super%-3.000 L widen 0.000 R widen 0.000 Pivot Center

⊠ **Note**: When applying superelevation in which the values go from negative to positive or positive to negative, it is not assumed this point is exactly between maximum positive and negative values. A superelevation value of 0% needs to be entered where superelevation is 0% on the road definition.

10.3 Roading Example

This section gives an example of SDR roading illustrating the use of all the definitions available.

This example consists of a single right-hand transitional curve. It has superelevation applied and widening and also has the added complication that over most of its length it is getting wider on its left side, but not its right side. Superelevation is applied to the first two elements of both templates. Widening is applied to the first element of both templates. You can enter the following information:

SDR V04-40		08-Oct-00 08:48	
	Angle Degrees	Dist Feet	Press Inch Hg
	Temp Farenht	Coord N-E-Elev	
ROAD KI	ID MANUAL ROAD		
SCALE	S.F. 1.00000000		
NOTE TS	09-Apr-92 10:11		
HORZ ALIGN	Start stn 0.000	End stn 422.760	Azimuth 342-43'00"
	North 10324.430	East 84342.540	
HORZ STRAIGHT	Sta..ing 0.000	Azimuth 342-43'00"	Dist 32.000
HORZ SPIRAL	Sta..ing 32.000	Dist 50.000	Radius 300.000
HORZ ARC	Sta..ing 82.000	Dist 210.760	Radius 300.000
HORZ SPIRAL	Sta..ing 292.760	Dist 50.000	Radius 300.000
HORZ STRAIGHT	Sta..ing 342.760	Azimuth 32-31'05"	Dist 80.000
VERT ALIGN	Sta..ing 0.000	Elev 33.000	
VERT POINT	Sta..ing 500.000	Elev 33.000	
X SECTION	Sta..ing 0.000	Left temp NARROW	Right temp NARROW
X SECTION	Sta..ing 82.000	Left temp NARROW	Right temp NARROW
X SECTION	Sta..ing 292.760	Left temp WIDE	Right temp NARROW
X SECTION	Sta..ing 500.000	Left temp WIDE	Right temp NARROW
DEFINE SUPER	Start stn 7.000	End stn 367.760	

APPLY SUPER	Sta..ing 7.000	L super%-3.000	R super%-3.000
	L widen 0.000	R widen 0.000	Pivot Center
APPLY SUPER	Sta..ing 32.000	L super	R super
	L widen 0.000	R widen 0.000	Pivot Center
APPLY SUPER	Sta..ing 57.000	L super	R super%-3.000
	L widen	R widen	Pivot Center
APPLY SUPER	Sta..ing 82.000	L super%6.000	R super%-6.000
	L widen 5.000	R widen 10.000	Pivot Center
APPLY SUPER	Sta..ing 292.760	L super%6.000	R super%6.000
	L widen 5.000	R widen 10.000	Pivot Center
APPLY SUPER	Sta..ing 317.760	L super	R super%-3.000
	L widen	R widen	Pivot Center
APPLY SUPER	Sta..ing 342.760	L super	R super
	L widen 0.000	R widen 0.000	Pivot Center
APPLY SUPER	Sta..ing 367.760	L super%-3.000	R super%-3.000
	L widen 0.000	R widen 0.000	Pivot Center
TEMPLATE KI	ID NARROW		
NOTE TS	09-Apr-92 10:15		
TEMP ELEMENT	Grade%-3.000	H.dist 20.000	V.dist -0.600
	Offset 20.000	HtDiff -0.600	Apply super Yes
	Apply widen Yes	Cd HIGHWAY	
TEMP ELEMENT	Grade%4.000	H.dist 10.000	V.dist 0.400
	Offset 30.000	HtDiff -0.200	Apply super Yes
	Apply widen No	Cd EDGE OF ROAD	
TEMP ELEMENT	Grade Horizontal	H.dist 5.000	V.dist 0.000
	Offset 35.000	HtDiff -0.200	Apply super No
	Apply widen No	Cd SIDEWALK	
TEMP-SIDESLOPE	Cut%20.000	Fill%20.000	
TEMPLATE KI	ID WIDE		
NOTE TS	09-Apr-92 10:17		
TEMP ELEMENT	Grade%-3.000	H.dist 25.000	V.dist -0.750
	Offset 25.000	HtDiff -0.750	Apply super Yes
	Apply widen Yes	Cd HIGHWAY	
TEMP ELEMENT	Grade%2.000	H.dist 20.000	V.dist 0.400
	Offset 45.000	HtDiff -0.350	Apply super Yes
	Apply widen No	Cd EDGE OF ROAD	
TEMP ELEMENT	Grade Horizontal	H.dist 10.000	V.dist 0.000

10.4 Working with Roads

The SDR provides you with tools to design, manage, and set out roads. All options needed to survey, define, and set out a road are contained in the Roading menu. This feature is designed to make roading quick and efficient using standard SDR workflow. Roading procedures share similarities with other SDR options.

Before setting out a road or performing any road topography, you will need to create a road, define any necessary templates and set up a road station. If you plan to do any set out work, other than the centerline of the road, you will need to establish a roading template. This section explains the basic operations associated with roading options.

With the SDR, you can create road templates using multiple template elements. You can create alignment roads and string roads using the SDR. Depending on the road type, you can add multiple roading elements including superelevation and widening. You can also upload alignment files from external sources.

After creating a road and defining the template, you can use additional SDR roading options to set out the road, set out road surface or perform road topography.

10.5 Road Basics

Roads are independent of jobs; however, they function in similar ways. The same management functions are available for roads as for jobs:

- Creating/deleting a road
- Reviewing road statistics
- Selecting a road

When you initially create a road, the SDR saves the road and any associated templates independently. You can import coordinates from the current job into the road file, although only the coordinates will be saved (point numbers will not be saved).

If you are going to perform any set out work, the SDR will import the road and template files into the current job. Whenever you access a roading set out option, the SDR will verify the current job contains the new roading file and templates.

10.5.1   Create a Road

To work with the roading features, you need to identify an existing road or create a new one. You can create multiple roads. however, the SDR will only work with one road at a time.

⊠   **Note**: Once a road has been created, it is considered the "selected" road; you do not need to select it. All road programs will use it as the definition until a different road is selected.

10.5.2   Select a Road

You can only work on one road at a time. If you just created a road, it is already selected as your current road. All roading options will use the selected road. You can switch between roads by selecting a new road in the *Select road* screen.

⊠   **Note**: Once a road has been selected, all road programs will use it as the definition until a different road is selected.

10.5.3   Access Road Statistics and Rename a Road

Using the *Road Statistics* screen, you can display the statistics for a road and rename the road. Roads operate similarly to jobs although they are saved separately. You will see the following screens:

ID....................................Name of the current road. You can enter a new ID here if necessary.

Job size (k) ....Size of the road file, in kilobytes.

Recs used ....The approximate number of records (point positions, observations, notes, etc.) currently stored in the road.

Date and Time............... Displays the date and time the road was last accessed; therefore, the date and time displayed will not necessarily relate to the last time data was saved in the road. For example, the process of selecting a road as the current road will access the road files and therefore update the date and time.

Point count.................... Displays the number of points currently stored. A new road will have a point count of 0.

10.6 Set Up a Road Station

Setting up a road station provides a known point for your road work. Whenever the **Road Topo**, **Set Out Road** or **Set Out Road Surface** options are selected, a road station must be set up.

If you select **Set Out Road** from the **Roading** menu. The *Confirm RSTN Station* screen displays:

RSTN Station .... This field specifies the station point name.

North, East, Elevation.. These three fields show the point's coordinates.

⊠ **Note**: You can also access this screen by selecting **Road Topo** or **Set Out Road Surfac**e from the **Roading** menu.

10.7 Working with Templates

Templates allow a predefined cross-section to be attached to the centerline definitions. A template can be used multiple times with different road definitions.

The roading program is not intended for road design, although this can be done. Road design typically originates from one of two sources: an office-based computer design system or a plotted design already on paper.

If you are using a computer-based design, transmit the design file to the SDR using a communication program. If the design has been plotted on paper, enter the design elements in the SDR using the **Define road** option.

When defining templates that will be joined together, you may want to use the same number of elements. If there is a significant difference between two templates the SDR will interpolate the difference between the templates. Creating templates with the same types of elements can aid in the interpolation and reduce the amount of manual corrections needed. Once a template is defined, you can modify it by removing or adding additional template elements.

10.7.1   Defining templates

A template defines a cross-section of a road for one-half of the road only. Templates are named with 16-character names and stored independently of both survey jobs and road definitions. Once you have defined your template, you can "attach" it to the road definition.

⊠   **Note:** Road templates created with the SDR are single surface templates.

Templates must not fold on themselves so as to create an overhang although two consecutive points may be at the same offset (one vertically above the other).
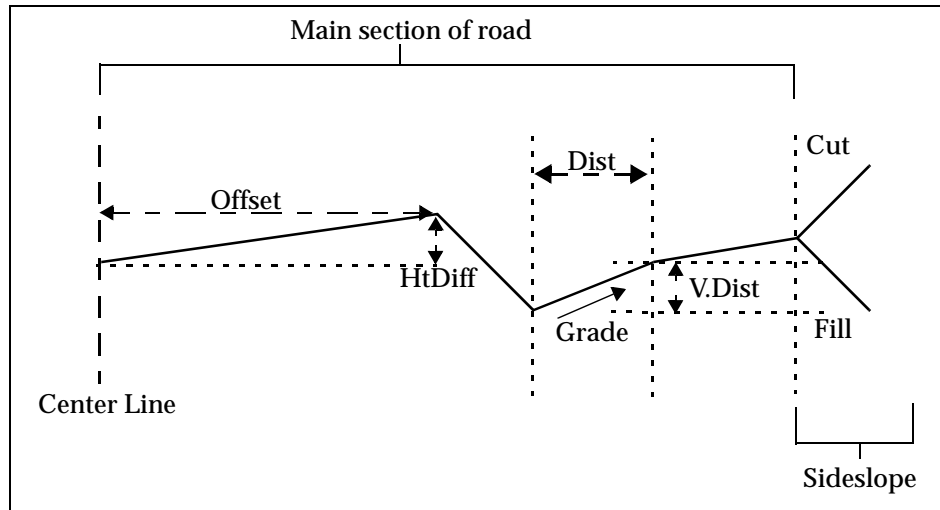
Figure 8-4: Road Template

⊠   **Note**: If no templates exist, the ***Create template*** screen displays first.

10.7.2   *Template point by offset and height difference*

This element will normally start your roading template definition. Define a height difference and an offset to the highest section of the road from the centerline. The SDR will interpolate the slope for the template element. You can specify superelevation and widening in this screen or as a separate element in the template.
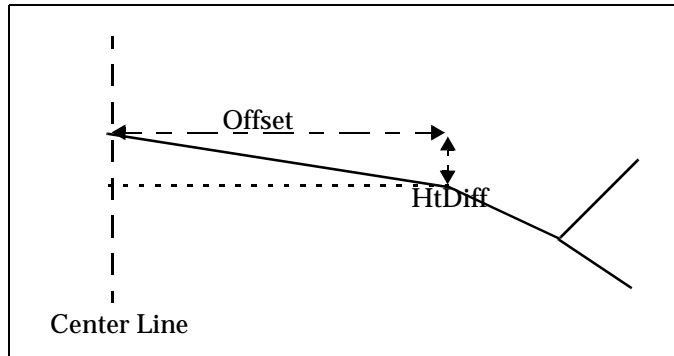
**Figure 8-5: Template point with offset and height difference**

Offset .... This field specifies the distance of the point from the centerline. This offset must not be less than the offsets of any previous points in the template (A template may not fold back on itself with an overhang). You can enter an offset the same as the previous point; this results in a vertical portion of the template. However, only two consecutive template points may have the same offset; you may not have three points one above the other.

HtDiff .... This field specifies the vertical height difference of the point from the centerline. A positive height difference means the point is above the centerline.

Apply Super .... This field specifies whether or not the element will be affected by the application of superelevation. Select Yes or No.

Apply Widen................. This field specifies whether or not the element will be affected by the application of widening. Select Yes or No.

Cd .... This field allows a code to be attached to the point that this element defines.

The defined point is joined to the previous template point to form the shape of the template. The element information is stored in the database in the following format.

TEMP ELEMENT	Grade%-3.000	H.dist 25.000	V.dist -0.750
	Offset 25.000	HtDiff -0.750	Apply super
Yes			

10.7.3   Template point by grade and distance

If you need to add another section onto your roading template defined by a grade and distance, use this option. Specify the grade and distance from the end point of your previous template element. You can specify superelevation and widening in this screen or as a separate element in the template.
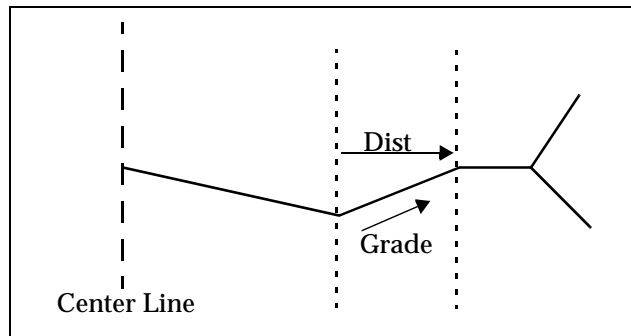
Figure 8-6: Template point with grade and distance

Grade .... This field specifies the grade of the element; it can be specified as **Horizontal**, **Vertical up** or **Vertical down**.

⊠ **Note**: The **<%>** and **<1:>** softkeys can be used to specify whether the grade is entered and displayed as a percentage or a ratio. If the format is percentage, the grade value specifies the slope to the next template point as a percentage. For example, 3% means that the template will rise 0.300 over a distance of 10.0. If the format is ratio, the grade value specifies the slope as a ratio. For example, 1:30 means that the template will rise 0.333 over a distance of 10.0.

Distance.......................... This field specifies the horizontal distance of the new template point from the previous template point. It may not be negative; the template shape may not double back on itself. If the grade is specified as either **Up** or **Down** then the distance is taken to be vertical with the horizontal distance being zero.

Apply Super.................. This field specifies whether or not the element will be affected by the application of superelevation. Select Yes or No.

Apply Widen................. This field specifies whether or not the element will be affected by the application of widening. Select Yes or No.

Cd .... This field allows a code to be attached to the point that this element defines.

Accept the screen and return to the template menu. The defined point can be considered to be joined to the previous template point to form the shape of the template. The element information is stored in the database in the following format.

TEMP ELEMENT	Grade%-3.000	H.dist 25.000	V.dist -0.750
	Offset 25.000	HtDiff -0.750	Apply super
Yes			

Once you have transferred a template to your office computer (or printed it out on a printer), you can remove it from memory.

Chapter 11   Transformations

The SDR can compute a Helmert or linear transformation to transform a survey job from one coordinate system to another using coordinate geometry. The two transformations use different methods to recalculate the coordinates into the new coordinate system. You can select the transformation best suited to your survey needs.

The parameters for a Helmert transformation are calculated using a least squares method to deal with redundant data. The northing and easting coordinate values are transformed using the computed transformation parameters; however, the elevation values are adjusted by the average elevation difference between the elevation of the control points in the proper coordinate system and the elevation of the equivalent points in the actual survey job. For more information about Helmert transformation, see 11.1, *Helmert Transformation*, Pg 11-2.

The SDR uses a combination of translation, rotation and scaling to effect the linear transformation. When calculating a linear transformation, the SDR does not alter redundant data. You may want to use this transformation when you are slightly altering coordinate system and do not need to average elevation values.

When performing a transformation (Helmert or linear), the SDR uses two jobs: the original job and a second job to store the transformed points. Using two jobs allows you to perform multiple transformations without ever altering your original data.

11.1 Helmert Transformation

The Helmert transformation uses the least squares method to transform the coordinates. To carry out a Helmert transformation you must first create a new job containing the correct datum coordinates of the control points.

You may want to send an existing job file to the SDR, or you can create a new job and key in the coordinate values from a plan. The SDR saves the input coordinates in the new (current) job. When inputting coordinates, remember to use the same naming conventions for easy transformation. The control point IDs in the job you wish to transform need to correspond to the correct datum coordinates you enter.

The SDR will search for any point names common to both jobs, and compare the coordinates in both jobs. It uses the coordinates of the equivalent points in the two jobs to calculate the best transformation Helmert parameters using least squares methods. Once this process is complete, the average deviation error is shown. This is a result of the least squares calculation from the redundant data supplied.

Each uncommon point in the selected coordinate system job will be transformed and stored in the new job. This process may take some time for large jobs. Each point number is shown as it is transformed. The control points common to both jobs are not transformed, as they already exist in both jobs. This also preserves the accuracy of the control points.

11.2 Linear Transformation

The linear transformation is a "simple" transformation, avoiding the use of least squares. The linear transformation performs a translation, rotation or both to the coordinates in the selected job.

When performing a linear transformation, you will need to establish a new job containing at least one control point to hold the transformed coordinates.

The ***Linear Transformation*** screen will show the following:

∆North .... This field shifts the north coordinates.

∆East .... This field shifts the east coordinates.

∆Elev .... This field shifts the elevation coordinates.

Rot Pt .... Enter a point ID to use as the rotation point. All coordinates will be rotated around this point.

Rotation .... Enter a rotation value.

Scale .... Enter the horizontal scale factor.

⊠ **Note:** When calculating the rotation in a linear transformation, you will receive an Invalid Input message if the calculated angle is -100 degrees or more.

11.3 Translation

If you wish to perform a translation transformation, the following fields are available to you on the ***Translation Transformation*** screen:

⊠ **Note**: If you enter a point ID that exists in the database, the SDR will automatically populate the fields with the stored coordinates.

Pt .... Enter the starting point ID.

Org.N .... Enter the original North value.

Org.E .... Enter the original East value.

Org.El .... Enter the original elevation.

Dest.N .... Enter the North destination value.

Dest.E .... Enter the East destination value.

Dest.El .... Enter the elevation destination value.

11.4 Rotation

If you wish to perform a rotation translation, the following information will be available to you on the ***Transformation Options*** screen:

RotPt .... Enter a point ID to use as the rotation point. All coordinates will be rotated around this point.

Old Azim .... Enter the original azimuth.

From .... Enter the beginning point ID of the point whose azimuth you wish to rotate.

To Pt .... Enter the ending point ID of the point whose azimuth you wish to rotate.

New Azim .... Enter the new azimuth.

From .... Enter the point you wish the SDR to use to calculate the azimuth.

To .... Enter the point you wish the SDR to use to calculate the azimuth.

⊠ **Note**: If you enter a point ID that exists in the database, the SDR will automatically populate the fields with the stored coordinates.

Chapter 12   **The SDR Database**

In this chapter we will discuss database conventions, viewing stored data, searching for data, editing notes and codes, observation views, coordinate search rules for total station instruments, coordinate search rules for elevations when both total station and leveling instrument observations are available, and application of total station coordinate search rules.

The SDR stores all observations, notes and calculated results in a database. This database is a list of records of different types, stored in chronological order. Each job's database starts with a **JOB** record, which defines the job's name, and continues with records within that job stored in the order they were generated.

The SDR database can contain many different types of records depending on the particular SDR software you have installed and the option that produced the record.

Different record types can help you find a specific record or track down an error or blunder. For more infomation about blunders, see 6.2.6.5, *Blunder detection*, Pg 6-17.

It is not possible to alter data once it has been stored, except for code fields and note records. Because code fields and note records are not used for calculations, you can edit them.

12.1 View the Database

You can view the SDR database at any time by pressing <**View**>.
Each line corresponds to one record in the database. Each record in
the database displays the record type, the derivation code (which
indicates which part of the program generated the record) and the
first data field of the record.

New records are added to the end of the database so record order is
chronological. The only exceptions are note records which can be
added anywhere in the database while viewing the database. A note
record is entered in the database immediately before the record that is
currently highlighted.

When the database screen is first accessed, the most recent record is
highlighted.

12.1.1   Search by point or feature code

After accessing the database, you can search the database for records
containing a particular point ID or feature code. For more
information about feature codes, see 14, *Feature Codes and Attributes*,
Pg 14-1.

⊠   **Note**: If both a point name and a code are entered, the SDR first
looks for point name matches. If none are found, then it searches
for code matches.

12.1.2   Open a record for viewing

You can open any record displayed in the database list to view the
stored information. However, you can only edit code fields and notes.

12.1.3   Edit notes and codes

Most of the information stored in the database records is not available
for editing; however, you can modify codes fields or notes with the
exception of program-generated notes such as Traverse closure
information.

12.1.4 Review observation records in the database

When you access the database with the <**View**> key and open a GPS observation record (GOBS), the data displays in the current view. The data can be displayed in any of several views, which are accessed via the softkeys at the bottom of the screen once the record is opened.

⊠ **Note:** The initial view presented is specified in the **GPS view stored** field in the **Configure Reading** option under the **Functions** menu. Upon viewing an observation, you will not necessarily see the raw data.

The available views are as follows:
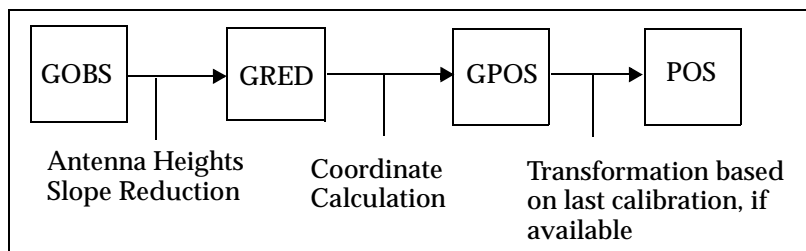
Figure 12-1: RTK Reduction
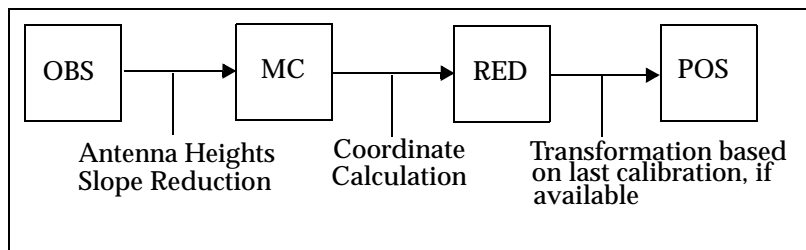
Figure 12-2: ETS Reduction

⊠ **Note**: Actual stored data does not change when different views are selected; the raw data is always retained. Only the method of data presentation changes.

The components of these views are illustrated as follows:
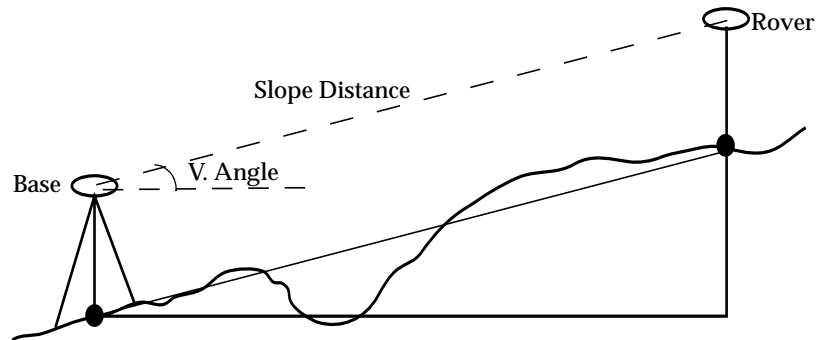
Figure 12-3: Components of observation views

The views are represented as follows:

GOBS..............................The azimuth, vertical angle, and slope distance from the base antenna to the rover antenna.

GRED..............................The horizontal distance and the vertical distance from A to C.

GPOS ....The coordinate at C.

POS ....The coordinate at position C with the transformation determined from the most recent calibration applied, if available.

⊠ **Note:** The illustration does not show the azimuth, which is part of the **GOBS** and **GRED** views.

Access the observation record views

The softkeys at the bottom of the screen, excluding the <**EDIT**> softkey, refer to different views of this observation that you can see.

Store the data in any of the views. When you look at the record again, it will be presented in the view you selected and saved.

⊠ **Note**: Actual stored data does not change: the raw data is always retained. Only the method of data presentation changes.

Once you have saved a particular view, the SDR treats the observation as a record of that type for all other purposes. For example, if you save an observation in **POS** view, it is subsequently treated by the SDR as a position record. Of course, you can change the view back to **GOBS** at any time.

When you transfer job data, you can transfer observation records in more than one view. Observation records are set to transmit in the current view as a default.

For example, you can choose to output your GPS observations in **POS** view.

⊠ **Note**: The ability to store observations in **GOBS** view or **POS** view has useful implications when combined with the SDR's search rules for calculating coordinates. For example, you can store your observation to override or ignore particular observations after they have been sorted. If you feel an observation is especially accurate, store it in **POS** view. This observation view is used by the SDR to calculate coordinates.

12.1.5 Reviewing records with transformation reduction

When you access a GPS observation record and have selected a transformation for the current survey job, your view options begin with the GOBS record. Like view option with no transformation selected, the GOBS record contains the observation from the base receiver antenna to the rover receiver antenna.

The softkeys at the bottom of the screen, excluding the **<EDIT>** softkey, refer to different views of this observation that you can see of this observation. The softkeys access the following:

<GOBS>......................... (GPS observation) The **GOBS** view shows the observation from the base receiver antenna to the rover receiver antenna.

<WGS84>...................... This view shows the original GOBS coordinates converted to WGS84 ellipsoidal coordinates. latitude, longitude, and height.

<DATUM>..................... This view displays the station and backbearing as WGS84 latitude, longitude, and height.

<GPOS>......................... (GPS position) The **GPOS** view shows you the observation reduced to coordinates relative to the station from which it was calculated.

<POS>............................ (position) The **POS** view shows the observation relative to the station from which it was calculated. If the record is a GPS observation, the transformation determined from the most recent calibration will be applied, if available
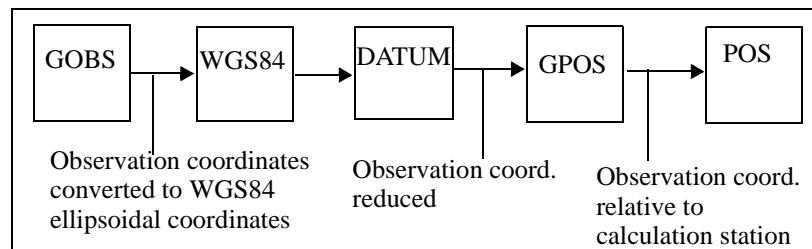
You can store the data in any of the views. When you look at the record again, it will be presented in the view you selected and saved.

12.2 Searching for Coordinates

If you want to find out what coordinates the SDR will use for a particular point name, use the manual entry option **Key in Coords** access from the **Keyboard Input** option in the **Survey** menu or the **COGO** menu. In the **Key in Coords** screen, specify the point name in the **Pt** field. The SDR then displays the point coordinates if they are known or can be calculated.

12.3 Using Coordinate Search Logic

A **POS** view record is, most typically, an observation (**GOBS/OBS**) in position (**POS**) view. However, **MC** and **RED** records can also be stored in **POS** view. These three types of **POS** view records (**GOBS/OBS** in POS view, **MC** in POS view, and **RED** in POS view) are equal in precedence to true **POS** (or **STN**) records in the coordinate search rules.

POS .... searches for last **POS** record in database

GPOS .... searches for last **GPOS** record in database

GRED/RED .... searches for last **RED** or **GRED** record in database

OBS MC .... searches for last **OBS MC** record in database

GOBS/OBS .... searches for last **OBS** or **GBOS** record in database

When the SDR program searches for the coordinates of a point, it always uses the latest information, except that **POS** and **POS** view records are used before more recent **GOBS/OBS** records.

The SDR searches for the latest coordinates of the station point to calculate the target's coordinates from the observation.

Coordinates are one of the following:

- Station record (**GSTN/LLHSTN**)
- Position record (**POS**)

Coordinates can be calculated from one of the following:

- An observation record (**GOBS/OBS**) stored in P**OS** view
- An observation record stored in raw or reduced view
- A reduced record (**GRED/RED**)

12.3.1 SDR search rules

When searching for the coordinates of a point, the SDR uses the following rules.

Rule 1: Observations in POS view are treated as a POS record.

For search purposes, any **GOBS**, **OBS**, **MC, GRED**, **RED** or **GPOS** record in **POS** view is treated the same as a true **POS** record.

Rule 2: The SDR uses POS, GSTN, STN and POS view records before using GOBS/OBS records even if the GOBS/OBS record is more recent.

The SDR will look for any **POS** records,**GSTN,** or **STN** records or **POS** view records, starting at the end of the current job (most recent records) and going backward in time. The first **POS**, **GSTN**, **STN** or **POS** view record found is used to determine the coordinates.

If the SDR finds a **POS**, **GSTN** or **STN** record, the coordinates are immediately available from that record. If however, the SDR finds a **POS** view record, it must reduce that record to coordinates.

Rule 3: If there are no applicable POS, GSTN, STN, or POS view records, the SDR will use the most recent GOBS, OBS, GPOS, MC, GRED or RED record. The record's view is no longer significant.

The SDR will look for any **GOBS**, **OBS**, **GPOS**, **MC**, **GRED** or **RED** records, starting at the end of the current job and going backwards in chronological order. If the SDR finds a **GOBS**, **OBS**, **GPOS**, **MC**, **GRED** or **RED** record in its search, it will reduce it to coordinates.

Rule 4: If no such record can be found, the search fails.

If the SDR cannot find any **POS**, **GSTN**, **STN**, **POS** view, **OBS**, **GPOS**, **MC**, **GRED** or **RED** records for the point in question, the search fails and the SDR assigns <**Null**> coordinates. An aborted Set may leave **OBS** records on the database, but these **OBS** records are ignored in database searching.

Rule 5: Coordinate searching is iterative.

Finding the coordinates of the point may necessitate finding the coordinates of several other points. This process will continue until a fixed position for some point (a **POS, GSTN** or **STN** records, not a **POS** view record) is found.

The number of iterations that the SDR can perform is limited. The search fails if the SDR has to coordinate more than 25 points before it can coordinate the original point in question.

12.3.2   Applying coordinate search rules

The SDR search rules have useful results. Understanding the search rules will help you determine the best way to use the SDR to solve surveying problems.

Example 1

When setting up on a new station, just enter the point name. The SDR finds the coordinates automatically and calculates them if there is one observation to the point.

Example 2

Cadastral surveyors may key in one starting coordinate and then a sequence of azimuths and distances as marked on a plan. In the field, any one of those points may be used as a station or reference point. The SDR's iterative search (Rule 5) automatically calculates the desired coordinates.

Example 3

When observing an existing point, the **Store POS** option stores the observation in **POS** view, whereas the **Store GOBS** option stores it in **GOBS** view. The searching rules ensure that a previous **POS** record (or observation in **POS** view) will be ignored or used as desired.

Example 4

If you change a **POS** view observation back to **GOBS** view, an earlier **POS** view observation to that point will be used in preference for calculating the coordinates. This gives you some control over what data is used, which is useful if a mistake occurs.

It is possible that sometimes the SDR will output coordinates different from those you expected. After checking for obvious survey errors, check that the coordinate search rules have not had an unexpected effect.

⊠ **Note**: If you use <**View**> to search for a point, you see the most recent record defining it. To see the coordinates of a point that the SDR will use for calculation, use the *Keyboard Input* option and enter the desired point's number and name. The coordinate values appear as defaults.

Chapter 13   Measurement of Collimation Error

When using a total station instrument, you may need to measure
collimation errors and correct for errors in observations. The SDR can
calculate errors and include corrections in the job files.

The **Collimation** option in the **Survey** menu lets you measure the
collimation error in your instruments to correct subsequent single
face observations. The error is measured by making angular
observations using both faces of the instrument to one or many
points. The minimum required data is a Face 1 (**F1**) observation and a
Face 2 (**F2**) observation to a single point. For more information about
Face 1 and Face 2, see 6.2.1, *Calculate Station Position*, Pg 6-5.

⌧ **Note**: If no station has been setup in the current job, the SDR
automatically displays the *Station* and *Backsight* screen.

⌧ **Note:** Observing two or more points with significant vertical
separation will improve the result.

Once a collimation record is added to the database, corrections are
applied to all subsequent observations until either the instrument
type is changed or a new collimation record is added.

Although, instrument type is maintained across jobs, collimation is
not. When you start a new job, the same instrument type is assumed,
but not the collimation measurement. For information on collimation
error and correction, see B.4.6, *Collimation correction*, Pg A-6.

Chapter 14   **Feature Codes and Attributes**

In this chapter we will define a feature code list, add feature codes to a feature code list, select feature codes, and attribute definition and entry.

Feature coding is a method of describing each observed point with an alphanumeric code. Feature codes are contained within Feature Code Lists on the SDR. You can add, modify or delete codes from the list and maintain multiple lists of feature codes.

Also, the SDR can collect attribute data with feature codes. Attributes are characteristics associated with a specific feature code. For example, you can create a feature code of "tree" with attributes of "type" and "size." The SDR would prompt you to enter the type and size of the tree whenever you use the feature code, "tree." Feature codes and attributes can help you collect meaningful survey data directly associated with the specific point.

The **Feature Code List** option in the **Functions** menu enables you to define feature code lists. You can create multiple feature code lists on the SDR with associated attributes. You may want to create several different types of feature code lists for separate jobs.

To use the feature coding option, be sure to set the **Code list active** field to **Yes** in the *Configure Reading* screen when setting up your job.

14.1 Manage Feature Code Lists

The SDR can access multiple lists of feature codes. Each list can be user-defined to provide a specialized set of feature codes in a specific order. Initially, the Feature Code list is named "Default List." You can populate the Default List with all the feature codes you plan to use or you may want to create several lists for different purposes.

> ⊠ **Note:** The Default List is sorted alphanumerically, and the sorting properties cannot be changed.

To access the lists, select **Feature Code List** from the **Functions** menu. The currently selected list and its designated feature codes will display (initially, the currently selected list is Default List).

Press the <**LISTS**> softkey to access the management functions for lists. All the feature code lists available in the SDR are displayed. You can manage feature code lists by:

- Selecting a list
- Adding a new feature code list (<**ADD**> softkey)
- Deleting the highlighted feature code list (<**DEL**> softkey)
- Changing the list name (<**EDIT**> softkey)
- Checking list statistics (<**STAT**> softkey)

For information about managing the feature codes in a list, see 14.2, *Manage Feature Codes in a List*, Pg 14-4.

14.1.1   *Select a feature code list*

Selecting a feature code list provides feature codes during data collection. You can select different feature code lists in the same job. However, you can only use one feature code list at a time.

> ⊠ **Note:** If you do not want to be prompted with a Feature Code List during data collection, set the **Code List Active** field to **No** in the **Configure Reading** screen.

14.1.2   Add a feature code list

You can add as many feature code lists as required (limited only by available memory). You may want to create separate feature code lists for specific surveys. On the ***Enter Feature Code*** screen you will see the following fields:

List Name....................... This field indicates the Feature Code List name (up to 16 characters).

Sort Type .... This field indicates the sorting option for feature codes in the list. For an example of the different sort types, see 14.3, *Use Feature Codes*, Pg 14-5..

> **Alpha** - As feature codes are enter in the list, they are automatically sorted alphanumerically. The Default List is sorted alphanumerically.

> **User** - The user-defined sorting option should be used if you repeatedly will use particular feature codes in the same order, for example a road cross-section with user-sorted feature codes of curb, gutter, center line and curb. As you enter points, the feature code list will always be one code away from the next observation. Additionally, the feature code lists starts from the beginning when it gets to the end.

⊠ **Note:** The sort option cannot be changed after a feature code list has been created.

14.1.3   Delete a feature code list

You can delete a feature code list. All associated feature codes and attributes will be deleted with the feature code list.

14.1.4   *Rename a feature code list*

You can rename any feature code list. Feature Code List names are limited to 16 characters.

14.1.5   *Review the statistics for a feature code list*

You can view the statistics of a feature code list to review the file size, the number of associated records and the creation date and time. In the *Stats* screen you will see the following fields:

ID...................................... This field displays the name of the feature code list.

File Size .... This field displays the size of the feature code list in kilobytes.

Recs used .... This field displays how many records occur in the feature code list.

Date .... This field displays the date the feature code list was created.

Time .... This field displays the time the feature code list was created.

Sort Type .... This field displays the sorting option.

14.2 Manage Feature Codes in a List

A newly created list contains no feature codes. You must add them one at a time. After you finish defining a feature code list, your SDR screen will display the Feature Code List screen.

14.2.1   *Add feature codes*

You can add feature codes to a new or established feature code list.

On the *Add Feature* screen you will see the following:

Cd .... Enter the name of the new feature code.

Join................................. The **Join** field determines whether points with this code are joined together as linework if the points are plotted.

⊠ **Note**: The SDR does not plot points. To use the **Join** field feature, you will need to export the SDR file and feature code library.

Attributes....................... This field is used for user-defined attributes. For more information, see see 14.4, *Define Attributes*, Pg 14-7.

⊠ **Note**: If your Feature Code List is sorted alphabetically, feature codes will display in alphabetical order, regardless of how the feature codes were added.

14.2.2   Edit feature codes

Individual feature codes can be edited. You can change the name or the join status. Also, you can modify the assigned attributes.

14.2.3   Delete feature codes

You can delete feature codes from a list to simplify your workflow or to provide more available memory on your SDR.

14.3 Use Feature Codes
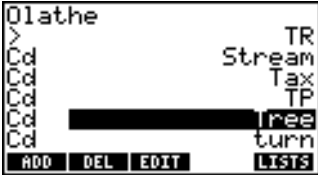
The feature code list is always accessible when editing any **Cd** field during your survey if the **Code list** option is set to **Yes**. You can set the **Code list** option in the *Configure Reading* screen. It is also accessible for **Note** fields, in this case, if the **Feature code insert** option is turned **On** in the *Note* screen. For more information about the Code list, see 4.7, *Feature Code List*, Pg 4-20.

In the following example you will see two different feature code lists that contain the same codes: tree, stream, tax, road, rim, tp, turn, curb and center. The example lists are:

Shawnee........................This list is user-sorted in the order in which the codes were just listed.

Olathe.............................This list is alpha sorted.

Enter	User-sorted list	Alpha-sorted list
T (one letter)	Shawnee > t Cd **Tree** Cd Stream Cd Tax Cd Road Cd Rim **ADD | DEL | EDIT | INS |LISTS** The SDR displays the first, occurring, feature code starting with the letter entered.	Olathe > t Cd Stream Cd **Tax** Cd TP Cd Tree Cd turn **ADD | DEL | EDIT** **LISTS** The SDR displays the first, alphabetical, feature code with the letter entered.
TT (two identical letters)	Shawnee > t Cd Tree Cd Stream Cd **Tax** Cd Road Cd Rim **ADD | DEL | EDIT | INS |LISTS** The SDR will display the next occurring feature code starting with the letter entered.	**Key in coords** Pt 1005 North <Null> East <Null> Elev <Null> Cd **TT** The SDR searches for the next feature code that begins with those two letters. If no matches are found, the input screen from which the feature code list was accessed appears.

Enter	User-sorted list	Alpha-sorted list
TR (two different letters)	 The SDR searches for a feature code containing the first letter entered and then a second feature code containing the second letter.	 The SDR looks for the first entry containing both letters entered.

14.4 Define Attributes

The SDR can collect attributes, specific information about a feature code. Attributes are optionally defined as part of the feature code definition. Each feature code can have up to five attributes. Each attribute can have a user-defined name and a type of Alpha or Numeric.

For example, you can create a feature code, "tree" and assign it several attributes: "type, "size" and "health." When surveying, if you enter the feature code, "tree," the SDR will prompt you to enter the type of tree, its size and the health. Attributes can aid you in collecting multiple types of information about surveyed points.

⊠ Alpha type attributes can be used to enter descriptive words (the type of tree) and may be up to 16 characters long.

Numeric types attributes can be used for collecting quantitative data (the height of a tree). Numeric attributes may be up to 10 digits long and limited to ±9999999. Three decimal places are displayed for numeric attributes.

14.5 Enter Attributes

Attributes values are entered when taking observations with applicable feature codes. Enter the feature code name in the usual way, by typing the first letter of the feature code desired to locate it. Review the selected feature code, if multiple feature codes with a letter exist, you may need to navigate to the correct feature code using the arrow keys or typing the next letter.

When the instrument reading is completed, store the reading. If a feature code has associated attributes, you will be prompted for them. Depending on the type of attribute, you may enter a descriptive word or a number.

The attributes are stored in separate Note records after the observation with a derivation code of AT (Attribute).

These notes can be printed or transferred to a personal computer to convert the notes and produce a file suitable for direct input into a GIS or other asset management system.

Appendix A Instrument settings

In this appendix we will address communication with Sokkia and non-Sokkia instruments.

The SDR supports a variety of instruments. When using Sokkia instruments with the SDR, most instrument settings will already be established. If you are not using a Sokkia instrument, refer to your instrument's documentation for specific information.

A.1 Sokkia Instruments

When using the SDR with Sokkia theodolites and total stations, there are simple guidelines to store data correctly. There are also operational differences between two-way SETs and older instruments. This information is discussed in the following sections.

A.1.1 Single direction communication

Prior to creating a survey job, certain parameters must be set on the SDR and the instrument it communicates with.

Units

Both the SDR and the total station or theodolite must be set to the same measurement units (feet/meters, gons/degrees and vertical angle zenith/horizontal).

Prism constant

The prism constant should be set on *either* the SDR or the instrument, but *NOT* both. Otherwise, the correction is applied twice. If the prism constant is entered in the SDR, a record of this will display in the printout.

PPM correction

PPM should be set *either* on the instrument or via SDR pressure and temperature entries at the station setup, but NOT both.

Tracking

The tracking mode on the instrument can be switched on or off; it does not affect the SDR. However, if the SDR tracking parameter in the *Configuration* menu is set to **Yes**, the SDR does not stop the EDM after a distance measurement. If the instrument is set to a single EDM measurement, the tracking mode will not be available.

A.1.2   Two-way SETs

The two-way SETs have full two-way communications. Target height, back sight azimuth, temperature and pressure and other values can be manually entered. Avoid confusion about where to enter information by *entering all your survey information into the SDR, not the SET.* The SDR creates a permanent record of your field work, sends this information to the SET and checks to make sure no data has been inadvertently changed.

The values such as the PPM and prism constant will be set the same in both the SDR and the SET, contrary to the instructions for non-two-way SETs. Configure the SET and SDR using the following parameters:

Parameter	Set	SDR	SDR Location
Baud rate	1200 or 2400	SDR will automatically detect setting	Comms
Parity	NO	set in SET	Comms
Checksum	On or Off	set in SET	Comms
Curvature and Refraction	set in SDR	On or Off	Job Settings
Instrument		two-way SET	Configure Reading

⊠ **Note**: For information on setting parameters in the SET, refer to the SET documentation.

Steps for setting parameters on the SDR

1. Set up the SDR with the correct angles and distance units for your survey requirements.

2. In the ***Instrument*** screen, choose **Two-way SET**. If the SDR is connected, it immediately sends its serial number, vertical angle type and prism constant. The latter two settings may be changed if required.

3. Choose the orientation option required.

4. Set up on a station and take a backsight reading. The SDR sends all relevant unit settings and values to the SET and gives an **INSTR PARAMS SET** message.

5. On each subsequent reading, the units and PPM are checked.

A.2 Non-Sokkia Instruments

With all non-Sokkia instruments, it is recommended you enter corrections in the SDR rather than the instrument. By using this method, a record of corrections is maintained in the SDR database.

A.2.1   Geodimeter

The standard SDR (top) cable with a male DB25 connects to the female 25-pin connector on the Geodimeter's Y-cable. Plug the connector at the junction of the "Y" into the Geodimeter. You also can plug the remaining connector into an external battery pack.

When using a Geodimeter, you will need to select several settings on the SDR, including:

• Instrument setting (***Func/*Instrument**)

- Prism constant (Set all parameters in the SDR) (***Func/* Job Settings**)
- Serial number (***Func/*Hardware**)
- Atmospheric corrections (***Func/* Job Settings**)
- Vertical observation mode
- Units (***Func/*Units**)

If you have a Geodimeter 440, press the following keys; otherwise consult your Geodimeter manual. The interface to the Geodimeter uses the standard table 0 so you do not need to set up any tables on the Geodimeter:

Geodimeter Display	Key to press	Comments
Menu	MNU	
1 Set		Menu selection
2 Editor 400		
3 Coord	ENT	
Menu		Select data communications menu
4 Data com	4	
5 Test		
Data com		
1 Select device	1	
2 Create table		
Data com		
1 Geodat	2	Select serial communications
2 RS232		
3 Ext. mem		

Geodimeter Display	Key to press	Comments
RS232 ON?	YES	
COM=1.7.2.1200	ENT	1200 baud, even parity
U.D.S.?	NO	No recording program required
Table No =	0 ENT	Select standard table 0
Request?	YES	

☒ **Note:** It is not necessary to enter an accurate HA ref; zero will suffice because the SDR considers the backsight azimuth.

A.2.1.1   Operating the Geodimeter

Steps for making observations include:

1. Aim the Geodimeter at the target.

2. Press the <**READ**> key on the SDR to initiate a full (angles + EDM) reading.

3. Store the reading by pressing <**OK**>.

4. For an angles only reading, press the <**ANGLE**> softkey on the SDR's *Take Reading* screen.

When the Geodimeter 440's noncoaxial EDM is used with a combined prism/target at short range and the theodolite is aimed at the target's center, the EDM beam misses the prism. Use the SDR's offset-reading facility to record the angles and distance to the target separately.

A.2.1.2   Test setup on the Geodimeter

As a shortcut for testing purposes only, press the keys in the list below to set up the Geodimeter quickly. This procedure avoids setting up compensation and leveling.

Geodimeter Display	Keys to press
	Switch <ON>
The electronic level is displayed	F22 ENT
Comp = 1	0 ENT
Temp = 22.0	ENT
Press = 760.00	ENT
Offset = 0.000	ENT
Hz Ref =	0 ENT

The standard table will display. Connect the SDR to the Geodimeter 440 and take simple readings to verify that the connection is working.

A.2.1.3   Tracking with the Geodimeter

Tracking can be performed by setting the Geodimeter to its tracking mode (TRK). The SDR tracking mode does not have to be enabled. Press **<READ>**, then A/M. The Geodimeter will take continuous readings, which can be stored in the SDR by pressing **<READ>**.

A.2.2   Laser Atlanta Optics

The SDR supports the ProSurvey 1000 laser range finder from Laser Atlanta Optics, Inc. Configure the ProSurvey 1000 to communicate in standard mode (4800 baud, no parity, 8 bits, 1 stop bit).

A.2.3 Laser Technologies

The SDR supports the Criterion 300 and Criterion 400 laser range finders from Laser Technologies, Inc. Configure the Criterion 300/400 and SDR using the following parameters:

Parameter	Criterion	SDR
Baud rate	4800	
Parity	NO	
Stop bits	1	
Vertical observations		Horizontal (refer to instrument settings)

When <**Read**> is pressed on the SDR, the last reading on the Criterion 300/400 is downloaded to the SDR. This enables the user to perform several readings with the laser range finder, but to download only the most recent to the SDR. The sequence is to initiate a reading, or readings, on the Criterion 300/400, then press <**READ**> on the SDR to download the last Criterion reading.

A.2.4 Nikon Instruments

The SDR supports the Nikon DTM-A series of instruments and the Nikon D-50 instrument. A special cable (Sokkia Product No. 5306-66) is required to convert the Nikon pin configuration to the SDR pin configuration. Even though the same type of connector is used, do *not* connect the SDR connector directly to the Nikon instrument.

The SDR and Nikon instrument must be set up to use the same angle and distance units. Corrections should be applied in the SDR *only*, so that a permanent record is maintained.

⊠ **Note:** Inconsistent unit or correction settings cannot be detected by the SDR, but *will* result in erroneous data. No automatic unit conversion is done in the SDR.

The SDR cannot shut off the Nikon's EDM. Select the desired cutoff time from the Nikon setup to preserve battery time.

A.2.4.1   Nikon D-50

The Nikon D-50 instrument does not automatically send data when a distance reading is complete. When the Nikon finishes the reading (usually signalled by an audible beep), a message will display. Press **<OK>** on the SDR. It will then retrieve the data from the instrument.

⊠   **Note:** It is important to wait for the instrument to complete the reading. If **<OK>** is pressed too soon, it will abort the reading and return the distance of the *previous* measurement.

A.2.4.2   Nikon DTM-A Series

The Nikon DTM-A series instruments will automatically send data to the SDR when a reading is complete, so no operator interaction is required beyond pressing **<Read>**.

To set up the Nikon A-Series instrument, press and hold the second key, turn on the power and release the second key. This should put the instrument in its mode setting screen. Configure the Nikon DTM-A and SDR using the following parameters:

Parameter	Nikon	SDR
Comm Mode	NkRS	N/A
	SET	N/A
Baud Rate	SET = 1200	4800
	NkRS = 4800 or 9600	4800

When you have establishing the settings, press the **<ENT>** key on the Nikon to accept the new setting.

A.2.5   Pentax Instruments

The SDR provides software to interface with the Pentax PTS-10, PTS-II, PTS-III, PTS-V and PCS. A special cable is required to convert Pentax cabling to the SDR's Hirose standard cabling configuration.

The Pentax instruments operate in the same way, but the older PTS-10 instrument is slightly different.

- To record distance observations, the PTS-10 *must* be in distance mode.

- Angles only measurements can be taken in any mode, but take considerably longer if the PTS-10 is in distance mode. Use ***angles*** mode if you need to make many angles only observations.

- When taking distance readings, the SDR automatically puts the PTS-10 into **AIM** mode until the signal is satisfactory. The SDR captures the reading from the PTS-10 when it is available.

Operation

Instrument checks include the following:

- The SDR checks that the prism constant and/or atmospheric correction(s) are not set on *BOTH* the SDR and the Pentax instrument(s). If they are, an error message is displayed.

- You need to manually check that the Pentax is not applying the curvature and refraction correction. It is not transmitted by the Pentax instruments.

- The SDR checks that the instrument is operating in the appropriate vertical angle mode (zenith or horizontal).

- The SDR also checks the instrument's units and raises an error message if units are different than expected.

⊠ **Note:** The SDR does *NOT* automatically convert from the Pentax's units to its own.

The SDR can not turn off the EDM after a distance reading. Manually turn off the EDM after each reading to conserve the PTS batteries if it needs to remain aimed at a prism.

Communication Parameters

On the PTS-II/III/V/PCS, make sure the instrument is configured to communicate in standard mode (1200 baud, no parity, 8 data bits, 1 stop bit). Consult your Pentax operations manual for information on setting parameters.

A.2.6   Topcon Instruments

The GTS-3 setting supports the older GTS-3 instruments, although a special hardware interface or factory modification is required (Sokkia product no. 5306-40).

The GTS/ET1/ET2 setting is used for any of the following: GTS-3B, GTS-4, GTS-6 and ITS-1. The GST-3000 applies to the GTS-300 series.

Cabling

No special cabling is required; the SDR's top cable has a Hirose connector that plugs directly into the Topcon data port.

Operation

The Topcon can work in any combination of units. The SDR checks each reading transmitted by the Topcon and warns you if the Topcon units are incompatible with the SDR's. If necessary, alter the total station or SDR units.

⊠ **Note:** The SDR will *NOT* automatically convert the units of transmitted values into its own units.

Set up the Topcon in slope distance mode, when EDM is selected.

Configure the Topcon's basic distance mode as *Slope Distance* (SD). Otherwise it will not work with the SDR. Set this parameter by holding down the <**F2**> key while turning on the total station. The SDR will set the slope distance mode of the GTS300 itself so it is not necessary to set it on the topcon at start up. The SDR cannot change the GTS3 from theodolite mode to slope distance mode or vice versa, thus the mode must be set in the instrument to reflect the type of reading being taken.

Atmospheric corrections may be applied in either the SDR or the total station. The SDR issues an error message if corrections are applied twice. It is recommended that corrections be applied in the SDR. If you have trouble maintaining 0 PPM in the Topcon, set the SDR to not apply atmospheric corrections.

Similarly, the prism constant may be set in either the SDR or the total station. An error message displays if it is non-zero in both.

Set the Topcon to communicate in standard (1200 baud, even parity, 7 bits, 1 stop bit) mode. Consult your Topcon manual for information on setting parameters.

A.2.7   Wild instruments

The SDR supports the following Wild (Leica) instruments:

T1000	T2000	TC/TCM series
T1000+DI	T2000+DI	T1600+DI
T1600	T1010/1610	T1010/1610+DI

The DI selections support either an external EDM or integrated Total Station (TC series). For example, the T1000+DI supports either a T1000 with DI connected or a TC1000. A special cable (Sokkia Product No. 5306-12) is required.

The SDR and the Wild instrument must be set up to use the same angle and distance units. Corrections may be applied in one or the other, but not both.

⊠ **Note:** Inconsistent unit settings result in an SDR message. The SDR does *NOT* automatically convert data from the Wild into SDR units.

Wild instruments will operate in the fast reading mode (referenced in the Wild manuals). If you are using a TC series instrument, configure the units to work with a GRE and not the Rec module.

Before using a Wild instrument, configure it to communicate with an external device in standard mode (2400 baud, 7 bits, even parity, 1 stop bit). Consult your Wild manual for information on setting parameters.

A.2.8   Zeiss

The SDR provides software to interface with the Zeiss Elta 2, Elta 3, Elta 46R, Elta RL, Elta 50 and DiNi 10/20. A special connector (Sokkia product No. 5306-30) is required to connect the SDR.

With the Elta 46R the SDR cannot initiate a reading automatically, this must be done by pressing the read lever on the Elta 46R. It is advisable to press <**READ**> or <**ANGLE**> on the SDR before starting the instrument. On other Elta instruments the SDR automatically sets the correct mode for observations and initiates each reading. Supported modes are **M1** (slope distance, vertical angle, and horizontal observation) and **M2** (angles only). <**READ**> and <**ANGLE**> on the SDR work in the normal way.

The SDR and Elta must be configured to use the same angle and distance units, or the SDR issues an error message. Corrections may be applied in either the Elta or in the SDR, but not both; an error message occurs if corrections are applied twice.

On the Elta 2/3/46R, make sure the instrument is configured communicate in standard mode (1200 baud, odd parity, 7 bits, 2 stop bits).

On the Elta RL, configure the instrument to communicate in standard mode (2400 baud, no parity, 8 bits, 1 stop bit).

On the Elta 50, configure the instrument to communicate in standard mode (2400 baud, no parity).

On the DiNi 10/20 configure the instrument for 2400 linespeed, input/output mode, no parity, no flowcontrol, 8 bits, 1 stop bit, and ASCII protocol. Consult your Elta manual for information on setting parameters.

Appendix B Observational Calculations

In this appendix we will address correctional categories, order of application, instruments, environmental and job-related corrections, geometric reductions, professional positioning calculations, and other formulas.

This appendix presents the formulas and constants used by the SDR for calculations.

B.3 Correction Categories and Order of Application

The SDR performs several corrections to readings as it makes conversions **POS** records. These corrections can be grouped into two general categories:

- instrument, environmental and job-related corrections
- geometric corrections.

Instrument corrections include equipment configuration, Face1/Face2 observations, collimation, mounting eccentricity and prism constant. Environmental corrections include pressure and temperature corrections. Job-related corrections include orientation, instrument height reduction and target height reduction.

Geometric corrections include such things as curvature and refraction, slope reduction, sea level and projection.

The SDR always applies corrections in a specific sequence as it converts a raw observation to coordinates. The instrument, environmental and job-related corrections are applied first, followed by the geometric corrections.

The SDR applies the prism constant and atmospheric parts per million (PPM) corrections as soon as the observation is accepted. This reading can be from a total station instrument or it could be manually input from the keyboard.

The SDR applies six different corrections when it converts an OBS record to a measured and corrected (**MC**) record. The order is face one/face two, mounting eccentricity, instrument and target height, collimation, orientation, arc curvature and refraction.

The SDR corrects for sea level and projection when converting an MC record to a reduced (**RED**) record. The final step in arriving at coordinates (**POS** record) is a mathematical coordinate calculation.
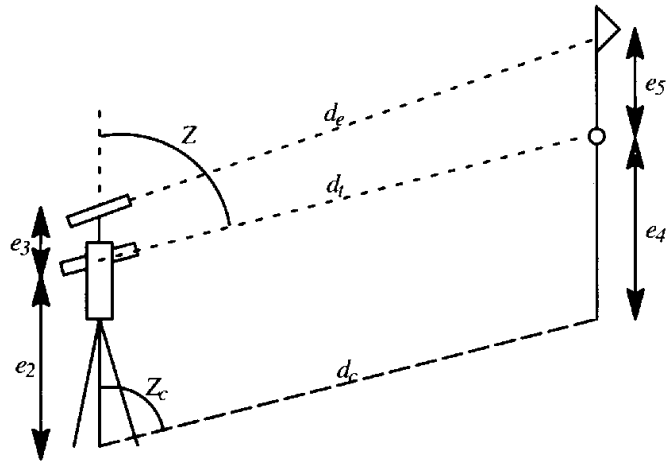
e_1=prism constant

e_2=theodolite height

e_3=EDM offset

e_4=theodolite target

e_5=EDM reflector offset

d_e=EDM slope distance

d_t=theodolite slope distance

d_c= slope distance, source to target point

Z=theodolite vertical angle

Z_c=corrected vertical angle

If you are using a total station with a simple prism on a pole, the EDM and theodolite are coincident; the prism and theodolite target are also coincident. In other words:

e_3=0

e_5=0

d_e=d_t

B.4   Instruments, Environmental and Job-Related Corrections

This category of corrections includes the following:

- prism constant corrections
- pressure and temperature corrections
- face one/face two corrections
- mounting eccentricity corrections
- instrument and target height reductions
- collimation corrections
- orientation corrections

B.4.1   Prism constant correction

This correction is applied to all slope distances:

$$S_2 = S_1 + e_1$$

S_1=measured slope distance

e_1=prism constant

S_2=resulting slope distance

⊠ **Note**: Prism constants are usually negative.

B.4.2   Pressure and temperature correction

Pressure and temperature corrections are applied to all electronically measured distances if the *Atmos crn* field is **Yes** during job creation, and pressure and temperature values are entered. The correction applied is:

$$S_3 = S_2 + S_2\left[J - \frac{NP}{273.2 + T}\right] \times 10^{-6}$$

S_2=slope distance

S_3=corrected slope distance

J=group refractive index for the EDM's carrier

N=constant for the EDM's carrier

P=atmospheric pressure in mmHg

T=dry air temperature in 5C

B.4.3   Face 1/Face 2 corrections

The vertical angle measurement (defined in the instrument record's *V.obs* field) is converted to an equivalent zenith angle. The derivation of the raw observation is determined as follows:

- If the vertical observation is in the range 0° to 180° the derivation is **F1** (face one). If it is in the range 180° to 360° the derivation is **F2** (face two).

- If the vertical angle observation is not present the derivation is assumed to be **F1**.

- If the vertical observation falls outside the range 0° to 180° it is converted to an equivalent angle within the range.

If the derivation code is **F2** it is assumed the telescope was reversed so 180° is added to the horizontal observation for horizontal angle calculations.

B.4.4 Mounting eccentricity correction

The slope distance measured by the EDM is corrected for the vertical eccentricity between the EDM and theodolite axis. This correction depends on the type of mounting system and is not applicable to total stations. Three common combinations of mounting systems and target/reflector systems are as follows:

- Standards-mounted EDM with nontilting reflector. The slope distance measured by the EDM (d_e) is reduced to the slope distance between theodolite and target (d_t). The EDM offset is e_3; the EDM reflector offset is e_5.

$$d_t = (e_3 - e_5)(\cos Z + \sqrt{d_e^2 - (e_5 - e_3)^2 \sin^2 Z})$$

- Telescope-mounted EDM with nontilting reflector. The slope distance measured by the EDM (d_e) is reduced to the slope distance between theodolite and target (d_t).

$$d_t = \sqrt{d_e^2 + -(e_3 - e_5 \sin Z)^2} - e_5 \cos Z$$

- Telescope-mounted EDM with tilting reflector. No correction for eccentricity is required. If you are using a tilting reflector system, set both the EDM offset and reflector offset to zero.

B.4.5   Instrument and target height reduction

Corrections for instrument and target heights are applied to uncorrected measurements of vertical angle and slope distance. In the next equations, these symbols represent the following:

e_z=theodolite height

e_4 =theodolite target height

d_t=theodolite slope distance.

The vertical angle from the source point to the target point (Z_c) is given by:

$$Z_c = \tan^{-1}\frac{d_t\sin Z}{d_t\cos Z + e_2 - e_4}$$

The slope distance from source point to target point (d_c) is given by:

$$d_c = \frac{d_t\sin Z}{\sin Z_c}$$

B.4.6   Collimation correction

The instrument collimation error, determined from the collimation program, is applied in the following manner:

Face one: $a_2 = a_1 + V_c$ $b_2 = b_1 + H_c$

Face two: $a_2 = a_1 - V_c$ $b_2 = b_1 - H_c$

a_1=measured vertical angle

a_2=corrected vertical angle

b_1=measured horizontal angle

b_2=corrected horizontal angle

H_c=horizontal collimation correction

V_c=vertical collimation correction

B.4.7 Orientation correction

If you have completed the normal procedure for establishing a backsight, an orientation correction is applied to the horizontal angle observation:

$$A = H + BKB_{azmth} - BKB_{h.obs}$$

A=azimuth of the observation

H=horizontal angle (circle reading) of the observation

BKB_{azmth}=azimuth field of the applicable backbearing record

$BKB_{h.obs}$=horizontal angle observation (circle reading) field of the applicable backbearing record

⊠ **Note:** The Backbearing (BKB) record is computed as geodetic when using Projected Grid Coordinates.

B.5   Geometric Reductions

The following geometrical reductions and corrections may be applied to observations by the SDR.
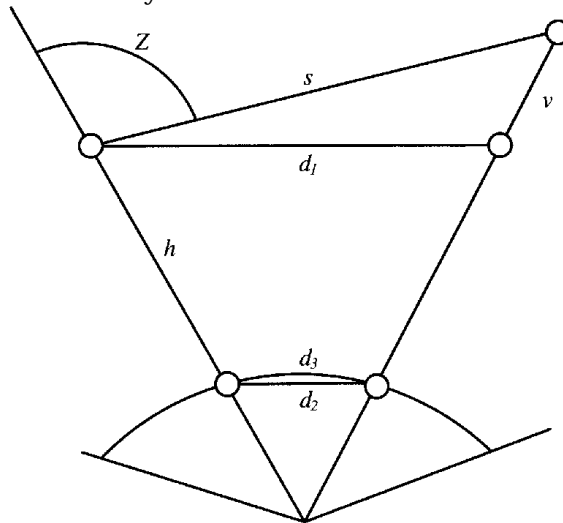
Z=zenith angle

v=vertical distance

h=elevation of source point

s=slope distance

d_1=horizontal distance at elevation of source point

d_2=sea level chord

d_3=spheroidal arc

d_4=projected distance (not shown)

B.5.1 Curvature and refraction correction

The following correction is applied to vertical angles if the curvature and refraction correction field (*C and R crn*) is set to **Yes** during job creation.

$$a_3 = a_2 - \frac{(1-k)S_3}{2R} \times \frac{180}{\pi}$$

k=coefficient of terrestrial refraction (either 0.14 or 0.20 as selected when the job was created)

R=approximate spheroid radius of 6,370,000 (meters)

S_3=slope distance from Section B.4.2, *Pressure and temperature correction*, page Appendix B-4

a_2=vertical angle from Section B.4.6, *Collimation correction*, page Appendix B-6

a_3=corrected vertical angle

B.5.2 Sea level correction

If the sea level correction field is **Yes** during job creation, the horizontal distance at the source point's elevation is reduced to the sea level chord (d_2) using the mean height of the vector:

$$d_2 = d_1 - \left[\frac{(h_1 + h_t)d_1}{2R} \right]$$

d_1=horizontal distance at the elevation of the source point

h_1=elevation of the source point

h_t=elevation of the target point

R=radius of the spheroid

Reduction of the sea level chord (d_2) to the spheroidal arc (d_3) involves a

correction of:

$$\frac{d_2^3}{24R^2}$$

    R=radius of the spheroid

This correction exceeds 1mm only on distances greater than 9.9km. Consequently, the correction term is ignored and the spheroidal arc is taken to be the sea level chord:

$$d_3 = d_2$$

B.5.3   *Projection correction*

The correction of the spheroidal arc (d_3) to a projected distance (d_4) depends on the projection used. Because the locally used projection is not known by the SDR, a simple scale factor is used. The value of the scale factor is specified during job creation. For short and medium distance EDM work, this provides sufficient accuracy.

The projection correction is:

$$d_4 = d_3 + sf$$

    sf=scale factor in the current scale record

B.5.4   *Slope reduction*

The horizontal and vertical components (d_1 and v) of an observation are found from the vertical angle (zenith distance) and slope distances by

    $d_1 = S\sin(Z)$ S=the slope distance

    $v_1 = S\cos(Z)$

    Z=the zenith angle

B.6   Professional Positioning calculations

The method of Least Squares minimizes the sum of the squared residuals. The Least Absolute Value Estimation (LAVE) minimizes the sum of the absolute residuals. To demonstrate, consider the data set below:

No.	1	2	3	4	5
Size	3.0	3.0	3.0	3.0	30.0
Arithmetic Mean	8.4				
Median	3.0				

The fifth observation is an obvious outlying observation. The *arithmetic mean* is determined by summing all observations and dividing by the total number of observations ($42/5 = 8.4$). The *median* is found by ordering the observations by their size and taking the middle one. The following table shows the residuals of the data set to the arithmetic mean and to the median.

No.	1	2	3	4	5
Arithmetic Mean (Least Squares)	5.4	5.4	5.4	5.4	21.6
Median (LAVE)	0.0	0.0	0.0	0.0	-27.0

As seen in the table above, LAVE, by using the median, is able to determine the outlying observation by the size of the residual. However, it is not effective in cases of more than one unknown parameter.

In contrast to LAVE, the Least Squares adjustment procedure is subject to "smearing effects" due to its utilization of the arithmetic mean as shown above. An outlying target point observation, or blunder, may therefore totally spoil an ordinary least squares adjustment. The outlying observations occur at a distance from the

bulk of observations, from its center of gravity, thereby holding the character of "leverage". The data set shown below illustrates this point.
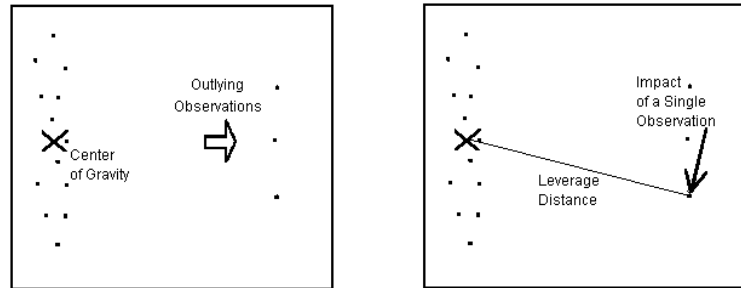
It can be seen that the bias of these leverage points would adversely affect the formulation of the initial X,Y position, or estimation. A more comprehensive adjustment procedure *must* determine this estimation by considering all observations without any preliminary selection or bias. To achieve this result, robust statistical techniques have been developed which are minimally affected by these outlying observations, or blunders. These techniques have been incorporated into the Balanced Least Absolute Value Estimation (BLAVE) adjustment procedure which is the essence of Professional Positioning. To better understand the BLAVE technique, further explanation of least squares is needed.

An ordinary least squares procedure begins with the linear model:

$$\mathbf{A}\,\mathbf{x} = \mathbf{l} + \mathbf{v} \text{ with } \mathbf{D(l)} = \sigma^2\,\mathbf{P}^{-1}$$

Let n = number of observations and u = number of unknowns. $\mathbf{A}$ = (nu) matrix of coefficients, $\mathbf{x}$ = (u,1) vector of unknowns, $\mathbf{l}$ = (n,1) vector of observations, and $\mathbf{v}$ = (n,1) vector of corrections, or residuals. The determinant of $\mathbf{l}$, $\mathbf{D(l)}$ = (n,n) variance-covariance matrix of observation, σ^2 the variance or error of unit weight and $\mathbf{P}$ = (n,n) matrix of observational weights.

The unknowns may be computed by:

$$\mathbf{x}_{\text{adjusted}} = (\mathbf{A}^T \, \mathbf{P} \, \mathbf{A})^{-1} \, \mathbf{A}^T \, \mathbf{P} \, \mathbf{l}$$

and the adjusted observations are given by:

$$\mathbf{l}_{\text{adjusted}} = \mathbf{A} \, (\mathbf{A}^T \, \mathbf{P} \, \mathbf{A})^{-1} \, \mathbf{A}^T \, \mathbf{P} \, \mathbf{l} = \mathbf{A} \, \mathbf{x}_{\text{adjusted}}$$

—or—

$$\mathbf{l}_{\text{adjusted}} = \mathbf{C} \, \mathbf{l} \text{ with } \mathbf{C} = \mathbf{A} \, (\mathbf{A}^T \, \mathbf{P} \, \mathbf{A})^{-1} \, \mathbf{A}^T \, \mathbf{P}$$

C, the orthogonal projection, can be used to determine the influence of each observation to the adjustment result. The diagonal elements of this matrix are the partial redundancies. Although the residuals suffered from least squares (arithmetic mean) smearing affects, the diagonal elements indicate a single leverage point by a large value and vice versa.

However, since the diagonal elements differ from each other, the matrix does not possess an equal distribution of the partial redundancies. The degrees of freedom are not shared in equal portion which introduces the bias, or leverage of any outlying observation.

Further least squares evaluation can be performed by considering the equation:

$\mathbf{I}$ - $\mathbf{C}$ with $\mathbf{I}$ = (n,n) unit matrix

Summing the diagonal elements of this matrix yields an integer value which is the redundancy or degree of freedom of the adjustment; exactly n - u. This is the Ansermet check when using the least squares procedure.

The BLAVE procedure differs in two fundamental areas. First, the initial linear model ($\mathbf{A} \, \mathbf{x} = \mathbf{l} + \mathbf{v}$) is developed by utilizing LAVE (median) to determine $\mathbf{v}$, the vector of residuals. Second, a matrix $\mathbf{P}_G$ that enables the same numerical values to the diagonal elements of the orthogonal projection is determined by

$$(\mathbf{A}\,(\mathbf{A}^T\,\mathbf{P}_G\,\mathbf{A})^{-1}\,\mathbf{A}^T\,\mathbf{P}_G) = \text{Constant}$$

The matrix $\mathbf{P}_G$, which now represents the matrix of *balanced* observation weights, is introduced to the LAVE creating a BLAVE (**B**alanced **L**east **A**bsolute **V**alue **E**stimation).

The aforementioned differences between the least squares and BLAVE procedures minimize the smearing effect by using the principle of the median and minimize the leverage effects of outlying observations by equally distributing the partial redundancies. These are the characteristics which give BLAVE, and subsequently Professional Positioning, its robust error detection capabilities.

Once the X, Y coordinates of the unknown station are computed, the observed vertical angles (and target heights) to the known points are averaged to produce the elevation of the station.

B.7   Other Formulas

The two formulas covered in this section include coordinate and inverse calculations.

B.7.1   Coordinate calculation

Coordinate calculation is the last step in converting an **OBS** record to coordinates, a **POS** record. The coordinates of a target point are calculated from observed measurements and the coordinates of the source point using:

$$N_2 \; = \; N_1 + d_4\cos(A)$$
$$E_2 \; = \; E_1 + d_4\sin(A)$$
$$Z_2 \; = \; Z_1 + v_4$$

N_1, E_1 & Z_1=coordinates of the source point

N_2, E_2 & Z_2=coordinates of the target

d_4=projected distance between the two points

A=azimuth

v_2=vertical distance

The calculation yields null results if the coordinates of the source point are unknown.

B.7.2   Inverse calculation

The distances and angles associated with a line between two points are calculated from the coordinates of those points as follows:

$$v = Z_2 - Z_1$$

$$B = \tan^{-1}\left[\frac{E_2 - E_1}{N_2 - N_1}\right]$$

$$h = \sqrt{(N_2 - N_1)^2 + (E_2 - E_1)^2}$$

$$a = \tan^{-1}\left[\frac{h}{v}\right]$$

$$S = \sqrt{\frac{((h^2 + v^2)R)\left/\left(R - \dfrac{Z_1 + Z_2}{2}\right)\right.}{sf}}$$

N_1, E_1 & Z_1=coordinates of the source point

N_2, E_2 & Z_2=coordinates of the target point

v=vertical distance from source to target point

B=azimuth of the line

a=zenith angle of the line

h=elevation of the source point

S=slope distance at the height of the station with slope reduction, sea level correction, and projection correction applied in reverse

R=radius of the spheroid

sf=scale factor

B.7.3   Compass rule

The Compass rule distributes the coordinate error in proportion to the length of the traverse lines.

The Compass rule formula is:

$$Northing\ adjustment\ = \frac{L}{TL} \times closure\ north$$

$$Easting\ adjustment\ = \frac{L}{TL} \times\ closure\ east$$

Where:L = length of the traverse line to the point
TL = sum of the traverse line lengths

B.7.4   Transit rule

The Transit rule distributes the coordinate error in proportion to the northing and easting ordinates of each traverse line.

The Transit rule formula is:

$$Northing\ \ adjustment = \frac{\Delta N}{\sum |\Delta N|} \times closure\ \ north$$

$$Easting\ \ adjustment = \frac{\Delta E}{\sum |\Delta E|} \times closure\ \ east$$

Where:ΔN =change in northing for the traverse line
ΔE =change in easting for the traverse line
$\Sigma |\Delta N|$ =sum of the absolute value of all the changes in northings of all the traverse lines
$\Sigma |\Delta E|$ =sum of the absolute value of all the changes in eastings of all the traverse lines

Glossary

<%> and <1:>

These softkeys can be used to specify whether the grade is entered and displayed as a percentage or a ratio. If the format is percentage, the grade value specifies the slope to the next template point as a percentage. For example, 3% means that the template will rise 0.300 over a distance of 10.0. If the format is ratio, the grade value specifies the slope as a ratio. For example, 1:30 means that the template will rise 0.333 over a distance of 10.0.

∆Chordarc

This field displays the maximum chord-to-arc separation that applies for the specified *Len incr*. This is useful for checking that the points to be set out around the arc will be spaced closely enough. Entering a required maximum chord-to-arc separation will result in the appropriate length increment being computed, such that this separation is achieved.

∆East

Represents the east distance to the desired point from your current position.

∆Elev

This field displays the elevation coordinates.

∆North

Represents the north distance to the desired point from your current position.

∆Offset

This field displays the distance to the centerline.

∆Sta

This field displays the distance to or from the nearest station.

dist rdgs

This field controls how many distance observations are made during each observational sighting. Enter a value between 0 and 9.

of epochs

This field establishes the criteria to complete an observation. The name of this field and the values entered are dependent on the entry in the *End obsvn* field (**Epoch**, **Time**, **RMS**, or **Manual**).

123...123

The SDR prompts for the second face of a set in exactly the same order as it prompted the first face. For example, if you select **123...123...**

and preenter points A, B, C, and D, you are prompted to observe points in the following order:

A,F1→B,F1→C,F1→D,F1→
A,F2→B,F2→C,F2→D,F2

123...321

The SDR prompts for the second face of a set be prompted in reverse order:

A,F1→B,F1→C,F1→D,F1→
D,F2→C,F2→B,F2→A,F2

123.321

The SDR prompts for the second face of a set be prompted in reverse order:

A,F1>B,F1>C,F1>D,F1>D,F2>C,F2>B,
F2> A,F2

3DRMS (m)

The RMS (root mean square) of observation residuals indicates the divergence of observed values. This field displays a total RMS value from receiver for the residual of all the components (three-dimensional).Enter the 3DRMS value in meters.

Accept float sol

This field determines if a warning is displayed when attempting to read while in a float solution and whether the end observation criteria includes the requirement of a fixed solution. Select **Yes** or **No** in this field to accept or reject the float solution.

Adj Selector

This field toggles between Yes and No. If Yes is displayed, you may select the adjustment method.

Adjustments

This shows the subsequent adjustments made to the coordinates of the initial position. Adjustments for both procedures are given as well as the initial coordinates.

Aim H. obs

This field shows the horizontal angles required to point to the target.

Aim V. obs

This field shows the vertical angles required to point to the target.with a matching code will be included in the list.

Alignment road

This is composed of the horizontal and vertical element definitions, cross-sections, templates, super elevation and widening. These elements can be entered manually or uploaded from a computer system.

ALL level

This displays general information about the collected sets, including the number of sets, the station point ID and the collected points.

Almanac

Message transmitted by each satellite which gives the approximate location of all GPS satellites. The almanac is provided so that the signals for individual satellites can be acquired rapidly. It is also a tool for predicting satellite conditions for planning purposes.

Alpha

The point names may contain 14 characters, both letters and digits.**Job size (k)** This field displays the size of the job, in kilobytes, currently occupied in memory.

Amb fix mode

Select from 1 through 8. This field sets the confidence ratio of the solution between 1 (95.0% confidence) and 5 (99.9% confidence). Higher confidence levels take a longer time to solve the integer ambiguity, but increase reliability. This ratio is fixed if you are using the Radian receiver. Available on some receivers.

Ambiguity

definition: The uncertainty inherent to an initial measurement which biases all measurements.

field: This field displays whether the solved position is **Fixed** or **Float**.

Amb status

The ambiguity status of the current solution from the rover receiver. The options are **Fixed** or **Float**. The current northing value of the receiver's position in the calibrated coordinate system displays.

Angle

Angle units apply to all horizontal and vertical angle measurements and azimuths. Units can be **degrees**, **quadrant bearings**, **gons**, or **mils**. The SDR assumes horizontal angles and azimuths are always measured turning to the right. Selecting quadrant bearing units only affects the display of bearings (30° displays as N30°E); the underlying units are still degrees.

Angular

Select your angular type. Your choices are **Weighted**, **Linear**, or **None**.

Ansermet < 2 No Redundancy caution

The determination for this warning message is the least squares ansermet. When the ansermet is equal to zero, there is no real redundancy in the adjustment. Error detection is not possible and all corrections become zero. If the ansermet is 1, error detection is not theoretically possible, but some corrections are made. It can be an indication to the user that a particular situation could produce unreliable results. In the case of ansermet = 0 or the case of ansermet = 1 with a blunder detected, it should be verified that the geometry of the target point constellation is stable.

<ANT>

This softkey accesses the *Antenna Setup* screen.

Ant Elev

This field indicates the elevation including the antenna height.

Antenna height

The distance between the position of the observed point and the antenna.

Antenna type

This field identifies the antenna type to be used. The options are **User** and several predefined types.

Ant meas method

This field allows selection of the measurement method for antenna height, which is to be directly input. The options are **Vertical or Slant**.

Apply Super

This field specifies whether or not the element will be affected by the application of superelevation. Select Yes or No.

Apply Widen

This field specifies whether or not the element will be affected by the application of widening. Select Yes or No.

Arc len

This field specifies the value used to define the distance along the **arc Atmos crn** *(Applies only to total station measurements)* If atmospheric correction is set to **Yes**, the SDR applies an atmospheric correction to observations based on the current temperature and pressure values.

Atmos crn

If atmospheric correction is set to **Yes**, the SDR applies an atmospheric correction to observations based on the current temperature and pressure values (applies only to total station measurements).

Attributes

This field is used for user-defined attributes.

Auto pt ID

If you do not enter a point designator, this is the next designator that SDR automatically suggests. Once a point designator has been suggested and accepted, the SDR automatically increments to determine the next value. For example, point 1000 is followed by 1001, and PIPE8 is followed by PIPE9 and then PIPF0. HELLO is followed by HELLP. The sequence continues until HELLZ, which is followed by HELMA.

Az

This field displays the azimuth value of the indicated satellite.

Azimuth

definition: A horizontal angle measured clockwise from a reference source. The reference, typically north, is defined as zero.

horz point: Azimuth at the end of the previous element.

traverse orientation: Enter the backsight azimuth.

horz arc: Azimuth at the end of the previous element, which is used as the azimuth for the start of the spiral.

horiz straight: The direction of the straight. It defaults to the azimuth at the end of the previous element. If the straight is the first element in the alignment, it defaults to the starting azimuth of the centerline. Generally, you will not need to change this value. It is acceptable to do so, but the alignment will not be smooth; a sudden change of direction will occur.

B (base)

The associated satellite is tracked by the base receiver.

Back tan

This field specifies the value used to define the back tangent direction.

Base Elev Mask (Base receiver only)

The elevation mask limits the base receiver to use only satellites above this angle from the horizon. Values between 0° and 90° can be used.

Baud rate

This field specifies the speed that characters are sent along the serial line. The baud rate is to the number of bits sent per second; there are typically 10 bits transmitted for each byte or character. For example, 9,600 baud means 960 bytes per second. Available baud rates are: 300**;** 600**;** 1,200**;** 2,400**;** 4,800**;** 9,600**;** 19,200 and 38,400.

Beep on epoch

This field will turn the data collector beep on or off.

BLAVE

This option performs a BLAVE adjustment.

Blunder detection

Because blunders have an adverse affect on Least Squares adjustments and are helpful in explaining the status of other indicators, it is important for the user to be made aware of their presence. A target point observation, bearing or distance, is marked as a blunder if the corresponding correction exceeds the apriori standard error of the observation multiplied by ten. The apriori standard error of the observation are the observation tolerances set in the Tolerance screen in the **Func** menu.

BPS age (s)

This field displays the time interval for broadcasting the base positional information.

BPS warn

This field displays the base position signal's from the base receiver. The messages displays as follows:

No refcoord: base station coordinates contain all zeros

No ref ant: antenna offsets were not entered in the base receiver

No ref raw: raw position was not computed at base

Bad ref pos: computed raw position differs from the entered base coordinates by 500 meters or more

No ref L2: L2 measurements are not available at base

BS pt

Enter the backsight point ID.

C (common)

The associated satellite is tracked by both base and rover receivers (receiver specific).

C/A (Course/Acquisition) code

Standard GPS code transmitted on the L1 frequency. The sequence contains 1023 modulations per signal at a rate of 1.023 MHz. The code reiterates every millisecond.

Calculate resection

This option calculates the station by performing a least squares adjustment.

Cd

This field allows a code to be attached to the point that this element defines.

Center

This field is used to define the center of the arc.

Chord In

This field specifies the value used to define the straight line distance between the arc's *From* and *To* points.

Close code

Select this code to be the line end code.

Circular VC

Define the vertical intersection point (**VIP**) and radius for a circular curve in this screen. The direction of the curve is determined by the relative position of the previous and following **VIP**s.

Code

A code can be specified in the **Cd** field; only points with a matching code will be included in the list.

Code Fields On?

If this option is selected, your codes will be split into subfields.

Code list active

When this field is set to **Yes**, any code field will use the feature code list for quick entry of codes. When this field is set to **No**, use normal entry of alphanumeric data in the code field.

Collect more sets

Select this option to collect more observation sets.

Combine F1/F2

When this field is selected **Yes**, the topography program prompts you for two observations, one from each face of the instrument.

Cogo

This menu allows you to perform coordinate geometry calculations and setting out field work.

Com sat

This field indicates the number of satellites common to both the current rover and base receiver. The warning will indicate if the number of satellites is equal to or less than number provided.

<CNFG>

This softkey accesses the *Configure Reading* screen.

Const Adj

This field displays the constant height shift for all points based on the difference.

Cont reading

This field determines the data collection method of observations. **Yes** - Continuous Reading. **No** - Single reading.

Cont. readings

Use this method to collect continuous observations by specifying time and distance parameters. This method is not available during **Type**The available fields in the *Configure Reading* screen vary depending on the instrument type selected. You can establish the configuration for any instrument whether it is currently connected or not. The options are **Total Stn** or **GPS RTK**.

Cont record rate

This field determines how often (in seconds) a position is stored during continuous reading.

Coord

Coordinate units do not refer to the coordinate values, but to the order in which they are displayed. Your choices are **N**-**E**-**Elev** (north, east elevation) or **E**-**N**-**Elv** (east, north elevation).

Corrections

This gives the bearing and distance corrections which were applied by each adjustment procedure. The BLAVE corrections will indicate certain observations with an asterisk next to the appropriate bearing or distance. The asterisk indicates that the corresponding correction exceeds the a prior standard error of the observation (observation tolerances as set in the *Tolerance* screen) multiplied by ten.

Cut

This grade will be applied to meet existing terrain when the template is in a cut situation.

Cut/Fill

This field shows the cut/fill determined by the current point

Cut or Fill

This field indicates the vertical distance above or below the desired elevation. If the field is **Cut**, the elevation is below. If the field is **Fill**, the elevation is above.

Cut o/s

This field is normally zero. However, if the design point is underground, you may want to enter a *Cut o/s* value of 1.000, for example, to accurately stake an above ground mark. (To set out a fill offset, enter a negative value in the *Cut o/s* field.) The vertical angle in the *V.obs* field changes to reflect the new desired position. If you observe this vertical angle, the actual Cut value in the first field changes to 1.000.

Date and Time

Displays the date and time the job was last accessed; therefore, the date and time displayed will not necessarily relate to the last time data was saved in the job. For example, the process of selecting a job as the current job will access the job files and therefore update the date and time.

D.ang

Angular closure error.

Data

This field controls which observational measurements will be collected together. The options are as follows:

HVD: All measurements are collected in each set of observations.

H,VD: The horizontal angles are collected during one observation. The vertical angle and distance are collected on the next observation.

H,V,D: The horizontal angle, vertical angle, and slope distance are collected in separate observations.

Where: **H** = horizontal angle, **V** = vertical angle, and **D** = slope distance.

Date

The date the feature code list was created.

<DATUM>

This view displays the point datum latitude, longitude, and height.

Datum And Ellipsoid

The simplest type of datum transformation; it allows a conversion between ellipsoids.

Datum Shift

Allows conversion between ellipsoids that have different origins.

Datum Shift Rotate

Convert further between ellipsoids whose Cartesian systems are rotated with respect to each other.

Datum Transformation

Ellipsoidal to ellipsoidal.

DBEN latency

This field displays the time interval for a message from the base receiver to the rover receiver.

D.Dist

Horizontal closure distance.

D.East

Closure distances for the north coordinates.

Dec shown

see *Decimals Shown.*

Decimals Shown

This field controls how many decimal places are shown. The options are **2**, **3**, and **4**. The number will be rounded at the specified decimal place.

Define horizontal

This option allows you to enter a variety of horizontal elements to your alignment road definition.

Define super

This option allows you to specify superelevation and widening to your road definition.

Define vertical

This option allows you to enter a variety of vertical elements to your alignment road definition.

Define Xsection

This option allows you to attach a roading template to use instead of defining individual elements.

D.Elev

This field shows the closure distances for the north coordinates. This field can also be used for specifying a known difference in elevation, from the interpolated height along the baseline to the point being set out. A negative difference in elevation value indicates the point to be set out is below the interpolated elevation along the baseline.

Description

This field displays a description of the transformation type selected in the Transformation field. Up to 16 characters can be entered.

Design Elev

This field displays the elevation of the point being staked out.

Design slope

This field displays the design grade of the slope being staked out.

Dest.N

Enter the North destination value.

Dest.E

Enter the East destination value.

Dest.El

Enter the elevation destination value.

Direction

calculate position/set collection: Observe several points using the same instrument orientation.

arc: This field specifies whether the arc being defined turns toward the right (clockwise) or left (counterclockwise) when viewed from the From point. This field toggles between **Right** and **Left** when the ← or → keys are pressed.

receiver: This field displays the current direction of the receiver based on azimuth.

cross-section: This field specifies the survey direction of the cross-section. Choose from Left->Right, Right->Left, Left, or Right using the <←> and <→> arrow keys.

Dist

units: The unit chosen applies to all distances, lengths and coordinates. The conversion factor used is 1 International foot = 1.000002 US feet = 0.3048 meters. For distances in land surveying, the difference between the International foot and the U.S. Survey foot is less significant than the error inherent in EDM instruments. However, take this factor into account in certain situations such as using state plane coordinate system values. Distance units can be **meters**, (**International) feet**, or **US feet**

baseline to point: This field indicates the set out distance from the baseline to the point to be set out. A negative distance value indicates that the point to be set out is in the opposite direction to that of the baseline (the point is "behind" the From point).

loop distance: This field displays the loop distance.

Distance

template: This field specifies the horizontal distance of the new template point from the previous template point. It may not be negative; the template shape may not double back on itself. If the grade is specified as

either **Up** or **Down** then the distance is taken to be vertical with the horizontal distance being zero.

horizontal straight: The length of the straight section.

radius: If a distance value is entered into the *Radius* field, only points within that area (radius) from the current station will be included in the list.

Distance range

If a distance value is entered into the **Radius** field, only points within that distance (radius) from the current GStn will be included in the list.

Dist exclusion

A position will not be stored based on the continuous reading setting if the point is within the specified distance of the previous point.

D.North

Closure distances for the north coordinates.

<DSGN>

Use this softkey to store a RPOS record containing the design coordinates, station, and offset from a selected part of the road design.

Dynamics

This field defines changes in velocity during observations. The setting filters out measurements that do not fit expected motion. Select an option best suited to movement (aircraft, vehicle, etc.) expected during the survey.

E

In this field, the east coordinate value will be displayed or must be defined.

East

The current easting value of the base receiver's position in the calibrated coordinate system.

<EDIT>

This softkey initiates an edit mode in which you can modify the *Cd* field of the current record.

EDM desc

This field is used to log EDM descriptions.

EDM S/N

A six digit numeric field for the EDM serial number. It is transmitted as part of the instrument record.

Edm tol (mm)

SDM fixed tolerance in millimeters specifies the SDM error that is independent of the length of line measured.

Edm tol (ppm)

(parts per million) Specifies the EDM error that is proportional to the length of the line measured.

El

This field displays the calculated elevation value of the indicated object. In some screens you will must enter the elevation point in this field.

Elev

GPS Stn Position: The current elevation value of the base receiver's position in the calibrated coordinate system.

Adjustment Options: Select **Weighted**, **Linear**, or **None**.

Elev mask

Values from 0° to 90°can be entered to exclude satellites below the rover receiver's elevation mask from being used in the observation.

End obsvn

The observation will end when the specified conditions are met. The selection in this field will affect the observation in the *Taking Reading* screens. The options are **Epoch, Time, RMS,** and **Manual**.

End stn

The end station for this application.

End vert algmnt

This option will end the vertical alignment definition.

Epoch rate (s)

This field allows you to enter the rate at which measurement epochs on the receiver are taken. An epoch is a point in time based on the rate in seconds set in this field. Each observation is a number of epochs.

Face order

This field controls the switching between F1 and F2 during the collection of single as well as multiple sets. Select from the following options:

F1 only	F1F2/F1F2	F2F1/F2F1
F2 only	F1F2/F2F1	F2F1/F1F2

Some selections show two sets, separated by a slash, indicating that both faces will be used. For example, F1F2/F2F1 specifies that, in the first set, observations will be made to points in the set beginning with Face 1 and then Face 2 of your instrument, and in the second set, you will re observe the same points beginning with Face 2 and then Face 1 of the instrument.

If you wish to observe only one set, taking first Face 1 then Face 2, you should choose either F1F2/F1F2 or F1F2/F2F1. (Since you are only collecting one set, ignore the second set specification.)

Fast Solution

The **Fast Solution** option will produce calculated estimates to your next point when you are in motion during a survey. This can be used when continuous readings are necessary when navigating between points in set out routines. Select **Yes (default)** or **No** in this field (Available on some receivers).

Feature Code

Specify a feature code in the *Cd* field; only points **Right/Left**This field shows you the distance to move either left or right to get on line. The direction is from the instrument operator's point of view.

File

This option copies the job to the SDR memory and will not send data through the com ports. The stored data can then be used by user programs.

File Size (k)

This field displays the size of the feature code list in kilobytes.

Fill

This field shows you the amount of cut or fill the currently observed position represents relative to the design point. Remember the currently observed point is the physical point at the bottom of the prism pole.

template: This grade will be applied to meet existing terrain when the template is in a fill situation.

From

transformation: Enter the beginning point ID of the point whose azimuth you wish to rotate and the point you wish the SDR to use to calculate the azimuth.

define baseline: Enter a point; this field plus one of the other point fields (*To pt, Center* or *Intersect pt*) must be entered.

arc: Enter a point from which the arc initiates in the direction defined.

loop: This field indicates the starting point ID of the level loop.

FS pt

Enter the closing foresight point ID.

Func

This menu is used to set up or start survey jobs, determine job and configuration parameters, remove jobs and communicate between the SDR and other devices as well as starting the calculator, setting up feature code lists and upgrading SDR software and languages.

<Func>+< [I] >

This key combination turns off the SDR.

<Func>+<Bksp (Del)>

This key combination deletes the character under the cursor.

<Func>+<C>

This key combination pops up the calculator.

<Func>+<L>

This key combination turns the SDR's backlight screen on or off.

<Func>+<M>

This key combination accesses configuration manager, enabling you to select whether a particular menu or a specific menu option is displayed.

<Func>+<O>

This key combination displays all the options available for a field.

<Func>+<SP (Ins)>

This key combination turns insert/overwrite mode on or off.

General Statistics

This provides general information about the points which were observed.

Gnd Elev

This field displays the elevation minus the antenna height.

<GOBS>

see *GOBS.*

GOBS

(GPS observation) The azimuth, vertical angle, and slope distance from the base antenna to the rover antenna. The **GOBS** view shows the observation from the base receiver antenna to the rover receiver antenna.

GOBS/OBS

This searches for last **OBS** or **GBOS** record in database.

<GPOS>

(GPS position) The **GPOS** view shows you the observation reduced to coordinates relative to the station from which it was calculated. It also searches for last **GPOS** record in database.

GPOS view

GPS position uncalibrated/uncorrected view.

GPS Coord system

Selecting Unknown requires all Stns and GStns to have connectivity. This connectivity (or homogeneity) requires all points to be connected by observations. A selection of Known allows the use of disjointed Stns and Gstns.

GPS view stored

The GPS observations are stored in the indicated view. Choices: GOBS, GRED, GPOS or POS.

Grade

This field displays the grade of the slope being staked out. You can edit this field if desired.

<GRED>

see *GRED view.*

GRED

The horizontal distance and the vertical distance from point A to point B.

GRED/RED

This searches for last **RED** or **GRED** record in database.

GRED view

(GPS reduced) The **GRED** view shows you the observation adjusted for base and rover antenna height reduced to its horizontal and vertical components.

H

A letter "H" displays if the associated satellite is healthy.

HDOP

This field displays a value of the two-dimensional Horizontal Dilution of Precision.

Height

Enter a height value in this field.

Horz

One or more points required for this calibration. Points must have at least Northing and Easting coordinate values.

Horizontal

This option performs a horizontal calibration.

Horizontal/Vertical

This option performs both a horizontal and a vertical calibration.

HRMS (m)

This field displays a HRMS value from receiver for the residuals of the horizontal component. Enter horizontal RMS value in meters.

H sets

This field controls how many sets of horizontal angles are collected.

HtDiff

This field specifies the vertical height difference of the point from the centerline. A positive height difference means the point is above the centerline.

Hz/Vt

One point or three or more points are required for this calibration. Points must have Northing, Easting and Elevation coordinate values.

ID

Road Statistics: Name of the current road. You can enter a new ID here if necessary.

Stats: This field displays the name of the feature code list.

Info Blocks

This field will split your note records into specific fields that contain different types of data.

In/Out

This field shows you the distance to move either in (toward the instrument) or out (away from the instrument) to get the prism on to the target point.

Intersect pt

The point field used to define the intersection of the tangents.

Job

This field holds the name of a new job. Enter a name with any combination of letters and numbers, up to 16 characters long. Do not use a period (.) within a job name.

Job size (k)

Size of the road file, in kilobytes.

Join

This field determines whether points with this code are joined together as line work if the points are plotted.

Latitude

Enter a value in this field for latitude (positive north and negative south). For example, to enter 37°25'42.0000N, type **37** + **<.>** + **25** + **<FUNC>** + **<.>** + **42**.

Least Squares

This option calculates the unknown station using a least squares adjustment.

Least Squares statistical data

used to determine, independently, the validity of the Least Squares result. This can be particularly helpful in the event that the LS and BLAVE results do not coincide.

Left template

This field indicates the name of the template to be inserted on the left side of the centerline.

Len incr

This field specifies distance increments along the set out line at which you want to set out points. For example, if you wish to set out points every 20 feet (or meters) along the set out line, enter 20 into this field.

Level

This menu accesses routines for differential leveling.

Level Desc

Enter the type of level you are using; this information is stored as part of the instrument record for documentation.

Level S/N

Enter the serial number of the level; this information is stored as part of the instrument record for documentation.

Linear

Any angular closure is distributed evenly among the angles of the traverse route.

Line len

This field defines the distance along the specified baseline from the selected *From* point to the set out point. You can enter into the *Line len* field the appropriate distance to the point to be set out or you can use the other fields on the screen to determine the distance.

Line work

Draw lines between points.

List Name

This field indicates the Feature Code List name (up to 16 characters).

Local coords

This field controls the coordinate system to which the computed coordinates are referenced.

Local Datum View

View local datum in latitude and longitude height.

Longitude

Enter a value in this field for longitude (positive east and negative west).

Low Wire

This field displays the low wire reading.

L super

The superelevation to apply to the template on the left side of the road.

<HORIZ>

applies horizontal superelevation to the left side of the road.

<|:> converts a superelevation value to a ratio format (1:300).

<%> converts the superelevation value to a percentage.

LS vs. BLAVE

The same tolerance is applied to the horizontal distance between the determined unknown station position of both adjustment procedures (times two). It informs the user when the results of the two procedures deviate from each other. This would be expected in the presence of blunders which typically, and incorrectly, alter a Least Squares position.

L widen

This field specifies the amount of widening to add on to the elements of the template on the left hand side of the road.

Manual Method

This selection field can be toggled between 1-wire and 3-wire. Select 1-wire if you are reading only the center cross hairs. Choose 3-wire if you are recording top, center, and bottom cross hairs.

MC view

Measure corrected observation view.

Memory (kB)

This field provides information on remaining instrument memory in kilobytes.

Method

Adjustment Options: Select the **Compass** or **Transit** coordinate adjustment method.

Set Collection: This field indicates the sets collection method:

Direction-observing several points using the same instrument orientation.

Repetition-observing a single angle between two points several times using different instrument orientations.

Method Selector

This field toggles between Weighted and Linear.

Mid Wire

This field displays the mid wire reading.

Model

This field provides the model of instrument based on the selected type; the information is stored as part of the instrument record.

Modem

If you are using a modem, set this field to **Yes**. This field can also specify the modem used. An extra screen appears whenever any communications are initiated.

Mount

In this field you may choose a type of EDM mounting method. Your choices are:

Not applic-EDM and theodolite are coaxial

Standards-EDM is standard mounted on the theodolite case

Telescope-EDM is mounted on the theodolite telescope and consequently moves as the vertical angle changes

N

This field displays the calculated north coordinate value. In some screens you must enter the north coordinate value in the corresponding field.

N1

This field displays the Signal to Noise ratio for the L1 frequency.

New Azim

Enter the new azimuth.

<NEXT>

This softkey moves you to the next occurrence of the record type you have currently highlighted.

None

No elevation adjustment is carried out.

North

The current northing value of the base receiver's position in the calibrated coordinate system.

North, East, Elevation

These three fields show the point's coordinates.

No RTK warn

This field, if set to **Yes**, provides a warning if no RTK solution is available. The options are **Yes and No**.

Number H Sets

This field controls how many sets of horizontal angles are collected.

Number of V Sets

This field appears only if the data being collected is **H,VD** or **H,V,D**; this field indicates how many sets of vertical angles are collected.

Numeric

Numeric point names, which contain four digits, that are compatible with the SDR20 series of data collectors.

OBS MC

This searches for last **OBS MC** record in database.

Obs order

This field specifies the order in which the SDR prompts you to observe points when collecting individual sets.

OBS view

Observation view.

Offset

roads: This field specifies the distance of the point from the centerline. This offset must not be less than the offsets of any previous points in the template (A template may not fold back on itself with an overhang). You can enter an offset the same as the previous point; this results in a vertical portion of the template. However, only two consecutive template points may have the same offset; you may not have three points one above the other. This field can also be used to define a parallel offset from the originally defined curve. A negative value indicates an offset to the left illustrates an offset arc to the right.

antenna: Represents the current offset of the antenna position.

store results: This field displays the calculated offset of the observed position.

arc: This field displays the perpendicular distance from the baseline or arc.

<OK>

This key accepts and stores all fields displayed on a screen form. (A form is a group of data fields displayed together).

<OPTNS>

This softkey accesses the options menu related to the active screen.

Org.N

Enter the origin North value.

Org.E

Enter the origin East value.

Org.El

Enter the origin elevation.

Other grades

This grade unit will be applied to all crossfall occurrences including the definition of the actual templates in ROADING (with the exception of the sideslope grades as discussed below). The options are: **Ratio** (1:10) or **Percent** (10%).

Output delay

This is designed primarily to give support for serial printers with little or no buffering. When this field is non-zero, it causes any output to pause for the number of milliseconds specified before sending each byte.

Paper

Paper size

Parabolic VC

Define the vertical intersection point **(VIP)** and length for a parabolic curve in this screen. The direction of the curve is determined by the relative position of the previous and following **VIP**s.

Parity

This field specifies the type of parity bit added to each character during sending. It also refers to the parity bit that is checked when a character is received. Your options are **Not set**, **Odd**, and **Even**. The parity bit is sent in addition to the specified number of data bits.

P.C. mm

The prism constant (in millimeters) is the optical distance from the plumb line to the reflexive surface of the prism. Apply the prism constant in either the SDR L5 or the instrument, but not both. The screen allows you to specify the receiver and where the GPS raw data should be stored.

PDOP

This field displays a value for the three dimensional Positional Dilution of Precision. PDOP is related to the volume of the geometric figure whose convergent point is the receiver and whose sides are defined by the vectors from the receiver to each of the satellites being tracked.

Permanent Installation

Load transformation (XFM) files to the SDR's non-volatile memory (NVM).

<PGDN>

This softkey moves you down a full screen (8 lines).

<PGUP>

This softkey moves you up a full screen (8 lines).

Pivot

This field specifies whether the center, left or right part on the cross-section is to be held at constant elevation during the application of superelevation and widening.

Plan form

Vertical, horizontal, or 3-D plan form.

Point ID

The first range criteria consists of a simple numeric range of points from the point name specified in the *From* field to the point name specified in the *To pt* field (inclusive). Any point names in the range that do not already exist are ignored.

POINTS level

This displays specific information about a point. Also, this level displays the average of all observations made to a point from each set in the station.

Point count

Displays the number of points currently stored. A new road will have a point count of 0.

Point range

The first selection method is a simple numeric range of points from the point name specified in the **From** field to the point name specified in the **To pt** field (inclusive). Any point names in the range that do not already exist are ignored.

Port

This field specifies the SDR port the serial cable is plugged into. Your choices are COM1 (top) and COM2 (bottom).

Position

This compares the coordinates calculated by both adjustment procedures.

<POS>

(position) The **POS** view shows the observation relative to the station from which it was calculated. If the record is a GPS observation, the transformation determined from the most recent calibration will be applied, if available.

POS

Configure Reading: The coordinate at position C with the transformation determined from the most recent calibration applied, if available.

SDR database: Search for last **POS** record in database.

POS view

Positional view.

Precision

Precision of the traverse as a ratio of the total horizontal distance traversed to the closure distance.

Preenter points

This field determines if you enter a list of points that you will observe, prior to observing any points in the set. The SDR will use the list's order, in conjunction with the **Obs order** field, to prompt you for the next point to observe.

If this field is **Yes**, the SDR allows you to enter a list of points that you will observe, prior to observing any points in the set.

If this field is set to **No**, you will not be asked for the point names prior to observing the points. The SDR will, however, intelligently guess which point you are observing based on the observations taken, and assist you by supplying the point name, code and target height, if required. This feature is active only for sets collected by direction.

Pressure

Pressure units apply to the atmospheric pressure values. Units can be millimeters of mercury (**mm Hg**), inches of mercury (**Inch Hg**) or **millibars**. Conversion factors used are 1 Inch Hg = 25.4 mm Hg and 1,000 mbar = 750 mm Hg.

<PREV>

This softkey moves you to the previous occurrence of the currently highlighted record type. For example, if a station (STN) record is highlighted,

pressing <**PREV**> moves the highlight bar to the previous station in the database.

Projection

Ellipsoidal to rectangular

Pt

String Road definition: This field indicates the current road station point ID.

Translation Transformation: Enter the starting point ID.

Pt 1

This field indicates the first point name to define the building face plane. Both *Pt 1* and *Pt 2* must have horizontal coordinates to properly define the building face.

Pt 2

This field indicates the second point name to define the building face plane. Both Pt 1 and Pt 2 must have horizontal coordinates to properly define the building face.

Pt 3

This field indicates the third point name to define the plane. If you are surveying a vertical plane, or building face, the Pt 3 field should be left blank.

Pt an orient

Point annotation orient.

Pt an pen

Point annotation pen.

Pt an size

Point annotation size.

Pt code

Point code.

Pt elev

Point elevation.

Pt num

Point number.

R (rover)

The associated satellite is tracked by rover receiver.

Radio link warn

This field, if set to **Yes**, provides a warning if the radio link is lost. The options are **Yes and No**.

Radius

spiral: Smallest radius of the spiral.

arc: Radius of the arc.

Radius (mm)

Antenna Settings: This radius of the antenna is entered in millimeters. This field displays only if **Ant meas method** is set to **Slant** and is editable if **Antenna type** field is set to **User**.

<RCHK>

This softkey stores a RCHK record and a note record of the observation.

Rcv

This field indicates in some receivers which receiver(s) is tracking this satellite. The available options are as follows:

B-Base

R-Rover

C-Common

Rcvr batt (%)

This field provides your remaining battery power by percent.

<READ>

This key records measurement readings from your instrument.

Recip Calc

Choose whether to perform reciprocal calculation. The options are **Prompted**, **Always**, and **Never**.

Recs used

(*Road Statistics* screen) The approximate number of records (point positions, observations, notes, etc.) currently stored in the road.

Recs Used

(*Stats* screen) This field displays how many records occur in the feature code list.

Recvr mode

The receiver mode identifies which receiver is currently connected and being set up. The options are Base and Rover.

RED view

Reduced view.

Report angle adjust

Select **Yes** or **No** to specify whether or not to display the updated closure and traverse precision details after the angular adjustment, but before the coordinate adjustment. The displayed angular closure after the angular adjustment is always zero.

Resection

This method uses least squares adjustment techniques to determine the coordinates of an unknown point.

Return sight

This field specifies whether you wish to sight again on the first observed point in a set when the end of the set is reached. For example, if points 1, 2 and 3 are observed and a return sight is selected, then the physical observations made would be 1, 2, 3, 1. Any error found in the return sighting is distributed between the other observations. This field displays only when the set collection method is **direction**.

Review existing sets

Select this option to review the collected observation sets.

Right template

This field indicates the name of the template to be inserted on the right side of the centerline.

RMS

The root mean square of the least squares calibration procedure.

Road

menu: This menu contains programs for road survey, definition and set out.

field: This field indicates the name of the road where you are taking cross-sections in the field. Specifying a different road name in the *Road* field after observing some sections allows you to take cross-sections of subsequent roads.

Rotation

Enter a rotation value.

Rot Pt

Enter a point ID to use as the rotation point. All coordinates will be rotated around this point.

<RPOS>

This softkey stores an RPOS record and a Note of the observation to the SDR database.

<RPT>

This softkey accesses the *Slope Staking Report* to insert staking notes in the SDR database.

RSTN Station

This field specifies the station point name.

R super

This field specifies the superelevation to apply to the template on the right side of the road. Highlighting the **R super** field displays the same three softkeys presented for the **L super** field:

<HORIZ> applies horizontal super-elevation to the right side of the road

<|:> converts a superelevation value to a ratio format (1:300)

<%> converts the superelevation value to a percentage

R widen

This field specifies the amount of widening to add on to the elements of the template on the right hand side of the road.

Sat

This field displays the tracked satellite's PRN.

Scale

Horiz Parameter: The scale factor is a uniform scale in all directions that relates the GPS coordinate system to the local defined system.

Linear Transformation: Horizontal scale factor.

Scale Factor

see *S.F.*

SDR search rules

Rule 1:Observations in POS view are treated as a POS record.

Rule 2:The SDR uses POS, GSTN, STN and POS view records before using GOBS/OBS records even if the GOBS/OBS record is more recent.

Rule 3:If there are no applicable POS, GSTN, STN, or POS view records, the SDR will use the most recent GOBS, OBS, GPOS, MC, GRED or RED record. The record's view is no longer significant.

Rule 4:If no such record can be found, the search fails.

Rule 5:Coordinate searching is iterative.

Segments

This field displays only if both the *From* and *To* points were specified for the baseline. This field interacts with the *Len incr* field, because it displays the number of segments of the length specified in the *Len incr* field that fit in the defined baseline. Therefore, if you want to split the baseline into a specific number of evenly sized segments, enter the required number of segments into the *Segments* field. The *Len incr* field will then display the computed length of each segment. The **<RNDUP>** softkey, when selected, will round the value in the *Segments* field up to the next whole number. Again the **<RNDUP>** softkey is available only when both the *From* and *To* points are specified for the baseline.

Select XFM

This field determines whether coordinate systems will be calibrated or applied during the survey process.

Send all as LELEV

Send all as level record (point defined only by elevation)

Send all as POS

Send all as a positional view

Send GPS as POS

Send GPS record as a positional view

Send partial job

Send a partial job

Serial no

This field displays the automatic number assigned to your project.

SETS level

The initial Set review screen indicates all of the points observed during the collection of set number 1 from the station to its left.

SETS-POINTS level

This displays all the observations to a point in a specific set. The fields in this level display the following information:

Third and fourth line-list the horizontal angles of each observation made to B in Set 1.

Fifth line-the average (represented as an **F1** observation) of the horizontal observations made to the point B in Set 1.

Sixth line-the maximum difference between the average and the individual horizontal observations.

Seventh line-the difference between the average from the fifth line and the average over all sets (Sets 1 and 2).

It should be emphasized that return sights are displayed independently of initial sights to the reference point.

SETS-POINTS-FACES level

This displays the raw observation data about a highlighted point.

Shift Rotate Scale

The most general type of datum transformation, is similar to Datum Shift Rotate, but also provides a scale factor for converting between the Cartesian coordinate systems.

S.F. (Scale Factor)

This field holds the plane scale factor of the job. If your job is using a transverse mercator projection you will need to calculate a suitable scale factor for your work area.

The scale factor is applied whenever non-GPS observations are reduced to generate coordinates. It is also applied in reverse to generate set out measurements.

<Shift>

This key alternates between lowercase to uppercase.

Sideslope at

This field displays the horizontal distance from the beginning of the sideslope to the current antenna location.

Sideslope grade

The sideslope is the crossfall which joins the edge of a roading template and the existing terrain at a catch point. It can be set independently of other grades with this unit. Options: **Ratio** (:) or **Percent** (%).

Single observations

Use this method to collect individual observations by pressing the **<Read>** key when the antenna is at the appropriate position.

Slope E

This field indicates the slope along the east axis, which indicates how the geoid changes in the northerly direction. Since it is a slope (or ratio), it has no units.

Slope N

This field indicates the slope along the north axis, which indicates how the geoid changes in the easterly direction. Since it is a slope (or ratio), it has no units.

S-O Align

This field enables you to select the type of information displayed when using setting out functionality for roading alignments and defined lines in **COGO** functions. The options are **Azmth/Dist**, **Deltas**, **Sta/Direction** and **Sta/Offset** (default).

S-O Points

This field determines the format of information in the when setting out functionality for roading alignments and. The options are **Azimuth** (default) and **Deltas**.

Sort Type

This field indicates the sorting option for feature codes in the list.

Alpha - As feature codes are enter in the list, they are automatically sorted alphanumerically. The Default List is sorted alphanumerically.

User - The user-defined sorting option should be used if you repeatedly will use particular feature codes in the same order, for example a road cross-section with user-sorted feature codes of curb, gutter, center line and curb. As you enter points, the feature code list will always be one code away from the next observation. Additionally, the feature code lists starts from the beginning when it gets to the end.

Speed

This field determines the speed at which the receiver is moving. The options are **KPH**, **MPH** and **knots**.

<SRCH>

This softkey enables you to search backward or forward for a particular point name or feature code.

Sta crn

This field represents the distance you need to move along the centerline in order to find a point.

Stadia

Select the stadia value, **1:100** or **1:300**, when entering 3-wire readings using the **Manual** instrument setting.

Sta incr

The *Sta incr* field indicates the distance between each station.

Sta..ing

Horz straight: The station (chainage) at the start of the straight section.

Horz spiral: Station (chainage) at the start of the spiral.

String Road definition: This field indicates the current stationing value.

Units: This field controls how stationing values are displayed. The options are **10+00**, **1+000** and **1000**.

Define Vertical: Define the point by specifying the station (chainage) to relate the vertical alignment to the horizontal alignment

Define Xsection: This field indicates the station (chainage) at the start of the cross section definition

Horz point: The station (chainage) at the end of the previous element.

Start

Enter a point name in the **Start** field; the point elevation value will display in the **Elev** field. (The point name itself is not actually stored in the vertical definition since the information and survey job are independent).

Start code

Select this code to be the line start code.

Sta crn

This field displays the distance to or from the nearest station.

Start stn

The starting station (chainage) of this application.

<STAT>

The softkey accesses the *GPS Status* screen.

Stationing

This field controls how stationing values are displayed. The options are 10+00, 1+000 and 1000.

Stn

This field displays the starting traverse point ID. You can also enter the ending traverse point ID.

Stn Pos(field)

This field specifies the station point name. If you enter a name known to the SDR, it fills in the coordinate fields with the point's coordinates; otherwise it sets the coordinate fields to **Null**.

Stn pos(warning)

A particular least squares statistic, the standard deviation, is used to determine a **Stn pos** as good or bad. The standard deviation, times two, is compared to a user-supplied tolerance in the **Func** menu under *Tolerances*. If it exceeds it, the **Stn pos** is determined as "bad". This is meant to be an indicator to the user that the LS standard point deviation is large prompting further investigation of the results.

Stop bit

The number of stop bits transmitted after each character. Your options are **1** and **2**.

<STORE>

Transfers the RPOS and NOTE records to the database and returns you to the *Set Out Road* screen.

Store obs

This field determines if raw observables are stored in the receiver's memory. The options are **Yes or No**.

Store Obs on

Select where the raw observation data should be stored. The options are **SDR** or **RCVR** (receiver) but depends on the receiver's functionality.

Surv

This menu accesses survey programs frequently used in the field for data collection.

Tan len

The tangent length of define arc.

Temp

see *Temperature.*

Temp-Dist/VDist

This element is used to create consecutive, incremental, joined cross-section lines specified by a distance and vertical distance.

Temp-Grade/Dist

This element is used to create consecutive, incremental, joined cross-section lines. Specify the grade and distance incrementally from the previous station element.

Templ-Offs/Htdiff

This element is used to create lines based off the center line of the road. Specify the offset distance and then the height difference from the desired station.

Templ-Sideslope

This element is used for defining a sideslope and can be only the last component in a template. Specify the cut/fill ratio desired for the sideslope.

Temperature

Temperature units apply to the atmospheric temperature values. Units can be **degrees Fahrenheit** or **degrees Celsius** (Centigrade). The conversion formula used is $°C = (°F - 32)/1.8$.

Temporary Installation

This enables you to send an XFM file directly from Sokkia software packages to the SDR. This process works similar to transferring a job.

Time

The time the feature code list was created.

To

Enter the point you wish the SDR to use to calculate the azimuth.

Tol H.obs

The field displays the horizontal distance measurement.

Tol V.obs

This field displays the vertical distance measurement.

Topo View stored

This field controls the view in which observations are initially displayed using the topography program. Your options are **OBS** (raw observation view), **MC** (measured and corrected view), **RED** (reduced view), **POS** (position view)**.**

To Pt

general: Enter the ending point ID of the point whose azimuth you wish to rotate.

arc: A point field describes the point upon which the arc terminates.

loop: This field indicates the ending point ID of the level loop.

Top Wire

This field displays the top wire reading.

Trans

see *Transformation*

Transformation

Select the type of transformation to be used on the job in this field.

Trans.E

The east shift parameter moves the GPS origin east to coincide with the locally-defined coordinate system.

Trans.N

The north shift parameter moves the GPS origin north to coincide with the locally-defined coordinate system.

Type

This text field addresses the type of instrument you are setting up.

U

A letter "U" displays if the associated satellite is unhealthy.

Unprompted

The SDR will not prompt you at all and observations may be made in any order.

User Datum

This is equivalent to the Datum Shift Rotate Scale, but the ellipsoid parameters are provided by the user.

VDist

This field specifies the vertical height difference of the point from the previous template point. A positive value means the point is above the previous point, a negative value means it is below.

Vertical

This option performs a vertical calibration.

Vertical offset (mm)

The vertical offset is the measurement from the antenna mount to the phase center of the antenna in millimeters. This field is editable if the **Antenna type** field is set to **User**.

VDOP

A value for the elevation Vertical Dilution of Precision. You may enter a value for height precision in this field

V.obs

The **vertical observation** field allows you to select a method to measure a vertical angle.

Zenith-Angles are measured with the upward vertical representing 0 degrees

Horiz -Angles are measured with the horizontal representing 0 degrees

VRMS (m)

This field displays a VRMS value from receiver for the residual of the vertical component. Enter vertical RMS value in meters.

V sets

This field appears only if the data being collected is **H**,**VD** or **H,V, D;** this field indicates how many sets of vertical angles are collected.

Weighted

Any closure in the elevations is distributed in proportion to the length of the traverse line leading to the point (like the Compass rule used in the coordinate adjustment).

<WGS84>

This view shows the original GOBS coordinates converted to WGS84 ellipsoidal coordinates. latitude, longitude, and height.

Word length

This field specifies the number of data bits in each character transmitted or received. You may use up to eight characters.

WGS84 LLH view

View coordinates in latitude and longitude height

Xsect crn

This field displays the distance (perpendicular) to the centerline.

Zero azimuth

This field determines which direction is used to define the zero azimuth. The options are **north** (default) and **south**.

Zone

Select the local zone to which the transformation will be applied.

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