Geotracer® GPS and GLONASS receivers

L1/L2 User Manual - 1

ver. 1.04c Part. No. 571 701 161

RADIO FREQUENCY INTERFERENCE

This equipment generates and uses radio frequency energy but may not cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B digital device in accordance with the specification in Subpart J of Part 15 FCC Rules and the EMC directive as stated in 89/336/EEC, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by switching the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures.

— reorient the receiving antenna
— relocate the instrument with respect to the receiver
— move the instrument away from the receiver

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commisions helpful: 'How To Identify And Resolve Radio-TV Interference Problems'.
This booklet is available from the US Government Printing Office, Washington, DC 20402, Stock No. 004-000-00345-4.

CE

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Chapter 1.

Introduction

1. Introduction

Forewords

Although this manual is written for the Geotracer 3220, 3320 and 3140 receivers, it is, in most respects, also valid for the Geotracer 2200 receivers. Chapter 12 is valid **only** for the Geotracer 2200 L1/L2 receiver.

Geotracer 3220 (Dual Frequency receiver), 3320 (GPS/GLONASS receiver) and 3140 (Single Frequency Receiver)

The Spectra Precision Geotracer 3220 is an "all in view" Dual Frequency GPS receiver which can track up to 12 satellites. There are separate channels for each signal from each satellite, C/A, P1 and P2, making 36 channels in total. Code and carrier data can be recorded on removable, ATA Flash cards. When A/S (anti spoofing) is active, the receiver uses Z tracking technology to reconstruct the carrier.

The Spectra Precision Geotracer 3320 is a combined GPS and Glonass L1 receiver which can track up to 24 satellites (12 from each system). Code and carrier data can be recorded on removable, ATA Flash cards.

The Spectra Precision Geotracer 3140 is an "all in view" Single Frequency GPS receiver which can track up to 12 satellites. There are separate channels for each signal from each satellite on C/A code, making 12 channels in total. Code and carrier data can be recorded on removable, ATA Flash cards.

Apart from the receiver engine, the 3220 and 3320 receivers have identical physical characteristics. The 3140 receiver unit has different physical characteristics (see figure on page...)

The receivers are designed to be connected to an external antenna and battery. A choice of antenna is available. An optional Control unit such as the Advanced Control Unit from Spectra Precision can be added to the system in order to control several receiver functions, and view satellite information. The Advanced Control Unit is PC based.

When switched on, the receivers search the sky automatically for satellite signals, and then track them. They monitor the code and carrier phase data and report the information to the optional external control unit. In addition, the data can be stored on the removable PCMCIA cards.

Only those memory cards supplied or recommended by Spectra Precision should be used. Recommended are SDP 5A and SDP 3B.

Applications - Geotracer Dual Frequency Receiver

The Geotracer Dual Frequency system allows the user to conduct Static, Kinematic and Real Time Kinematic surveys over large distances. Static surveys in particular can be made over very long distances due to the capability of a dual frequency system to correct for ionospheric delays which act on the satellite signals. These delays are frequency dependant, and several corrections can be applied during Post Processing. Spectra Precision optionally offers a full GPS Post Processing package called GeoGenius which handles all GPS data and processing.

Geotracer Dual Frequency receivers also allow users to perform precise surveys in a more productive manner than GPS L1. This is because it is possible to use faster ambiguity resolution techniques using the L1/L2 data. The faster ambiguity resolution is of great value when carrying out RTK surveys. Both ShortStatic and OTF (On The Fly) processing strategies can be used.

Typical observation times needed for Post Processed Short Static ambiguity fixing depends on the local conditions, number

of satellites and their relative position in the sky (measured in PDOP). As a guide, we recommend the following times for baselines up to 10 Km, and a PDOP below 7. The actual times needed are not guaranteed.

No of Satellites	*Time*
6	3-5 minutes
5	5-8 minutes
4	10-15 minutes.

On distances above 10 km, one minute per km can be added. In areas where multipath is suspected, more data is needed.

For Real Time Kinematic (RTK) applications, it is usual to perform OTF initialisations. The time taken to initialise is also dependent on local conditions. Typically, when using Spectra Precision external RTK processing systems, and having 6 satellites together with a PDOP of 4 or better, OTF initialisations will take place in 20-90 seconds.

The connections and controls are described below. It is recommended that the user studies these, and learns their names and locations.

Since Real Time Kinematic is the most widely used application for the Dual Frequency system, most of this manual is devoted to its description. Classical Static and Stop and Go surveying is described in a separate chapter.

On board Processing

The Dual Frequency receiver can optionally be used for applications where "on board" RTK calculations can be used. Only OTF initialisations can be carried out. An initial position can be entered.

Applications - GPS/GLONASS receiver

This receiver can be used for Post Processed Static and kinematic surveys using the GPS and GLONASS data. The data can be post processed in Spectra Precision's GeoGenius software. As an option, RTK surveys using the GPS signals only can be carried out.

Applications - Geotracer Single Frequency Receiver

The Geotracer Single Frequency system allows the user to conduct Static, Kinematic and Real Time Kinematic surveys over large distances. Static surveys in particular can be made over very long distances, but due to the inability of a single frequency system to correct for ionospheric delays which act on the satellite signals, there will be an increase in the error at longer ranges. The delays are frequency dependant, and several standard corrections can be applied during Post Processing. Spectra Precision optionally offers a full GPS Post Processing package called GeoGenius which handles all GPS data and processing.

Geotracer Single Frequency receivers allow users to perform precise surveys in a very productive manner. This is because it is possible to use faster ambiguity resolution techniques found in Spectra Precision's GeoGenius Post Procesing software, and On board software.

Typical observation times needed for Post Processed Short Static ambiguity fixing depends on the local conditions, number of satellites and their relative position in the sky (measured in PDOP). As a guide, we recommend the following times for baselines up to 10 Km, and a PDOP below 7. The actual times needed are not guaranteed.

No of Satellites	*Time*
6	5-10 minutes
5	10-15 minutes
4	25-30 minutes.

On distances above 10 km, one minute per km can be added. In areas where multipath is suspected, more data is needed.

For Real Time Kinematic (RTK) applications, it is usual to perform Short Static initialisations. The time taken to initialise is also dependent on local conditions. Typically, when using Spectra Precision external RTK processing systems, and having 6 satellites together with a PDOP of 4 or better, Short Static initialisations will take place in 3-7 minutes. Alternatively, a Very Short Fixed baseline, or good known point is used. In either of theses cases, initialisation can be made in 10-20 seconds.

The connections and controls are described on page 1.8. It is recommended that the user studies these, and learns their names and locations.

Since Real Time Kinematic is the most widely used application for a GPS system, most of this manual is devoted to its description. Classical Static and "Stop and Go" surveying is described in a separate chapter.

On board Processing

The Single Frequency receiver can optionally be used for applications where "on board" RTK calculations can be used. Only Short Static and VSFB initialisations can be carried out. An initial position can be entered.

Unpacking and Inspection

Before starting to use your Geotracer receivers, it is advisable to become familiar with the equipment supplied:

Receiver	Antenna cable
Transport case	PCMCIA card
Tribrach	Base with level
Antenna	Control Unit
Power cable	Control Unit cable
Radio	radio cable
Program utility disk	PC adaptor
Range pole adaptor	Antenna cable adaptor

Note: The contents will vary depending on the configuration ordered.

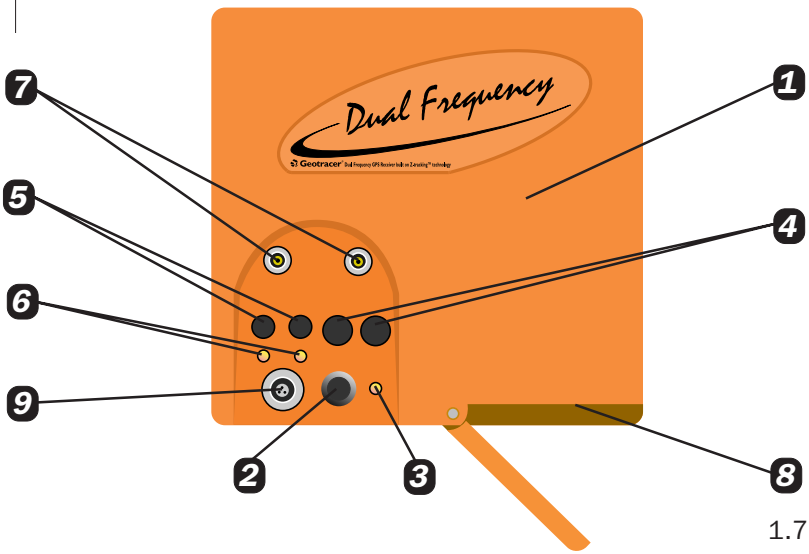
Inspection

Check the outer packaging. If it is not intact, make a visual check of the equipment for possible damage. In the event of damage, immediately advise the transport company or forwarder, and inform the Spectra Precision representative that supplied the equipment. Save all the packaging materials.

Mechanical Functions Geotracer 3220 and 3320

1. Receiver unit
2. On/Off button
3. Main function LED (*the receiver's current operational mode is indicated by the colour of the LED (see page 1.9)*)
4. 2 Hirose connectors for battery and/or Serial communication (12 Pole female).
5. 2 Hirose connectors for battery and/or Serial communication (4 Pole female).
6. Secondary Function/battery warning LED's
7. Connectors for 1PPS and Event marker.
8. Dual PCMCIA card slot. Drive C is the bottom slot and Drive D is the top.
9. Antenna connector.

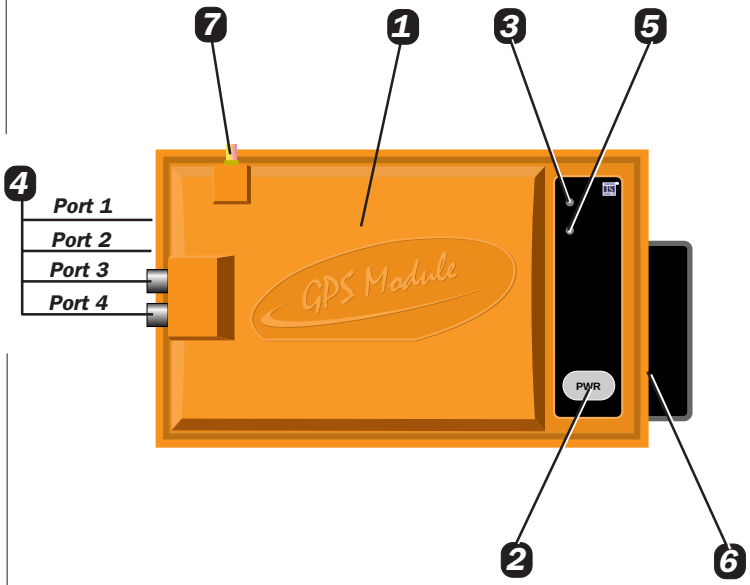
(This applies for the Geotracer 3220 and 3320 models)



Mechanical Functions Geotracer 3140

1. Receiver unit
2. On/Off switch
3. Function LED (*the receiver's current operational mode is indicated by the colour of the LED (see next page)*)
4. 4 Hirose connectors for battery and/or Serial communication (4 Pole female).
5. Secondary Function/battery port 3 indicator LED
6. Dual PCMCIA card slot.
7. Antenna connector.

(This applies for the Geotracer 3140 model)



Main Function LED

The main function LED (3) indicates the following functions:

- ***Yellow Continuous*** - Receiver is switched on, but is not tracking satellites
- ***Green flashing*** - Receiver is tracking 1-3 satellites and is in navigation or RTK mode
- ***Green continuous*** - Receiver is tracking 4 or more satellites and is in navigation mode
- ***Red flashing*** - Receiver is tracking 1-3 satellites and is storing data to the PCMCIA card
- ***Red continuous*** - Receiver is tracking 4 or more satellite and is storing data to the PCMCIA card
- ***Yellow Flashing*** - Receiver is reporting a problem on the PCMCIA card or radio.
- ***Yellow/Green Flashing*** - The receiver is tracking 4 or more satellites, is in RTCM output mode, or RTK Rover mode with Single point, DGPS or RTK positions being calculated on board.
- ***Yellow/Red Flashing*** - The receiver is tracking 4 or more satellites, is in RTCM output mode, or RTK Rover mode with DGPS or RTK positions being calculated on board. Raw Survey Data is being stored to the PCMCIA card.

Power On/Off Button

Short press on Power On/Off button

The receiver will start up in navigation mode, tracking all satellites in view. If data output has been set, data will be sent to the relevant serial port. By default, data is sent on Port 3 in Geotracer RTK format. On a short press, all LEDs will be yellow for 3 seconds, off for 2 seconds, then the function LED will be yellow until at least one satellite is tracked. When the first satellite is tracked, the LED will change to flash green until at least 4 satellites are tracked and the data is fully checked. When at least 4 healthy satellites are tracked, the LED will become solid green.
If the receiver had previously been set to RTK calculation mode, it will restart in this mode. In this mode, the main LED will flash green/yellow (not recording raw data).
The receiver will make one or two beeps, depending on the state of the receiver at previous power down. The main beep will be made when the main battery LED is switched on.

Quick Start Survey – Long press on Power On/Off button

The receiver will have started up in survey mode, storing data to the chosen default PCMCIA card. If data output parameters have been set, data will be sent to the relevant serial port. The receiver will output Geotracer RTK corrections if one serial port has been set to radio (the default is Com 3). If the receiver had been set to RTK mode, the main LED will flash red/yellow after at least 4 satellites are tracked.

Press and hold down the button for approximately 6-10 seconds, until the main function LED turns red. During this time, all the LEDs will be yellow, before going red. Release the button. The main function LED will then return to yellow until at least one satellite is tracked. When the first satellite is tracked, the LED will briefly be green, then flash red until at least 4 satellites are tracked and the data is fully checked. When at least 4 satellites are tracked, the LED will become solid red. If the light stays solid green, then the memory card is full, the wrong card is set as default or you did not hold the button down for long enough.

The receiver will make one or two beeps, depending on the state of the receiver at previous power down. The main beep will be made when the main battery LED is switched on.

The survey will use the last chosen survey parameter settings based on the following:

Filename

Characters 1-4:	last 4 characters of the point number (station name)
Characters 5-7:	Day of the year
Character 8:	Session ID Starting with a, counting up through b, c etc.

Point Number

Characters 1-4:	P00X where X starts at 1 and counts up with subsequent presses of the push button.
Characters 2-8:	Last 4 digits of the receiver serial number

Point Code
As previously used
Point Info
As previously used
Elevation mask
As previously used
Tracking Interval
As previously used
Storage Interval
As previously used
Antenna height
Set to Zero
Offsets
As previously used
Duration
No limit, (except by memory size)
PCMCIA card
As previously used.
Survey Type
Static

Power Off

The receiver is switched off with a short press of the on /off button. It will not shut down immediately. The battery LED(s) will remain red or orange for some seconds until the system is shut down. The LEDs may briefly change colour, then the receiver will be off. If the battery is removed before the receiver has shut down, the current survey parameters may be lost.

A survey can be stopped by switching the receiver off with a short press of the On/Off button. All files will be closed properly. A PCMCIA card should never be removed during a survey, otherwise some data files may be corrupted.

Connectors

Antenna

The receiver is fitted with one type N or push on connector for the antenna. Only connect antennas supplied or recommended by Spectra Precision. Use only the correct antenna type(s) for your receiver.

Serial and Battery ports

The receiver is fitted with 4 dual purpose serial and battery ports.

Ports 1 and 2 have 12 pole female Hirose connectors (Geotracer 3140 have 4 pole female connectors). They allow both power and serial communication to be used simultaneously. The serial communications allow hardware handshake and communications at speeds of up to 115,200 Baud. Ports 3 and 4 have 4 pole female Hirose connectors. They allow both power and serial communications to be used simultaneously. The serial communications allow speeds of up to 115,200 Baud but allow no hardware handshake. Port 4 is restricted to use 2 stop bits when 115,200 Baud is selected.

The Geotracer system will monitor each battery port independently and the battery level at each ports 3 and 4 is indicated by colour on the secondary LED. All 4 power ports can be used simultaneously – the battery with the lowest voltage will be

used first and continue to be used until empty. Spectra Precision standard batteries or power supply can be connected. The receiver can operate at voltages between 10.5 volts and 16 volts. An adaptor is available to operate at 30 Volts. On Geotracer 3220 and 3320, if a battery is connected to com 3 or 4, the LED will indicate the following meaning.

Solid Green	Battery connected, in use, good condition (above 11.5 V)
Solid Red	Battery connected, in use, poor condition (below 11.5 V)
Flashing Green	Battery connected, not in use, good condition
Flashing Red	Battery connected, not in use, poor condition.

On Geodimeter GPS Module L1 (Geotracer 3140), the battery LED will indicate the status on the battery in use. The LED will indicate with a number of flashes every 10 seconds, which port is suppling power in use. For example, if com 2 is in use. it will flash twice before returning to solid green. Power will be taken through the back connector if power is sensed there.

Note that many batteries, especially NiMH have an output voltage that will reduce very slowly under a steady load, but vary significantly with a fluctuating load i.e the voltage will depend on the current being drawn. When using RTK systems for example, the radio will only draw power when transmission is being made, and it is therefore a normal operating condition that the battery LED will alternate between green and red for some time. In cold conditions, with poorly conditioned batteries, or with NiMH batteries, the indicator may be red for a considerable period before power down is necessary.

A Spectra Precision Advanced/Graphical Control Unit (ACU), a Control Unit (CU) or a PC can be connected to the Geotracer receiver via one of the serial connectors to start and stop surveys. A radio can be added as part of an RTK system.

Additional outputs

1 PPS output can be taken as an NMEA string on one of the serial ports.

Default connections

The default connections and ports recommended for applications are as follows:

RTK - Base or Rover

Battery - Any connector (e.g. Port 3)
ACU - Com1
Radio - Com3 (via battery)

Static/Stop and Go with ACU or PC

Battery - Any connector (e.g. Port 3)
ACU - Com1
(Radio - Com3)

Static/Stop and Go with CU

Battery - Any Connector (e.g. Port 1)
CU - Com1
(Radio - Com3)

By default the radio output for RTK is active on port 3.

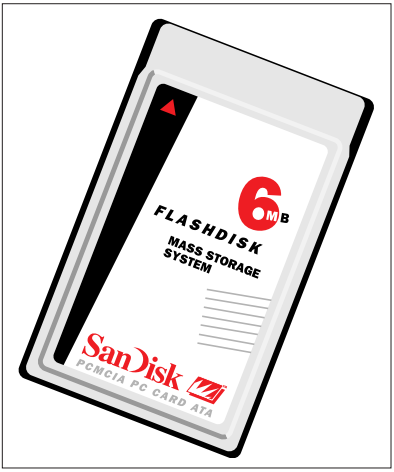
Card Slots for Memory Cards

When an Advanced Control Unit is connected, all surveys can be started and stopped from there. Although some Spectra Precision programs, such as for RTK, allow storage of data on the Control Unit, data that is only for Post Processing will be stored on the Geotracer unit. The Geotracer 3220, 3320 and 3140 has a dual PCMCIA slot located at the bottom of the receiver, under a protective cover. Spectra Precision CUPlus program controls the storage of data on the PCMCIA cards, and is fully described in chapter 13.

The Geotracer 3220, 3320 and 3140 uses ATA Flash cards of the sundisk and SanDisk standard. We recommend only to use

cards supplied by Spectra Precision. Currently we recommend SDP5A and SDP 3B. Capacities of up to 40 Mbyte is supported, but the system is restricted to 32 Mbyte. Two cards can be inserted. The bottom slot is drive C: and if only one card is used it should be used in preference to the top slot, which is D:. Although cards can be "Hot inserted" at any time, no card should be removed when in use during a survey. All PC manufacturers recommend that their devices are switched off before removing PCMCIA cards.

If only one card is in the receiver, and a survey is started with a long push of the On/Off button, data will be stored on that card. If two cards are in the receiver, data will be stored on the card previously in use, unless it is full, in which case, data will be stored on the other card.

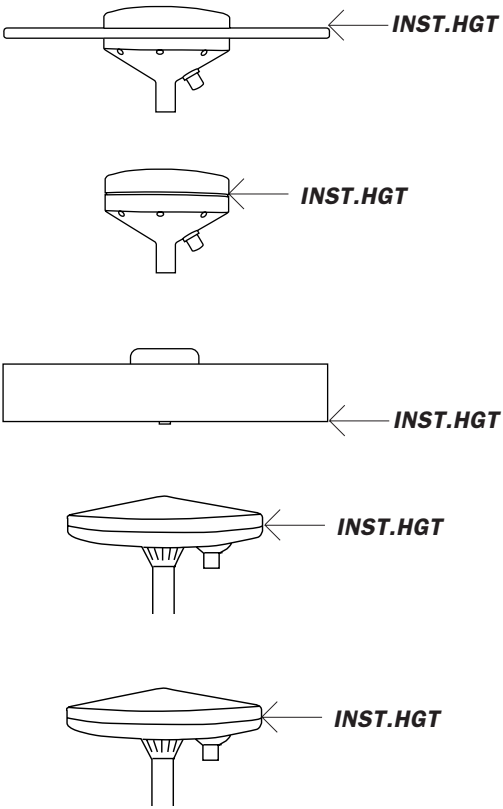


Data is stored on standard PCMCIA ATA Flash disks.

Antennas

There are five different external antennas available:

- Geodetic antenna with ground plane
- Compact antenna for RTK and Stop & Go
- Choke ring antenna
- Mini Geodetic antenna (**always use with height adapter to get the correct height when using a tribrach or range pole**).
- GLONASS antenna (**always use with height adapter to get the correct height when using a tribrach or range pole**).



Advanced Control Unit (ACU)

The Advanced Control Unit for Geotracer® receivers contains a full alphanumeric keyboard and a large graphical display.

571 212 230
Advanced Control Unit
(field computer)

Accessories

The standard equipment is supplemented by a wide range of accessories for the Geotracer® receivers. Here is a selection:

571 905 560
Tribrach

571 125 728
Instrument height meter

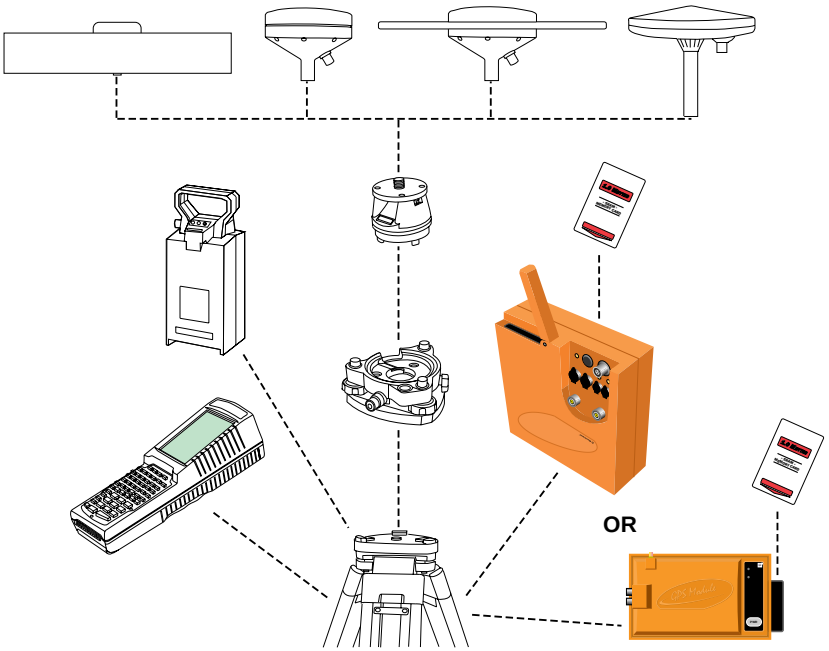
571 125 950
Base with level

570 590 385
Base without level

571 212 222
Transport Case

571 908 190
Backpack for RTK Surveying

Configurations



▲ *Fig. 1*
Static Surveying
How to configure with Geotracer® type 3220, 3320 or 3140.

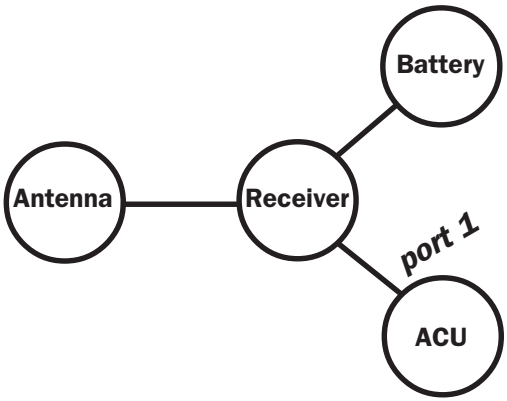
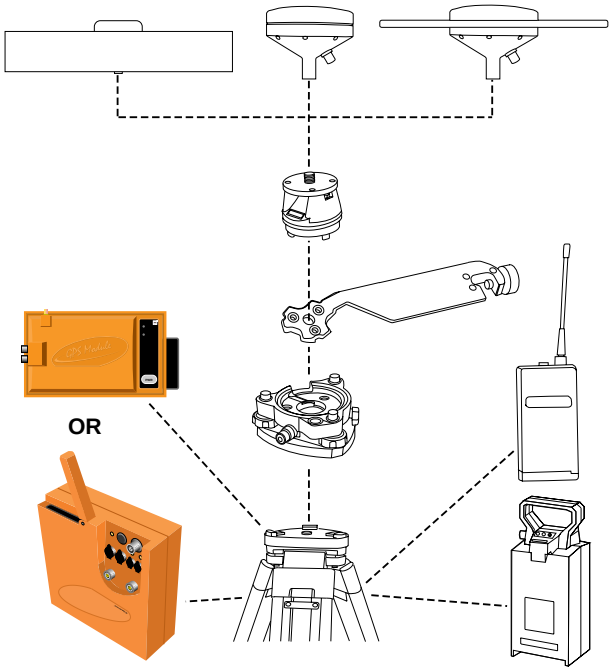


Fig. 2
How to connect the different units with each other.



▲ *Fig. 3*
RTK Surveying, Reference Stn. How to configure with Geotracer® type 3220 or 3140

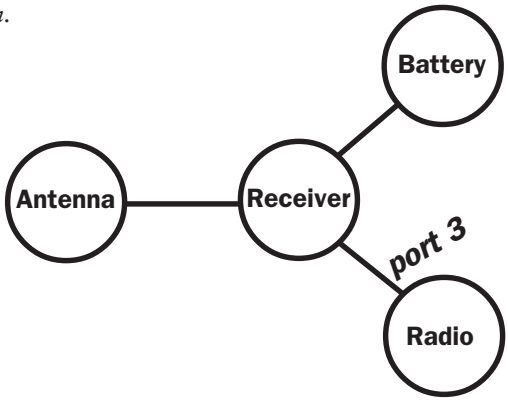
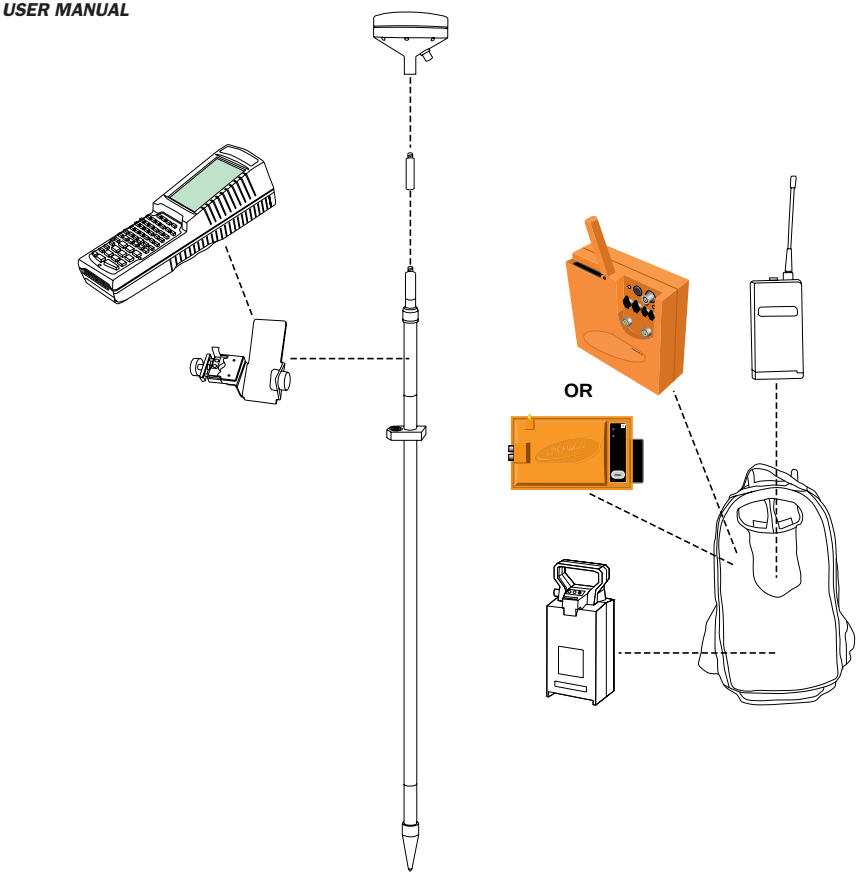


Fig. 4
How to connect the different units with each other.



▲ *Fig. 5*
RTK Surveying, Rover
How to configure with Geotracer® type 3220 or 3140.

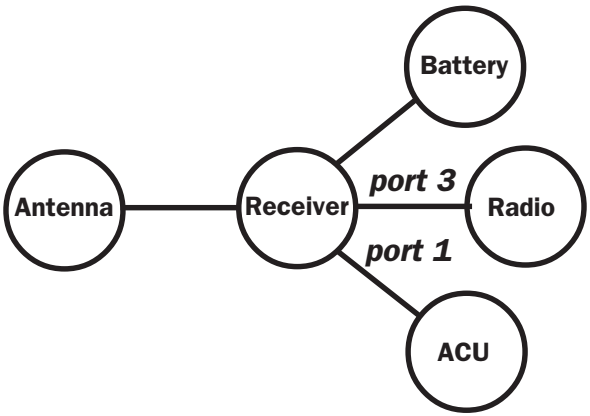


Fig. 6
How to connect the different units with each other.

Starting the Receiver

The receiver is switched on by pressing the *ON/OFF* button, (*see page 1.7 and 1.8*).

Searching for visible satellites

After starting up, the receiver starts its search for those satellites that according to the almanac should be visible. When each has been found, the receiver locks on to it and continues to track it until it disappears out of the receiver's field of view. A maximum of 12 satellites can be tracked with Geodimeter Single Frequency receiver (3140) and Geotracer Dual Frequency receiver (3220). 24 satellites can be tracked with Geotracer GPS/GLONASS receiver (3320).

Control Program

The Geotracer receivers use the CUPlus control unit program. This is a DOS based program which can be used to set up and control all features of the receiver including the storage of data. The program is described in the Clasical surveying chapter, and although this chapter was written for L1/L2, all commands, except those referring to the BNC connectors apply to L1 or L1/L2 receivers.. Note however that no on board RTK is available for the GPS/GLONASS receiver so several functions described in this chapter will not be visible when the GPS/GLONASS receiver is attached.

The Geotracer 3220 and 3320 receivers should be used with the CU/L2 Plus program version 3.0 or higher in order to use its full capabilities.

The Geotracer 3140 receiver should be used with the CUPlus program version 3.1 or higher in order to use its full capabilities. It must not be used with version 2.2 or lower.
IMPORTANT! The 3140 receiver will not function with the CU program written for System 2000 L1 receivers.

Program Start

The ***GEOGPS*** program will start automatically when the Advanced Control Unit is rebooted but you may also start the program by the command `GEOGPS` from the MSDOS level.

The following display will appear on the screen allowing you to start surveying control with F1 (CUPlus Control Unit program), Real-Time-Kinematic (RTK) with F2, Communication with F3 and exit the program with F4.

Main menu of the GEOGPS program

Exit the Program

To exit the ***GEOGPS*** program, use the F4 button.

Chapter 2:

How to Survey Points With the Geotracer® RTK System

In this chapter you will learn step by step how to easily survey points with the RTK system.

- Initialization of the reference-station receiver
- Initialization of the rover receiver
- Initialization of the RTK system (here: VSFB initialization)
- Measuring cm-accurate positions with RTK positioning

You will find detailed information on initialization in chapter 4, on surveying with RTK in chapter 5.

Initialization of the reference-station receiver

A L1 receiver can be made to function as a reference station either by a long press of the on/off button or by using the Advanced Control Unit. With the L1/L2 system the receiver will act as a reference station outputting data on port 2 as soon as you switch it on.

In order to initialize a L1 receiver as reference station with the control unit you should connect the control unit with the reference-station receiver and switch power on. Now the system will be started and the following display welcomes you to the Geotracer® Main Control Menu.

The four function keys F1 to F4 are available. The following functions are associated:

Classical surveying options (postprocessing)

Real Time Kinematic

Communication

Exit to DOS

Press **F2** in order to start the RTK program. When the application has been loaded, the system welcomes you to RTK and gives information on your system configuration.

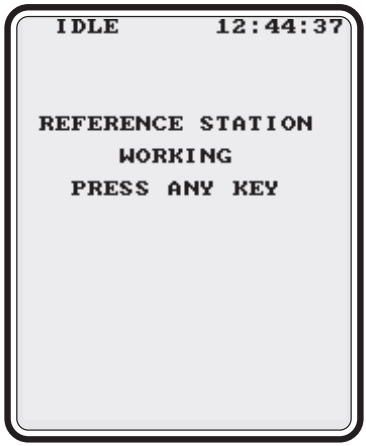
When the program has started you will see the comment "IDLE" in the header line which tells you, that the handheld computer is currently not receiving any data from the reference station.

The lower part of the screen shows icons which are displaying the functions which you can perform.

Pressing the F1 button will automatically start the reference station receiver. Some comments will be displayed during the initialization.

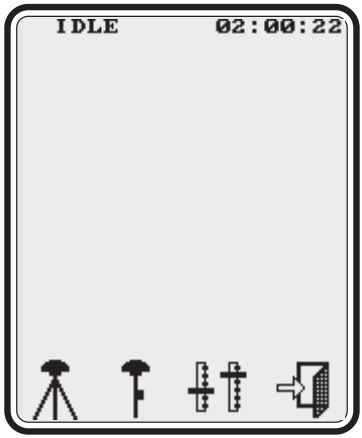
On the right hand side of the header line you will find the time in hours, minutes and seconds since you have turned on the control unit and started the RTK program on the handheld computer.

When the initialization of the reference station has finished successfully it will give you the message "`Reference station working`".



YES

Press any key in order to go back to the main screen. When the main screen is displayed, you will find that the right part of the top line has changed and the exact time is being displayed. When shipped from Geotronics this time is set to GPS-time. Refer to chapter 7 for instructions on how to select your time zone (lines `Time offset Hour` and `Sec`).



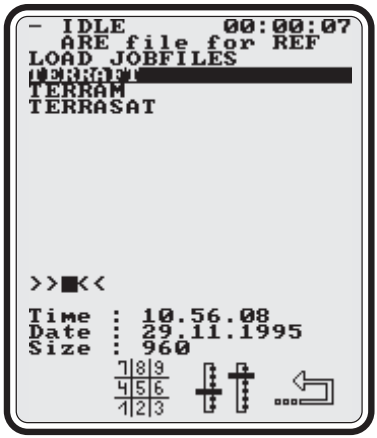
Initialization of the rover receiver

Disconnect the serial cable from the reference station receiver, connect it to the rover receiver and switch the rover receiver on.

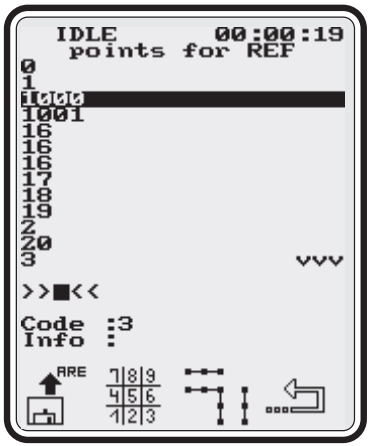
You should now press the **F2** key in order to initialize the rover receiver. When initializing the rover receiver a display will show up on the screen using a title line. Please note, that the second line of the screen will always be used as a title line.

The second line of the screen will always be used as a title line!

You will now find, that all available data files are displayed. Typically, you will work with area files (or job files) that contain the coordinates of survey points. Area files are coordinate files which are used in the Geodimeter® and in the Geotracer® product line. In order to use this system most effectively, you should create area files containing the coordinates of all points of interest within the survey area. This will make it very easy for you to define the reference coordinates, and to set out (stake out) points.



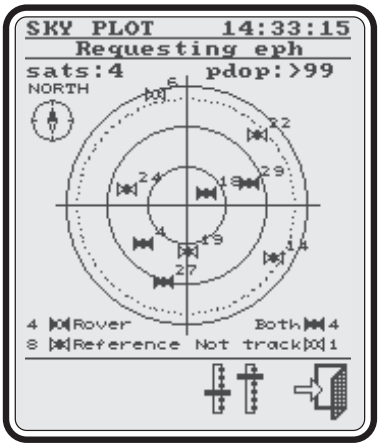
Select the area file of interest now by using the cursor-keys ▲ and ▼ and then press the YES key in order to accept the selection. In the next display you will find a point selector which works in the same way as the area file selector.



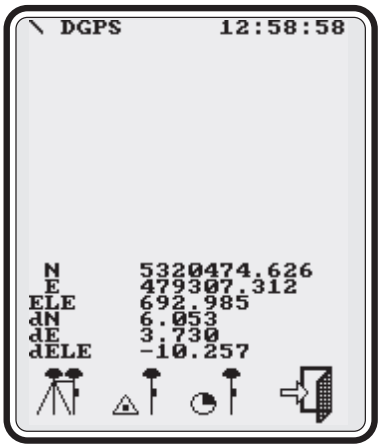
You can move the highlighted bar with the cursor-keys ▲ and ▼ in order to select and highlight the point of interest for the reference station definition. After you have highlighted the reference station point number, press the YES key again to activate this point.

The next display will ask you to enter the antenna heights for the reference station receiver and the rover receiver. IH stands for the instrument height of the reference receiver antenna above the reference point, SH for the antenna height of the rover antenna (signal height).

After initializing the rover it may happen, that a sky plot is displayed. The sky plot displays the azimuth and elevation of all satellites visible. Here it only indicates that the system is requesting satellite ephemeris information to update satellite position information. This will usually take only a few seconds.



The next screen displays DGPS as the top line comment, which stands for Differential GPS Mode. DGPS is a calculation of the position of the rover with respect to the reference station in the meter-level.



The top line will display a rotating bar indicating that you are receiving data from the reference station via a radio link together with the current time. In the lower part of the screen you will find four different icons which indicate the different types of initialization that can be performed.

Icons always are symbols for the assignment of the function keys F1 to F4, resp.

The icons on the display have the following meanings:

Initialization by measuring the Very Short Fixed Baseline

Known point initialization

Short static initialization

Leave program

Above the icons, the coordinates of positions currently determined with this rough differential GPS technique are displayed. You will find that the coordinates can jump by several decimeters.

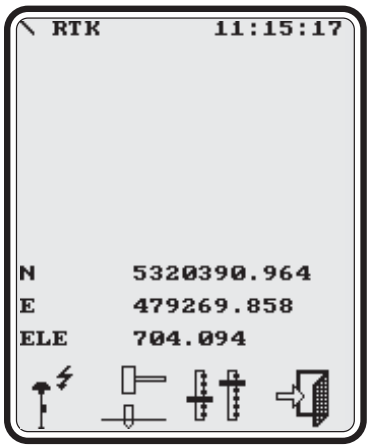
Very short fixed baseline initialization

In this introductory chapter we will just explain the simplest form of initialization of the RTK-system which is the VSFB (Very Short Fixed Baseline, see chapter 4). In order to start the VSFB initialization press the F1 key.
The system will display a screen which says "Measuring the VSFB".

In the lower part you will have an icon with a stop sign refering to the F1 key to interrupt VSFB processing. Normally the VSFB initialization of the system will take no more than six seconds. After successful initialization the top comment line changes from DGPS to RTK. We use the RTK abbreviation to indicate that the system now has centimeter accurate positions. The position coordinates are now displayed with centimeter accuracy. Therefore, you will find that the coordinates are now changing by no more than a few centimeters. You will also find that the coordinates are displayed with an update rate of 4 hertz (4 times per second) on an L1 system, 2 hertz (2 times per second) on an L1/L2 system. This is the position update rate of the system. That means that when you are moving the rover receiver you will have updated position information two or four times per second.

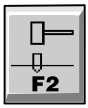
Measuring cm-accurate positions with RTK positioning

We have now initialized the system and are able to perform surveys of individual points.



The lower part of the screen has now changed. Using the function keys you may select the mode of operation or set some parameters. The function keys are assigned as follows:

Survey mode, also called point positioning mode



Stake out (set out) mode

Parameter settings

Leave program

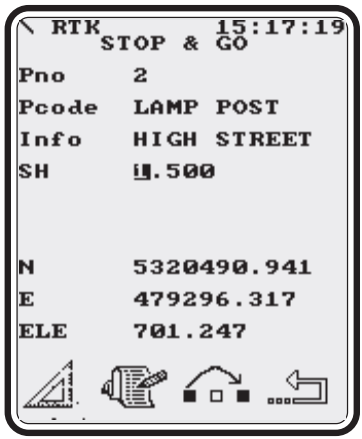
In this introductory chapter we would like to make you familiar with the possibilities of the Geotracer® RTK System to measure the location of new points. Therefore, we suggest pressing the F1 key now to enter the point survey mode.

The only change to the display after pressing the F1 key, is that new icons are displayed. A title line `Stop & Go` indicates the point survey mode. The system has changed to a mode where you are now able to perform a survey of new points.

In order to measure a point disconnect the rover receiver from the VSFB device and go to that new point. While moving, you should make sure that you are holding the range pole with the receiver vertically, so that you do not lose lock to the satellites. Now position the rod at your new point making sure, that the rod is perfectly vertical. Then press the F1 key. After pressing the F1 key the display will show that the system is measuring a new point.

This will again take approximately four seconds depending on the user defined accuracy specification. System accuracy definition will be explained in more details in chapter 7 (set parameters `Sdev`).

After measurement, the screen will show up a dialog display.



You may make the following entries:

- Pno: the point number,
- Pcode: the point code which is used for a coding of individual description of the point
- Info: the info which can be used by yourself as a comment line,
- SH: the antenna height of rover. The instrument height displayed now on the screen is identical to the height you entered before. It is measured as true vertical. You may change the instrument height at any time you are measuring a point.

The point number may have up to sixteen alphanumeric characters, so you can use alpha and numeric characters. Note, that when using the resulting jobfile in connection with Geotracer® GPS Postprocessing only the first eight characters of the point number will be used.

The point number may have up to 16 alphanumeric characters. But when using the jobfile in connection with Geotracer® GPS Postprocessing only the first eight numbers are accepted.

If you are using point numbers containing numerals and the default equipment you will find that the point number will be increased by 1 at each new point. So when starting with point number `stat1a` the second point will be point number `stat2a`. If you intend to store a lot of points with increasing number, make sure, that the point number contains a sufficient amount of continuous numeric characters. With the example above, you could store no more than 9 points. To allow the storing of point number `stat100a`, the first point must have the number `stat001a`.

In order to change lines you can use the ▲ and ▼ arrow keys. To move the cursor within the field you can use the ◄ and ► arrow keys and change the individual entries according to your wishes.

After you have entered all information you are interested in, you can use the **F2** key for registering the information. The information will then be stored by the system.

When pressing the **F2** key for the first time in a survey you will be asked for the name of the job file in which you want to store your data. The job file name can have up to eight characters which can be of alphanumeric or numeric type. Please note that you will be asked for the job file name only once, so the next time you are going to a new point you will not be asked for the job file. The information for additional points will be appended to the job file each time you are registrating point information.

Only when registering the first point in a survey the program will require a jobfile name automatically. Subsequent points will be appended to the job file.

If you have measured the point with the F1 key but do not wish to register the point in the job file you can use the F3 key in order to skip the information measured.

In order to go back to the main screen of the RTK system you can use the F4 key.

When measuring the next point you will find that the system has increased the point number. It still has the same point-code and information as the previous point and it still has the same instrument height. This is in order to offer a convenient survey possibility without the repeated necessity to enter the type of information you are gathering. E.g., usually the user will want to measure a lot of different points with the same point code type information so there is no need to change that.

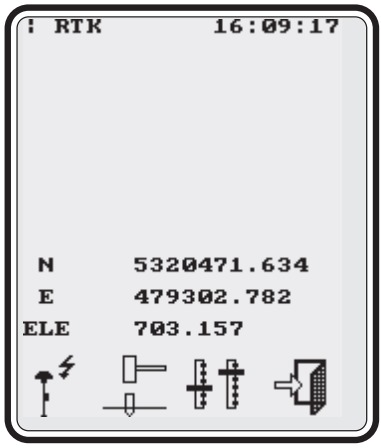
If you wish to measure a point twice or more times and you go back to a point, you will find that the system automatically realizes that you are on a point which was measured previously and it will display the old information for point number, point code, and point info. The measurement can be repeated. The job file will then contain the individual measurements and the weighted mean of the measurements.

Chapter 3.

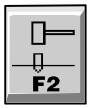
How to Stake out (Set out) Points with Geotracer® RTK

In this chapter you will learn how to stake out (set out) points with the RTK system. First however, you must initialize the receivers and the system. For information about initialization refer to chapters 2 and 4.

Chapter 6 offers detailed information on the stake out option. It concentrates on position information sources and the graphic guidance to the point to stake out.



Start from the mode selection screen which is displayed after the initialization.

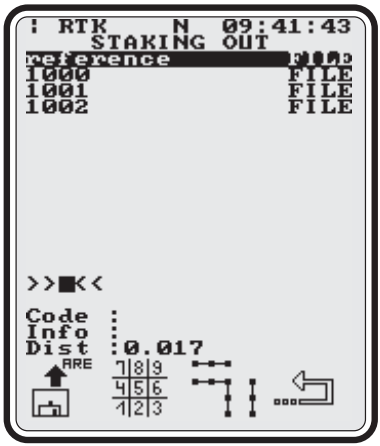


In order to enter the stake out mode, press the **F2** key from this display. After pressing the **F2** key you will be asked for the job file in which you want to store the observed information.

If you have previously defined a job file during your survey you will be prompted with that job file again but have the possibility to change to a different job. Please note, that the jobfile name can have up to eight characters. These will be used to form the name on the PCMCIA card. It will be given the extension `*.JOB`. If you choose a job file you have previously used, you will find that the new survey data you observe will be appended to the existing job file.

Staking out requires that the system is provided with the coordinates of each point to set out. This information can be generated in different ways.

The simplest method to test the procedure and to become familiar with the system is to stake out points which have just been measured with the RTK system in the current job. If you accept the default (which is the current job), a list of all the points you have measured will be displayed.



The display will have a slightly different headline. This tells you that you are in stake out mode. Starting with the third line you will get a list of the different point numbers you can choose from. In order to select a point you should use the ▲ and ▼ arrow keys to highlight the selected point number and press the YES key to accept it.

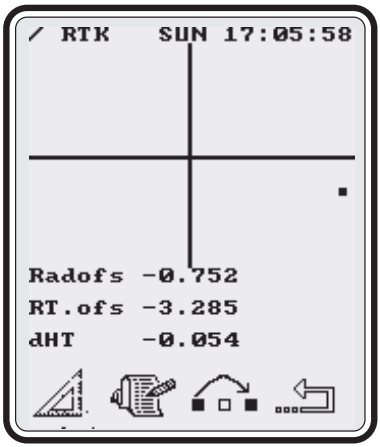
The screen also contains more detailed information in order to help you to select the right point. This information consists of point code, point info and distance of the point you have selected from the current (rover) position.

In order to aid the selection of a point from a larger point number list or larger area file an intelligent key entry system is available. You can enter the initial character via the alpha-numeric keys and this will rearrange the sorting of the point numbers in numerical and alphabetical order. The first point starting with the entered characters is displayed and highlighted automatically. This makes the selection of a specific point number much easier.

However, you can also use a different type of automatic point selection. This is used by the system as a default. The Geotracer® RTK system will consider which points have been staked out and will always prompt with the point nearest to the rover station as the next point to stake out. This will increase the efficiency and productivity of the system during staking out.

The parameter menu allows you to switch off one or both sorting methods in Point Selector Displays (see chapter 7). This might be preferable when working with very large area files.

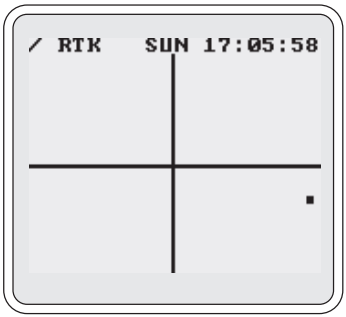
After highlighting the point to stake out with the arrow keys and acknowledging with the YES key a graphic display will show up on the screen with additional information below the graphic cross.



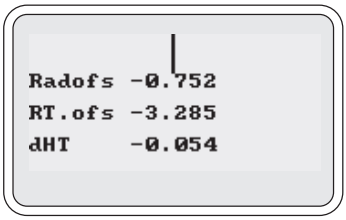
The graphic part of the screen provides you details about your current position and the position of the point to stake out.

By default the system will use the north direction as orientation direction, indicated by the abbreviation N in the first line of the screen. The RTK system offers different types of orientation possibilities such as SUN, as shown above. In chapter 6.2 the types of orientation and the ways of selection are described in detail.

You should then position the rover so that you have the control unit display in front of you and you are looking towards the reference orientation.



Within the graphic display you will find a cross hair and a small square which moves on the screen as soon as you move the rover receiver. This small square represents the point to be staked (set) out. The center of the cross is your current position.

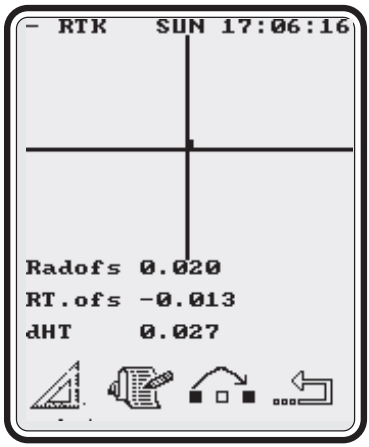


Below the graphic cross you will find additional, more precise position information. In particular you will find the radial offset (Radofs) and the right angle offset (RT.ofs) to the line between your point to stake out and your chosen orientation point.

In order to stake out a point you should move towards the square. You will see that you are moving closer to the point to be staked out.

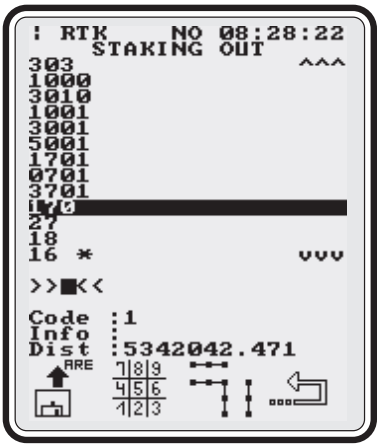
The graphic display works in different resolution modes. If you are far away from the point you will work in a mode where it is guaranteed, that your square will be on the display. As you move closer to your point you will find that the graphic display zooms in, clearly visible because the square moves faster the more you approach the point and "jumps" to the outer edge when at a distance of 40 cm.

The Geotracer® RTK system zooms in so that you precisely see the displacement of your current receiver antenna position in relation to the point to stake out.



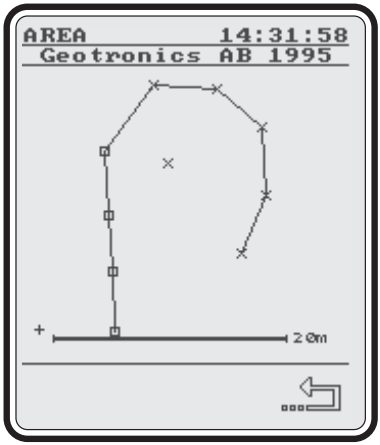
When you have positioned the rod at the point to be staked out and you have levelled the bubble and are satisfied with the accuracy, you can measure the point by using the F1 key. Use the F2 key in order to add the information to the job file.

Instead of pressing **F1** and **F2** you could use the **F2** key only. This way you may store measurements automatically without the possibility to skip the measurement. After doing that the point selection mode reappears where the points which have not been staked out yet are displayed. Points which have been staked out are marked by an asterisk after the point number.



The point staked out by the system can be graphically displayed in a form of a two-dimensional plot. This allows you to verify which points you have staked out and which are still missing. Use the **Shift** + **M** hotkey combination to activate the area plot.

The graphic display shows all the points staked out so far. They are marked with a square. Other points of the area are marked by an x. Sequences of points with the same point code are connected via lines.



Notice the + which determines the position of the rover. The scale is indicated at the bottom of the display.

Chapter 4.

Start-up and RTK Initialization Methods

4.1 Start-up of Reference and Rover Receiver

The Geotracer® RTK system is basically a precise Differential GPS System. For DGPS purposes you use a reference station. Usually its coordinates are known very accurately, but for some purposes even if the reference station coordinates are measured using single point positioning the system will operate in a completely satisfactory way. A reference station helps you to correct the satellite signals in order to minimize error effects produced by S/A effect, ionospheric delays, tropospheric delays, clock errors and ephemeris errors. Using these corrections, the precision of the measurement will increase considerably.

With Geotracer® RTK you have two possibilities to set up a reference station.

- Establish your own reference station using another receiver and antenna together with a radio. You can choose whether or not you use an ACU. If you use the ACU, you can use the one from your rover receiver (see chapter 4.1.1).

- Use the signals of one of the RTCM reference stations. You only need a radio to receive RTCM messages. No reference station initialization is necessary (see 4.1.2).

Then, the rover receiver has to be initialized. This includes giving it the positions of the reference station.

4.1.1 Initialization of the Reference-Station Receiver

Start-up receivers L1

A L1 receiver can be made to function as a reference station

- By a long press of the on/off button .
  This function must be set the first time you use the receiver. Enter the CU program by pressing **F1** to set the "LONG ON MODE" = RTK. To do this, go to the GTR CONTROL menu and select "ON/OFF SW." (see the **Geotracer® System 2000** manual, chapter 5, menu 5-5). Then select RTK as entry for "LONG ON MODE" . Switch the receiver off now.
  The receiver will from now on act as reference station if you switch it on by holding down the on/off button for about one second until the LED is Red.

- By using the Advanced Control Unit.

L1/L2

With the L1/L2 system the receiver will act as a reference station outputting data on port 2 as soon as you switch it on. If you press the on/off button of the L1/L2 receiver for a long time (approx. 5 seconds), the receiver will be initialized and, in addition, will begin to store data onto the internal memory card.

Start-up L1 receiver using ACU

Initialization by Using the Advanced Control Unit

In order to initialize the reference station with the control unit you should connect the control unit with the reference-station receiver and switch power on. Now the system will be started and the following display welcomes you to the Geotracer® Main Control Menu.

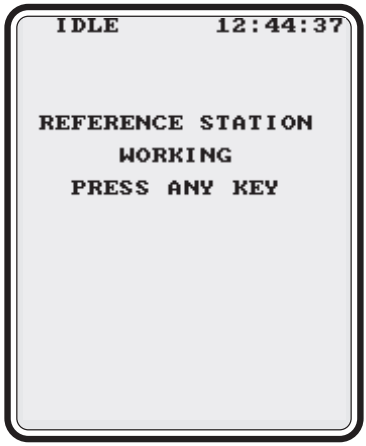
Press **F2** in order to start the RTK program. When the application has been loaded, the system welcomes you to RTK and gives information on your system configuration.

When the program has started you will see the comment "IDLE" in the header line which tells you, that the handheld computer is currently not receiving any data from the reference station.

On the right hand side of the line you will find the time in hours, minutes and seconds since you have turned on the control unit and started the RTK program on the handheld computer.

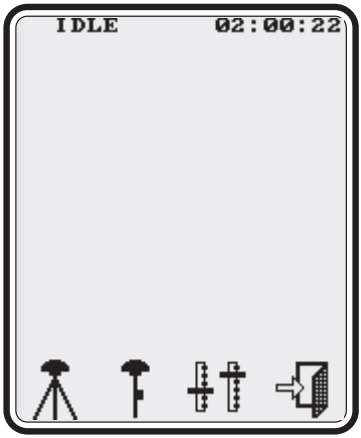
Pressing the F1 button will automatically start the reference station receiver. Some information will be displayed during the initialization (concerning, e.g., tracking interval, the elevation mask, the duration of measurement and tracking mode).

When the initialization of the reference station has finished successfully the following display will show up, giving the message "`Reference station working`".



YES

Press any key in order to return to the main screen. When the main screen is displayed, you will find that the right part of the top line has changed and the exact time is being displayed. When shipped from Geotronics this time is set to GPS-time. Refer to chapter 7 for instructions on how to select your time zone.



Initialization of the Rover Receiver, Using a Geotracer® as a Reference Station

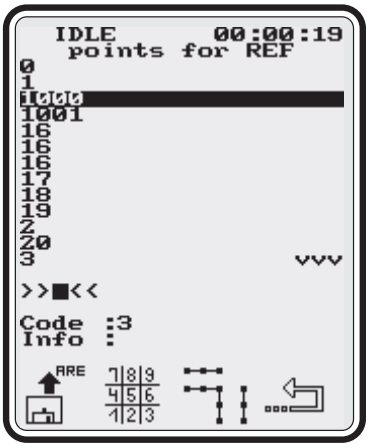
Start-up of rover, Geotracer® as reference station

If you started the reference receiver using the ACU, disconnect the serial cable from the reference station receiver, connect it to the rover receiver and switch the rover receiver on.

You should now press the **F2** key in order to initialize the rover receiver. All available data files are displayed. Typically, you will work with area files (or job files) that contain the coordinates of survey points. Area files are coordinate files which are used in the Geodimeter® and in the Geotracer® product line. In order to use this system most effectively, you should create area files containing the coordinates of all points of interest within the survey area. This will make it very easy for you to define the reference coordinates, to set out (stake out) points or to enter known points for the Known Point RTK Initialization.

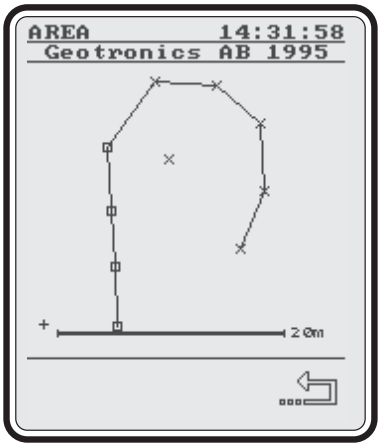
Select reference position

Select the area file of interest by using the cursor-keys ▲ and ▼ and then press the YES key to accept the selection. In the next display you will find a point selector which works in the same way as the area file selector.



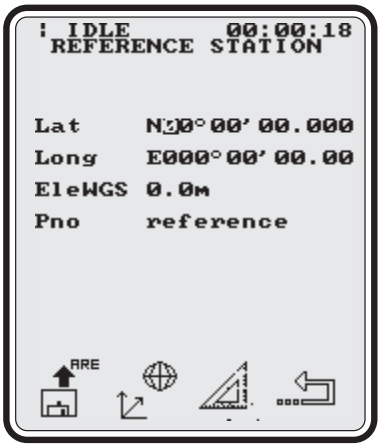
You can move the highlighted bar with the cursor-keys ▲ and ▼ in order to select and highlight the reference station name.

If you are unsure, whether this file contains the point you want, you may make use of the area plot option. Press **F3** and the system will display a sketch plot of the points of the selected file.



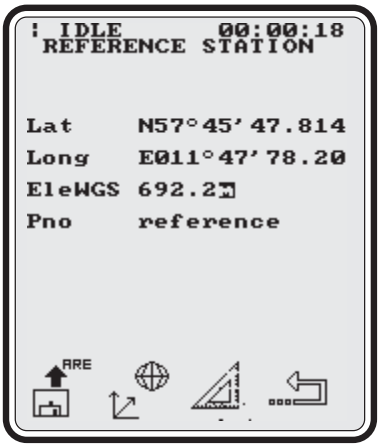
After you have highlighted the reference station point name (or number), press the **YES** key again in order to activate this point.

It is also possible to manually key in the coordinates of the reference station or to define a reference station position via single point positioning of the reference data received via radio link. Press **F2** .



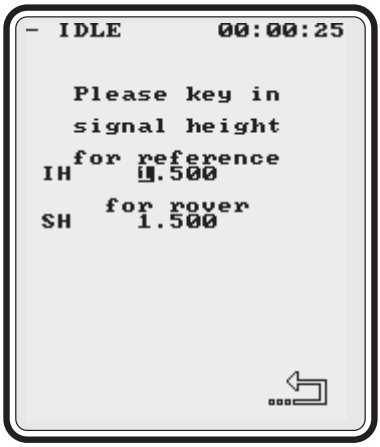
Now you my enter the coordinates and a point number of up to 16 digits. This point number allows you to identify the reference station in the point list later on.

It is also possible to use the current position of your reference station. If you press **F3**, the current position measured by the reference station will be transmitted via radio to the rover and this position of the reference station will be displayed to be accepted.



Enter antenna heights for both, reference and rover

The next display will ask you to enter the antenna heights for the reference station receiver and the rover receiver. IH stands for the instrument height of the reference receiver antenna above the station, SH for the antenna height of the rover antenna (signal height).

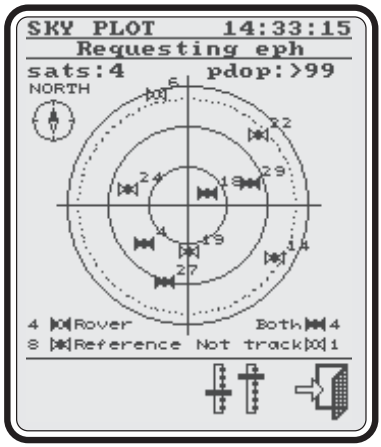


If you use the default U.D.S., the reference station instrument height will be kept the same throughout the survey, but the entered rover height may be changed during the survey. But, you may also change to a different U.D.S. (see chapter 10) which may include a line for the display and editing of the instrument height.

Now, enter the individual values in the fields which are highlighted and accept them using the YES key.

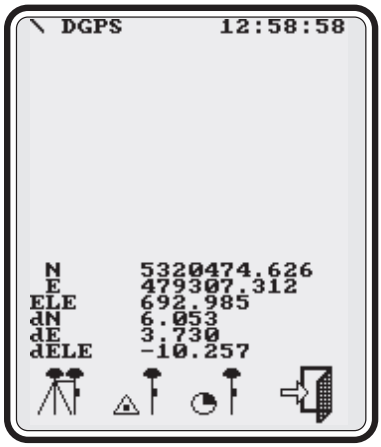
Sky plot

After initializing the rover it may happen, that a sky plot is displayed. The sky plot displays the azimuth and elevation of all satellites visible. Here it only indicates that the system is requesting satellite ephemeris information to update satellite position information. This will usually take only a few seconds.



Hardware initialization has finished

The next screen displays DGPS as the top line comment, which stands for Differential GPS Mode. DGPS is a calculation for the position of the rover with respect to the reference station in the meter-level using only the C/A code. This method requires no further initialization.



The top line will display the rotating bar indicating that you are receiving data from the reference station via a radio link together with the current time. In the lower part of the screen you will find four different icons which indicate the different types of initialization that can be performed.

The icons on the display have the following meanings:

Initialization by measuring the Very Short Fixed Baseline

Known point initialization

Short static initialization

Leave program

Above the icons, the coordinates of positions currently determined with this differential GPS technique are displayed. You will find that the coordinates are changing in the meter-range.

You may now proceed with your RTK initialization in order to get cm-accurate positions (see chapter 4.2).

RTCM for reference station

4.1.2 Using RTCM Instead of a Geotracer® Reference Station

The following information refers to the RTCM data transmission used with the RTK. For more details concerning RTCM structure please consult:

- RTCM special committee n. 104: *RTCM recommended standards for differential Navstar GPS service.*
- ICD GPS 200.

General

If you do not have a reference station or want to minimize your cost by using a fixed reference station, whose positions are known accurately, you may use one of the RTCM Reference Stations instead. Corrections are transmitted according to the RTCM standard. The RTCM format was developed by the RTCM committee 104, in order to establish a standard for GPS data communications. This information is sent using different messages, depending on the application.

The RTCM committee defined the format for the RTCM transmission. It has the following characteristics.

Characteristics for RTCM transmission

All messages are transmitted by words containing 30 bits. The first 2 words are the header that is present in all the messages. All the words that refer to every message follow.

In the header, several types of data are broadcasted, including

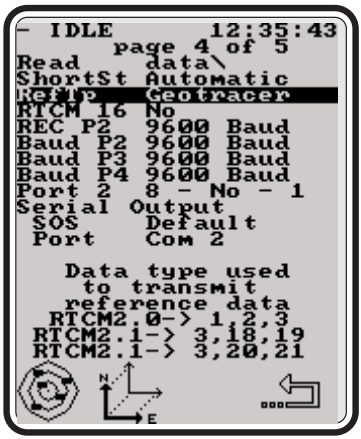
- the preamble that is used for detection and synchronization
- the station identification
- the time that corresponds to the message
- the sequence number of the message,
- the number of words belonging to that message,
- the message type, to identify what kind of information is contained in the message, and
- the "health" of the broadcasting site.

There is a second header for the message types 18 to 21 that includes better time definitions important for RTK applications.

Activate RTCM

In order to activate RTCM

- connect RTCM telemetry to port 2 of the ACU,
- change to the parameter menu, page 4

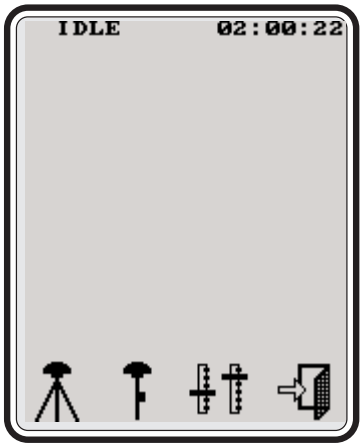


- select the baud rate of port 2 in the parameter menu (line `Baud P2`, default 9600),
- select the version of RTCM you want to use for positioning in the parameter menu (line `RefTp`),
- select now or later, whether you want to receive messages of type 16 (line `RTCM 16`, default `No`),
- if necessary select the processing mode you want to work in (line `PrcMode`).

Start-up of the rover receiver, using RTCM

Start-up receivers, when using RTCM

If the RTCM option is activated the start-up procedure differs from the initializing procedure of the RTK system using a Geotracer® reference station. Having entered the RTK system you start with the Initialization Mode Display.



Press the **F2** button from the Initialization Mode Display. The system requests directly for the antenna height of the rover.

The reference station position will be received via RTCM message type 3 from the RTCM Reference Station. Therefore, you do not have to take care of any reference station coordinates. After accepting the antenna height of the rover the following screen will show up.

The system is now activated for receiving RTCM data from port 2.

Wait till this message disappears

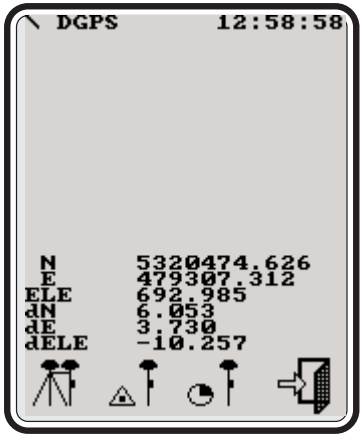
If the first message containing observation data arrives before any reference station coordinates are decoded, the following screen informs you to wait for message type 3.

For RTCM 2.0 users only!

Note: If you are using RTCM 2.0 you do not necessarily have to wait for message type 3. The system will ask you, whether you want to wait for a message type 3 or not. If your answer is **NO**, the system will use a single point position of the rover data as virtual reference position. If a message type 3 arrives, this position will be used instead (if you have pressed **YES** or did not answer, the system waits until a message type 3 arrives).

If you are working without message type 3 and your U.D.S. contains labels for horizontal or vertical angle, slope, vertical, or horizontal distance or relative north or east coordinates (labels 7,8,9,10,11,47,48,49), these values are set to zero.

After decoding message type 3 (reference station coordinates) the system starts to use the RTCM messages for positioning according to the positioning mode you selected.



If a message type 3 arrives with different reference station coordinates than the ones used before, a warning message will show up:

During all of your DGPS or RTK measurements the RTK system will receive and decode the different RTCM messages.

Supported Messages

The RTK system supports the following types of messages. The type of message decoded depends on the RTCM version selected (see next paragraph).

Type	Description
1	Corrections for code measurements
2	Necessary informations if the rover is using other ephemeris data than the reference station
3	Reference station coordinates
16	Message text receiving from the reference station
18	Full phase measurements
19	Full code measurements
21	Corrections for code measurements

Supported Versions

The RTK system supports the following RTCM versions:

Version:	RTCM 2.0	RTCM 2.1 corr	RTCM 2.1 full
Messages necessary	1,(3)	3,21	3,18,19
Message also supported	2,16	2,16	16
Processing mode	DGPS	DGPS	DGPS, RTK
Update rate RTCM	< 20 sec	< 6 sec	< 6 sec

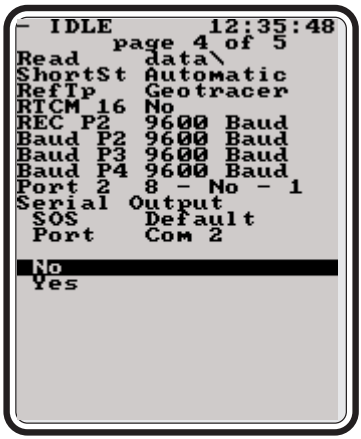
Annotations

Suppress RTCM message of type 16

1) If a message type 16 arrives, the following screen display will show up to inform you.

Please accept the message by pressing any key.

If the reference station sends message type 16 containing only information about settings used by the reference station, you will repeatedly be disturbed in your work by having to accept the message. Therefore, it is possible to ignore message type 16 by setting the switch to NO within the parameter menu, page 4.



2) For calculating the corrections for each satellite the reference station uses the ephemeris data for that satellite. Therefore, it is necessary to use the same set of ephemeris data for all further processing in the RTK system. To ensure that, all corrections contain also an identification of the used set of ephemeris data. If the ephemeris data used at the reference station are not available at the rover, the RTK system can not use that satellite. This may happen, when the reference station receives and uses a new set of ephemeris data, but not the rover. The message type 2 contains the corrections to continue working with the old set of ephemeris data and the code corrections generated with a different set of ephemeris data.
It is possible to work with the system without message type 2, but in this case there might occur time spans without usable RTCM corrections.

3) If you are using RTCM 2.1 corr and you are working in RTK mode, there could arise a time span without usable data for positioning. The reason for that is, that in RTCM 2.1 no equivalent exists for message type 2 concerning phase corrections.

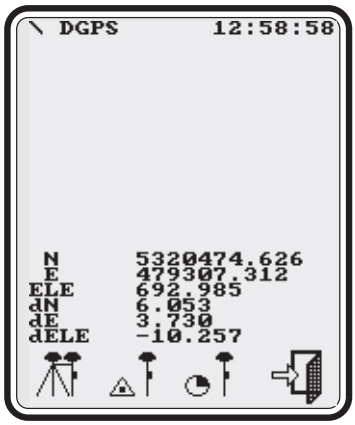
4.2 RTK Initialization Methods

Before starting the survey the RTK system has to be initialized. Without initialization no cm-accurate positions are possible. This initialization is also known as ambiguity fixing.

In this chapter you will learn how to initialize the RTK system using different methods.

- VSFB initialization is a very convenient method. It makes use of a short device which positions the base (reference) and rover receivers with a predefined short distance between them.
- If you start your survey at a known point you may use the known position information for initialization. This must be accurately known, preferably measured by GPS.
- Short static initialization is used when neither VSFB nor Known Point initialization are possible.
- By default L1/L2 receivers initialize automatically on-the-fly (OTF).
- If lower (meter) accuracy is required it is not necessary to initialize the system at all. All surveying options are still available in DGPS mode.

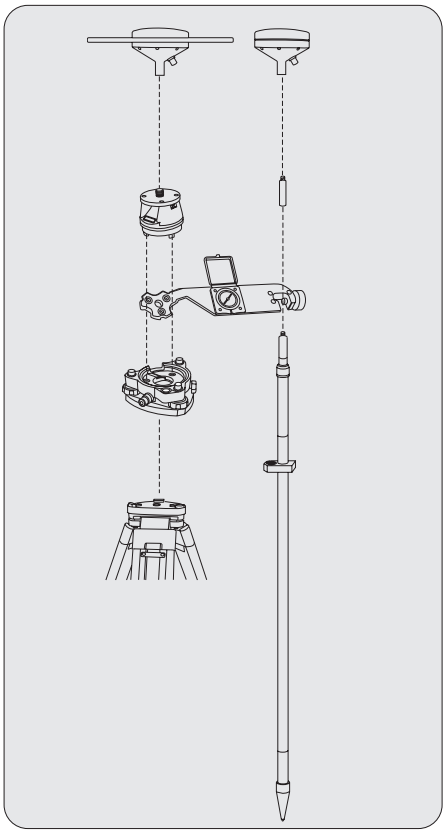
Start the RTK initialization from the Initialization Menu Display:



4.2.1 VSFB Initialization

VSFB (Very Short Fixed Baseline) is a very convenient way to get the system initialized. However, the VSFB can only be used, if you have access to the reference station.

The VSFB in the Geotracer® RTK system is a device which guarantees, that both receiver antennas are separated by an exactly known distance. The initialization is very simple to handle and fast, however, this requires that the heights of the two antennas are identical or the height difference is known precisely. Note, that the VSFB device fitted with a compass guarantees a distance of 25 cm, the one without a compass guarantees 30 cm.



Setup hints

Before starting the VSFB initialization the receivers have to be positioned a very short distance apart (hence Very Short and Fixed Baseline). Use the VSFB for setting up the receiver antennas so that both antennas are at the same height. During the setup of the VSFB and the two receiver antennas it is ***not*** necessary to orient the VSFB in any specific direction. The RTK system will find out in which direction the VSFB is oriented. The length of the VSFB baseline (25 or 30 cm) and the height difference of the VSFB antennas are the only parameters of interest for the VSFB initialization.

Most comfortable: always use the same VSFB device as well as height difference = 0

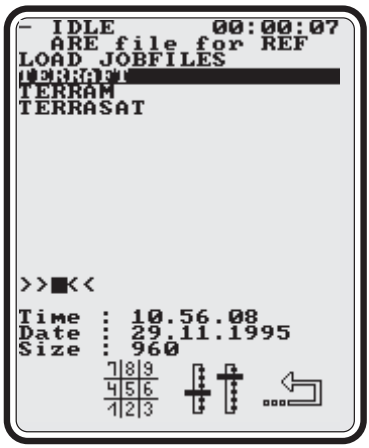
If you always use the same VSFB and make sure that the height difference is zero, you do not have to modify the setup in any of the parameters given in the parameter menu.

How to change parameters

Nevertheless it is possible to change the length of the VSFB and the height difference between the two antennas in the parameter menu. You may use one of the following two ways:

Go to parameter menu - first method

After you have switched on the rover receiver and connected it with the serial cable to the control unit the following is displayed:



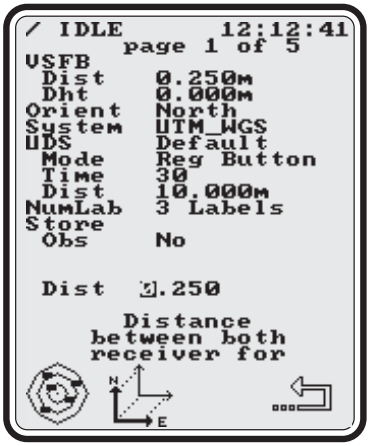
Press the **F3** key to change to the Parameter Settings Menu, where you may change parameters. Use the **▲** and **▼** keys to change lines for your entries. Changes are accepted with the **YES** key.

Go to parameter menu - Second method

An alternative method to change the parameters is to use the combination **Shift** + **P** any time during the operation (the **Shift** key is the yellow key on the Advanced Control Unit).

Change parameters VSFB distance. dht [m]

Move the highlighted line to `VSFB dist` and press YES. Note that all values are entered in the selected unit.



You may now change the length to the value desired. Acknowledge your input with YES and move to the `dht` line.

Edit the height difference in the same way. Please note that the height difference is defined as rover - reference, i.e., dht > 0 if rover is higher than the reference station antenna.

Height difference: dht > 0, if the rover antenna is higher than the reference antenna.

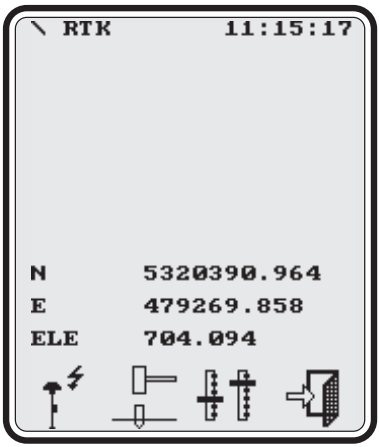
Initialize VSFB

To initialize the RTK system via VSFB press the **F1** button. The system will display `Measuring the VSFB`. Normally the VSFB initialization of the system will take not more than six seconds. After successful initialization the top comment line changes from `DGPS` to `RTK`.

We use the RTK abbreviation to indicate that we have centimeter accurate positions now. The position display will now show coordinates that have centimeter accuracy. Therefore, you will find that the coordinates are now changing by not more than a few centimeters. You will also find that the position changes are displayed with an update rate of four

hertz (4 times a second) in case of L1 receiver or two hertz in case of L1/L2 receiver. This is the position update rate of the system. That means, that when you move the rover receiver you will have updated position information two or four times per second.

We have now initialized the system and are able to perform surveys of detail points.

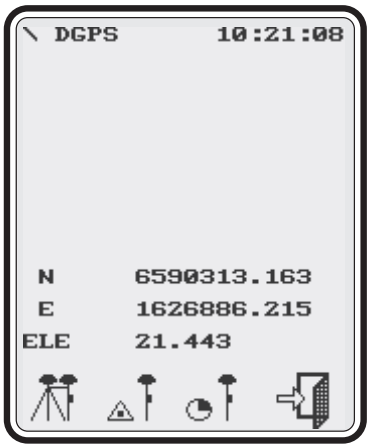


Change coordinate display

In order to change the display of the coordinates from the north, east and elevation type of display to baseline component coordinates use the PG↑ or PG↓ key. The system will then change between different coordinate type displays, which are preprogrammed in the system. The user may change the displays easily via label settings in file `LABEL.LAB` (refer to chapter 10: Programming the System).

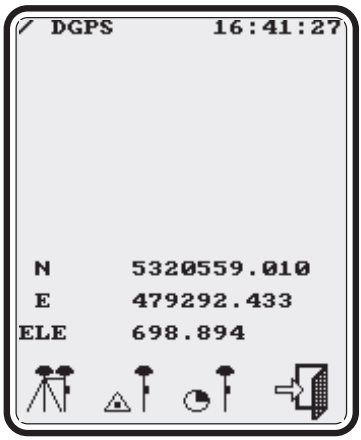
Stop initialization

If you press the F1 button during the initialization process, initialization will be stopped and you are returned to the following menu.



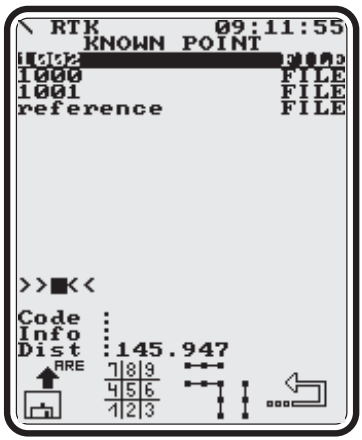
4.2.2 Known Point RTK Initialization

You may initialize the RTK system with the help of accurately known point positions.



Choose a known point from a list provided by the RTK system

Press the **F2** key at the initialization page. A display will show up which allows you to select from a list of given points. These points might have been observed previously or might be imported from an area file. The selected points need to have an accuracy of 1 - 2 cm to perform the known point initialization.



Choosing Jobfile and Known Point

Default known point

The point which is closest to the current rover position will be used as a default suggestion in this point selection menu. As in other point selection menus it is possible to choose a point by moving the highlighted line with the ▲ and

Select other point

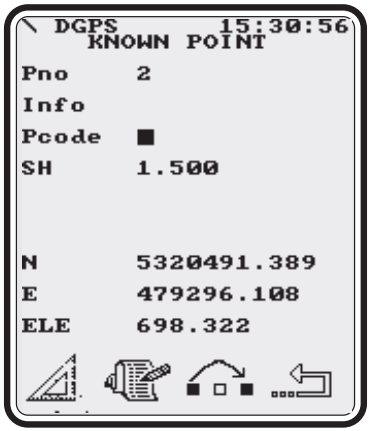
▼ keys or by entering the initial character to find the point faster from the given list of points.

Enter jobfile name

Having chosen the point you will be prompted for a jobfile name. All survey results will be stored in this file.

If you have already used the system, and therefore have already defined at least one job file, the last one used will be suggested as a default and you can just accept the name by pressing YES, otherwise enter your desired jobfile name.

After accepting a jobfile name the Known Point Measurement Display will show up. You can edit the point number, point info, point code and instrument height.



Again you have the possibility to select one of four functions.

Initialization by measuring at the known point.

Store the measurement results or measure and store if no measurement was made.

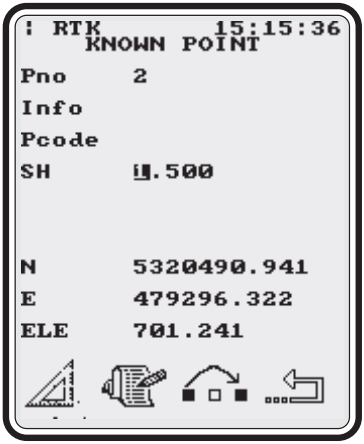
Skip point, discard the survey result.

Return to main initialization display.

Initialize known point

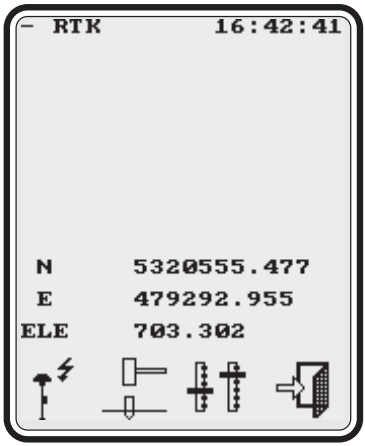
In order to initialize press the **F1** button. After pressing **F1** the comment `Measuring known point` will be displayed.

After a few seconds you will find the position display again, but now the comment in the top line will indicate, that the system is now in RTK mode.



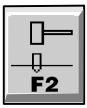
or

You may store the new measurement of the point by pressing **F2** or skip with **F3**. Then the system will go to the following display.



Go on

or

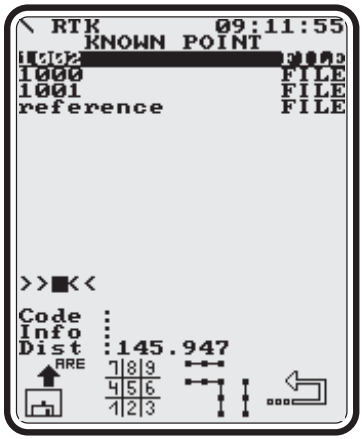


The system is initialized. You may now survey new points by pressing **F1** or stake out (set out) points with **F2**.

Point Selection Methods

Other point definition methods

Let us go back to the Known Point Initialization Display. If you do not want to use one of the suggested points, you may select a point from an area file, job file or by manually entering the coordinates. These options are offered by the function keys.



The function keys have the following meanings:

Display a list of area or job files

Manual entry of coordinates via key pad

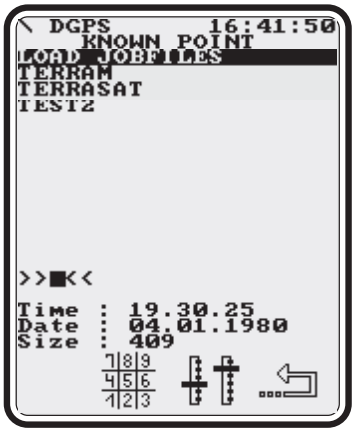
Survey Plot of the current area file

Return to the initialization display

1.) Initialization from file definition

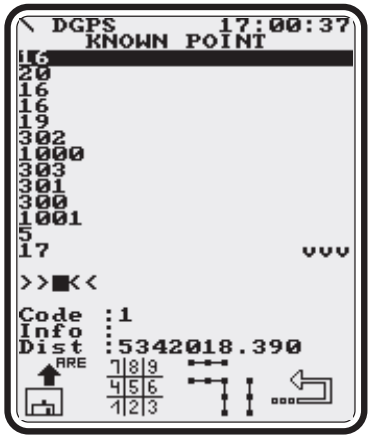
Known Point Initialization from File Definition

When you wish to select a reinitialization point from an area file, pressing **F1** will display all available area files. In addition, the entry `LOAD JOB FILES` allows you to change to the list of available job files.



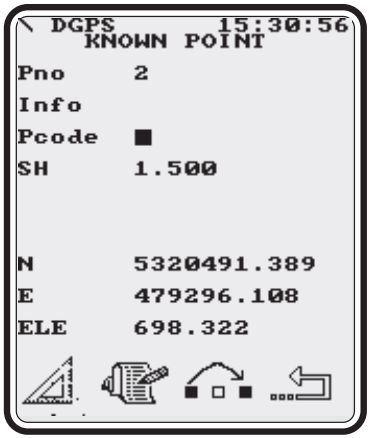
Select file

You may choose any job or area file by highlighting it, then press the **YES** key. The system will then display all available points within that file.



Choose one of the points

You now may choose one of the points (highlight it and press the YES key). The sorting of the points depends on the parameter setting in the parameter menu, page 5, line `Sort`. Again, the system prompts you to confirm the jobfile name. The Known Point Measurement Display pops up.



Initialize and go on

and

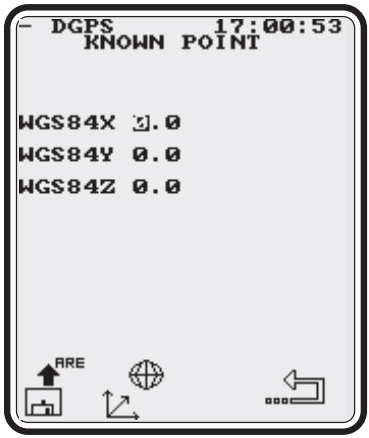
or

Initialize by pressing the F1 key. The system will change to the measuring known point mode. It shows the display `MEASURING KNOWN POINT`. Then, when successful, the known point display reappears. Its comment line will have changed from `DGPS` to `RTK` . You may register this new point measurement by pressing F2 or skip it by pressing the F3 key.

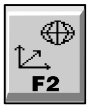
2.) Manual known point definition

Initialization via Manually Entered Coordinates

You can key in coordinates of a known point manually. Press the **F2** key. The manual point entry display will show up, allowing you to enter point information in the WGS84 coordinate system.



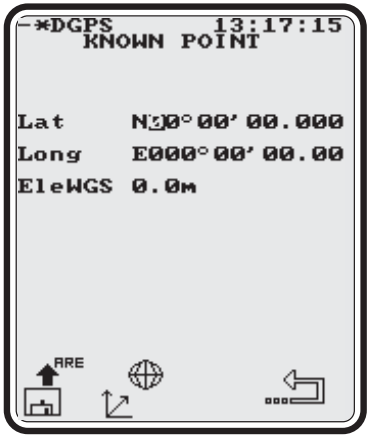
Select coordinate system

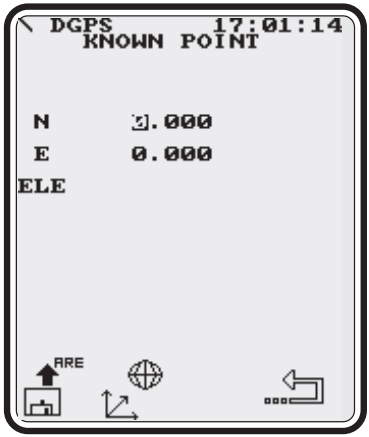


If you want to use another coordinate system press the **F2** key several times. You will see that you can toggle between the following three coordinate systems:

- WGS84 coordinates XYZ (see display above).
- Ellipsoidal coordinates within the national grid datum (see left display next page)
- National grid / state plane coordinates north, east and height component (see right display next page)

Press the **YES** key to accept each line of coordinate information. When the final line is correct, press **YES** (3rd press) to accept the position values.





When you have entered the position information, press the **F4** key in order to go back to the Known Point Measurement Display.

Go on

and

or

Now it is possible to initialize by pressing the **F1** key. The system will measure the known point, and then the headline of the display will change from DGPS to RTK. You may store this new point measurement with **F2** or skip it with the **F3** key.

The system does not distinguish between the different methods of providing the coordinates of the known point. Therefore, the procedure for measuring to initialize on known points is always the same, only the methods of how the system retrieves individual point coordinates are different.

Point distribution of area

Identification of Points and Point Distribution

The function button **F3** in the Known Point Measurement page offers the possibility to view a survey plot of the points. This helps to identify points and point distribution of the area of interest. The sketch plot facility is described in later chapters (chapters 5.5, 6.2 and App B give more detailed information on survey plots).

Return

Return to Initialization Menu

To return to the RTK Initialization Menu, press the function key **F4**.

4.2.3 Short Static RTK Initialization

Why use short static initialization

If you can not provide coordinates of a known point to the system within the survey area and if you are not able to perform a VSFB initialization, because you can not reach the reference station, an alternative method of initialization is the short static initialization.

Short static might also be used if no real RTK survey is to be performed. E.g., if the points to be surveyed are a long distance apart, or the survey task is simply to measure the coordinates of some new survey stations, a short static occupation with real time processing will be the correct GPS survey method.

In every case points measured by short static positioning have a superior accuracy than points surveyed for a few seconds within the RTK survey. This is due to extra redundancy of observations in the short static survey.

How to use short static initialization

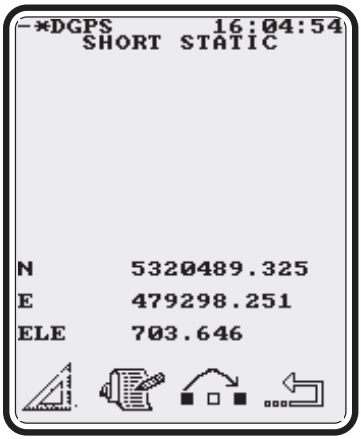
Set up rover on unknown point

In order to perform a short static RTK initialization position the rover receiver at a good point during measurement. In principle, this point could be absolutely arbitrary but we suggest that you either make a new mark or use some kind of existing mark in order that you can reoccupy the point later on. The best would be to choose a point, which you want to survey in any case. After setting up the rover on this new point you should press the **F3** key to make a short static measurement.

After pressing the **F3** key you might be prompted to confirm a job file name, depending on your U.D.S.

Enter jobfile name

Key in the jobfile name and acknowledge with the **YES** key. You will then be in the short static main display, and you will find the following:



The DGPS coordinates of the point are given. Below are the standard survey measurement icons. These are **F1** to measure, **F2** to store a measurement or measure and store if no point has been measured, **F3** to skip a measurement and **F4** to return to the initialization display.

Activate measurement

In order to start the measurement press the **F1** key. The system will now start to process all incoming data as a short static baseline. Initial information pops up.

First satellite informations

The three different values are:

Sec	Number of seconds since start of short static mode.
NSat	Number of satellites currently visible
PDOP	Current Position Dilution of Precision

New information after one minute of positioning

After an initialization phase of less than one minute additional information shows up:

Ratio	The test ratio derived from a statistical Fisher test. This value should be larger than 2 before a solution is acceptable.
Sets	The number of integer ambiguity combinations the system has to check in order to find the correct solution. The above display shows that 4471605 different solutions are possible. Only one solution is correct. In time, this number will decrease allowing the system to update solutions faster.
Prob	Statistical probability for solution in percent.

Note, that the ratio and probability will slowly improve, but will be displayed as zero when the ambiguity search parameters are being calculated. At these times the ratio and probability are not calculated.

Information after convergence of solution

When the solution is acceptable, additional information is displayed. Note, that the headline will change to `RTK`.

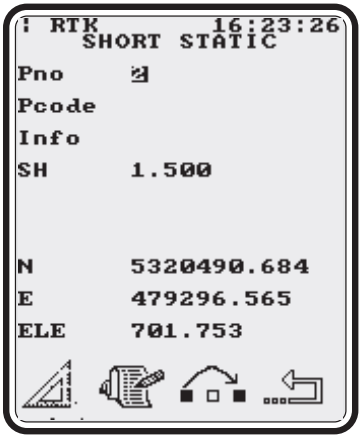
Sdev	Standard deviation of position. Change its limit in the parameter settings menu (`Sdev shst`).
sigN	Standard deviation of position in north direction.
sigE	Standard deviation of position in east direction.
sigH	Standard deviation of position in elevation.

System is improving solution until ratio of >2 is reached or until you stop it

Although a solution was found the system will continue to get data and improve the solution. You may watch the changes in accuracy, reliability and position and decide by yourself, when you want to stop the short static survey. Use **F1** to stop the survey as soon as you are satisfied with the solution.

Note: if you use the default parameter "`ShortSt: Automatic`", the short static calculation will stop when `Ratio` of 2, `Sdev` as defined (default 0.02) and `Prob` of 99.99 are reached. However, you may change the parameter to MANUAL (see chap. 7). In this case calculation goes on until you stop it by pressing F1 .

The dialog display of the short-static measurement screen pops up allowing you to enter or confirm additional point information (depending on your U.D.S.).



Go on

You may choose one of three possibilities:

1.

1. Enter point information and store with **F2** . Return with **F4**.

2.

2. Skip the measurement with **F3** and return to the main display with **F4**. The system will be initialized, but the measurements are not appended to a job file.

3.

3. Enter point information and store with **F2** . Then move on to the next short static point. When at the new point, start the short static survey again with **F1**.

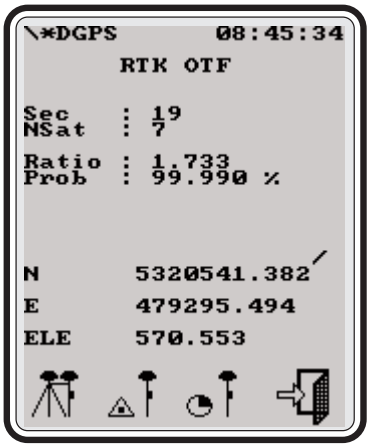
OTF initialization is the default initialization process for the L1/L2 receiver

4.2.4 On-The-Fly RTK Initialization (L1/L2 Receiver Only)

As described above the initialization of the Geotracer 2000 RTK system can be performed in different ways. All of the methods discussed so far do require static occupation of a point or position information.

However, in some applications this is not a very convenient way of surveying. Dual-frequency receivers perform initialization during movement (on-the-fly). Using the On-The-Fly (OTF) method you do not have to stop at any point. You may walk to the area of interest while initializing the system with OTF. OTF initialization is the default initialization process for the L1/L2 receiver. It is not supported for single frequency receivers. You may stop it by pressing any of the function keys, in order to use one of the previously described initialization methods or to leave the program.

The only requirement is that the rover receiver tracks five or more satellites during this OTF initialization period. As soon as the system is initialized four satellites are sufficient for surveying. During the OTF initialization the following screen with status information is displayed.



The system will accept a solution when different criteria are fulfilled, e.g., the displayed ratio value has to be > 2 and the probability of the solution has to be > 99.99%.

As soon as the criteria are fulfilled the comment in the headline will change from `DGPS` to `RTK`.

4.2.5 Working in Differential GPS-Mode (DGPS) Without any RTK Initialization

By default the RTK system requires initialization

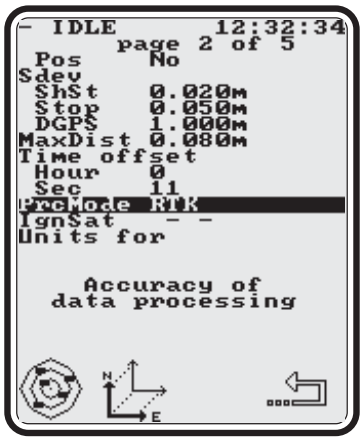
For some applications, such as GIS, it will be of interest to use the system with a lower accuracy. The system can be used without any initialization, this is called DGPS mode. However, when shipped from Geotronics the system is set up so that it will always request for an initialization procedure (RTK mode).

How to avoid initialization

In order to select DGPS mode, and therefore avoid any initialization, go to the parameter settings menu. page 2.

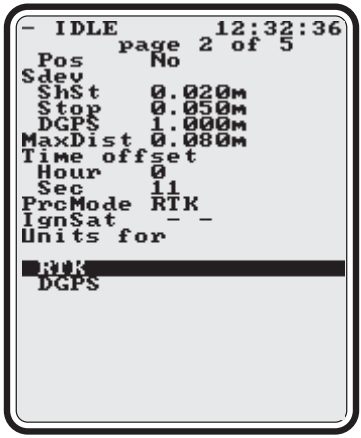
Go to parameter menu

You can enter the parameter settings menu at any time by pressing the **Shift** + **P** keys (the **Shift** key is the yellow key on the keyboard).

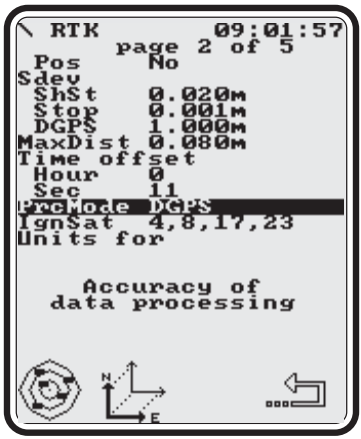


Change Process Mode

Go to the line `PrcMode` and press the YES key.



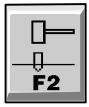
You may now change the mode by highlighting `DGPS` with the cursor keys and accepting by pressing the YES key.



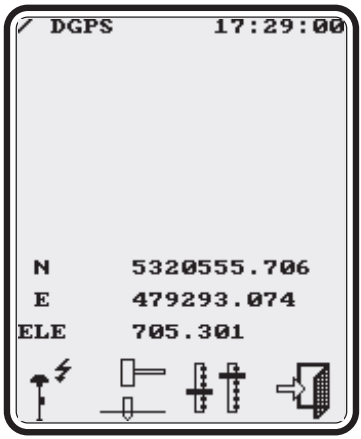
Use the F4 key to leave.

Go on

or



The main display will reappear and you can select survey with the **F1** key or stake out points with **F2** key now.



Position accuracy only in the dm - m level !

The positions registered in DGPS mode will have decimeter to meter accuracy instead of centimeter accuracy which you would be able to reach in RTK-mode. To indicate the mode in which you are working in you will find, that `DGPS` will always be displayed in the top line. This indicates, that you do not have centimeter precision in your point positioning, but you are able to use the full functionality of the system for survey, stake out, point coding and point information recording.

In DGPS mode accuracies are in the decimeter to meter level, but the full functionality of the system is usable! DGPS mode is displayed as `DGPS` in the header line.

In point surveying you will find the familiar display for point information definition, measuring and registering. It will depend on your U.D.S.

You may control the point measuring process using the parameter menu, page 2, line `Sdev DGPS` (see chapter 7). Measuring stops automatically, as soon as the standard deviation of position is equal or better than this value.

Chapter 5.

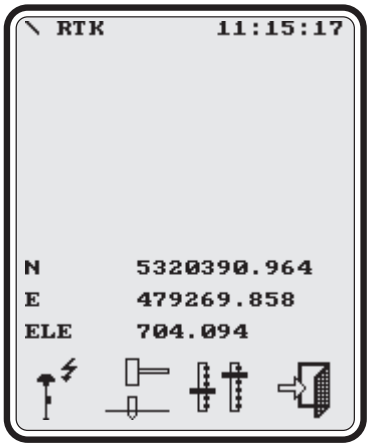
Surveying with RTK

This chapter provides information on how to perform point surveys with the Geotracer® RTK system.

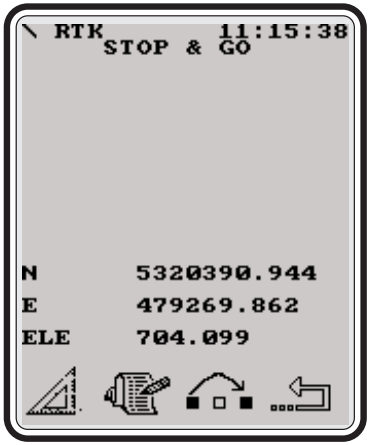
The previous chapter described how to initialize the RTK system in order to have centimeter accurate point positioning capabilities. This chapter provides detailed information on how to perform surveys.

5.1 Starting Point Surveys

We assume that initialization has been performed by one of the methods described in chapter 4. You can start a survey by pressing the F1 button when in the Mode Selection Display.



After entering survey mode with F1, the Survey Mode icons show up. These control the measurement of survey points.



Data input and display

The human interface via keyboard and display is controlled by Geotronics User Defined Sequences (U.D.S.) (see chapter 10.2). By default, an internal U.D.S. controls the data input and display, but you may create own `*.UDS` files. The default U.D.S. allows the input of information on point number, point code, point information and instrument height. It has the following structure:

0=37	North
0=38	East
0=39	Elevation
0=47	Relative North with respect to reference station
0=48	Relative East with respect to reference station
0=49	Relative Elevation with respect to reference station
0=120	Baseline component X (WGS84)
0=121	Baseline component Y (WGS84)
0=122	Baseline component Z (WGS84)
0=138	Covariance matrix element (1,1) of baseline
0=139	Covariance matrix element (1,2) of baseline
0=140	Covariance matrix element (2,2) of baseline
0=141	Covariance matrix element (1,3) of baseline
0=142	Covariance matrix element (2,3) of baseline
0=143	Covariance matrix element (3,3) of baseline
0=118	Satellites tracked
0=115	PDOP
0=132	Time span of static measurement [seconds]
0=129	Standard deviation of three-dimensional position
4=5	Point number (increment)
3=4	Point code (duplicate)
3=0	Point info (duplicate)
3=6	Signal height (duplicate)
5=79	Repeat sequence

Data will be stored according to labels and label type

All lines starting with `0=` instruct the system to measure and store data according to the labels. The default U.D.S. stores North, East, Elevation absolute and relative components for each point, baseline components in WGS84 with associated covariance matrix. Also number of satellites tracked (118), the PDOP (115), the time span of measurement in seconds

(132) and the standard deviation of the three-dimensional position will be stored. Displayed and prompted labels are point number (5), point code (4), point info (0) and signal height (6). The last line `5=79` instructs the system to repeat the sequence.

In order to survey a point you should position the rod with antenna at the point to be surveyed, make sure that the rod is hold vertically and measure by pressing the **F1** key.

Enter point information after measure-ment

When the measurement has been completed (typically 1-2 seconds) the system offers the opportunity to enter point information parameters. The default point information consists of point number, point code, point information and height of the rod.

You may make the following entries:

- Pno: the point number,
- Pcode: the point code which is used for a coding of individual description of the point
- Info: the info which you can use as a comment line,
- SH: the antenna height (signal height). You may change the antenna height at any time you are measuring a point. The antenna height is measured as TRUE VERTICAL.

As default, the Pcode, Info and SH are automatically duplicated from the previous measurement. If you are using numeric point numbers you will find that the point numbers are auto-increased by 1 at each new point. When starting with point number 1 the second point is given point number 2, etc. When a point number is made up of alpha and numeric information, the last numeric digit is auto-increased. See also chapter 5.4 on automatic point number identification.

The point number may have up to sixteen alphanumeric characters. Note however, that when you want to use the resulting job file in connection with Geotracer® GPS Postprocessing only the first eight characters of the point number will be recognized.

The point number may have up to 16 alphanumeric characters. But when using the job file in connection with Geotracer® GPS Postprocessing only the first eight numbers are accepted.

In order to change lines you can use the ▲ and ▼ arrow keys. To move the cursor within the field you can use the ◀ and ▶ arrow keys and change the individual entries according to your wishes. You may also accept values and move directly to the next line by using the YES key. You may delete values using ←Sp or Del (the combination Shift + ←Sp, see App B.3).

Enter jobfile name when registering

To store, or register the information measured and keyed in, press the **F2** key. The first time you do this within this session a display pops up prompting for the name of the job file in which the survey results shall be stored. By default, the system suggests the last used previous job file. Key in a name of a job file. The job file may have up to 8 alphanumeric characters and you will find the job file later on the PCMCIA card of your system stored as the name of the job file with the extension `*.JOB`.

If you accept the previously used job file, all new measurement data will be appended to it. If you define a new file name, the system will create a new file.

Another possibility to construct a job file is to use label type 10 (LOGON) in the beginning of your own U.D.S. (see chapter 10.2).

You may also send data to one of your field computer´s serial port . This may be done simultaneously or instead of writing to a job file. For more details refer to chapters 7 (lines `Serial output`) and 10.3.

5.2 Measuring and Registering Methods

As soon as you have entered the measuring mode using **F1** , Geotracer® RTK offers a choice of methods to measure and register points.

a) Measure a stop point with **F1** and register with **F2** (the measurements for all epochs at each stop point are accumulated and averaged until the chosen standard deviation is achieved).

b) Measure and register using **F2** (the measurements for all epochs at each stop point are accumulated and averaged until the chosen standard deviation is achieved).

c) Automatically measure and register points each time a certain time span has elapsed (measurement of one kinematic epoch).

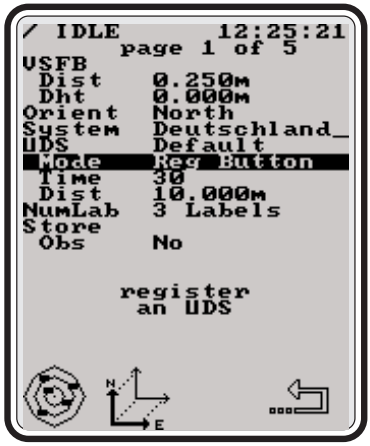
d) Automatically measure and register points regularly after a certain distance (measurement of one kinematic epoch).

e) Automatically measure and register points regularly after a certain time span or distance, whichever should be the first event (measurement of one kinematic epoch).

f) Automatically measure and register points regularly after a certain time span and distance (measurement of one kinematic epoch).

The automatic methods also allow manual measurement and registration using the **F1** and/or **F2** function keys. With above keys you can still add measurements of stop points to your job. When using one of the automatic methods, you should design your selected U.D.S. in a way, that the manual entry of information is not necessary.

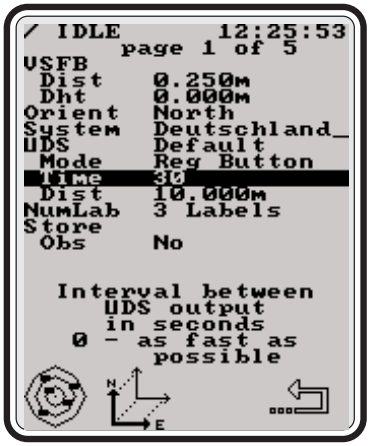
Your chosen method for survey is selected using the parameter menu, page 1, line `UDS Mode` .



The default is manual measurement and registration using the function buttons, but, you may change to any of the automatic methods at any time. Press the YES key in order to get the selection of measurement modes.

Press YES again after having highlighted one of the modes. Your selection will now be displayed. Automatic measurement and registration will start as soon as the system is in point collecting mode (either when you press F1 the next time or, if you are in measuring mode already, when you leave the parameter menu using F4).

You have a lot of control over the automatic modes: you can change the values for the time span and distance after which measurements shall take place. Note that a value of 0 means that measurements are made as fast as possible and so will depend on the update rate of your receiver.

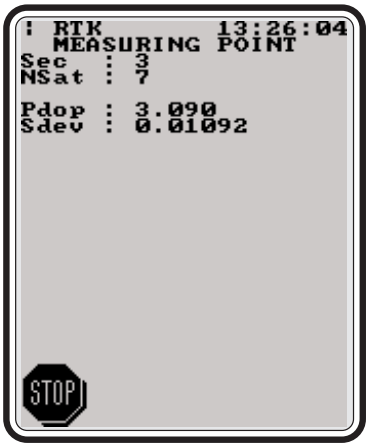


The following chapters 5.3 and 5.4 describe how to manually measure and register points.

5.3 Measuring Points

Each time you press the F1 key the following display shows that the system is currently measuring a point.

You see the number of seconds of data accumulation and the number of satellites used for processing. The next display additionally shows the current PDOP value and the standard deviation of the position.



Measurement will continue until the standard deviation is better (lower) than the value defined in the parameter menu, page 2, line `Sdev Stop` and, as long as the PDOP is lower than the value defined in the parameter menu, page 3, line `PDOP` (see chapter 7). You may change these values any time. If you are measuring in DGPS mode, the standard deviation value of line `Sdev DPGS` is used instead of `Sdev Stop`!

Interrupt measure-ment

You may also interrupt the measurement by using the stop key with the **F1** function button. The following display will be shown.

If you want to accept the measurement in spite of the higher standard deviation, press **YES** . Any other key skips the measurement.

In most conditions, the Measuring Point Display will be visible for 1 - 2 seconds. The time depends on the accuracy specified in the parameter menu (parameter `Sdev stop`), steadiness of the rod with the antenna during measurement, number and geometry of satellites, and PDOP. If you specified a high accuracy, the measurement will take up to several seconds. The measurement will continue until the specified accuracy is reached.

The system will stop measurement and, depending on your U.D.S., will prompt for additional point information when the accuracy of the newly calculated position is better than the limit you selected in the parameter menu. Normally this will happen after a few seconds of data accumulation. The coordinates displayed in the lower 3(6) lines (position display) are the measured coordinates. They can be stored, or the results can be skipped. The measured point´s coordinates are held fixed in the display until **F2** or **F3** is pressed.

Measurement failure

When the antenna is not held steady during the point survey, it may happen, that the system fails to reach the specified accuracy and a warning message will be displayed. Should that happen, make sure, that you hold the antenna steady and press the **F1** key to try again.

5.4 Registering Points

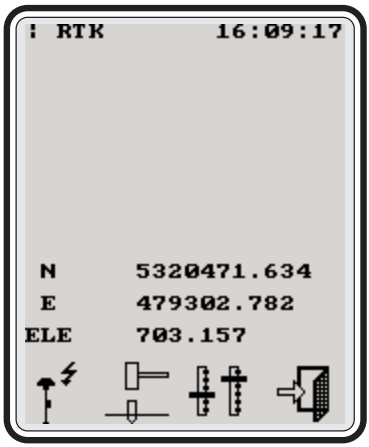
After measuring a point and entering the additional point information you may use the **F2** key to store (register) the measurement in the desired job file. As soon as you have stored the measurements, the ACU will resume showing the continuously updated coordinates of the rover receiver.

Special tip

To speed up the point survey you may use the F2 key directly (instead of first pressing F1 and afterwards F2). In this case the system measures a point and stores the results directly to the PCMCIA card following your chosen U.D.S. The system will generally not prompt for any point information, but the U.D.S. will auto-increase the point number and auto-duplicate relevant labels.

If you do not want to store the point measurement, you may use the **F3** key to skip the measurement and go to the next point or repeat the measurement. The display will return to showing constantly updated coordinates, i.e., the current position of the rover.

Press the **F4** key to leave the point survey mode. The mode selection display pops up again.

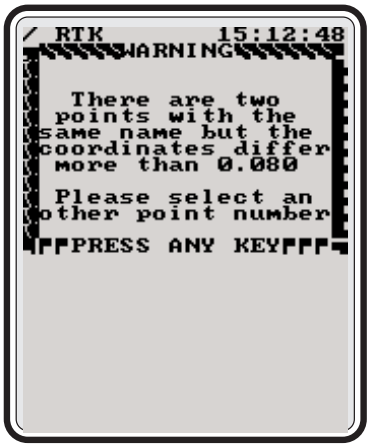


5.5 Automatic Point Number Identification

The Geotracer® RTK system is able to identify points automatically. This is a big advantage, which makes surveying even easier and error proof.

Same point number for different points not allowed!

If you enter the same point number for two different loacations, the system will give an error message.



You are not allowed to store the point number. Press any key and then change the number.

You may define the tolerance in the parameter menu. Change the value of line `MaxDist`. By default the value used is 0.08 m. If you need to store discrete points that are located close together, this value can be reduced to 0.001 m (1mm).

If you enter the value 0, no multiple point occupation is possible!

Multiple Point Occupations

If you occupy a point several times during a survey, the system will automatically recognize, that you have visited that point previously. It will display and offer as a suggestion the point number that it recognizes as being correct for the current rover position. However, you may change the suggested point number to a point number of your choice.

New position and weighted average appended

When a multiple point occupation occurs, the system will store the newly measured coordinates beside the earlier ones as a raw data measurement. It also stores a weighted mean of all measurements to that point. A remark line `99=Mean` following the point number denotes this in the job file. The mean values follow the raw data.

```
5=8
0=HIGH ST
4=MAN HOLE
6=2.000
37=5320583.177
38=479303.999
39=495.973
47=-4.126
48=-0.946
49=0.005
5=8
99=MEAN                ← weighted mean
0=HIGH ST
4=MAN HOLE
6=2.000
37=5320583.176
38=479304.004
39=495.960
47=-4.128
48=-0.942
49=-0.007
```

5.6 Survey Plot

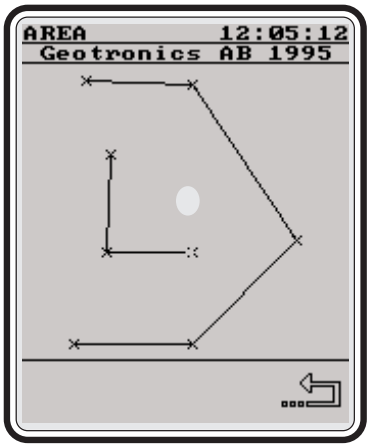
At any time you can look at a plot of your surveyed points. The plot offers a great opportunity to get a quick and easy overview of your survey.

A plot is available for points

- **surveyed in the current session (job file),**
- **listed in an area file,**
- **staked out (see chapter 6.2).**

Quick method to enter plot display

A very quick method to view the survey plot is to use the hotkey combination Shift + M.



The location of the surveyed points shows up as a map. The orientation of the map is - independent of the orientation of survey - always to the north. Points with the same point code are connected by lines. The current position of the rover receiver - independently whether measured or not - is shown by a + -shaped position mark.

When you want to leave the plot press F4. The display where you started from reappears.

Chapter 6.

Staking out (Setting out) with RTK

This chapter will explain how to stake out (set out) with the Geotracer® RTK system.

6.1 Position Information Sources

Staking out: find and mark point positions in the field

The staking out (setting out) method is used to find point positions and mark these point positions in the field. Position information sources can be:

1. Geotronics area or job files
2. Manual input via display and keyboard

Geotronics Area or Job Files

What does an area file look like?

The most convenient way to provide point position information to the Geotracer® RTK System is to use area files. Area files contain information on point positions, point numbering, code information etc.

The following is an example for an area file with point number information and point position information.

```
5=16
4=1
37=45.122
38=76.431
39=120.636
5=17
4=1
37=1.784
38=81.176
39=121.215
5=18
4=1
37=-15.828
38=0.499
39=122.094
5=11
4=1
```

The point number is coded with the label 5, so `5=16` means, that the following information relates to point number 16. The Point code is labeled `4=1`. The following three labels `37, 38, 39` represent north, east and height information for the point 16. The next line is `5 = 17` which indicates that information for point 16 has finished and that point 17 has started. All following information now refers to point 17. An area file could in principle hold thousands of point coordinates and correlated information.

Possible coordinate systems for staking out include:

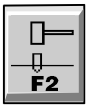
WGS84 X,Y,Z
Lat, Long, Ele
Ha, VA, Slope
N, E, h of your current local coordinate system

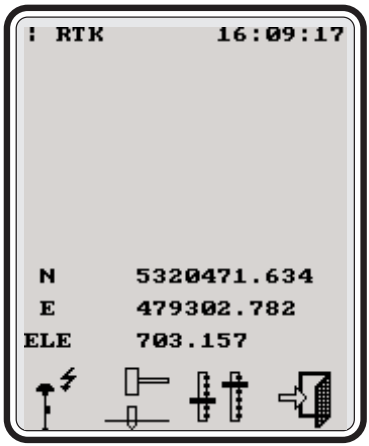
For more information on area files refer to chapter 10.1.

The Geotracer® RTK system can read all the relevant coordinates and point information from an area file and use it to stake out points.

Enter stake out mode

The staking out procedure is initiated from the following display:





Job file requested: Provided job file may be accepted or exchanged

The file to store the stake out measurements in may be an other than the position information source. Therefore, at first a display pops up, prompting for the job file name.

The jobfile name may consist of eight alphanumeric characters. If you have previously already used a job file within your current session the default value will be the last used previous jobfile name. Drive and directory of a job file need not necessarily be the same as for area files. You may select drives and directory for storing and reading in the parameter menu, pages 3 and 4.

You can overwrite that name or enter a new one.

Three different situations are possible:

- If you want to use the last previous job file you can press YES and the old jobfile name will be accepted. In that case, new survey data will be appended to the existing job file.

- You enter a new jobfile name and press YES . In that case, all measurements will be registered in this new job file.

- You do not enter a jobfile name. In that case, the system will return to the previous menu.

After entering the jobfile information the program will consider two different situations:

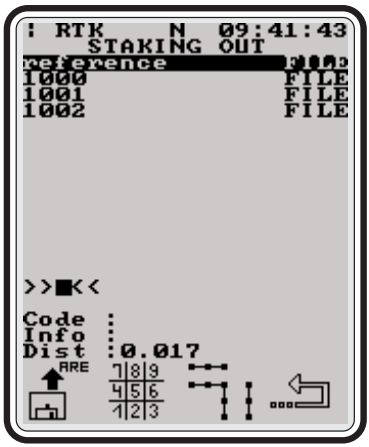
- Entering stake out mode using data from an area or job file,
- Staking out without an area or job file.

Entering Stake out Mode Using an Area File

If your PCMCIA card contains files with extension `*.ARE` the following area file selection menu will pop up:

Choose one area file of list

You can now change to the Jobfile Selector Display or select an area file of your choice and will then be prompted for the point number to stake out.



The points are displayed (scroll through using the ▲ and ▼ keys!) in order according to the distance to your current position. The first point in the list is the nearest. The text at the end of each line informs you, whether the point was measured (`MEAS`) or positions are derived from a file (`FILE`). Point Code, Point Info (both, if available) and distance between the highlighted point and your position are displayed in the position window above the icons. If you enter the first character of a point number, the list will be sorted numerically and alphabetically.

Sorting procedure may be changed

If, however, point lists are very large, sorting by distance may take some time. Therefore, the system offers the possibility to switch off one or both of the sorting procedures. This is done in the parameter menu, page 5, line `Sort` (see chapter 7).

Choose a point to stake out

After selecting a point the RTK system guides you to its location with the graphic display.

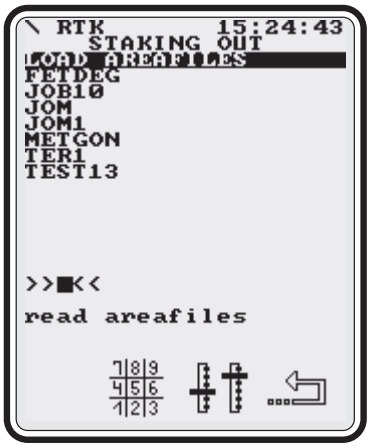
Repetition of area file selection

If you notice that you chose the wrong area file when you view the list of points, you can press the **F1** key in order to go back to the area file selection menu.

Entering Stake out Mode Using a Job File

Load job file

If your PCMCIA card also contains job files, you may load any of these. Move the highlighted bar to the line `LOAD JOB FILES` and press YES. Again a file selector menu pops up, containing your job files.



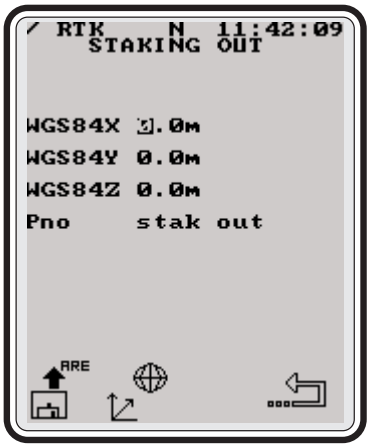
The first line LOAD AREA FILES allows to return to the Area File Selector. Scroll through the job files using the ▲ and ▼ keys until you find the desired file. Press YES again and the Point Selection Menu will pop up.

You can use the F1 key again to switch to the area file selection menu. From that situation the program flow is identical to the program flow described in the first case.

Manual point position input

Staking out Without Area File and Point Information

If you press **F2** or no area or job file is available you will automatically enter the manual point position input which is shown below.



Choose coordinate system

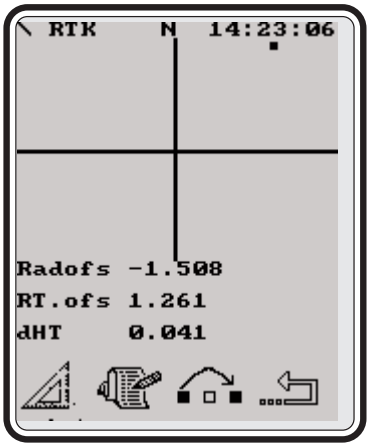
You may switch between three different coordinate reference systems by using the **F2** key. The three different coordinate systems are (see chapter 9.1 - 9.3) :

1. the local north, east, elevation system,
2. the latitude, longitude, elevation system,
3. the global WGS84 system with geocentric cartesian coordinates.

Enter the coordinates using one of these coordinate systems and enter a point number. The point number may have up to 8 digits and will allow you to identify the point later on. Then, the RTK program will switch to the graphic stake out display.

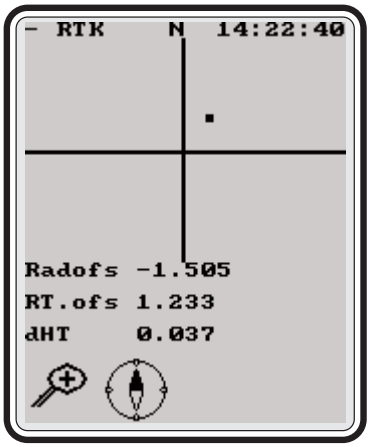
6.2 Graphic Guidance to the Point to Stake out

Having entered the stake out mode and provided coordinates of a point to be staked out, the RTK system will switch to the graphic stake out display. A graphic cross and a square occupy the upper part of the screen, while the position window displays the coordinates of your current position. The values are constantly updated until you have staked out and measured a point. Updates will resume after you have registered or skipped the measurement.



At the bottom you find the familiar icons, representing the function keys. The function of the four icons is the same as in surveying mode.

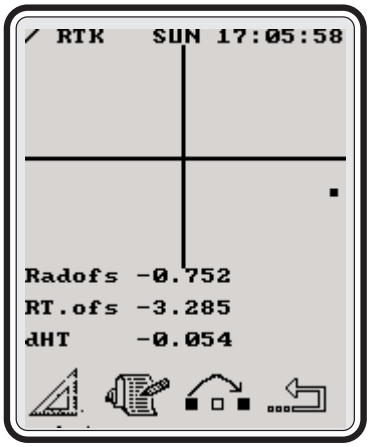
However, in the stake-out mode you will find two specially created extra icons. The RTK system offers 6 different functions in total. You can toggle between the set of the four familar functions and a set of two special functions. Press the YES button and you will find the two other icons :



The function of the two function keys F1 and F2 is now the following:

Zoom in manually - the square jumps to outer edge. The scale of the display increases.

Change the orientation of the graphics (see below). The orientation is displayed in the middle of the topline.



Graphic display:

Graphic cross = operator´s position

Square = point to stake out

The center of the graphic cross on the screen represents your current position, whereas the small square moving on the screen represents the point to be staked out. The first thing you should do is to orientate the control unit so that the display points to your reference direction. By default the reference direction is the north direction. You may change the orientation at any time. This will be described in more detail below. For the example above the sun was chosen as reference (`SUN`).

Alpha-numeric display:

Information may be changed

In addition to the graphic display you will also find digital information showing the descrepancies between the current position of the rover and the points to be staked out. By default the system gives you information about

- the radial offset,
- the right angle offset to the line from the mobile receiver to the reference point and
- the horizontal distance to the point.

However, you can independently define the whole label display and set it up in file `LABEL.LAB`. Block `#Staking out` defines the values displayed before measurement, block `#Measure Staking out` defines the values displayed and written to the job file when registering. This equals to the user defined output table of a Geodimeter total station.

```
#KINEMATIC
37
38
39
40
41
42
7
8
9
110
111
112

#Staking out
72
73
75
5
119
120

#Measure Staking out
133
134
75
5
72
73
```

The labels given under the header line `#Staking out` will be displayed during staking out either in a block of three variables or six variables depending on the settings in the parameter menu (see chapter 7). If more labels are chosen in the `LABEL.LAB` file than are displayed on the screen you may use the PG↑ and PG↓ keys in order to switch between the different blocks of labels to be displayed during staking out.

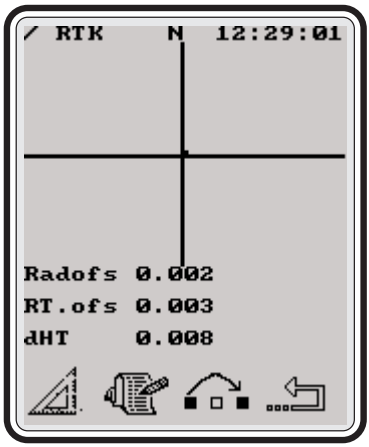
Goal of staking out

The goal in staking out is now to move the mobile rover receiver so that the graphic cross moves to the small square representing the point to be staked out.

Please note that during movement to the point the display zooms in dynamically. But you may zoom in manually, too.

As soon as you have reached the point with the required accuracy you should mark the point in the field, and then (in order to double check the position you have staked out) you should put the rod at the point and measure with the F1 key.

The following display depends on the set of labels you selected in the LABEL.LAB file. You may page through the given list of labels using the PG↑ and PG↓ keys. After you have measured, the system will stop updating the coordinates and hold the measurement results.



Refinement of position

If you wish to refine your position you may again mark the point and measure it with the F1 key. If you are satisfied with the solution, you may record the result and the deviations from the points to set out with the F2 key.

If you do not want to store the measurement skip it. Press F3.

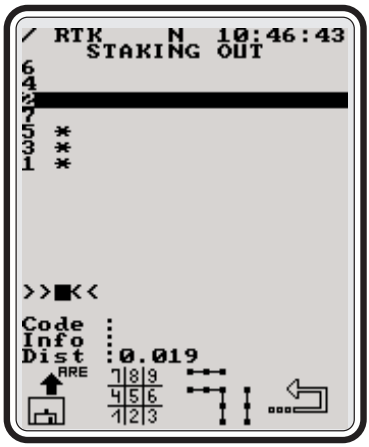
As in the survey mode, you may skip display of the measurement with F1 and instead, both measure and store by pressing F2 .

Next point

After pressing the F2 or F3 key a point selection menu will show up again. By default, the system will suggest the nearest point to the current receiver location as the next point. This is in order to optimize the staking out task by minimizing the distance travelled between stake out points.

The point you have just staked out and all points staked out previously are marked with an asterisk.

You will also find, that all points already staked out are moved to the end of the list in the point selection menu.



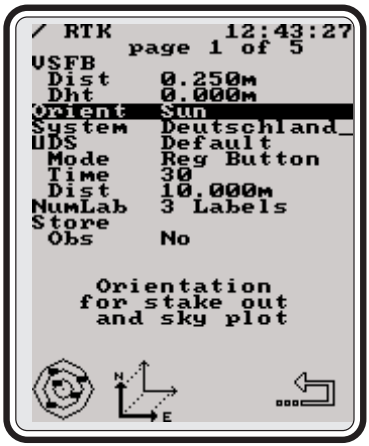
Orientation possibilities

Orientation of the Stake out Graphics

The stake out graphics can be orientated in many ways. This is so that you can choose one that is convenient for your current survey situation. You can define the orientation with the F2 key of the Graphic Staking out Display. But first, press YES. Only the icon bar will change. Now press the F2 key, and a window pops up offering all selectable orientation directions.

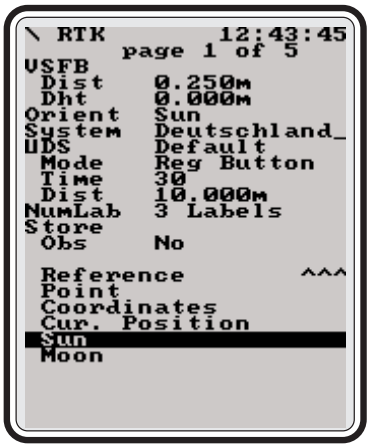
The parameter menu offers another possibility to change the orientation direction. In order to switch to the parameter menu you may use the F3 key from most displays. If the icon is not available, you can always use the hotkey combination Shift (yellow key) + P .

The following display will then appear:



Orient

Move the highlighted bar of the Parameter Menu to the `Orient` line and press YES. In the lower part of the display you will now find a selection of all available options for the orientation direction.



Orientation to North South East West

The directions easy to understand are the north, east, west and south directions. However, in some situations these directions are not known. Geotracer® RTK therefore offers a much wider choice including some which can be of much more use in such situations.

Orientation to the Reference Station

Orientation to Reference station

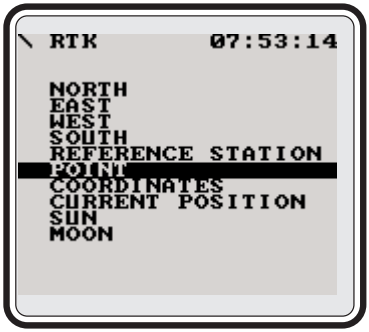
When you are working in a small area the reference station might be very well visible. In that case you should use the reference station as reference orientation for staking out. When doing that you should always have the display of the ACU pointing towards the reference station.

Orientation to a Given Point

Orientation to Point

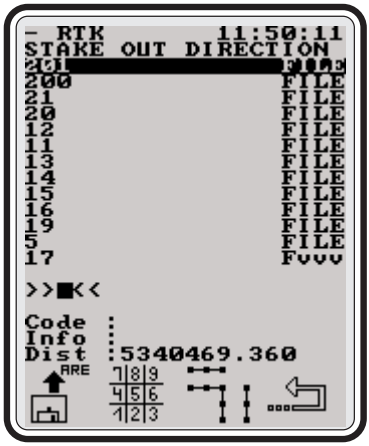
You may have a situation where you do not have the reference station in view and instead, want to use a local point whose coordinates are known, and which is visible from many places.

In order to use a known, local point, you should move to line POINT within the orientation selection menu, and press YES.



The display will now list all area files of your current drive and directory to be read and you can choose the one that contains the point.

After selecting the area file, all points in that file will be listed and you can now select the point which you want to use for your reference position.



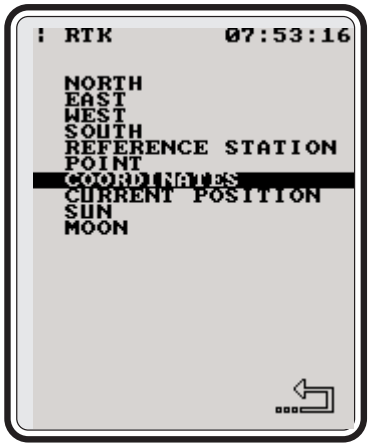
You can switch back to the area file list at any time (press F1 !) and search for all available point information in the area and job files until you have found the point you want to use for your reference orientation. In order to accept a point press YES in the point selection menu and you will be prompted back to the parameter menu.

In practice, the chosen point should be marked in the field in order to make it possible for you to see the point's location from any point within the area where you want to stake out points.

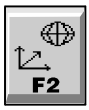
Orientation with Respect to Manually Input Coordinates

Orientation to Coordinates

In cases where you do not have any point position information in area files you can enter point coordinates manually via the keyboard. In that situation you should choose the `Coordinates` entry in the orientation selector.



The system will prompt for the coordinates to be entered in the north, east, elevation coordinate system. If you want to provide coordinate information in another system you can use the **F2** key to switch between three different coordinate systems. The entered coordinates will then be used for the reference direction in staking out.

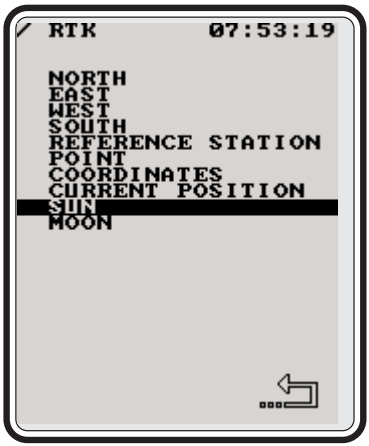


Make sure that the coordinates you entered refer to a point that is clearly marked, so that you are sure, that you are using the correct point for your reference orientation.

Orientation with Sun and Moon

Orientation to Sun Moon

In some situations it may happen, that you can not use any of the above described orientation options. In order to supplement these orientation schemes we have provided in the Geotracer® RTK system a possibility to use the sun and moon as objects for orientating the graphic display in the stake out mode display and in the sky plot.



After selecting Sun or Moon in the orientation selector the previous display reappears straight off.

Sun and Moon do not require any other information since the system knows the current position on the earth and the location of sun and moon with respect to this position.

Current Position as Reference Point for Orientation

Orientation to Current position

When you are in stake out mode you can also use the current rover receiver position as reference point for orientation in the stake out. This allows you to use any new point in your survey area as your reference orientation point. You simply mark the point and measure it in the stake out mode.

In order to change the reference orientation to the current position select the entry act `Current position` from the orientation selector. The current position of the mobile, rover receiver will then be mesured and used for orientation as long as you are not redefining the orientation scheme by selecting another entry of the orientation selector.

If you are still in DGPS mode (e.g., before initializing the RTK system), but have selected RTK processing mode, a warning will appear: `The system is not in the accuracy mode you selected. The position coordinates might be wrong.` This warning might be ignored, if the accuracy of the orientation derived with a DGPS measurement should be sufficient for your application.

The Survey Plot

When staking out you may want to look at the layout of the points from an area file or from survey. Again the survey plot of the Geotracer® RTK system offers a great opportunity to get a quick and easy overview of your survey.

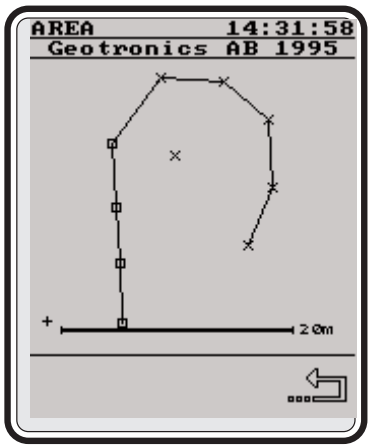
A plot is available for points

- **surveyed in the current session (job file),**
- **listed in an area file,**
- **staked out.**

The plot function allows you to

- graphically display the points already staked out,
- identify which of the points to be staked out have not yet been done,
- investigate that all points which are necessary for the project you are working on have been staked out.

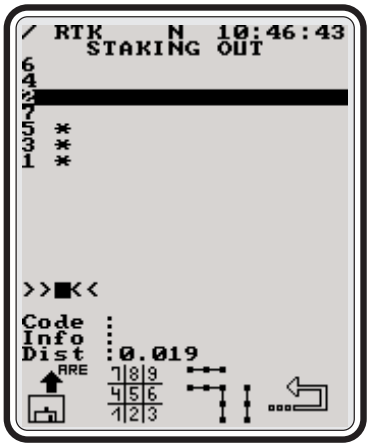
A very quick method to view the plot display at any time of your survey is to use the hotkey combination **Shift** + **M**.

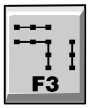


The location of the surveyed points (**M** stands for **M**easured) shows up as a map. The orientation is - independent of the orientation of survey - always to the north. Points with the same point code are connected by lines. Points already staked out are marked with a square, while other points of the area file are marked by an x. The scale is indicated at the bottom of the display.

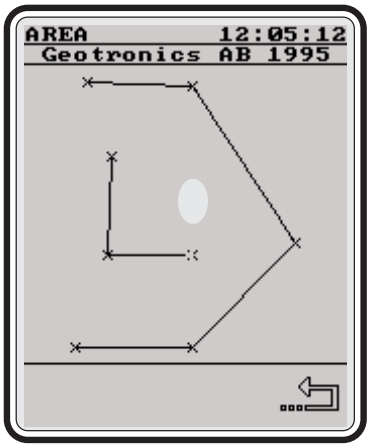
X-shaped point marks represent points which were not yet staked out, squares mark points already staked out, and the current position of the rover is +-shaped, independent of whether staked out or not.

As an additional option you may enter a plot of your area file in the Point Selection Display.





Enter the survey plot with function key **F3**.



This plot is a little bit different from the one discussed before. Here you find only points saved in your area file. Points with the same point code are connected by lines.

Leave area plot display

When you want to leave the plot, press **F4**. The display where you started from reappears. That may be the Point Selection Display or any other display, if you had used the **Shift** + **M** hotkey combination.

Chapter 7.
Parameter Settings

The parameter menu can be reached in most menus via the F3 key or via the hotkey combination Shift + P . It allows you to define and modify all system related parameters. It is divided into pages. In order to select the available parameters, use the ▲ and ▼ keys. The cursor will then scroll through the display allowing you to edit all parameters by then pressing the YES key. The PG↑ and PG↓ keys allow scrolling the pages, the 1 ... 9 keys allow the direct selection of a page.

If the full name of a parameter is too long to be displayed, the ▶ and ◀ keys can be used to display the full name by scrolling left or right.

In this chapter you will find a complete description of all user-defined, editable parameters, in the same order as they appear in the Parameter Settings Menu.

1

VSFB - Dist : VSFB Distance

To perform a VSFB (Very Short Fixed Baseline) measurement to initialize the Geotracer® RTK system (see chapter 4.2.1) you have to define two parameters, distance and difference in height (the system calculates the azimuth of the VSFB automatically).

The parameter `VSFB Dist` allows to define the horizontal distance between the phase centers of the two antennas used to initialize with the VSFB.

The default value of 25 cm refers to the Geotracer® VSFB device containing a built-in compass. The VSFB device without compass has a length of 30 cm.

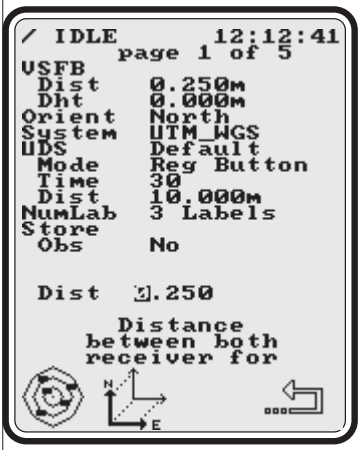
If you want to use your own design of VSFB, enter the horizontal distance between the phase centers of both antennas. An accuracy of ±1 cm is sufficient to initialize the system.

1

How to change the VSFB length (distance) ...

Use the ▲ and ▼ keys to move the highlighted bar to `Dist`below `VSFB`.

Press the YES button.



You may now enter the new value and accept it by pressing the YES button again.

If you do not want to make any changes, cancel with NO.

1

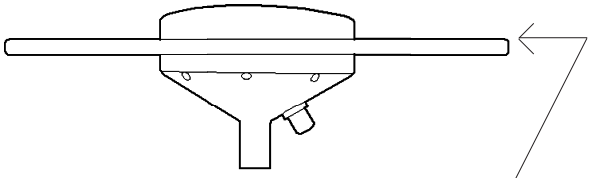
VSFB - Dht : VSFB Height Difference

To perform a VSFB (Very Short Fixed Baseline) measurement to initialize the Geotracer® RTK system (see chapter 4.2.1) you have to define two parameters,distance and difference in height. The system calculates the azimuth of the VSFB automatically.

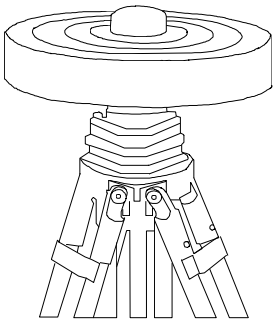
You may enter a difference in height between the phase centers of the two antennas. If you use a compact antenna, the line at which the white colour changes to orange exactly marks the antenna instrument height.

An accuracy of ±1 cm is sufficient to initialize the system, so it will be easy to estimate the height difference. Adjust the telescopic rod so that the height difference is within one centimeter. This improves speed and accuracy of the initialization.

The height difference value has a positive sign if the rover antenna is higher than the reference antenna, a negative sign if the rover antenna is lower than the reference antenna!



Geodetic antenna with ground plane

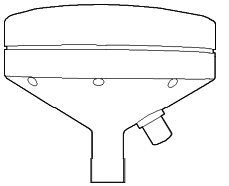


INST.HGT, SIGNAL HGT for height difference

Choke ring antenna

1

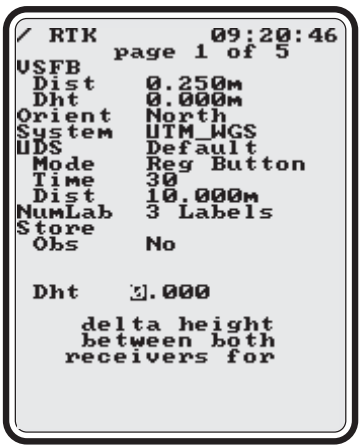
Compact antenna:



INST.HGT, SIGNAL HGT for height difference

How to change the VSFB height difference...

Use the ▲ and ▼ keys to move the highlighted bar to the line `Dht` below `VSFB`. Press the YES button.



You may now enter the new value and accept it by using the YES button again.

If you do not want to make any changes, cancel with NO.

1

Orient : Orientation

When using a graphical display within the Geotracer® RTK system, you have to know its orientation. Graphical displays are used to provide Sky Plots and to provide a guide to reach points in the staking out mode. The Survey Plot, however, like a map is always orientated to the north. To use the system, aim the ACU at the chosen reference point or direction. The chosen reference method is indicated at the top of the display.

Available orientation directions are:

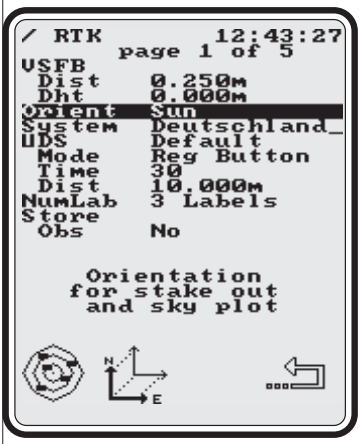
Entry	Orientation to
North (N)	the north,
South (S)	the south,
East (E)	the east,
West (W)	the west,
Reference Station (REF)	the reference station,
Point (PO)	any point, whose accurate position is known and available in a file. Select file and point number.
Coordinates (CO) (CP)	a point, whose accurate position is known, but not available as file entry. Enter Coordinates manually.
Current position	a point whose position is not known. Mark your current position, then stake out.
Sun (SUN)	the sun. The system calculates the current position on the earth and the location of the sun with respect to this position.
Moon (M)	the moon (if you want to work by night). The system calculates the current position on the earth and the location of the moon with respect to this position.

1

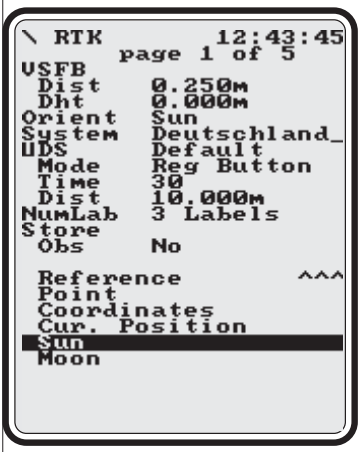
F2

The orientation parameters are also available directly from the stake out mode. Just press YES and then the F2 button. A display will appear offering all selectable orientations (see chapter 6.2).

How to change the Orientation direction...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Orient`. Press the YES button.



You may now choose the new orientation direction by using the ▲ and ▼ keys to move the highlighted bar. Press the YES button to accept the choice. The new orientation direction will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

Do not hesitate to change orientation during work. To do so might be very useful when doing staking out on long distances.

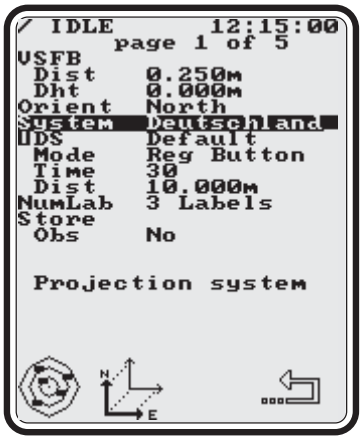
1

System : Coordinate System

All coordinates that the RTK system computes are in the WGS84 coordinate system. However, you may also want to work in your national grid system or in a purely local reference system. For more information on selectable coordinate systems please refer to to chapters 8 and 9.

The parameter `System` allows you to instruct the program which coordinate system should be used for registration of point information in the `*.JOB` file, display or read-out of a `*.JOB` or `*.ARE` file.

How to change the reference system...



Use the ▲ and ▼ keys to move the highlighted bar to the line `System`. Press the YES button.

1

A new window appears, allowing you to select the names of

Datum	a (national) datum system
Ellipsoid	an ellipsoid type
Projection	a projection type(national grid coordinates)
Zone	a zone / part of a national grid
or	
Local Transformation	a user defined transformation into pure local coordinates.

Move the highlighted bar to the item you want to change and press the YES button. You may now choose a name out of a list or enter a new name. Additionally, you may add new coordinate systems or change the transformation parameters of already existing systems. A complete description of this feature is given in chapter 8, and the theoretical background on coordinate systems in chapter 9.

Press the YES button to accept the entries. The new coordinate system will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

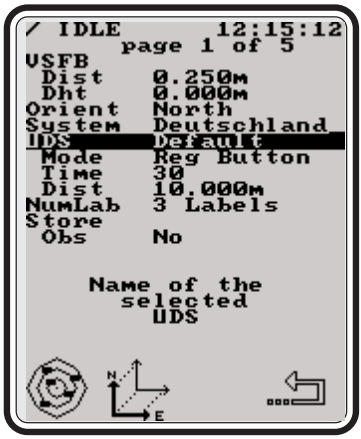
1

UDS : U.D.S. File

Geotronics designed and developed U.D.S. (User Defined Sequences) are a powerful tool for highly efficient surveying. A default U.D.S. is implemented in the Geotracer® RTK Program, but may be replaced by any `*.UDS` file you have created and stored. How to create a `*.UDS` file is explained in detail in chapter 10.2.

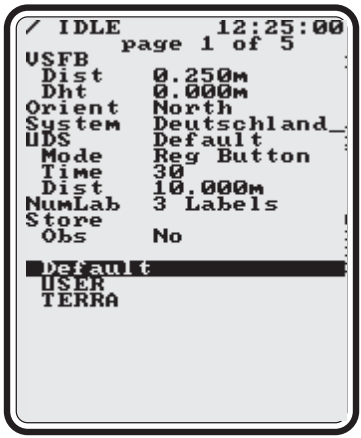
The parameter `UDS` allows you to choose a `*.UDS` file from all files stored on your Control Unit in subdirectory `RTK\USERPROG`. Your selected `*.UDS` file will be used for your current application. It will be replaced as soon as you choose another `*.UDS` file.

How to choose a `*.UDS` file...



Use the ▲ and ▼ keys to move the highlighted bar to the line `UDS`. Press the YES button.

1



You may now choose the new file name by using the ▲ and ▼ keys to move the highlighted bar. `Default` is the name of the default U.D.S. as described in chapter 10.

Press the YES button to accept the choice. The new U.D.S. will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

Using the hotkey combination Shift + U will enter the list of U.D.S.s without opening the parameter menu first.

1

UDS - Mode: Mode of applying U.D.S.

The Geotracer® RTK Program uses `*.UDS` files to control data collection. In survey mode, data collection may be done automatically after a certain time span or distance and/or manually by using the F1 key (see chapter 5.2).

The parameter `UDS Mode` allows you to choose one of the following options:

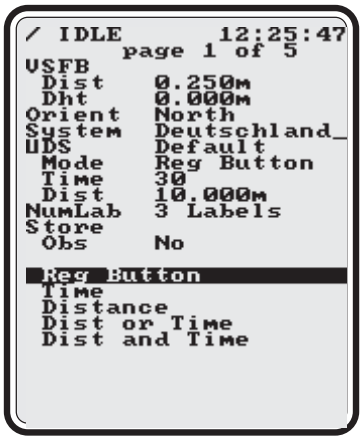
Reg Button	Measure a stop point with F1 and register with F2 or measure and register using F2 . No automatic measurement or registration is possible.
Time	Automatically measure and register points each time the last measurement is older than the number of seconds set in parameter `UDS Time`.
Distance	Automatically measure and register points each time the distance to the last measurement is bigger than the value in meter/feet defined in parameter `UDS Dist`.
Dist or Time	Automatically measure and register points each time one of the options above is true.
Dist and Time	Automatically measure and register points each time both options are true.

The automatic methods additionally allow manual measuring and registering using the F1 and/or F2 function keys. With that you can add conventional stop points to your job.

1

How to choose the UDS Mode ...

Use the ▲ and ▼ keys to move the highlighted bar to the line `Mode` below `UDS`. Press the YES button.



You may now choose one of the modes by using the ▲ and ▼ keys to move the highlighted bar. The default is `Reg button` .

Press the YES button to accept the choice. The new measuring mode will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

1

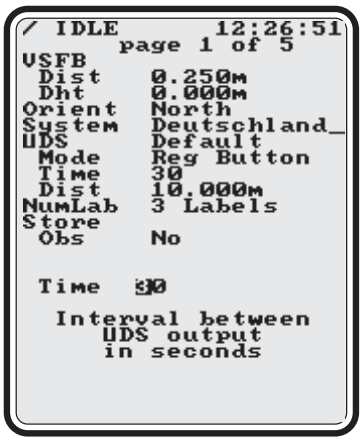
UDS - Time / Dist : Time and Distance for U.D.S Mode

Time: Defines the time to elapse between two automatic data measurements. A value = 0 defines that data is collected as fast as possible, depending on your receiver. Unit: Seconds.

Dist: Defines the distance after which an automatic data measurement shall take place. Unit: Depends on the setting in parameter `Unit Length`.

How to choose the UDS Time or Distance ...

Use the ▲ and ▼ keys to move the highlighted bar to the line `Time` or `Dist` below `UDS`.
Press the YES button.



You may now enter a value for time or distance.

Press the YES button to accept the choice. The new value will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

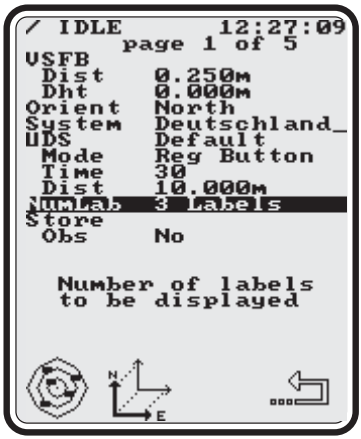
1

NumLab : Number of Labels

The last 6 lines of the screen above the icons are reserved for label display information. Each line displays one information item. Of course, there might be more information measured than can be displayed within 6 lines. In such cases the PG ↑ and PG ↓ keys allow you to switch through all the point information available.

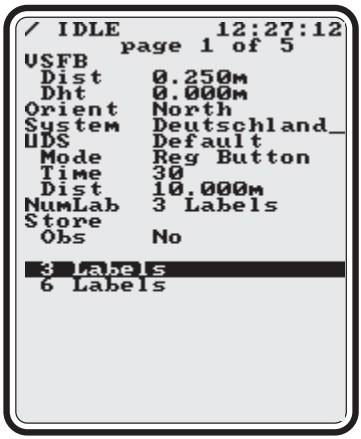
This option allows you to decide whether you prefer 3 or 6 items to appear in the display. 3 items with blank lines in between may be easier to look at, but 6 items allow you to display more information per window.

How to change the number of labels displayed...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Num Lab`. Press the YES button.

1



You may now choose the number of lines to be displayed by using the ▲ and ▼ keys to move the highlighted bar. Press the YES button to accept the choice. The new number will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

1

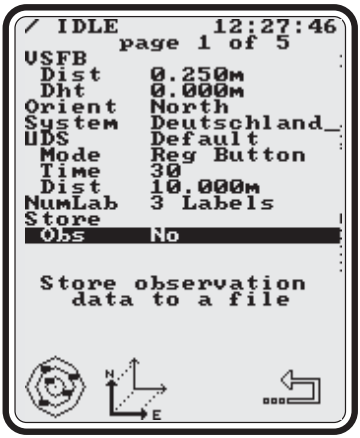
Store - Obs : Store observations

The Geotracer® RTK system offers the possibility to store raw measurement files for postprocessing in binary files named *.OBS. This will happen when Store Obs in the parameter settings menu is set to Yes. The RTK system will store both the reference and the rover data. This creates very large data files. The observation interval is 1 second.

If you use the system continuously for a long time, a new observation file will be started every 6 hours or at 0.00.00 o´clock on sundays (according to the time selected).

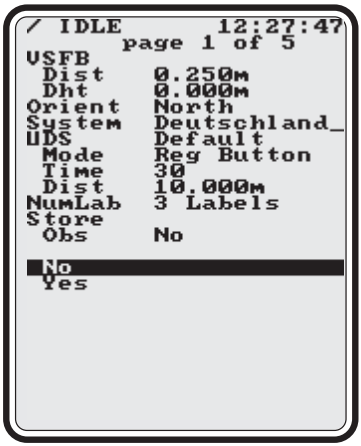
*.OBS files are the standard format in the Geotracer® GPS product line for the postprocessing process. You may also create RINEX files from the *.OBS files using Geotronics software.

How to store raw observational data...



Use the ▲ and ▼ keys to move the highlighted bar to the line Obs below Store. Press the YES button.

1



You may now choose whether to store observations by using the ▲ and ▼ keys to move the highlighted bar to `Yes` or `No`. Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

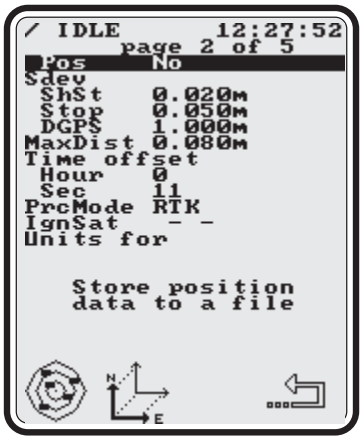
2

Store Pos : Store positions

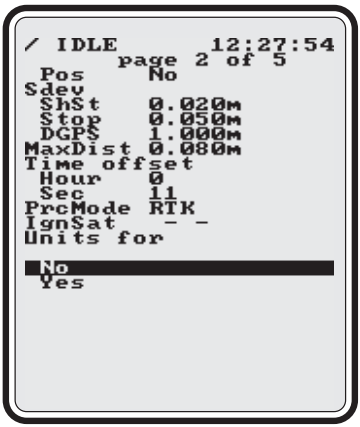
The Geotracer® RTK system offers the opportunity to store position files named *.POS containing positions for each epoch. This storage takes place continuously as soon as you set the line Store Pos in the parameter settings menu to Yes.

*.POS files are the standard continuous kinematic result format used in the Geotracer® GPS postprocessing software.

How to store positions...



Use the ▲ and ▼ keys to move the highlighted bar to the line Pos below Store. Press the YES button.



You may now choose whether to store positions by using the ▲ and ▼ keys to move the highlighted bar to yes or no. Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO.

2

The `*.POS` file has the following structure:

```
Time (sec)     Lat           Lat           Height     sig_e     sig_n     sig_h     PDOP    #   mode

381612.999545  48.022137635  11.720957947  759.162    0.005     0.005     0.005     2.9     5   DGPS
381613.999546  48.022137618  11.720957954  759.161    0.005     0.005     0.005     2.9     5   DGPS
381614.999546  48.022137645  11.720957935  759.160    0.005     0.005     0.005     2.9     5   DGPS
381615.999546  48.022137659  11.720957956  759.160    0.005     0.005     0.005     2.9     5   DGPS
381616.999547  48.022137648  11.720957945  759.161    0.005     0.005     0.005     2.9     5   DGPS
381617.999547  48.022137670  11.720957923  759.157    0.005     0.005     0.005     2.9     5   DGPS
381618.999547  48.022137673  11.720957952  759.159    0.005     0.005     0.005     2.1     6   RTK
381619.999548  48.022137667  11.720957945  759.158    0.005     0.005     0.005     2.1     6   RTK
381620.999548  48.022137685  11.720957979  759.159    0.005     0.005     0.005     2.1     6   RTK
```

The time is given in seconds of the GPS week, the geographic latitude and longitude are given in decimal degrees and the ellipsoidal height is given in meters. Please note, that the positions refer to the reference system and the ellipsoid chosen in the parameter setting `System`. The standard deviations for north (`sig_n`) east (`sig_e`) and height (`sig_h`) are given in meters. Immediately to the right of the PDOP each column contains the number of satellites used to determine the position and the measuring mode.

2

Sdev - ShSt : Standard deviation in short static mode

You may choose the maximum error of the position computed and accepted in a short static measurement. Enter a value for the maximum error. Data collection in short static mode will continue after successful ambiguity fixing until the estimated position error improves below this value.

Minimum value allowed is 0.001 m.

How to change the standard deviation definition...

Use the ▲ and ▼ keys to move the highlighted bar to the line `ShSt` below `Sdev` . Press the YES button.

You may now enter a value. When the standard deviation gets below this value, the measurement will stop. Its unit depends on the entry in `Unit` in the Parameter Menu. Press the YES button to accept the value. The value will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

2

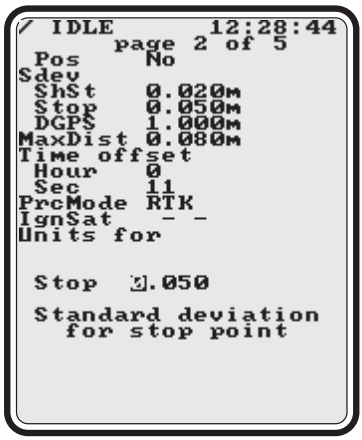
Sdev - Stop : Standard deviation at stop point

This setting determines the desired accuracy of the position computed for a stop point in either surveying or staking out mode. The static measurement will continue until the required standard deviation is obtained.

Minimum value allowed is 0.001 m.

How to change the standard deviation definition...

Use the ▲ and ▼ keys to move the highlighted bar to the line `Stop` below `Sdev` . Press the YES button.



You may now enter a value. When the the standard deviation gets below this value, the measurement will stop. Its unit depends on the entry in `Unit` in the Parameter Menu. Press the YES button to accept the value. The value will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

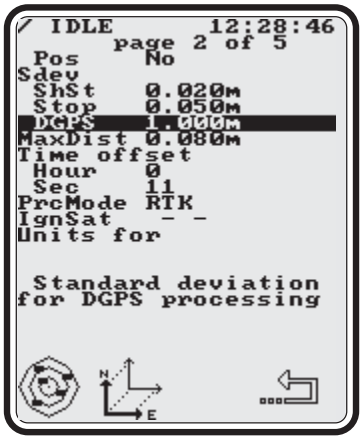
2

Sdev - DGPS : Standard deviation for DGPS mode

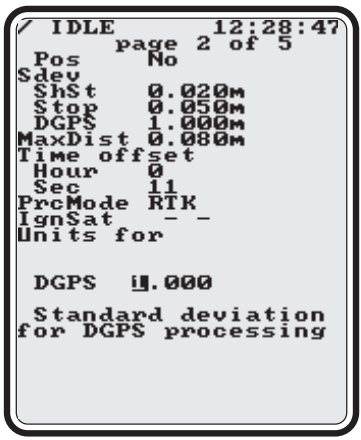
This setting determines the desired accuracy of the position computed for a stop point if you are using the less accurate DGPS mode.The static measurement will continue until the required standard deviation is obtained.

Minimum value allowed is 0.05 m

How to change the standard deviation definition...



Use the ▲ and ▼ keys to move the highlighted bar to the line `DGPS` below `Sdev` . Press the YES button.



You may now enter a value. When the accuracy improves and gets below this value, the measurement will stop. Its unit depends on the entry in `Unit` in the Parameter Menu. Press the YES button to accept the value. The value will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

2

MaxDist : Maximum distance

The Geotracer® RTK system considers two points to be identical, if the computed distance between positions does not exceed a certain value. This distance value is by default 8 cm (0.08m).

This value is used when considering the automatic identification of revisited stop points, acceptance of known point initializations and acceptance of multiple measurements for one point (multiple point occupation).

You may enter any distance. A value of 0 does not allow multiple point occupation.

How to change the maximum distance definition...

Use the ▲ and ▼ keys to move the highlighted bar to the line `MaxDist`. Press the YES button.

2

You may now enter a value for the maximum distance between two positions to be considered the same point. The unit depends on the entry in `Unit` in the Parameter Menu. Press the YES button to accept the value. The value will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

2

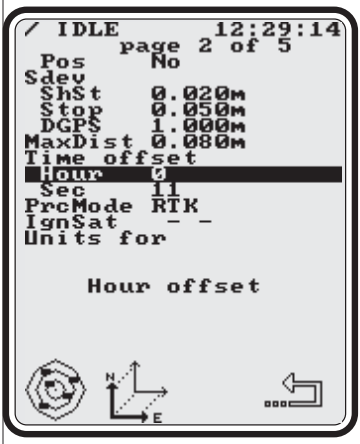
Time offset - Hour : Time offset - Hours

GPS measurements are given in GPS time, but your local time may differ by several hours from GPS time.

GPS time is almost the same as UTC (GMT) and differs by only some seconds. You may change differences in seconds in the setting `Time offset Sec`.

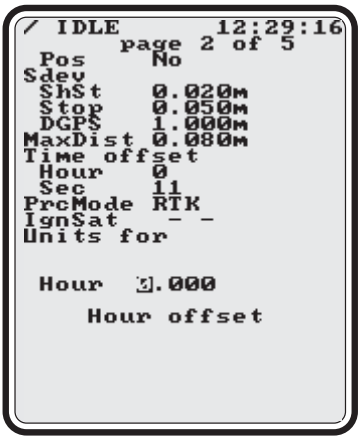
E.g., for Central European Time (CET), choose value +1 (hours), on daylight saving +2 (hours).
Eastern Standard Time EST would be -5,
Eastern Daylight time EDT -4

How to change the Time offset - Hour ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Hour` below `Time offset`. Press the YES button.

2



You may now enter a value for the time difference to GPS time in hours. Press the YES button to accept the value. The value will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

2

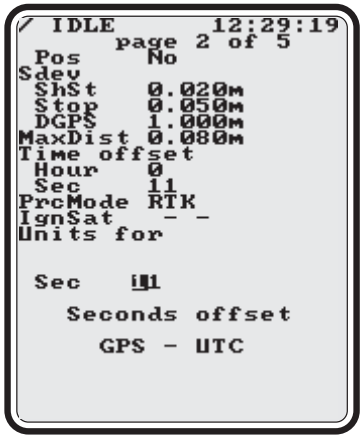
Time offset - Sec : Time offset - Seconds

Time offset of GPS time to UTC (GMT) time in seconds. The difference is caused by defined leap seconds for UTC and is currently (Summer 1996) 11 seconds.

The default value of this setting is the number of leap seconds valid when the RTK is delivered. The value is positive.

How to change the Time offset - seconds ...

Use the ▲ and ▼ keys to move the highlighted bar to the line `Sec` below `Time offset`.
Press the YES button.



You may now enter a value for the leap seconds from GPS time to UTC. Press the YES button to accept the value. The value will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

2

PrcMode : Processing Mode

You may choose between two RTK processing modes.

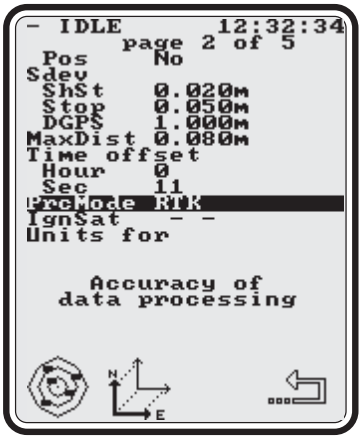
DGPS mode needs no initialization and gives an accuracy of one meter or better. This is the correct choice for faster, but less accurate positioning. It is the default value before initialization, and after initialization is lost. If you use DGPS mode, the DGPS standard deviation definition will be used for point measurements.

Although the GPS code data is smoothed, the standard deviation calculation is based mainly on the data which has been logged at a point. If the data is collected over an only short period of time, and multipath exists due to the observation environment, then the standard deviation reported by the GPS system can be optimistic. Typically, 30 seconds of data are needed for the Geotracer 2100® series before sub-meter accuracy is achieved. Less data is needed for Geotracer® 2200 series.

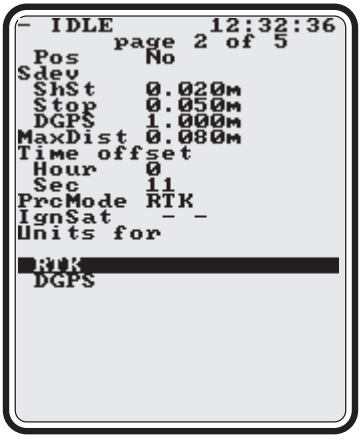
RTK mode uses carrier phase measurements to reach centimeter accuracy after RTK initialization (see chapter 4.2).

2

How to change the Processing Mode ...



Use the ▲ and ▼ keys to move the highlighted bar to the line PrcMode. Press the YES button.



You may now choose the processing mode by using the ▲ and ▼ keys to move the highlighted bar to DGPS or RTK. Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

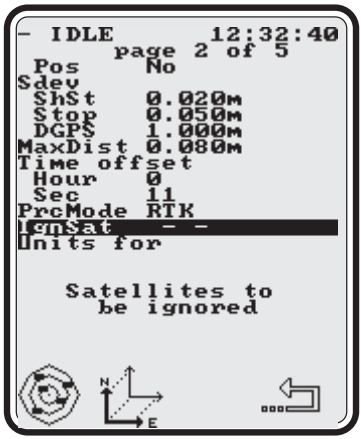
2

IgnSat : Ignore Satellite(s)

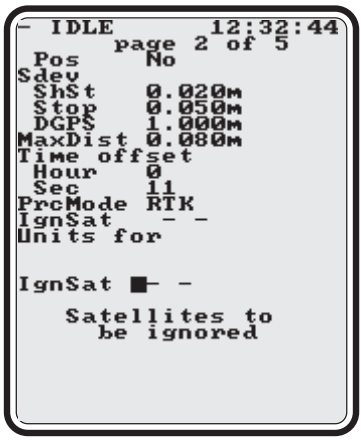
You may want to ignore a satellite, because it may be set unhealthy or or have technical problems not recorded in the satellite broadcast message.

Use this setting to enter the numbers of all satellites that should be ignored for the following measurements.

How to ignore satellites ...

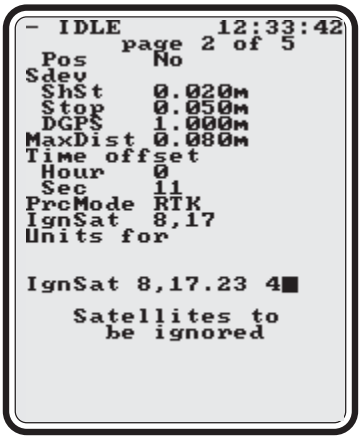


Use the ▲ and ▼ keys to move the highlighted bar to the line `Ign Sat`. Press the YES button.



You may now choose the satellite to be ignored by entering the respective PRN-number.

2



You may activate and deactivate an unlimited number of satellites. Enter all PRN-numbers, separated by a separator sign, such as space, fullstop, comma, slash.

Return to the parameter menu with YES when you have finished your selection.

If you do not want to make any changes, cancel with NO.

3

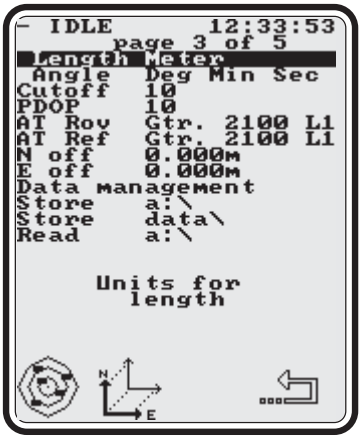
Units for - Length

Choose the unit of measurement for length output on the display and in the job / area files. Note that this specification is used for import from job and area files and export to job files. **Please make sure that settings are consistent with your files. Otherwise positions might be completely wrong.**

The Geotracer® RTK system offers :

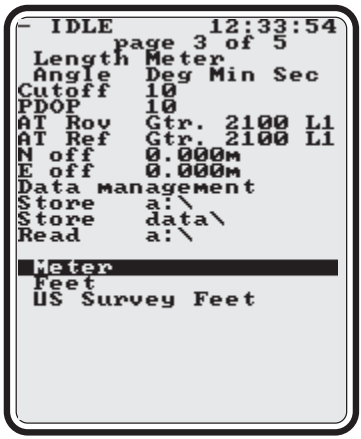
- meters METER
- imperial feet FEET (1 ft = 0.3048m)
- U.S. Surveyor feet US SURVEY FEET (1ft = 0.3048006096 m)

How to choose the unit for length ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Length` below `Units for`. Press the YES button.

3



You may now choose the unit by using the ▲ and ▼ keys to move the highlighted bar to `Meter, Feet,` or `US Survey Feet`. Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

3

Units for - Angle

The Geotracer® RTK system offers a choice of angle measurement units:

- Gon — A full circle is divided into 400. Fractions are outputs as decimals
- Degree Decimal — A circle is divided into 360°. Fractions are output as decimals.
- Deg Min Sec — Corresponds to DEGREE DECIMAL, but fractions are output as minutes and seconds and decimal fractions of seconds.
  60 seconds = 1 minute
  60 minutes = 1 degree (°)

How to choose the unit for angles ...

Use the ▲ and ▼ keys to move the highlighted bar to the line `Angle` below `Units for`. Press the YES button.

3

You may now choose the unit by using the ▲ and ▼ keys to move the highlighted bar to `Gon, Degree Decimal` or `Deg Min Sec`. Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

3

Cutoff : Cutoff elevation angle

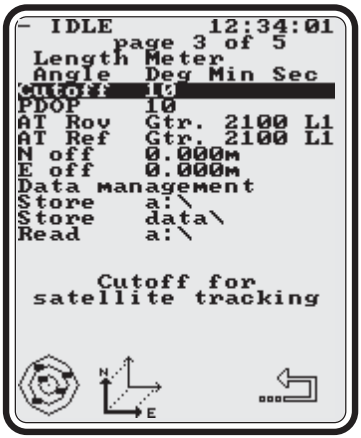
The Geotracer® RTK system uses a cutoff elevation angle below which satellites are ignored. This is useful, because low elevation satellites are influenced very much by atmospheric and multipath effects. The system allows you to work with cutoff elevation angles between 0° and 90°.

However, we recommend strongly that you do not change the cutoff from the default value 10°.

With higher elevation cutoffs fewer satellites will be tracked, which can mean that the performance of the system will be poorer. However, a higher elevation cutoff angle, such as 15°, should be selected, if at a specific location the low elevation multipath is extremely strong.

An elevation cutoff set to less than 10° would result in using satellites that have a poor signal and therefore increase the danger of multipath effects. Normally, such low satellites are not usable and can make OTF resolutions fail.

How to choose the cutoff elevation angle ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Cutoff`. Press the YES button.

3

You may now enter a value between 0 and 90. Press the YES button to accept the entry. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

3

PDOP : PDOP limit

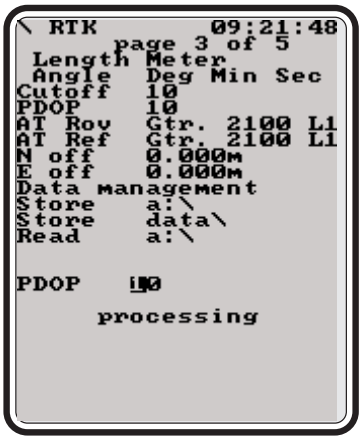
PDOP parameter defines the PDOP limit above which the system will not compute results. By default, the value is 10.0 in RTK mode. You may wish to change the maximum allowed PDOP to increase or decrease your system accuracy and performance. However, in RTK mode you are not allowed to use a value higher than 10. In DGPS mode the maximum PDOP allowed is 90. However, if you use a PDOP of 90 you can expect very bad position estimates. The system will not compute positions as soon as the PDOP limit is exceeded.

We recommend that you do not set the maximum value to be less than 4 as this would mean that the times available for doing an RTK survey are restricted.

How to choose the PDOP limit ...

Use the ▲ and ▼ keys to move the highlighted bar to the line PDOP. Press the YES button.

3



You may now enter a value between 0 and 10 for RTK mode or 0 and 90 for DGPS mode. Press the YES button to accept the entry. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

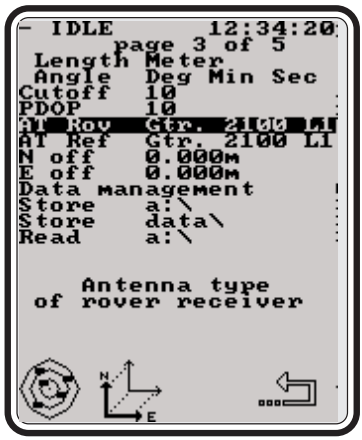
3

AT Rov / AT Ref : Antenna Types for Rover and Reference

You have to select the correct antenna types you are using in the RTK system. AT Rov stand stands for the antenna type of the rover, AT Ref for the antenna type of the reference. The RTK system knows the individual antenna eccentricity offsets of different antennas and considers them automatically. If the antenna types are not set correctly it could result in inaccurate heights. The system offers a choice between the following antennas:

- Geotracer 2100 L1
- Choke ring L2
- Choke ring L1
- Geodetic GP L2
- Geodetic GP L1
- Compact L2
- Compact L1

How to choose the antenna type ...



Use the ▲ and ▼ keys to move the highlighted bar to the line AT Rov for the rover antenna or AT Ref for the reference station antenna. Press the YES button.

3

You may now select the correct antenna type for the chosen receiver. Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

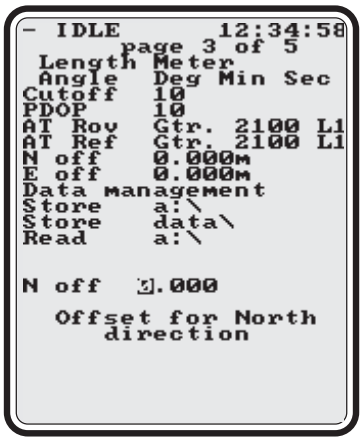
3

N off / E off : Offsets for Plane Coordinates

To maintain compatibility with Geodimeter total stations two offsets for North and East coordinates are used for export/import to/from job/area files. This will guarantee that all Geodimeter total stations will be able to read the positions (labels 37 and 38) from a Geotracer® RTK job file. For example, some UTM coordinates are too large for a Geodimeter, so the first digit is not used.

How to choose the offsets for plane coordinates ...

Use the ▲ and ▼ keys to move the high-lighted bar to the line `N off` or `E off`, resp. Press the YES button.



You may now enter a value. Press the YES button to accept the entry. The choice will show up in the parameter settings menu.

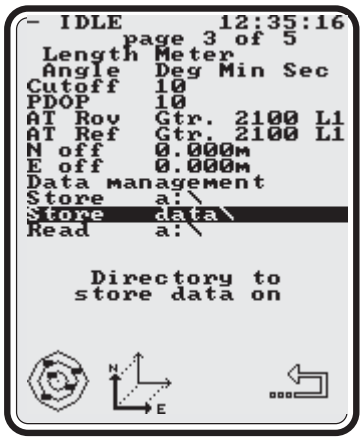
If you do not want to make any changes, cancel with NO .

3

Data management
Store : Directory and drive for file storage

You can define the drive (first line) and the directory (second line) for file storage. Currently the system supports local ACU `A:` and `B:` drives only. It does not support storage on the receiver internal PCMCIA card.

How to choose the directory for file storage ...



Use the ▲ and ▼ keys to move the highlighted bar to lines `Store`. The first line allows you to enter the drive, the second line to enter the name of the directory in which files will be stored. Press the YES button.

You may now choose a drive such as
`A:\`
or a directory such as
`DATA\`
Other volume identifiers or directories not conforming to the MSDOS standard for defining directories are not valid.
Press the YES button to accept the entry. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

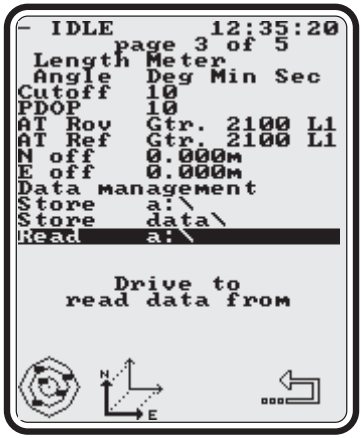
3

4

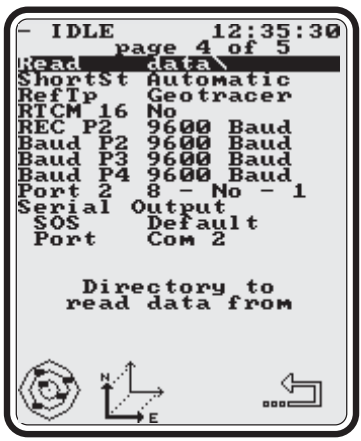
Data management
Read : Directory and drive for file reading

You can define the drive (first line) and the directory (second line), from where area files will be read. Currently the system supports local ACU `A:` and `B:` drives only.

How to choose the directory for file storage ...



Use the ▲ and ▼ keys to move the highlighted bar to lines `Read`. The first line allows you to enter the drive, the second line to enter the name of the directory to read files from. Press the YES button.



You may now choose a drive such as
`A:\`
or a directory such as
`READ\`
Other volume identifiers or directories not conforming to the MSDOS standard for defining directories are not valid.

Press the YES button to accept the entry. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

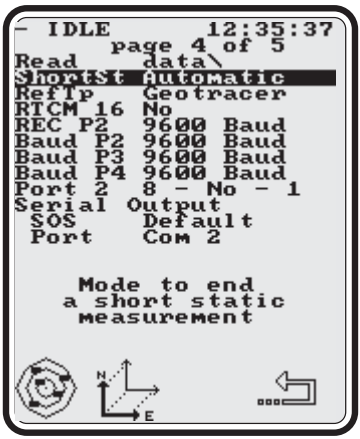
4

ShortSt : Short Static Stop Mode

You may choose whether the program stops a short static initialization automatically or whether it expects you to stop the initialization manually. If the automatic stop is selected, it will stop when the accuracy has reached the value set in the parameter `Sdev ShSt`. To stop manually, press F1 from the measurement display.

STOP F1

How to choose the short static stop mode ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `ShortSt`. Press the YES button.

You may now choose
`AUTOMATIC`
or
`MANUAL`
Press the YES button to accept the new choice. The choice will show up in the parameter settings menu.

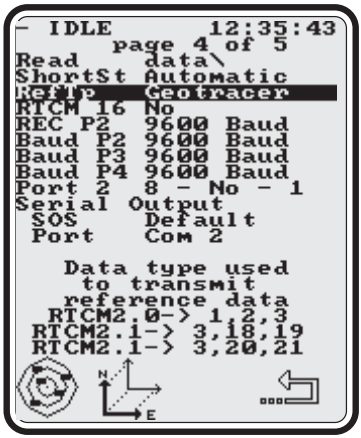
If you do not want to make any changes, cancel with NO .

4

RefTp : Reference Station Type

For DGPS or RTK surveying the RTK system needs a reference station. You may choose whether the RTK system uses a Geotracer® reference station or one of 3 RTCM reference station correction transmission versions. The versions differ in the messages that are transmitted. The RTK parameter menu shows the name of the version as well as the necessary message types (see chapter 4.1.2).

How to choose the Reference Station Type ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `RefTp`. Press the YES button.

You may now choose
`Geotracer`
`RTCM 2.0`
`RTCM 2.1corr`
or
`RTCM 2.1full`
Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

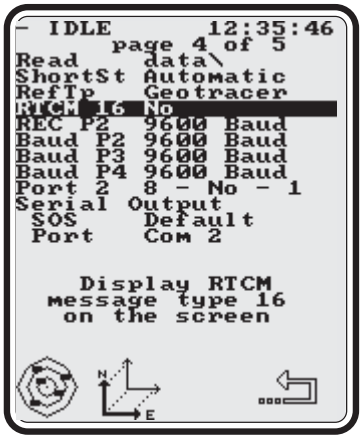
If you do not want to make any changes, cancel with NO .

4

RTCM 16 : RTCM Message Type 16

If your RTK system uses RTCM messages, you can decide whether messages of type 16 shall be displayed or not. If this switch is set to `Yes` and these messages are displayed during measurement, you will have to accept each message by pressing any key (see chapter 4.1.2).

How to switch on/off RTCM messages of type 16 ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `RTCM 16`. Press the YES button.

You may now choose, whether the RTK system informs you on message 16 (`YES`) or not (`NO`).
Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

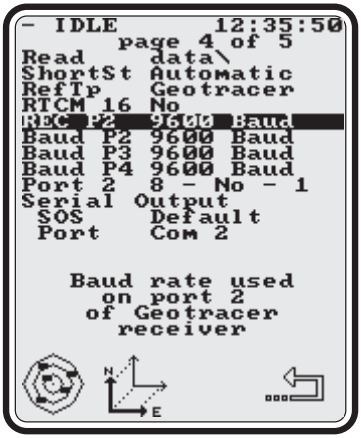
If you do not want to make any changes, cancel with NO .

4

REC P2 : Data transmission baudrate at receiver port 2

Here you can define the baudrate of port 2 of your receiver. The default baud rate is 9600. Baudrates between 1200 and 57600 are available.

How to choose the baudrate at the receiver ...



Use the ▲ and ▼ keys to move the highlighted bar to the line REC P2. Press the YES button.

You may now choose one of the baudrates displayed.
Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO.

4

Baud P2 / P3 / P4 : Data transmission baudrate at the ports of your ACU or PC

Here you can define the baudrate of port 2, 3 or 4 (if available) of your ACU or any IBM-compatible computer you are using with the system. If, e.g., your RTK system uses RTCM messages, you can choose the baudrate of the RTCM transmission. The default baud rate is 9600. Baudrates between 1200 and 57600 are available.

How to choose the data transmission baudrate at one of the computer´s ports...

Use the ▲ and ▼ keys to move the highlighted bar to the lines `Baud P2`, `Baud P3` or `Baud P4`. Press the YES button.

You may now choose one of the baudrates displayed.

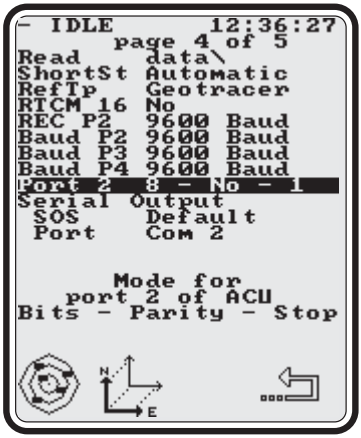
Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO.

4

Port 2 : Settings for port 2 of the ACU

Here you find information on the settings of Port 2 of the ACU. The default setting is 8 data bits, no parity, 1 stop bit.



4

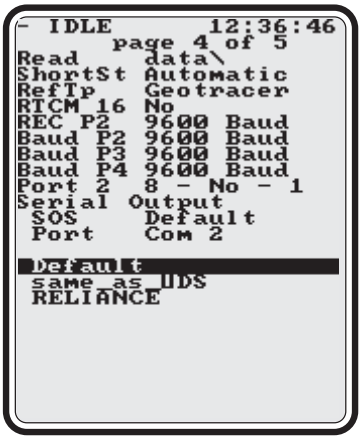
Serial Output
SOS : Serial Output Sequence file

Geotracer® RTK offers the opportunity to send result data to the serial port of the ACU (or of any field computer). As with data collecting to a job file, labels define which data are to be sent. You may create `*.OUT` files, containing the labels for serial output. The parameter `SOS` allows you to choose a `*.OUT` file from all files stored on your control unit in subdirectory `RTK/USERPROG` . However, you may also choose the default serial output setting implemented in the Geotracer® RTK Program or the `*.UDS` file currently defined in Line `UDS`. Your selected `*.OUT` file will be used for your current application, if the Serial output mode is not set to `None`. It will be replaced as soon as you choose another `*.OUT` file.

How to choose a `*.OUT` file ...

Use the ▲ and ▼ keys to move the highlighted bar to the line `SOS` below `Serial Output`. Press the YES button.

4



You may now choose one of the *.OUT file displayed.

Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

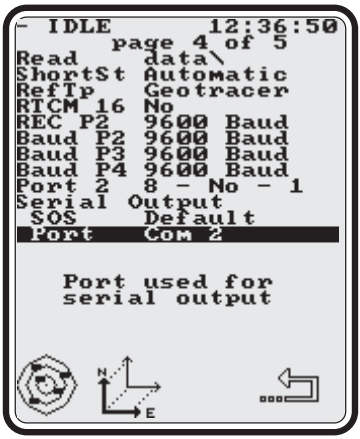
If you do not want to make any changes, cancel with NO .

4

Serial Output
Port : Port of computer for serial data output

Geotracer® RTK offers the opportunity to send data to the serial port of the ACU. The parameter `Port` allows you to define the port addressed.

How to choose the serial port ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Port` below `Serial Output`. Press the YES button.

You may now choose one of the ports displayed. Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

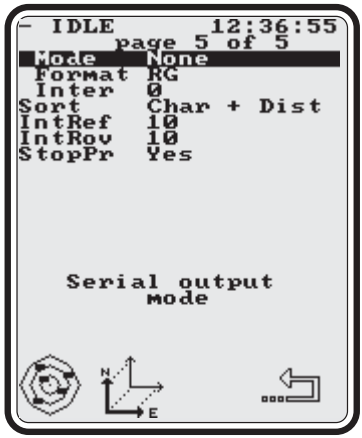
5

Serial output
Mode : Mode of serial data output

Geotracer® RTK offers the opportunity to send data to the serial port of the ACU. The parameter `Mode` allows you to define the mode, when to send data. Four modes are available:

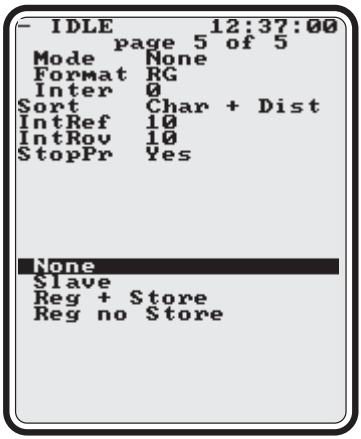
None	No serial output. Default mode.
Slave	Serial output at predefined time intervals, which can be every epoch or determined using the parameter setting `Inter`.
Reg + Store	Output each time measurements are registered manually or automatically. Additionally, the measurements will be written to a job file.
Reg no store	Serial output each time measurements are registered manually or automatically. No entry into a job file.

How to choose the serial output mode ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Mode` below `Serial Output`. Press the YES button.

5



You may now choose one of the modes displayed. Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

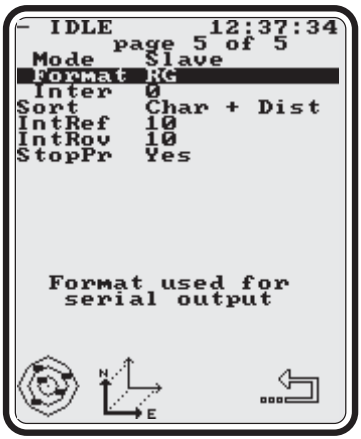
If you do not want to make any changes, cancel with NO .

5

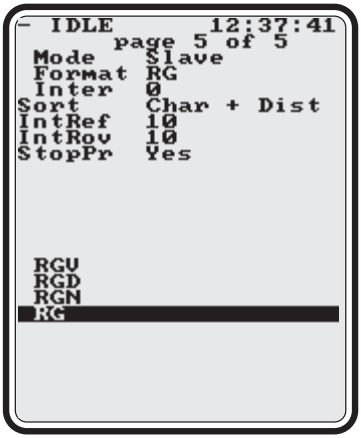
Serial Output
Format : Format of serial data output

Geotracer® RTK offers the opportunity to send data to the serial port of the ACU. The parameter `Format` allows you to define the format of the resulting data flow. For more information on the formats available refer to chapter 10.3.

How to choose the format ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Format` below `Serial Output`. Press the YES button.



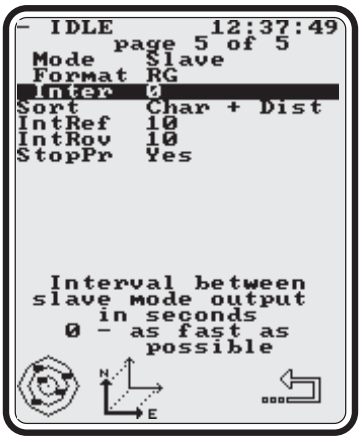
You may now choose one of the formats `RG, RGN, RGD, RGV.`
Default is `RG.`
Press the YES button to accept the choice. The choice will show up in the parameter settings menu.
If you do not want to make any changes, cancel with NO .

5

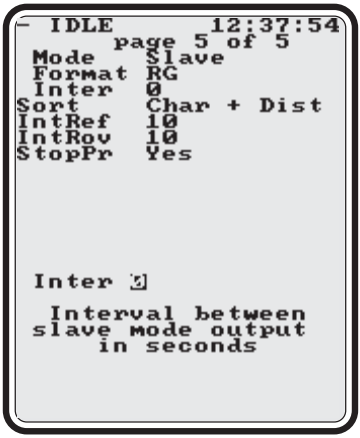
Serial Output
Inter : Interval between slave outputs

Geotracer® RTK offers the opportunity to send data to the computer´s serial port. The parameter `Inter` allows you to define the time interval between each data output (slave mode). A value of 0 defines to output as fast as possible, which is the default.

How to choose the interval ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Inter` below `Serial Output`. Press the YES button.



You may now enter a value for the interval between two output events. The unit is seconds.

Press the YES button to accept the value. The value will show up in the parameter settings menu.
If you do not want to make any changes, cancel with NO .

5

Sort : Sorting mode

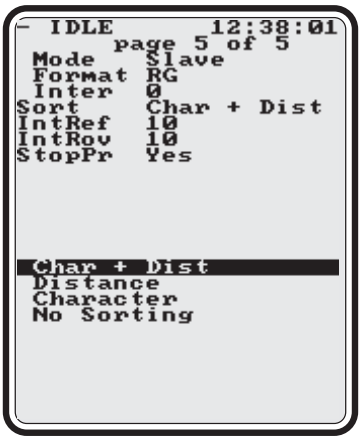
When working with large point lists, sorting the files can take some time and delay screen changes. Therefore, Geotracer® RTK offers two highly efficient methods for the sorting of points, which can be used individually or in combination. Always, when direct character input is possible, you may enter the first character of a point number and the list will be sorted by characters. When staking out, initializing on a known point or defining a local coordinate system, point numbers can be also sorted by the distance to the current position of the rover. The following options and combinations are available:

Char + Dist	Sorting by distance and character available (default)
Distance	Only sorting by distance available
Character	Only sorting by character available
No Sorting	No sorting option available

How to choose the sorting mode ...

Use the ▲ and ▼ keys to move the highlighted bar to the line `Sort` . Press the YES button.

5



You may now choose one of the sorting modes. Default is `Char+Dist`. Press the **YES** button to accept the choice. The choice will show up in the parameter settings menu.

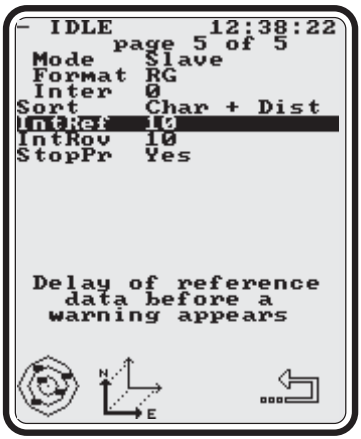
If you do not want to make any changes, cancel with **NO** .

5

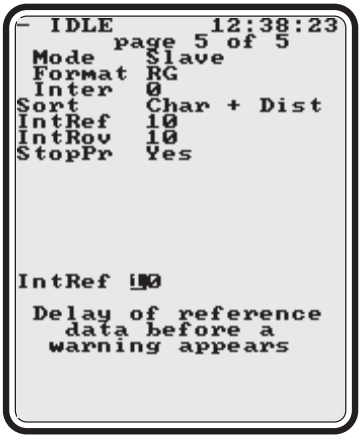
IntRef / IntRov : Time interval for warning messages

The Geotracer® RTK displays a warning message `No Data`, if the ACU receives no data either from the reference receiver or from the rover receiver. Here you may change the time interval in seconds which has to elapse before this message shows up. You can set a value for each receiver, reference or rover.

How to choose the time interval ...



Use the ▲ and ▼ keys to move the highlighted bar to the line `Int Ref` for the reference station or to the line `Int Rov` for the rover, resp. Press the YES button.



You may now enter a value in seconds. Default is `10`. Press the YES button to accept the value. The value will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

5

StopPr : Stop processing if no data arrives

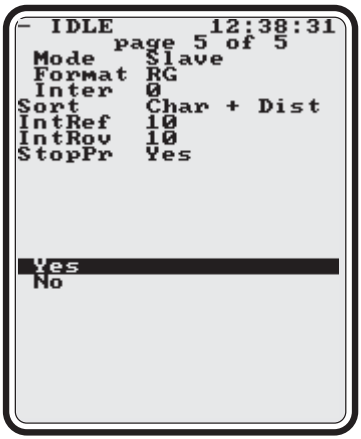
If a warning message is displayed, it might be useful to reset the entire RTK processing. E.g., you may need to change batteries. Here you may choose between

Yes	All processing will be reset and the RTK will switch back to start-up of receivers (default), or
No	The ACU continues waiting for data.

How to choose whether processing shall be stopped...

Use the ▲ and ▼ keys to move the highlighted bar to the line `StopPr`. Press the YES button.

5



You may now choose YES or NO. Default is YES.

Press the YES button to accept the choice. The choice will show up in the parameter settings menu.

If you do not want to make any changes, cancel with NO .

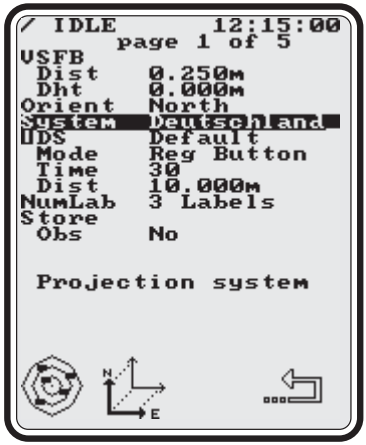
Chapter 8.
Coordinate System Selection

Your requirements for position display or registration can be very different. You may need positions in your national grid datum or in WGS84, or, you may want to use a pure local coordinate system. The Geotracer® 2000 RTK system calculates positions in the coordinate system that you select (see also chapter 9 on transformations).

This chapter explains about the practical use of the coordinate system definition. You will find the theoretical background in chapter 9.

Start from any display and enter the parameter menu:
F3 or Shift + P .

Move the highlighted bar to the line `System` and press YES.



The Coordinate System Selection Menu pops up:

You may now change the following entries.

- Datum
- Ellipsoid
- Projection
- Zone
- Local Transformation

8.1 Datum

Datum= National Datum System

A datum is the size, location and orientation of a mathematical model used as an approximation for the surface of the earth. Typically, a datum will fit a specific country very well, but perhaps not an adjacent country. Datum, therefore, usually means a national datum system (see chapter 9.2). A lot of national datums are implemented in the Geotracer® RTK system, but you may install others, using the Geotracer® Communication option, e.g., when you receive software upgrades (see App. A.2), or by defining it directly in the menu.

How to change the Datum

Move the highlighted bar to the datum installed and ackowledge by pressing YES. A list of all available datums will pop up.

Use the ▲ and ▼ keys and the names of more datums will be displayed. If you enter the first letter(s) of the desired name the system will switch to the correct place in the alphabetically sorted list.

You may now choose one of the datums listed. Press YES. The Coordinate System Selector displays the chosen datum now.

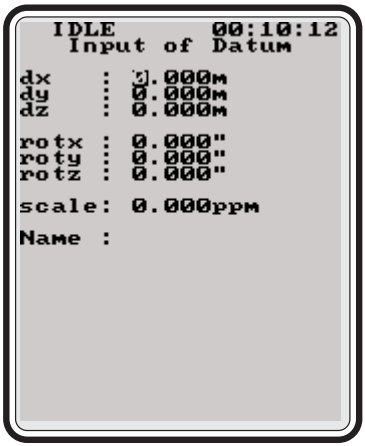
If you want to cancel, press NO.

If the chosen datum does not match the current ellipsoid a warning message occurs:

Press the **Y** key if you want the matching ellipsoid installed. Otherwise, use the **N** key.

To avoid inconsistencies the RTK system recommends that you use the matching Ellipsoid for a selected Datum.

If you need a datum which is not listed you may enter the seven transformation parameters and store the datum under a name of your choice. Move the highlighted bar using the ▲ key to the first entry `Define new` and press YES.



The RTK system asks for the input of 3 translation parameters in meters, 3 rotation parameters in arcseconds and a scale difference in ppm. Some parameters can be left as zero, e.g., if only dx, dy and dz are specified.

Enter all parameters, accepting each with YES. Finally you should in most circumstancesy enter a name. It may have 40 characters, the first 20 characters will be displayed under the line `Datum`. The datum will now be available for all future applications.

You may use the Geotracer® Postprocessing software network adjustment to calculate the seven parameters most appropriate for a survey location.

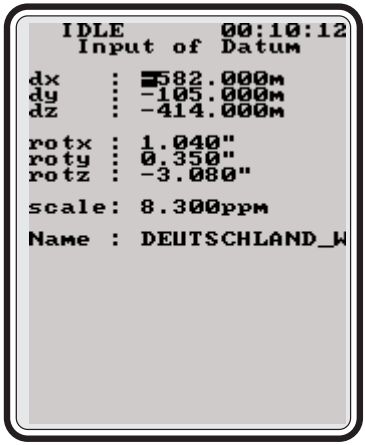
If you want to use the new datum only in the current application you can skip the name field. The system stores the last unnamed datum under the name `Defined by user`.

Using the datum `Defined by user` allows you to always step back to your previously defined datum.

To clear up your database the system offers the opportunity to delete one or more datums. Move the highlighted bar to the name of the datum you want to delete and press the key combination Shift + ←Sp (= Del). The warning message will occur:

If you accept with Y the datum will be missing now in the datum list. You may, however cancel with N.

The Geotracer® 2000 RTK system offers another helpful feature for the definition of a new datum. Load an already existing datum. You can then change any parameter that you need. Move the highlighted line to the name of the datum and press **Shift** + **R** (Read). The Define-new-display shows up, containing the transformation parameters of the chosen datum as default.



You now may change some or all parameters and may store the new datum under the old name or choose a new one.

At any time you may cancel without making changes using the NO key.

8.2 Ellipsoid

Ellipsoid = basis for projection

Ellipsoids are used to model the size and shape of the earth used by a datum. They serve as a basis for the different projections.

A lot of ellipsoids are implemented in the Geotracer® RTK system, but you may install others, using the Geotracer® Communication option in case of software upgrades (see App. A.2), or defining it directly in the menu.

How to change the Ellipsoid

Move the highlighted bar to the ellipsoid installed and press **YES**. A list of all available ellipsoids pops up.

Use the **▲** and **▼** keys and the names of more ellipsoids will be displayed.

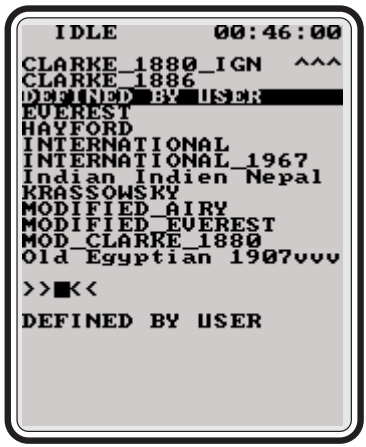
You may now choose one of the ellipsoids listed. Press **YES**. The Coordinate System Selector displays the chosen ellipsoid now.

If you want to cancel, press **NO**.

If you need another ellipsoid you may enter the semi major axis and flattening, then store the ellipsoid under a name. Move the highlighted bar using the ▲ key to the first entry `Define new` and press YES.

Enter the length of the semimajor axis as well as the inverse flattening, accepting each with YES. Finally, you may enter a name. It may have 40 characters, the first 20 characters will be displayed under the line `Ellipsoid`. The ellipsoid will now be available for all future applications.

If you want to use the new ellipsoid only for the current application you can skip the name field. The system stores the last unnamed ellipsoid under the name `Defined by user`.



Using the ellipsoid `Defined by user` allows you to always step back to your previously defined ellipsoid.

To clear up your database the system offers the opportunity to delete one or more ellipsoids. Move the highlighted bar to the name of the ellipsoid you want to delete and press the key combination **Shift** + **←Sp** (= **Del**). The warning message will occur:

If you accept with **Y** the datum will be missing in the datum list from now on. You may, however, cancel with **N**.

You may also overwrite a previously stored ellipsoid with a new one. Move the highlighted line to the name of the ellipsoid and press **Shift** + **R** (Read). The Define-new-display shows up, containing the transformation parameters of the chosen ellipsoid as default.

You may now change one or both parameters and store the new ellipsoid under the old name or choose a new one.

8.3 Projection

Projection= National Grid Coordinates

Projection means the projection of ellipsoidal coordinates based on the local ellipsoid to a flat surface (see chapter 9.3). Many national grid and all US state plane coordinate systems are implemented in the Geotracer® RTK system, but you may install others, using the Geotracer® Communication option, e.g., when you receive software upgrades (see App. A.2). You may also define projection parameters directly from the menu.

How to change the Projection

Move the highlighted bar to the projection installed and press YES. A list of all available projections pops up.

Press the ▲ and ▼ keys and the names of more projections will be displayed.

You may now choose one of the projections listed. Press YES. The Coordinate System Selector displays the chosen projection now.

If you want to cancel, press NO.

If the chosenprojection does not match the current ellipsoid a warning message occurs:

Press the **Y** buttons if you want the matching ellipsoid installed. Otherwise, use the **N** key.

To avoid inconsistencies, the RTK system recommends that you use the matching Datum and Ellipsoid for a selected Projection and the matching Ellipsoid for a selected Datum.

Define Your Own Projection

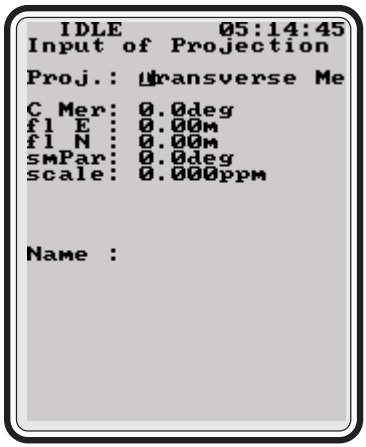
If you want to define an additional projection, you may enter the parameters and store the projection under a name. Move the highlighted bar using the ▲ key to the first entry `Define new` and press YES.

You will find that the system offers the Transverse Mercator projection as a default. This projection is the most used projection. However, when entering the "Input of Projection" screen the cursor is at that line, and, by pressing YES the system offers you a variety of projections. It is possible to select between the following:

- Transverse Mercator
- Oblique Mercator
- Lambert secant
- Lambert tangential

After accepting the projection of interest the input parameter display is depending on the selection.

With an Transverse Mercator projection the following screen will be displayed, allowing you to enter the required parameters:



The following parameters are required:

- Projection type
- Central meridian east longitude in degrees (0° ... 360°)
- False Easting in meters
- False Northing in meters
- Southernmost parallel of latitude in degrees (-90° ... 90°)
- Scale factor difference in ppm

Enter all parameters, accepting each with YES. Finally you may enter a name. It may have 40 characters, the first 20 characters will be displayed under the line `Projection`. The projection will now be available for all future applications.

With an Oblique Mercator projection the following input parameter menu will be displayed, allowing you to enter the required parameters:

The parameters are in detail:

- Projection type
- Central meridian east longitude in degrees (0° ... 360°)
- False Easting in meters
- False Northing in meters
- Axis azimuth in degrees
- Latitude of southernmost parallel in degrees (-90° ... 90°)
- Scale factor difference in ppm

Enter all parameters, accepting each with YES. Finally you may enter a name. It may have 40 characters, the first 20 characters will be displayed under the line `Projection`. The projection will now be available for all future applications.

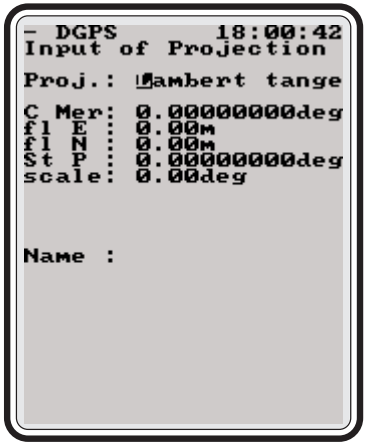
With an "Lambert secant" projection the following will be displayed:

The parameters in this case are:

- Projection type
- Central meridian east longitude in degrees (0° ... 360°)
- False Easting in meters
- False Northing in meters
- Latitude of southern standard parallel in degrees (-90° ... 90°)
- Latitude of northern standard parallel in degrees (-90° ... 90°)
- Southernmost parallel of latitude in degrees (-90° ... 90°)

Enter all parameters, accepting each with YES. Finally you may enter a name. It may have 40 characters, the first 20 characters will be displayed under the line `Projection`. The projection will now be available for all future applications.

With an "Lambert tangential" projection the following will be displayed:



The parameters in this case are:

- Projection type
- Central meridian east longitude in degrees (0° ... 360°)
- False Easting in meters
- False Northing in meters
- Latitude of standard parallel in degrees (-90° ... 90°)
- Scale factor difference in ppm

Enter all parameters, accepting each with YES. Finally you may enter a name. It may have 40 characters, the first 20 characters will be displayed under the line `Projection`. The projection will now be available for all future applications.

If you only want to use the new projection in the current application you can skip the name field. The system stores the last unnamed projection under the name `Defined by user`.

Using the projection `Defined by user` allows you to always step back to your previously defined projection.

To clear up your database the system offers the opportunity to delete one or more national grid coordinate systems. Move the highlighted bar to the name of the projection you want to delete and press the key combination **Shift** + **←Sp** (= **Del**). The warning message will occur:

If you accept with **Y** the projection will be missing now in the projection list. You may, however, cancel with **N**.

Additionally, you may overwrite an already existing projection with a new one. Move the highlighted line to the name of the datum and press **Shift** + **R** (Read). The Define-new-display pops up, containing the transformation parameters of the chosen projection as default.

You may now change some or all parameters and may store the new projection under the old name or choose a new one.

At any time you may cancel without making changes using the NO key.

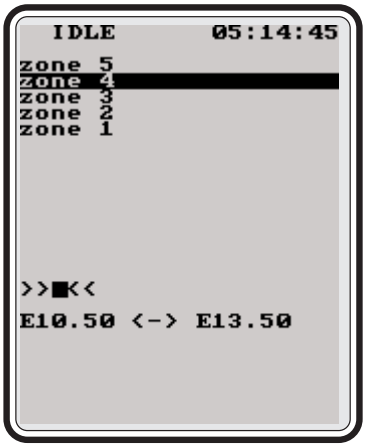
8.4 Zone

Some projections allow you to use different zones, e.g., UTM. For these projections, you are required to provide the correct zone in the parameter menu in order to allow the RTK system to output correct national grid coordinates for display and to job files. Input area files are also required to be in the projection and zone system defined on the parameter menu before reading in the area files. This is necessary since the RTK system is converting the positions to WGS84 when reading the files.

If your selected projection uses a zone system you will find a preselected zone number. Otherwise the zone is `not used`.

How to change the Zone

To choose a zone move the highlighted bar to the zone and press YES. A list of all available zones is displayed.



At the bottom of the display you will find the value of the left and right border meridian of the marked zone.

At any time you may cancel without making changes using the NO key.

8.5 Local System Definition

Purely local coordinate system without geocentric reference

The `Local Trans.` item of the Coordinate System Selection Menu allows you to choose or define a local system instead of a global projection system. These systems are purely local in the sense that no geocentric reference is given. The origin, scale and orientation of the local coordinate system can be completely user-defined.

When you use a global projection the text "`not used`" is displayed under line `Local Trans.` in order to indicate that no purely local coordinate system is used. If the text is different the global projection parameters are ignored and a pure local coordinate system is used for outputting data.

When you move the highlighted line to `Local Trans.` and press YES a selection of several options that are used to create and modify a local coordinate system will be displayed. The list contains the default local coordinate system "`USER_DEF`" and all local coordinate systems defined previously.

Items of the selection list are:

`Not used`	indicates that no local coordinate system shall be used. The RTK system shall use the global coordinate system defined in line `Projection`.
`Measure new`	allows you to define a new local coordinate system. Enter control point information and measure the control points with the RTK system. The RTK system computes the transformation parameters automatically.
`Define new`	allows you to directly key in the local transformation parameters.
`USER_DEF`	The name of the file (extension `*.LCS`) where the last set of local coordinate system parameters that you defined without providing a name is stored.

Create and use your own local coordinate systems!

The names of other local coordinate system definitions follow in the list. In our case the following files are available: TERRA 1 and TERRA 2. These files contain the parameters of local coordinate systems. They are named according to the name of the local coordinate system with the extension `*.LCS` and are stored in subdirectory `\RTK\USERPROG`.

Defining a local coordinate system

We start defining a new local coordinate system using `Measure new`.

8.5.1 Measuring A New Local System Via Control Points

New local systems can be easily defined by measuring control points

This is the normal procedure to define a purely local coordinate system for the RTK system. It is based on two or more control points with coordinate information in the local system you want to work in. Accept `Measure new` and the following display pops up.

There are a number of options you can use to define a set of local parameters.

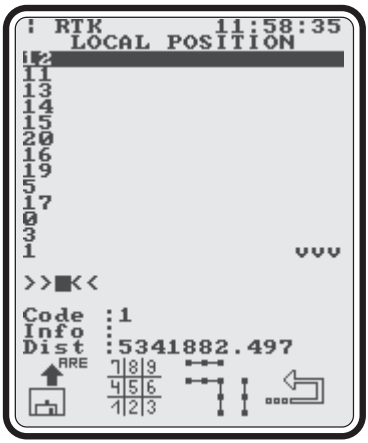
Add the first control point coordinates

8.5.2 Adding A Point To The Local System Definition

The local system is normally defined via positions of control points which are provided in two different coordinate systems: The local system coordinates which are entered manually via keyboard or selected from area files and the GPS positions in WGS84 which are derived via GPS RTK positioning.Two or more points have to be added to the local system calculation procedure in order to define your reference system. If you enter one point only you will get a simple local system, using only a translation, but no rotation and no scaling. In order to start you have to move the highlighted line to `Add point` and press the YES key.

Area or job file offer point list

The RTK system will then offer you a selection of available area and job files stored in drive and directory as defined inthe `Read` option of the parameter menu, from which you can select previously stored coordinates. When you select and acknowledge the area file with YES a list of available points in the area file will be displayed.

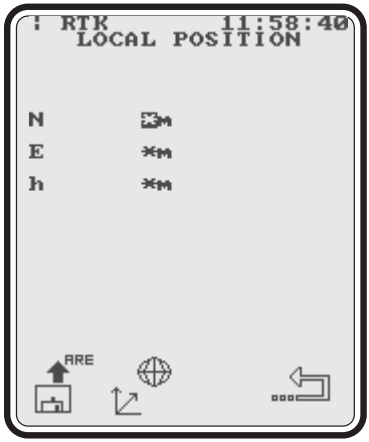


Please make sure, that the coordinates of points you want to use for the definition of your local coordinate system are saved as N, E (and h) coordinates! If the job or area file contains additionally coordinates of WGS84, the point will not show up in the point list!

Coordinates manually keyed in

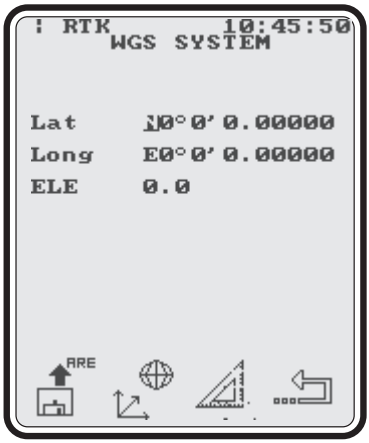
Alternatively, you can also use the **F2** key in order to enter the coordinates via the keyboard.

In this case the following display will occur allowing you to input your local position manually.



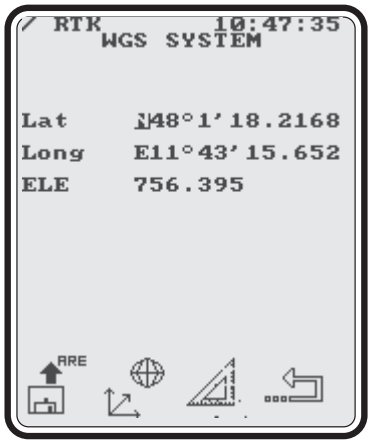
When data is imported from an area file, the local position is taken from that file. An asterisk (*) indicates that the component will not be used in the transformation parameter calculation. This is in order to distinguish between horizontal and vertical control points. Horizontal and vertical transformations to the local system are done separately and the vertical transformation is discussed below in chapter 8.5.8.

Next, the system will display and prompt for entry of the Lat, Long and Elevation in the national grid datum.



Coordinates provided by GPS measurement

Usually you will not provide the coordinates from the keyboard, but will measure them using the GPS-System. In order to measure the point, you have to go to the new point with the RTK system, press the **F3** key allowing to measure now. The system will then calculate the position in WGS84 system and display the Lat, Long and Elevation in the WGS84 system.

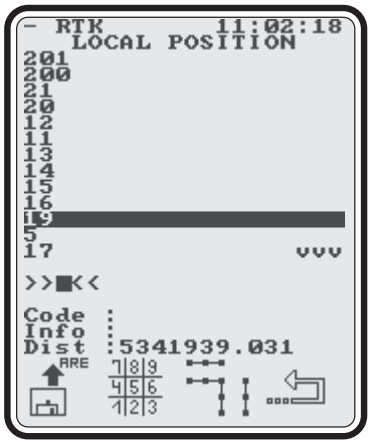


Accept coordinates of the first control point

The coordinates of the the first point (number 12) have now be entered in both systems and you can accept the WGS 84 positions by pressing the YES key three times. The selection input menu displays now the currently defined transfomation parameters at the bottom.

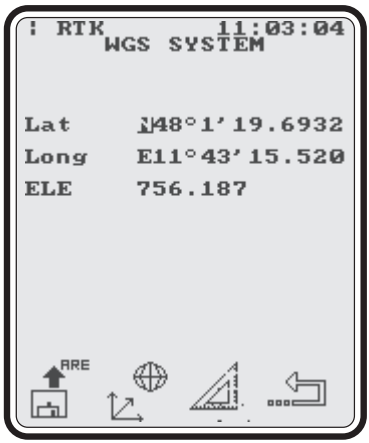
Second control point

Again the system will expect an `Add point` which requires a point selection from the area file or a manual input via the keyboard. In our example, we will select point 19 as an additional control point and move the highlighted line to point number 19 and acknowledge with the YES button.



Please note, that the distance to the point will be wrong. This is due to the fact, that the coordinate system is not fully established yet. As soon as the local system is correctly defined, it will show the correct distance to the point.

After accepting point 19 with the YES button, again the display for measuring a point shows latitude, longitude and elevation with zero quantities. You should take the RTK system to point 19 and press the measure button F3. The position is computed and we have now defined two points, allowing us to have a local transformation system defined.



Please use YES key three times to accept the point and to return to the selection of input parameters. Use the F4 key to skip the point definition.

First informations on your new local system

The point is now provisionally accepted as a new point with information in the local system. The following display appears on the screen, providing you information on an offset in north/east direction, rotation and the scale difference in ppm.

It also provides information on the maximum errors in horizontal and in the height. The height definition will be described later. But at this stage, since we have provided height information for both points, the RTK system will also model the height system.

Parameters can be modified and/or stored

When pressing the F4 key, the parameters will be displayed again in order to allow the user to edit and modify the parameters, which were computed.

To store these parameters, move the cursor to the line with the text `name`, enter a text and acknowledge with the YES button. By pressing YES, the RTK system will accept the local transformation, will save it as file `*.LCS` in the subdirectory `RTK\USERPROG\` and will work in that system from now on. Press the F4 key to go back to the Local Projection Menu. You can now use the system for surveying new points or for setting out points from an area file.

If you decide not to key in a name for the local projection, just press F4. The system will store the transformation parameters under the name `USER_DEF` . They will be also available for usage.

If you want to leave without storing the transformation parameters, press NO . The Coordinate System Selection Menu will pop up, no local coordinate system having been stored.

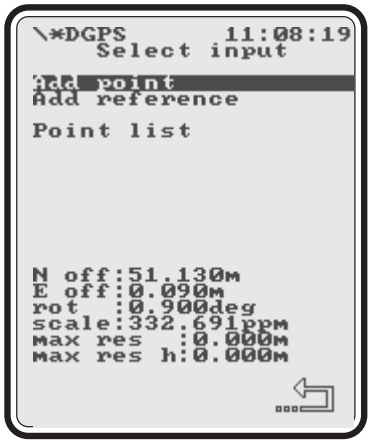
You may add (or delete) more control points

If you decide at a later date to add more additional points in order to improve the local system, reenter the Local Projection Menu,

move the highlighted bar to `System` and press YES, move the cursor to `Local Trans`

and press the YES key.

Use the `Continue meas.` item in order to add an additional point.

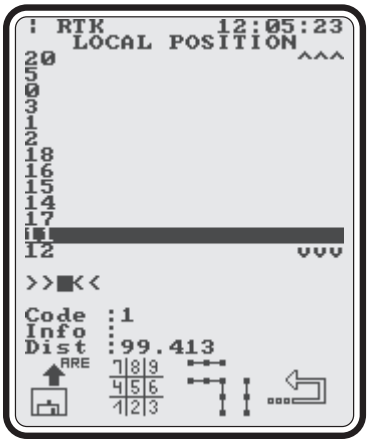


`Continue meas.` will only show up on the screen, if you continue a measurement

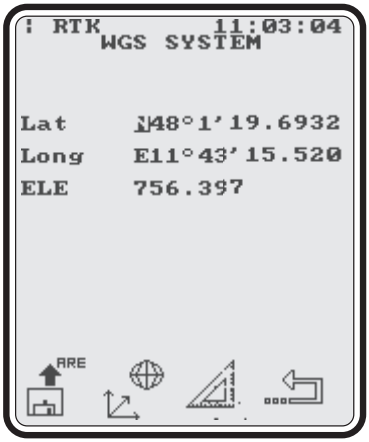
- **started in the same session, or**
- **loaded from a `*.LCS` file referring to the same reference station as currently used in the RTK system!**

If you have not loaded a `*.LCS` file or have loaded a file referring to another reference than the currently used, the option `Continue meas.` will not be available.

In our case we will add the third point 11 via selection from the area file.



After we have visited point 11 and measured by pressing the **F3** key, the resulting position in latitude, longitude and elevation will be displayed on the screen



and can be accepted by pressing the **YES** key three times.

You will now find, that the parameters for northing offset, easting offset, rotation and scale have changed. The residual in the height will also have changed. In order to view the residuals on the individual points we can move the cursor to the line `Point list` and accept with the YES key.

All points which were used as control points, namely 11, 19 and 12 are now displayed and in the lower part of the screen the residuals in north, east and elevation for the points are displayed.

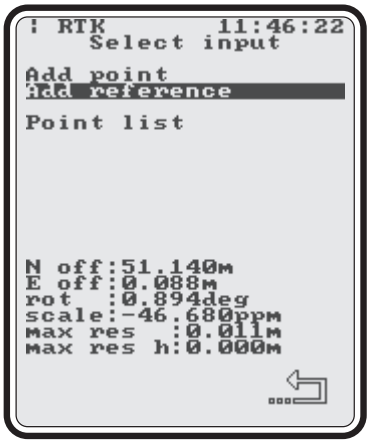
You can move the cursor to each individual point and see what residuals you have then. You may also use the combination of Shift and ←Sp keys (Delete) in order to delete points from your point-list. This would automatically reduce the number of points in the transformation to those remaining. This feature allows you to eliminate suspect control point information. You will have to confirm deletion on the following prompt with Y or N.

If you have deleted a point of the point list, the system recomputes the transformation parameters at once.

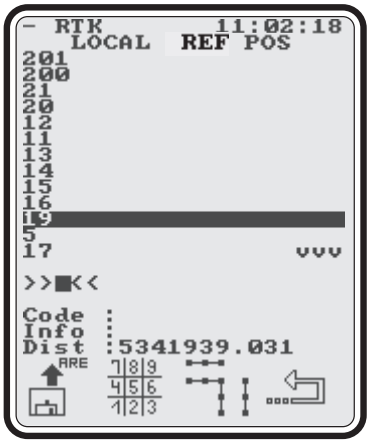
Reference point as control point

8.5.3 Add Reference Position To The Local System Definition

You can also add the reference point (base station) to the local system. In order to do this, you should select the "`Add reference`" line from the select input menu.



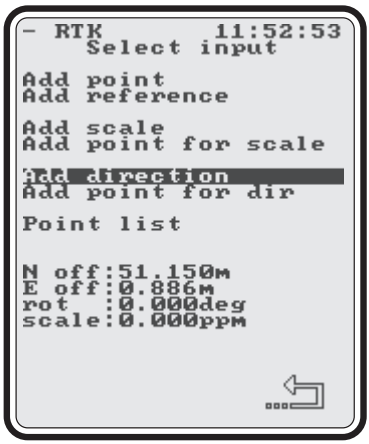
When selected, the following screen will appear, allowing you to define the point number from the reference position you are using. The local coordinates of the reference station can be read from area files or entered via manual input. This feature is of interest if you have your reference station on a known control point in your local system.



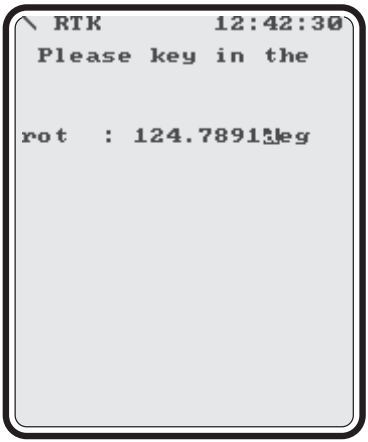
Add direction

8.5.4 Define Local System By One Point And An Azimuth

If you want to define your system by providing the local coordinates of only one point and by defining an orientation by providing an azimuth, this can be done by selecting the option `Add direction`.



Key in the rotation angle defining the azimuth in your local coordinate system, then press the YES key.



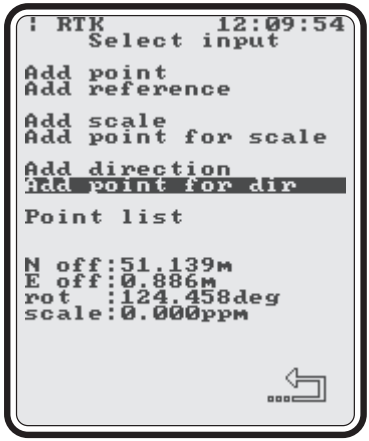
On the bottom of your screen you will now find the transformation defined as translation and rotation parameters, which are expressed in your local system.

You will also find, that the scale difference is zero. This means that you have not provided any scale for your local system. The system will use the scale direct from the WGS84 system (GPS-System).

Note, that the local scale is not reduced to mean sea level.

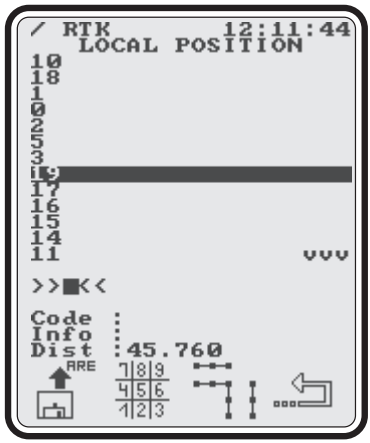
8.5.5 Adding A Point For Azimuth Information

Instead of providing the direction directly in form of an angle you may also use a second point to provide the direction and keep the WGS84 scale. In order to do that, you must first of all have used `Add point` to define one point. Afterwards, choose `Add point for dir`.



You should then go to the point which you want to use for your orientation definition, select the point from the area file or input the coordinates via the keyboard.

In our case we are selecting the point number 19 from the area file and will accept it by pressing the YES key.



Next, measure the point with the F3 key, and accept by pressing the YES key three times. Your orientation is now defined. This is shown in the display below, where you have now provided an offset in north and east and the orientation angle.

8.5.6 Defining The Scale Of The Local System

Add scale

If you want to use a local scale factor in the coordinate system, but define the orientation from the GPS-System itself, you can define one point and/or an orientation as shown above and then use the option "`Add Scale`" from the display shown below.

After pressing the YES key you will be prompted for the scale factor of your local system.

The scale you are providing there, is the scale difference between the WGS84/GPS-Scale and your local scale in parts per million. For example, if a survey grid has a scale factor of 0.996, this represents -400 ppm. A scale factor of 1.000025 represents 25 ppm.

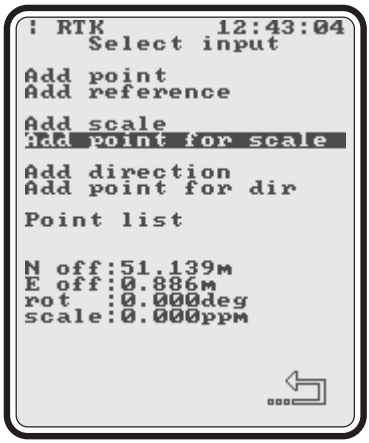
Accept the entered parameters by pressing the YES key. You will now find the following screen,

providing you information on the offset in north, east and scale difference.

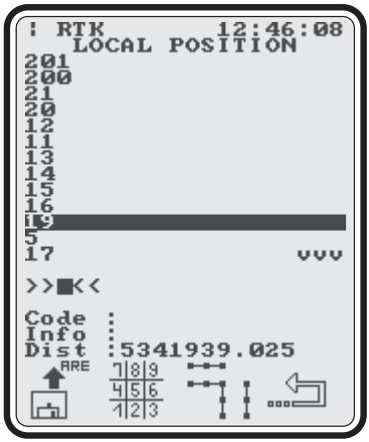
Please note, that the rotation angle is zero, i.e. the orientation of this local system is identical to the GPS system.

8.5.7 Providing Scale Factor From Point Measurement

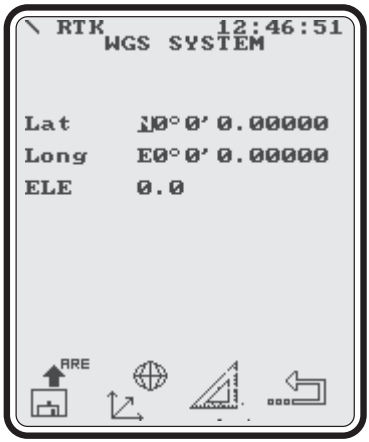
You may also provide a scale difference between your local system and the GPS-System by a local control point and a measurement with the GPS RTK System. In order to do that you must first of all have used `Add point` to select one point. Then, move the highlight to the line `Add Point for scale` (see below) and press the YES key.



You will then be prompted for a point number.



In our case we will select the point number 19 to provide a scale factor between the GPS-System and your local system definition.



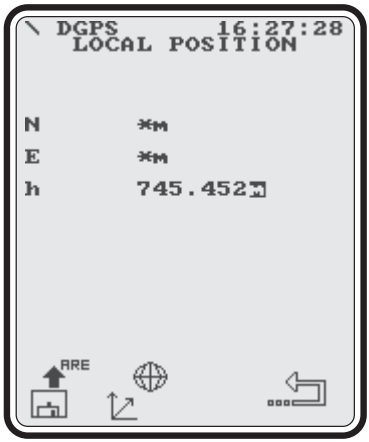
We have to measure the point 19 with the F3 key and then accept with pressing the YES key three times, when the point information is derived by the GPS RTK system.

You will now find the northing offset, easting offset and scale difference displayed on the screen. In our example, we have derived a scale factor of 352 ppm.

8.5.8 Definition Of Local Height System

Add local height system

As already mentioned above, control points can be defined for horizontal control only, or for horizontal and vertical control, or for vertical control only. Any combination can be used.

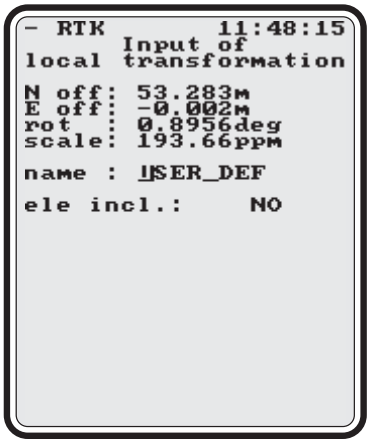


In order to provide only vertical control for a point, you should use the `Add point` feature in the main display for local system definition and press the **F2** key to enter height information manually via the keyboard.

In order to provide heights only, skip northing and easting information with the YES key and leave asterisks (*) for these horizontal components. Enter the known height in line "h" and press the YES key again to accept the definition. You may define one or more height control points. The RTK system will use the mean height difference for all height control points to define the height correction.

Discrepancies at different height control points can be displayed by using the Point list feature.

If height control is provided to the RTK system it is indicated by setting of the `ele incl.` parameter to "`YES`".



If height control is not used the RTK system will provide GPS heights instead of local heights.

Chapter 9.

Coordinate Systems

The Geotracer® 2000 RTK system works in different coordinate systems. These include ellipsoidal, cartesian, and various mapping systems. The following chapter informs you in detail about the different systems.

9.1 The World Geodetic System WGS84

The WGS84 is a well-defined reference system which has its origin at the gravitational center of the earth. The definition of WGS84 consists of geometrical (ellipsoidal shape) as well as dynamical parameters (mass of earth, earth rotation rate etc.). GPS uses the WGS84 system, i.e. all positions derived by a GPS receiver refer to WGS84. Additional transformations are necessary to convert the position to local coordinate systems.

9.1.1 The Cartesian WGS84 Coordinate System

The Z-axis of the WGS84 system is parallel to the Conventional International Origin (CIO) derived from astronomical measurements in the years 1900 - 1906. The X-axis points to Greenwich and the Y-axis is perpendicular to the other axes so that a right-handed system is established. Within the GPS processing scheme positions are usually defined in this cartesian (X, Y, Z) WGS84 system. Baseline components are defined as vectors within this coordinate system.

! For Cartesian WGS84 coordinates choose labels 110 111 112

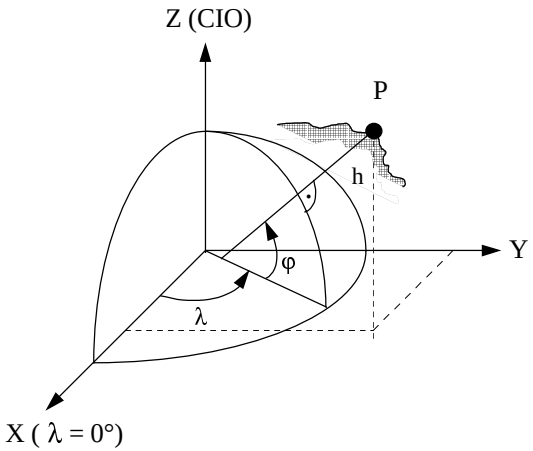


Fig. 1: The WGS84 system

9.1.2 The Ellipsoidal WGS84 Coordinate System

With the given ellipsoidal parameters it is possible to convert the cartesian to ellipsoidal coordinates and vice versa.

! For ellipsoidal WGS84 coordinates choose the WGS datum and labels 113 114 39

The relationship is defined by the following equations

$$X = (L + h)\cos\varphi\cos\lambda$$
$$Y = (L + h)\cos\varphi\cos\lambda$$
$$Z = (L\,(1 - e^2) + h)\sin\varphi$$

with
- φ ... ellipsoidal latitude
- λ ... ellipsoidal longitude
- h ... ellipsoidal height
- a ... semimajor axis (a = 6378137.000.m)
- b ... semiminor axis (b = 6356752.3142, m)
- e ... first ecentricity (e = 0.0818191908426)
- L ... radius of curvature in prime vertical

$$L = a\,(1 - e^2\sin^2\varphi)^{-1/2}$$

9.2 National Datum System

Only very few countries have adopted the WGS84 system as their official coordinate datum. Datum systems are used which were sometimes defined more than hundred years ago. These systems often have their origin hundreds of meters from the geocenter (translations). The coordinate axes are not parallel to the axes of the WGS84 system (rotations) and even the scale is different.

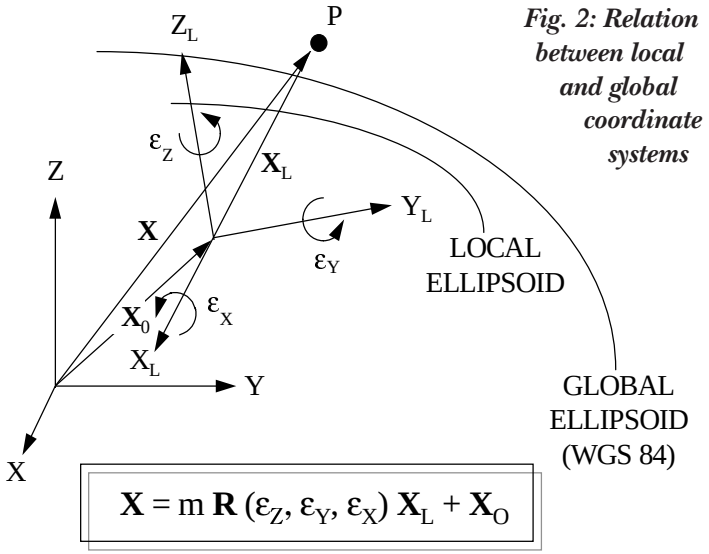


Fig. 2: Relation between local and global coordinate systems

This is the reason why GPS results have to be transformed to the official datum system via given formulae. The most common relation between two systems is the seven parameters similarity transformation.

The seven parameters transformation consists of three translations composing vector X_0 (Δx, Δy, Δz), three rotation angles ε_X, ε_Y, ε_Z and a scale factor m. The relation between local and global WGS84 Cartesian position vectors is given by the vector-matrix equation in fig. 2. Please note that the given values used within the Geotracer® System can not be representative for the whole country with centimeter accuracy. However, parameters for this type of relation are sufficient for a rough coordinate transformation with at least an accuracy in the meter range. This accuracy is sufficient for a lot of applications and even tasks within a high-precision GPS positioning system.

In the national datum system we will find also cartesian and ellipsoidal coordinates. However, traditionally cartesian geocentric coordinates are not used within local coordinate systems.

A seven parameter transformation for a national datum can be determined in Geotracer® Postprocessing software.

9.3 National Grid Coordinates

Traditionally national coordinates are derived by a projection of ellipsoidal coordinates based on the local ellipsoid to a flat surface. This can be done in different ways. The most common procedure is the projection to a cylinder touching the earth at a great circle which is also called reference or central meridian (figure 3).

! For national grid coordinates choose labels 37 38 39

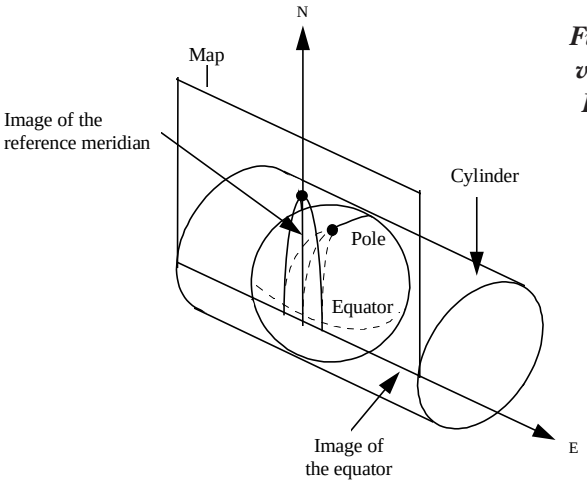


Fig. 3: Transverse Mercator Projection

This type of projection is called Transverse Mercator Projection. If rotated differently to the N-S axis, it is called Oblique Mercator Projection. An other often used projection is the Lambert Projection which is using a cone. Different countries use totally different projection schemes. Most of them are resulting in different scales depending on the distance to the central meridian.

9.4 Pure Local Coordinates

You only need an origin and a north direction to set-up this coordinate system. As origin of the system choose a point number P which you define to have local coordinates x_p and y_p. Define a local north direction y by, e.g., providing the azimuth α (figure 4). Additionally, you may provide a scale difference between your local system and the GPS-system.

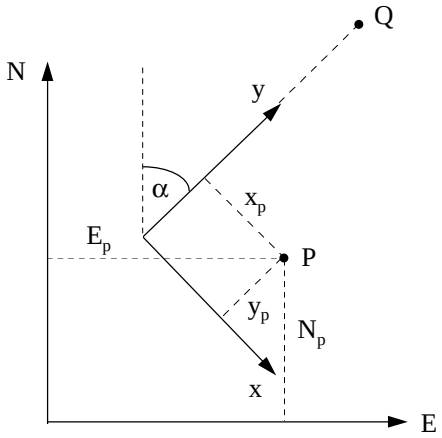


Fig. 4: Local coordinate system

! For pure local coordinates choose labels 37 38 39

The local system can be defined in four different ways.

1. Provide local coordinates x_p and y_p for point P. Use the national grid North N and define y to be parallel to N ($\alpha = 0$).

2. Provide local coordinates x_p and y_p for point P. Provide an azimuth α by using a direction to a second point Q (see chapters 8.5.5 and 8.5.7).

3. Provide local coordinates for point P and a second point Q. Derive the azimuth α and the scale k from two points (see chapter 8.5.2).

4. Use the same method as in 3, but use distance and azimuth between Point Q instead of the coordinate sets (see chapter 8.5.4 and 8.5.6).

In summary up to 4 parameters x_p, y_p, α and k are used to define the local coordinate system.

If you want to work with different reference stations within a larger area (< 10 km) it is usually necessary to use coordinates N, E in a national grid or state plane system. This is necessary for the projection process to guarantee a coordinate system with consistent properties from one reference station to the next. However, this is only of importance for internal system consideration. You will not notice it except that you have to make sure that only known points are used as a reference station within the local network. I.e., if Q is a second reference point to be used, it should be known or observed from the previous reference point P first.

If 3 or more control points are available in the local system, you may perform a least-squares adjustment to optimally define the offsets, orientation and scale (see chapter 8.5).