RT-Base

GPS
Base
Station

RT-Base
User Manual

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Revision

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Introduction

The RT-Base is a GPS Base Station suitable for transmitting Differential corrections to the RT3000 and other products that use GPS. The position accuracy of Differential and RTK GPS receivers is improved when using the RT-Base.

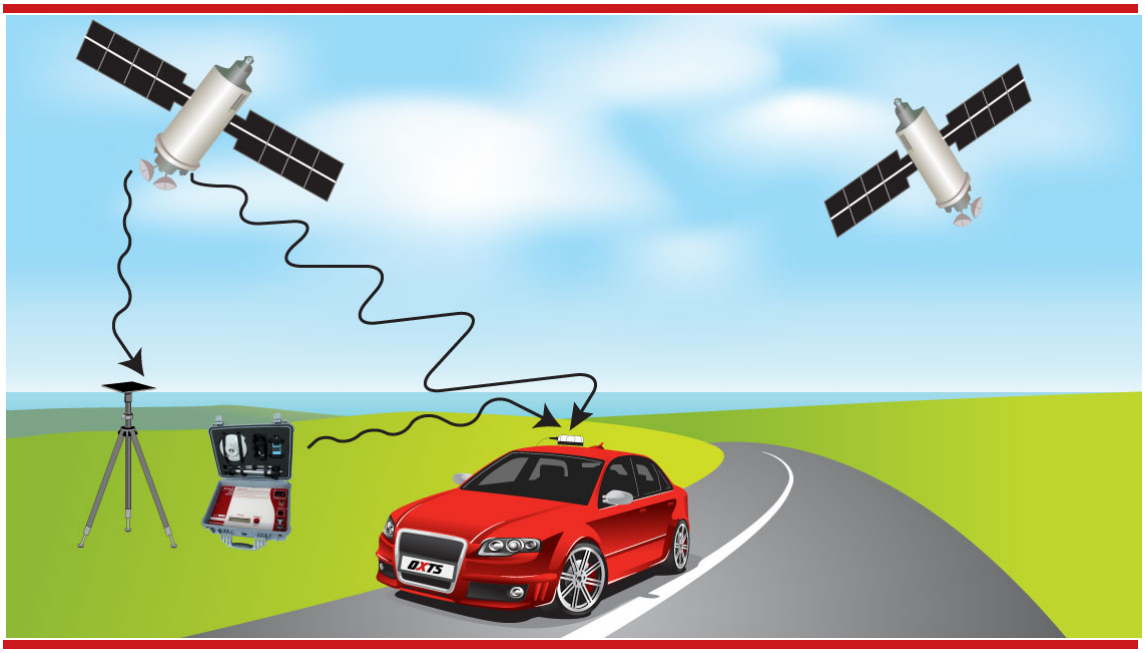
Two models of the RT-Base exist; the RT-Base-20 can supply L1 corrections suitable for 20cm positioning and the RT-Base-2 can supply L1/L2 corrections suitable for 2cm positioning. Both models are identical in their operation.

The RT-Base is available with several different radio options. Different radios are required for license free operation in different countries.

Overview

Figure 1, below, gives an overview of how Differential GPS works. The information from each satellite is measured by both the RT-Base and by the GPS in the car. The RT-Base works out the error in the satellite's information and transmits it to the car using a radio link. The GPS in the car then applies the correction to each satellite's measurement before it computes position and time.

Figure 1. Differential GPS Overview



For RTK (Real-Time Kinematic) Carrier-Phase measurements the principle is the same, but the GPS in the car also has to figure out the difference in the number of carrier-phase cycles between the RT-Base and the car. The RT-Base measures the carrier-phase of the signals from each satellite and transmits it to the car.

Differential GPS works in real-time because the corrections from each satellite vary slowly and predictably. The GPS in the car uses a model to predict the error from each satellite. It can update its model when the radio link transmits new data. It is not necessary for the GPS in the car to wait until the radio has transmitted the correction before it outputs its latest value.

Table 1, below, lists information about each of the different correction types that are available.

Table 1. Summary of Differential Correction Types

Correction	Measurement	Accuracy	Max Age (typical)	Packet Type[2]	RT-Base Model
Differential	L1 Pseudo-Range	45cm[1]	60s	RTCA1	RT-Base-20 RT-Base-2
L1	L1 Carrier-Phase	20cm	30s	RTCAOBS	RT-Base-20 RT-Base-2
L1/L2	L1/L2 Carrier-Phases	2cm	30s	RTCAOBS	RT-Base-2 only

Note 1: Using the smoothing of the Inertial Navigation System the RT3000 can achieve 40cm of position accuracy using Differential GPS.

Note 2: The RT-Base also transmits the RTCAREF packet.

For Pseudo-Range (not carrier-phase) Differential GPS the corrections can be up to 60s old (depending on the GPS in the car). For RTK corrections (20cm and 2cm) the corrections can be up to 30s old (again, depending on the GPS in the car).

Features

The RT-Base is a self-contained unit that includes:

- The Base-Station GPS receiver.
- Battery suitable for over 12 hours of operation.
- Radio Modem.
- Mains Power Supply and Battery Charger.

- GPS Antenna, 15m Cable and Tripod.
- Radio Modem Aerial, Cable and Magnetic Mount.

The RT-Base also includes a Remote Radio Modem and Antenna for use on the vehicle.

The Radio Modem in your RT-Base will be factory configured for use in a particular country or territory. Typically the radio can transmit between 2 km and 5 km line-of-sight. Trees, buildings, hills and other obstructions limit the range that can be used.

The RT-Base is also suitable for use as a general base-station for other products, such as the Datron MicroSAT. The RT-Base transmits corrections in RTCA format, accepted by many GPS receivers.

Table 2. Overview of different radios

Radio	Specification
SATEL	380 - 480 MHz band, up to 1 W, typically 5 km. License free bands available for many European countries. Radio will typically cover 8 bands with 25 kHz channel spacing.
SATEL	869 MHz band, up to 500 mW, typically 2 km. License free across most of European Union.
Freewave	900 MHz band, up to 1 W, typically >10 km. License free in USA, Brazil, Canada.
Futaba	2.4 GHz band, 10 mW, maximum 2 km. License free in Japan.

Scope of Delivery

Table 3, Table 4 and Table 5, list all the items that are delivered with an RT-Base and the respective radio modem.

The customer must check that the radio can be used without a license or obtain a suitable license before using the RT-Base. Oxford Technical Solutions cannot be held responsible for using this equipment illegally without the correct radio license.

Table 3. Summary of the RT-Base Components with SATEL radio

Qty	Description
1	RT-Base Unit
1	GPS-C006 15m GPS Antenna Cable
1	GPS-702-GG GPS Antenna
1	SATEL Satelline-3ASd Radio Modem (for remote vehicle)
2	Radio Modem Aerial/Antenna with 3m cable and Magnetic Mount
1	Lightweight Tripod
1	IEC Mains Cable (UK, EU and US-style plugs can be specified)
1	77C0002B Power Cable
1	Internal Radio Link – fit to use internal radio
1	RT-Base User Manual
1	RT-Base Quick Guide

Table 4. Summary of the RT-Base Components with Freewave radio

Qty	Description
1	RT-Base Unit
1	GPS-C006 15m GPS Antenna Cable
1	GPS-702-GG GPS Antenna
1	Freewave FGR-115RC 900MHz Radio (for remote vehicle)
1	14C0044B Freewave Radio Cable
1	Car Antenna (short) with 20ft cable
1	Base-Station Antenna (long) with 20ft cable
1	Lightweight Tripod
1	IEC Mains Cable (UK, EU and US-style plugs can be specified)
1	77C0002B Power Cable
1	Internal Radio Link – fit to use internal radio
1	RT-Base User Manual
1	RT-Base Quick Guide

Table 5. Summary of the RT-Base Components with Futaba radio

Qty	Description
1	RT-Base Unit
1	GPS-C006 15m GPS Antenna Cable
1	GPS-702-GG GPS Antenna
3	Radio Antenna, SMA connector and Magnetic Base
2	2m SMA-SMA Antenna Extension Cable
1	5m SMA-SMA Antenna Extension Cable
1	TNC-SMA Adaptor (fitted to one of the Radio Antennas)
1	Lightweight Tripod
1	IEC-US Mains Lead
1	77C0002B Power Cable
1	14C0045A RT3000 Futaba Radio Cable
1	Internal Radio Link – fit to use internal radio
1	Futaba Radio Modem (for remote vehicle)
1	RT-Base User Manual
1	RT-Base Quick Guide

Figure 2. RT-Base Components

Specification

The technical specification of the RT-Base unit is shown in Table 6, below.

Table 6. Technical Specification (except Radio Modem)

Parameter	Specification
Mains Power	110-240 V AC. 50-60Hz. 3A Max.
Battery	12V, 7Ah, Sealed Lead-Acid
Charge Time	2 hours
Operating Time	> 10 hours
Operating Temperature	0 to 50°C
Charge Temperature	10 to 40°C
Environment	IP65 – with lid closed
Relative Humidity	95%, non-condensing
Corrections	RTCA (Differential, L1, L2)
Frequency	1 Hz
Format	RS232
Dimensions	486 x 392 x 192 mm
Weight	12.6 kg

Warranty

Oxford Technical Solutions Limited warrants the RT-Base products to be free of defects in materials and workmanship, subject to the conditions set forth below, for a period of one year from the Date of Sale.

'Date of Sale' shall mean the date of the Oxford Technical Solutions Limited invoice issued on delivery of the product. The responsibility of Oxford Technical Solutions Limited in respect of this warranty is limited solely to product replacement or product repair at an authorised location only. Determination of replacement or repair will be made by Oxford Technical Solutions Limited personnel or by personnel expressly authorised by Oxford Technical Solutions Limited for this purpose.

In no event will Oxford Technical Solutions Limited be liable for any indirect, incidental, special or consequential damages whether through tort, contract or otherwise. This warranty is expressly in lieu of all other warranties, expressed or implied, including without limitation the implied warranties of merchantability or fitness for a particular purpose. The foregoing states the entire liability of Oxford Technical Solutions Limited with respect to the products herein.

Conformance Notices

The RT-Base complies with the radiated and conducted emission limits Class B of FCC CFR 47, Class B of Part 15 of the FCC rules, with the conducted emissions limits for Class A of EN 61326, with the radiated emissions limits for Class B of EN 61326 and immunity limits of EN 61326. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Re-orient or relocate the receiving antenna
- Increase the separation between the equipment and the receiver

It is occasionally possible for the LCD display of the RT-Base unit to become black following electrostatic discharge, however the RT-Base continues to work correctly.

The RT-Base incorporates a GPS receiver. Any GPS receiver will not be able to track satellites in the presence of strong RF radiations within 70 MHz of either GPS frequencies (1575 MHz (L1), 1228 MHz (L2)).

The RT-Base conforms to the requirements for CE.

Regulator Testing Standards

- EN55022
- EN61000-4-2
- EN61000-4-3
- EN61000-4-4
- EN61000-4-5
- EN61000-4-6
- EN61000-4-11
- FCC CFR 47: Class B

Operation

Follow these steps to operate your RT-Base unit correctly.

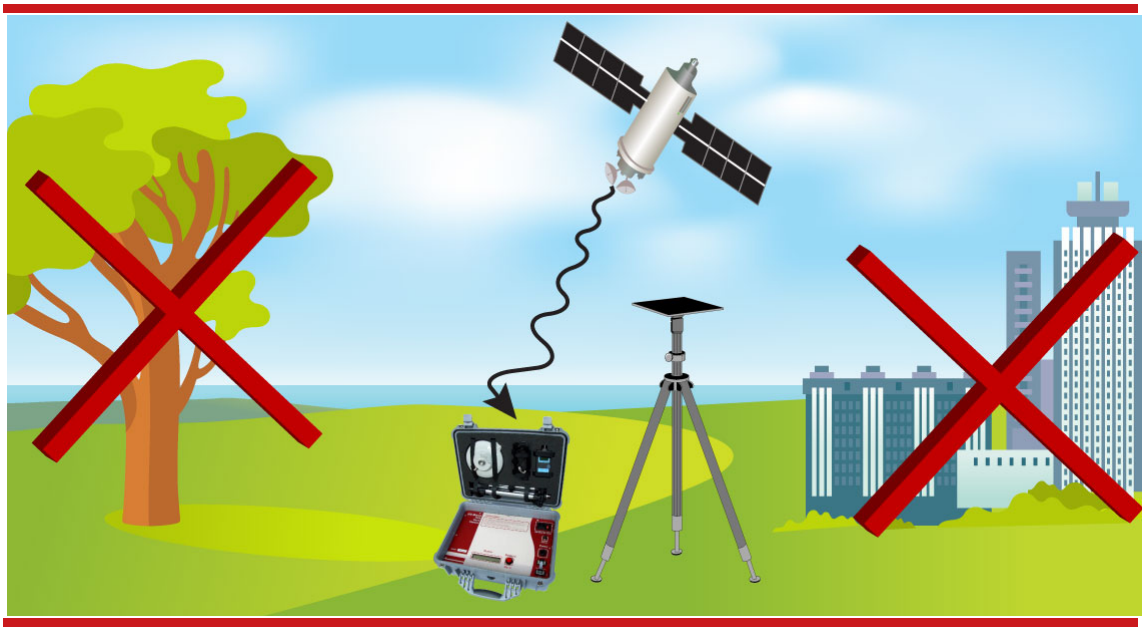
Charging

Before using the RT-Base for the first time charge the battery in the unit by connecting it to the mains. A switch next to the mains plug can be used to turn the mains power on or off. The RT-Base takes about 2 hours to fully charge.

Choosing a Suitable Location

For correct operation of the RT-Base it is essential to locate the GPS antenna in a location where it has a full view of the sky, down to an elevation of 10 degrees in all directions. It must also be away from reflective objects, like buildings and trees.

Figure 3. RT-Base Location away from Buildings, Trees and Reflective Objects



The RT-Base unit should not be left in direct sunlight or the internal temperature may exceed the specification. The temperature range of the unit is restricted because of the internal battery.

Connecting the RT-Base System

Connect the GPS Antenna to the tripod or to a secure pole. The mounting should ensure that the antenna does not move, including in wind or gusts (such as when a car drives past). Connect the GPS Antenna Cable to the GPS Antenna and to the GPS Antenna input on the RT-Base unit.

Ensure that the link wire is fitted between the two 9-way D-type connectors to activate the internal radio, see section on Using an External Radio for more details.

Note: Never extend or shorten the GPS Antenna Cable. The loss in the cable is carefully matched to the GPS Receiver and lengthening or shortening the cable will reduce the performance of the RT-Base system.

Connect the GPS Cable to the GPS Antenna TNC on the front of the RT-Base.

Note: Never connect the GPS Antenna to the Radio Aerial connector. The use of two TNC connectors is required since they have much better ground properties compared to BNC connectors. The Radio Aerial output has a high-power signal that may damage the GPS Antenna.

Locate the Radio Modem Aerial at least 2m away from the GPS Antenna. Clip the Radio Modem Aerial on a metal object, such as the roof of a car. Connect the Radio Modem Aerial to the Radio Aerial connector on the RT-Base unit.

Figure 4. RT-Base Connections

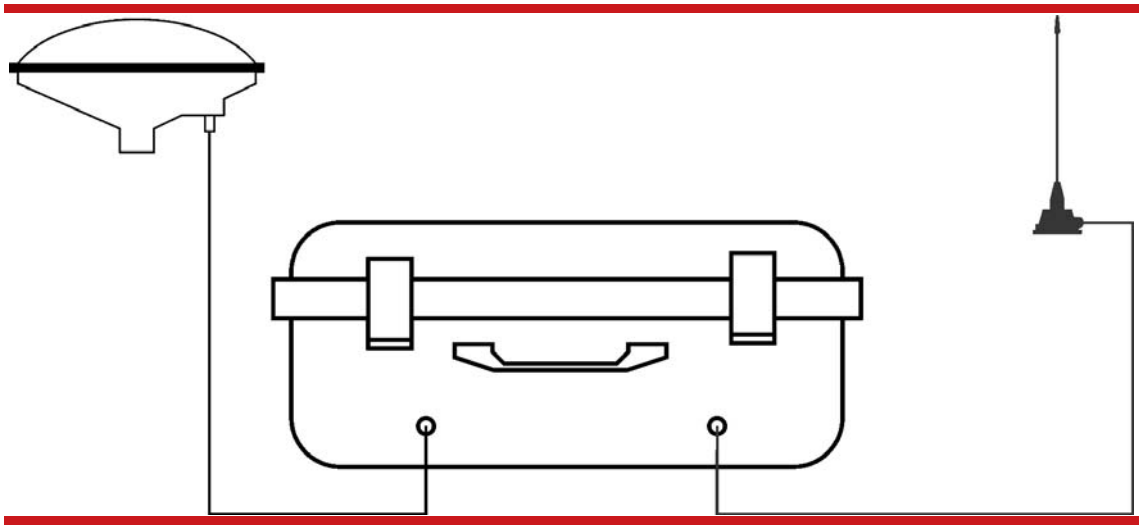
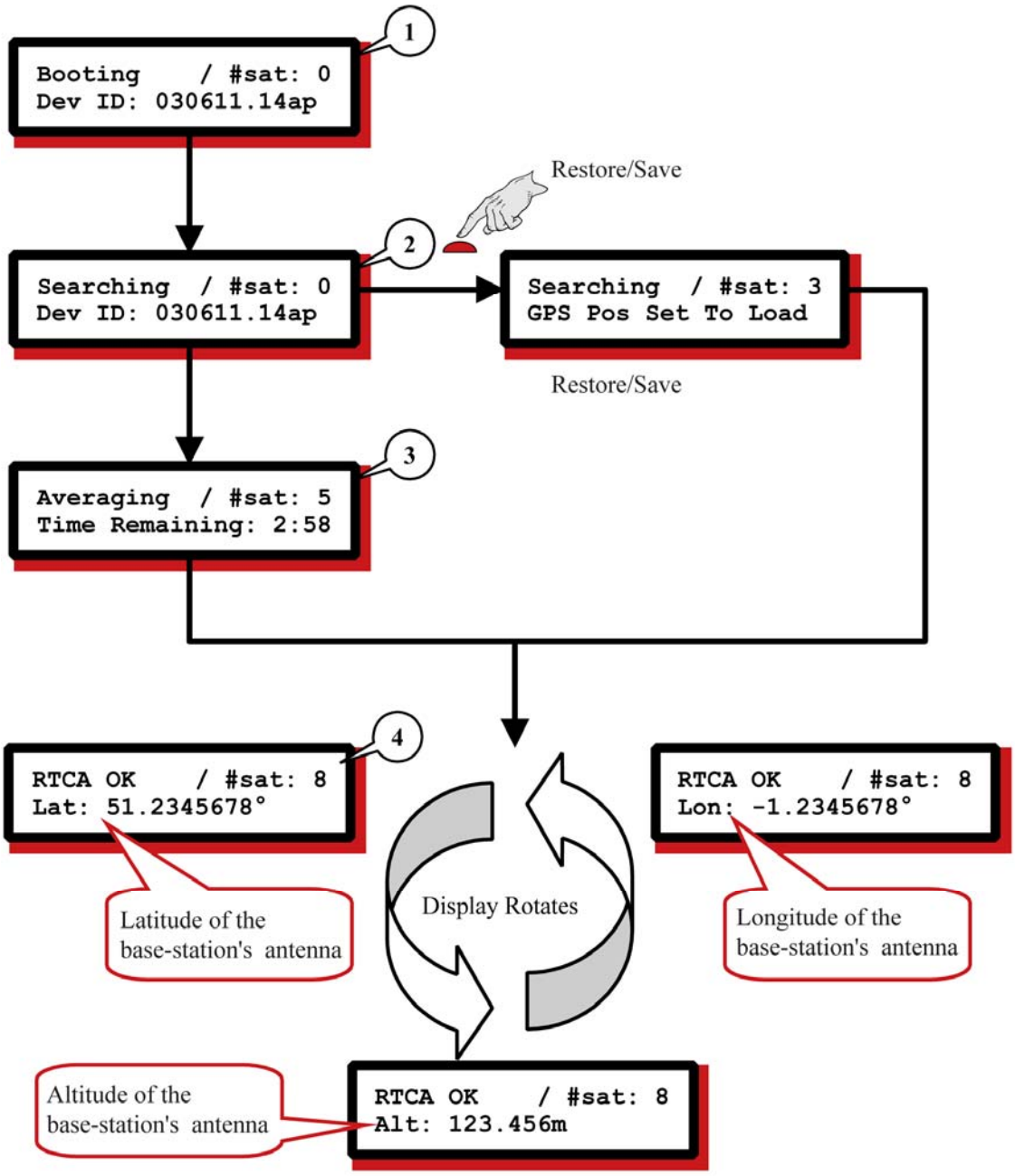


Figure 4, above, shows the connections for the GPS Antenna and the Radio Aerial.

Using the RT-Base System

After turning on the RT-Base unit, it follows the sequence in Figure 5, below.

Figure 5. RT-Base Flowchart



Step 1. The RT-Base unit boots the GPS receiver.

Step 2. The GPS receiver starts searching for satellites. This normally takes about 90s, but can take up to 20 minutes if the unit has been turned off for a long period of time or has been moved a significant distance since last time it was used.

The number following the "`#sat:`" counts the number of satellites being *tracked*.

Step 3. Once the GPS receiver has found its position it averages the position for three minutes. This does not give a very repeatable position. For repeatable performance the averaged position should be saved and restored next time.

To use the Restore/Save button you must have the GPS Antenna in exactly the same location (ideally to 2mm or better) as when the position was saved.

Once the Position Averaging has started you cannot use the Restore feature any longer. Turn the RT-Base off and on again if you need to use the Restore feature.

Step 4. In Step 4 the RT-Base unit starts transmitting corrections (the radio will be inactive until now). The display shows the Latitude, Longitude and Altitude of the location of the GPS Antenna.

Once at Step 4 press the Restore/Save button to save this location. This will overwrite the last saved location and can be restored next time the RT-Base unit is started.

ESD notice

- The LCD display is sensitive to electro-static discharge (ESD).
- The display may go blank when ESD occurs to some parts of the RT-Base.
- Other components in RT-Base continue to operate correctly even if diplay appears blank due to ESD.

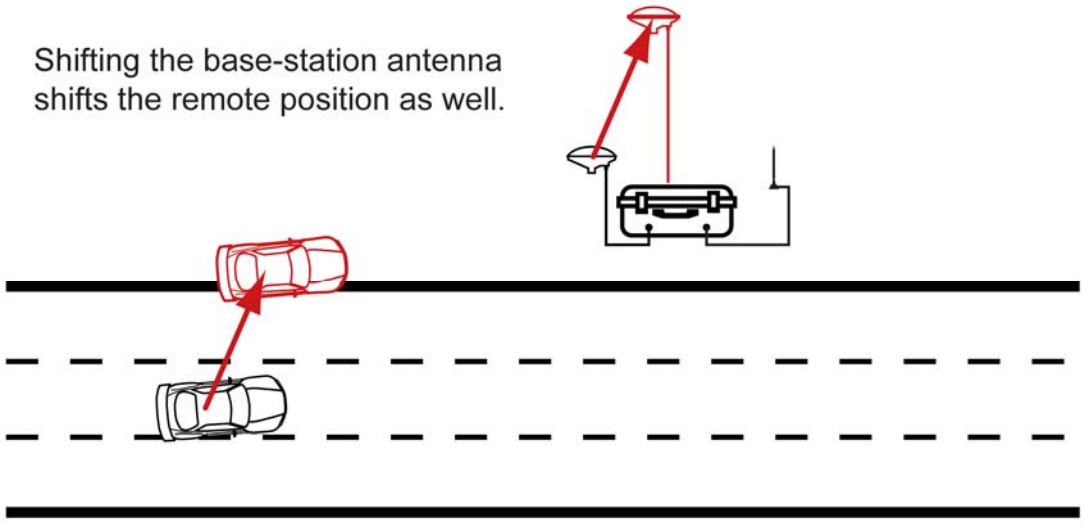
Discussion on Repeatability

Differential Corrections for GPS change the way that a GPS receiver works. When using Differential Corrections the GPS receiver is effectively measuring the position *relative* to the base-station, not the absolute position on earth. This leads to several effects that the user should be aware of:

1. If the base-station antenna is moved then the remote GPS receivers move too. It is important to put the GPS antenna in a location where it cannot move or be moved. See Figure 6.

2. The base-station has to measure its own position. If the base-station gets this position wrong then the remote GPS receivers will also be wrong. They will be correct relative to the base-station, but they will have the same error on the earth that the base-station has. This is important when turning the RT-Base off and on again. See Figure 7.

Figure 6. Shifting Base-Station Antenna Example

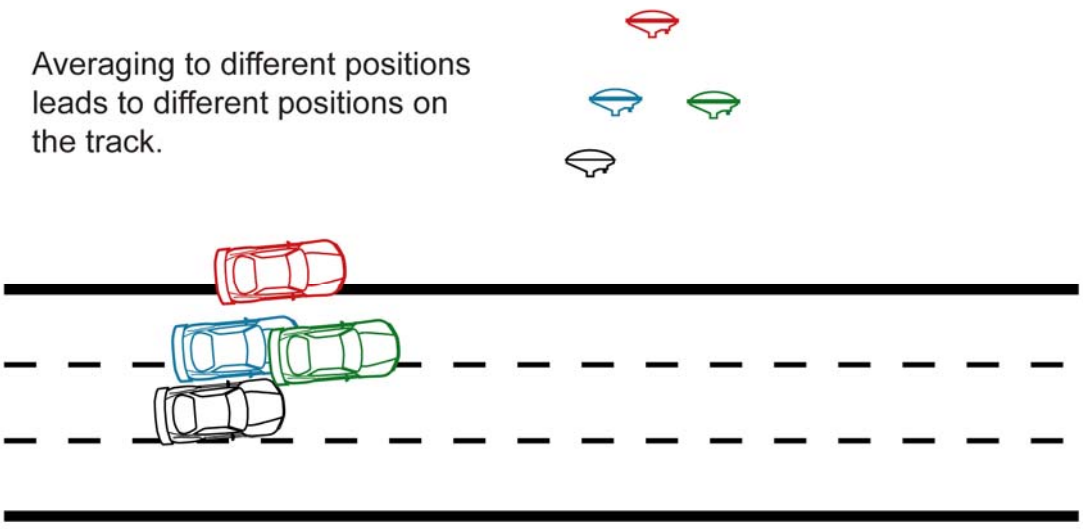


The problem of shifting the antenna typically occurs when:

- The tripod is knocked over and picked up again. It is hard to get the antenna back to the same location accurate to 1cm.

- If the RT-Base is used one day, packed up then returned to the same location the next day. It is very hard to replace the tripod in the same location. It is better to have a pole that is fixed to the ground if you intend to use the same surveyed location on several days.

Figure 7. Averaging to a Different Position Example



The problem of averaging to a different position happens each time that the RT-Base goes through its averaging process. There is nothing magical about the RT-Base that allows it to get its own position accurate to 2cm or better. It is subject to the same errors that all GPS receivers have and can only average its position to about 1.8m CEP.

If the user is prepared to wait a long time (typically more than 24 hours) then GPS is able to improve the accuracy of the base-station antenna so it is accurate to 2cm or better. However, since the timescale for this is long it is not usually practical, except for permanent installations. (Even when you have a permanent installation it is not required since all it does is allows you to relate your measurements to a surveyors measurements and this is rarely required).

To overcome the problem of averaging the save/restore feature of the RT-Base should be used. When using the Save/Restore feature the RT-Base will save the position where it last averaged and then use this next time (instead of averaging again). This way the error is the same each time and the repeatability is perfect. You must remember to put the antenna in the same location each time, accurate to 1cm or better, when using the Save/Restore feature.

Using an External Radio

It is possible to disable the internal radio and use an external radio instead. This is useful if you need to use the RT-Base in several countries and different radios are required to conform to the local licensing laws.

On the RT-Base panel are two 9-way D-type connectors: Radio Configuration and GPS Configuration. These are linked to activate the internal radio. To use an external radio disconnect the link wire; the GPS Configuration connector is wired as a standard 9-way D-type connector with the exception of the ring pin, which has power on it. Table 7 gives the pin connections for the GPS Configuration connector.

Table 7. Pin Connections of the GPS Configuration connector

Pin	Direction	Signal
1		N/C
2	In	Receive
3	Out	Transmit
4		N/C
5	Out	Ground
6		N/C
7		N/C
8		N/C
9	Out	Power from internal batteries

To use the internal radio, replace the link cable.

The RT-Base does not use the hardware handshake lines, so it is necessary to use a modem that does not need these lines. You cannot use a modem that requires software handshaking since the data on the RT-Base will include the XON and XOFF characters as part of its data. You have to use a modem that can transmit all the data sent.

The settings of the data sent from the RT-Base are given in Table 8. The radio modem must use these settings or the data will not be transmitted correctly.

Table 8. Serial Port Settings for RT-Base transmissions

Parameter	Setting
Baud Rate	9600
Data Bits	8
Parity	None
Stop Bits	1

The Power Output pin of the GPS Configuration connector supplies between 11V and 15V, depending on whether the internal batteries are charging or flat. If you are using a standard modem cable then take care in case this power damages the modem. You will probably have to make a special cable so that the signals and power from this connector can go to the radio modem correctly.

Note that this output is not fused individually; shorting the power on this connector will blow the main fuse in the RT-Base. You are recommended to always make connections to the GPS Configuration port when the power is off.

When using an external modem it is not possible to close the top of the RT-Base. Without the top closed the RT-Base is not rated to IP65 and protection from moisture is required.

Special Configuration of the RT-Base

Sometimes it is necessary to store more than one position for the base-station antenna. For example, the RT-Base may be used at more than one location. The software in the RT-Base cannot do this and the extra positions have to be stored elsewhere and then programmed to the RT-Base using a computer.

Setting the Base-Station Position

If you want to use a previously computed position (to match earlier surveys or work) and this is not the position saved in the RT-Base you can follow the procedure here.

1. Remove the Link Cable that connects the Radio Configuration connector to the GPS Configuration connector. Connect a Null Modem Serial cable between a PC COM Serial Port and the GPS Configuration connector.

2. Run a serial port application, such as Hyperterminal. Configure the communications for 9600 baud, 8 data bits, no parity, 1 stop bit, no handshaking and no flow control (same as Table 8, above).

3. The RT-Base may be sending some undecipherable data over this port; these are the Differential Corrections. Ignore the data sent from the RT-Base.

4. Type the following commands:

```
FIX NONE↵

FIX POSITION xx.xxxxxxxx yy.yyyyyyyy zzz.zzz↵
```

where `xx.xxxxxxxx` is the Latitude in degrees; `yy.yyyyyyyy` is the Longitude in degrees and `zzz.zzz` is the Altitude in degrees. You should enter at least 8 decimal places for the Latitude and Longitude and three decimal places for the Altitude.

It is often difficult to type these correctly, especially since the RT-Base will be sending data all the time. It is usually easier to type them into an editor, such as Notepad, and then paste them into the serial port application.

5. Check on the RT-Base display that the position you have requested has been received correctly and that the display matches the values you have entered.

You can save this location to the RT-Base by pressing the Save/Restore button on the RT-Base. Otherwise, the previously saved position will remain in the RT-Base but the new location will be used until power-off.

To use the RT-Base immediately you need to reconnect the Link Cable between the Radio Configuration and GPS Configuration connectors. This must be done very carefully if the power is left on since it is possible to short between Pin 9 of the GPS Configuration connector and the connector chassis; this will blow the internal fuse. It is recommended to save the new location to the RT-Base; turn off the RT-Base connect the Link Cable; turn the RT-Base on again and press the Save/Restore button to restore the new location.

Saving the RT-Base Position

You can save the RT-Base Position by writing down the Latitude, Longitude and Altitude values that are displayed in the LCD display. You should write down all 8 decimal places for the Latitude and Longitude.

Revision History

Table 9. Revision History

Revision	Comments
030617	Initial Version
051116	Added Repeatability Discussion; External Radio connection; external configuration of position (requires Software Dev Id: 050919.14ap or later).
070316	Updated images, incl. different radio modems.