User Manual

GPS-Base
GNSS-aided inertial navigation system

Measure with confidence

OXTS

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Revision

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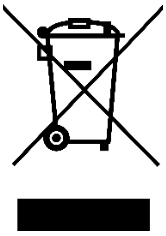

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Common abbreviations

AB Dynamics	Anthony Best Dynamics
CAN	Controller Area Network
CEP	Circular Error Probability
CPU	Central Processing Unit
DGPS	Differential Global Positioning System
ECCN	Export Control Classification Number
EGNOS	European Geostationary Navigation Overlay Service
FTP	File Transfer Protocol
GAGAN	GPS Aided Geo Augmented Navigation
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
LED	Light Emitting Diode
MFDD	Mean Fully Developed Deceleration MSAS
MTSAT	Satellite Augmentation System
NMEA	National Marine Electronics Association
NTRIP	Networked Transport of RTCM via Internet Protocol
PPS	Pulse(s) Per Second
RD	Raw Data (an OxTS file format)
RINEX	Receiver Independent Exchange format
RTK	Real-Time Kinematics
SBAS	Satellite Based Augmentation System
SDCM	System for Differential Corrections and Monitoring
SPS	Standard Positioning Service
TCP	Transmission Control Protocol
TNC	Threaded Neill-Concelman
TTFF	Time to First Fix
TTL	Transistor-Transistor Logic
UDP	User Datagram Protocol
VUT	Vehicle Under Test
WAAS	Wide Area Augmentation System
WGS 84	World Geodetic System 1984
WLAN	Wireless Local Area Network

Introduction

Thank you for choosing Oxford Technical Solutions.

The GPS-Base is a highly-portable GPS base station that transmits differential corrections to one or more differential enabled GNSS receivers via radio modem. The position accuracy of differential and RTK GNSS receivers is improved when using the GPS-Base. The GPS-Base is available with several different radio options. Different radios are required for license free operation in different countries.

Four models of the GPS-Base exist, as listed in Table 1. All models are identical in their operation but are able to track different satellite signals.

Table 1. GPS-Base models

Model	Measurement/accuracy potential*
GPS-Base-2	L1/L2 GPS corrections suitable for positioning down to 1 cm accuracy
GPS-Base-2G	L1/L2 GPS and L1/L2 GLONASS corrections suitable for positioning down to 1 cm accuracy

* Note: The maximum positioning accuracy is determined by the GNSS hardware in the mobile receiver.

How do base stations work?

A base station significantly increases the position accuracy of mobile GNSS receivers by sending them corrections. The base station does this by independently identifying the errors affecting the signal from each GNSS satellite it can see. Information about those errors is then broadcast via radio modem or something similar. Other GNSS receivers in the area—which are also connected to similar radio modems—receive the correction information and take it into account when calculating their own position measurements. Removing the errors results in more accurate position estimates.

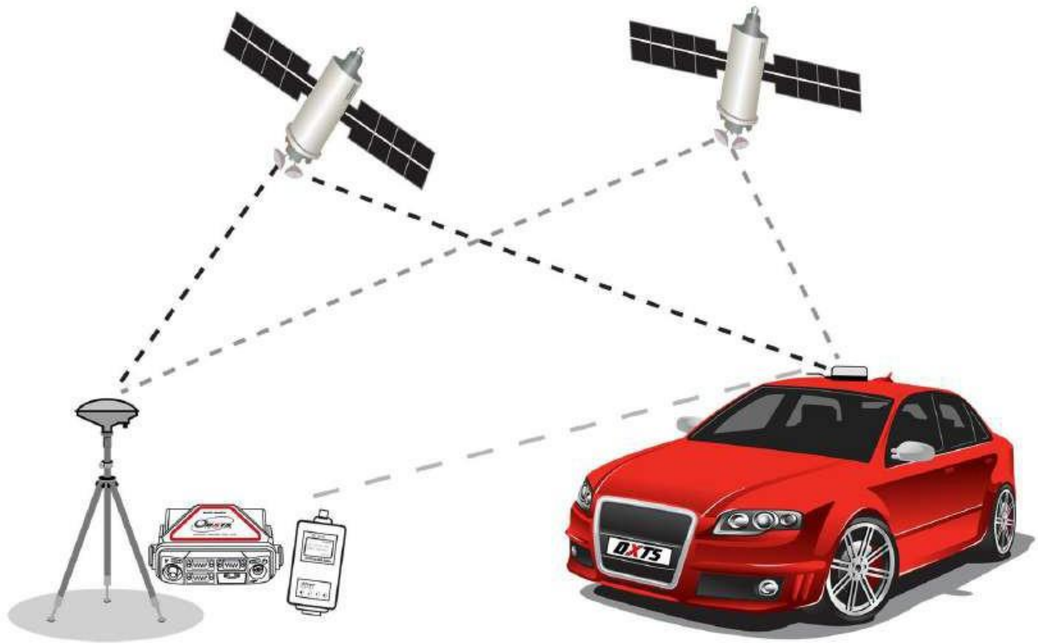
A base station identifies the errors affecting GNSS signals in one of two ways. If the base station is placed at a precisely surveyed location, it calculates a GNSS position measurement in the normal way, then compares that calculated position to the known location. If the position measurements match exactly, no correction is required. If there is a difference however, the base station calculates the length of time each satellite signal would need to be delayed by, in order to cause the difference between the surveyed location and the GNSS measurement being produced.

Alternatively, if the base station is not placed at an accurately surveyed location, the only way for it to estimate the errors is to measure its own position as accurately as possible. It does this by averaging the GNSS measurements over a period of time before settling on one location. It then compares all further measurements to that chosen location in order to identify the errors in the same way as before.

In both cases the base station calculates the errors affecting the signal from each satellite it can see, and shares that information with other GNSS receivers in the local area. This is normally achieved using radio modems or via an optional Wi-Fi system. A transmitter connected to the base station broadcasts corrections, and each GNSS receiver has a modem attached to it that listens for those corrections.

For RTK (Real-Time Kinematic) carrier-phase measurements, the principle is the same, but the remote GNSS receiver also has to figure out the difference in the number of carrier-phase cycles between the GPS-Base and itself. To do this, the GPS-Base measures the carrier-phase of the signals from each satellite and transmits it to the remote system.

Figure 1. Differential GNSS overview



The base station is either placed at a precisely known location or left to average its position over time. It can then estimate the errors affecting each satellite it is tracking and broadcast information about those errors using radio modems. Nearby GNSS receivers use radio modems to listen for corrections, and apply them to the signals from the common satellites, reducing the errors in their own position calculations.

Differential GNSS can work in real-time applications because the errors affecting each satellite vary slowly and predictably. The mobile GNSS receiver in the vehicle 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 mobile GNSS receiver to wait until the radio has transmitted the correction before outputting its latest value. Depending on the GNSS receiver in your INS, pseudo-range differential GNSS corrections can be up to 60 seconds old, and RTK corrections can be up to 30 seconds old.

Transmitting the corrections

Each new GPS-Base is supplied with a pair of radio modems suitable for use in the country specified when ordered. Typically, these radio modems have a range of 2–5 km line-of-sight. However, trees, buildings, hills and other obstructions will limit the range that can be achieved. Table 2 shows the different radios that can be supplied with the GPS-Base.

Please note that the use of the frequency bands 403–473 MHz is not harmonised across Europe. Please contact OxTS if you require further details on the specific frequency band and power settings for the radios supplied with your GPS-Base, and in which countries they can be used.

Table 2. Overview of different radios

Radio	Specification
SATEL SATELLINE-EASy (with display) 403–473 MHz	Up to 1 W, typically 5 km. License free bands available for many European countries. Radio will typically cover eight bands with 25 kHz channel spacing, except for SATEL Easy radios, which have a much wider range of configurable frequency
SATEL SATELLINE-EASy (with display) 869 MHz	Up to 500 mW, typically 2 km. License free across most of European Union. When using a radio in the 869 MHz band in countries or regions where ETSI EN 300 220-1 is mandated, the option "Limit output corrections message rate (ETSI EN 300 220-1)" must be selected in NAVbase
FreeWave FGR2-900 MHz	Up to 1 W, typically >10 km. License free in USA, Brazil, Canada

While the GPS-Base will work seamlessly with our own GNSS-aided INS products, it is not limited to them in any way. The GPS-Base can also serve as a general base station for other products. To help achieve this, the GPS-Base transmits corrections inthree common formats:

- RTCA
- RTCA2
- RTCMv3

Correction types

The GPS-Base can transmit differential corrections in one of three different formats as shown in Table 3. The output type should match one supported by the mobile receiver.

Table 3. Differential correction formats supported by the GPS-Base

Format	Purpose
RTCA	The RTCA format is suitable for GPS differential corrections but is not suitable for GLONASS
RTCA2	The RTCA2 format is suitable for GPS and GLONASS differential corrections
RTCMv3	The RTCMv3 format is suitable for GPS and GLONASS differential corrections

Transmission frequency

The rate at which each message type is broadcast is listed in the tables below. The limited frequency is automatically selected when the Limit output corrections option is selected in NAVbase.

Table 4. RTCA message output

Message	Standard frequency	Limited frequency*
RTCAOBS (L1/L2 pseudo-range and carrier-phase)	1 Hz	0.25 Hz
RTCAREF (base station position)	0.2 Hz	0.2 Hz
RTCA1 (pseudo-range corrections)	1 Hz	0.25 Hz

* Used when the Limit output corrections message rate (ETSI EN 300 220-1) option is enabled.

Table 5. RTCAv2 message output

Message	Standard frequency	Limited frequency*
RTCAOBS2 (L1/L2 GNSS+GLONASS pseudo-range and carrier-phase)	1 Hz	0.25 Hz
RTCAREF (base station position)	0.2 Hz	0.1 Hz
RTCA1 (pseudo-range corrections)	1 Hz	1 Hz

*Used when the Limit output corrections message rate (ETSI EN 300 220-1) option is enabled

Table 6. RTCMv3 message output

Message	Standard update rate	Limited update rate*
RTCM1004 (extended L1/L2 GNSS pseudo-range and carrier-phase)	1 Hz	0.25 Hz
RTCM1012 (extended L1/L2 GLONASS pseudo-range and carrier-phase)	1 Hz	0.25 Hz
RTCM1005 (base station antenna position)	0.2 Hz	0.14 Hz
RTCM1007 (extended antenna descriptor and set-up information). The base station firmware always configure the base station antenna as a Novatel GNSS Antenna	0.1 Hz	0.1 Hz
RTCM1033 (base station and antenna descriptor)	0.1 Hz	0.1 Hz

* Used when the Limit output corrections message rate (ETSI EN 300 220-1) option is enabled.

File logging

As well as broadcasting differential corrections, the NAVbase software can log correction data to the hard disk of the PC when connected. Files can be logged in Novatel binary and RTCMv3 format.

Scope of delivery

With the exception of a computer running Microsoft Windows, everything you need to utilise your GPS-Base should be included with the delivery. Please check carefully that everything shown on the delivery note is present. The following tables list the standard and any optional components delivered with your product.

Please note: the customer must check that the supplied radio can be used without a license, or obtain a suitable license before using the GPS-Base. Oxford Technical Solutions cannot be held responsible for using this equipment illegally without the correct radio license.

Figure 2. Example of GPS-Base system

Table 7. Summary GPS-Base components common to all versions

Qty	Description
1	GPS-Base unit
1	15 m TNC-TNC GNSS antenna cable
1	Power cable
1	Radio modem cable
1	PC-USB cable
1	Transit case
1	Vexxis GNSS-802 antenna
1	Professional tripod
1	GPS-Base user manual
1	GPS-Base Quick Installation Guide

Table 8. Additional components supplied with SATEL 380–420 MHz radios

Qty	Description
2	SATEL SATELLINE-EASy (with display) radio modem, 380–420 MHz
2	3 m Satel 420 magnetic antenna with TNC connector

Table 9. Additional components supplied with SATEL 869 MHz radios

Qty	Description
2	SATEL SATELLINE-EASy (with display) radio modem, 869 MHz
2	3 m Satel 869 magnetic antenna with TNC connector

Table 10. Additional components with Freewave radios

Qty	Description
2	Freewave FGR2-900 MHz radio modem
2	3 m Satel 869 magnetic antenna with TNC connector
2	Freewave FGR2-900 converter cable (short)

Conformance notices

Any use or misuse of the GPS-Base, in a manner not intended by OxTS, may impair the protection provided.

The GPS-Base complies with the radiated and conducted emission limits for CISPR 25 Level 2 and Class B of Part 15 of the FCC rules, and with the radiated emission and immunity limits for Class B 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 The GPS-Base conforms to the requirements for CE.

Regulatory testing standards

- EN 55025
- CISPR 25 Level 2
- EN 61000-4-2
- EN 61000-4-3
- EN 55001 (EN 61326) Class B

Operation

The GPS-Base has been designed to be as easy to operate as possible. However, it is important to have a sound understanding of how the system works, so please read the manual thoroughly before operating the product.

The set-up procedure is summarised below. More detailed information on each step is also presented in the following sections.

Process of setting up the GPS-Base:

1. Select a stable, suitable location for the GNSS antenna.
2. Connect all cables and then power up the system.
3. Configure the system, if required.
4. Download and convert the data if required.

General precautions

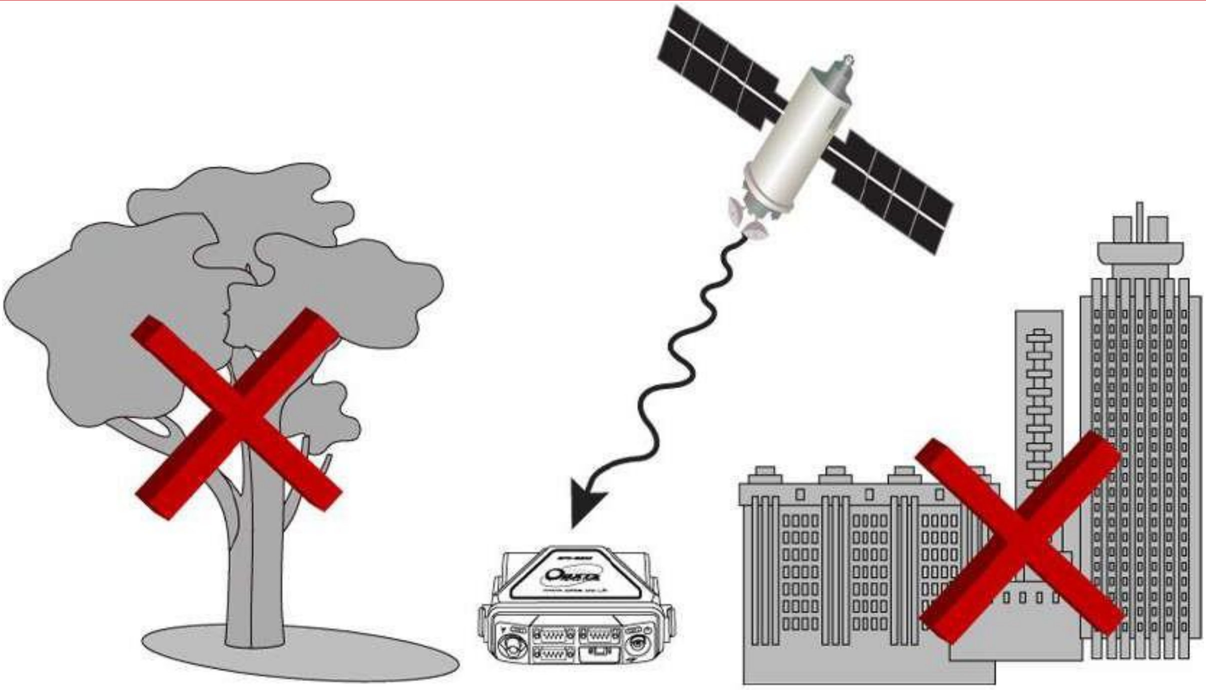
- The GPS-Base unit should not be left in the rain or other wet conditions.
- Ensure the antenna is not affected by gusts of wind—such as when vehicles pass.
- Never extend or shorten the GPS antenna cable. The loss in the cable is carefully matched to the GPS-Base and lengthening or shortening the cable will reduce the performance of the system.
- Never connect the GNSS antenna to the radio aerial connector, which uses the same 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 GNSS antenna.

Selecting a suitable antenna location, and setting up the tripod

For the GPS-Base to work to specification, it is essential to put the antenna in a location where it has a clear view of the sky. GNSS antennas do not only look for satellites from above, they also receive signals from the side-down to an elevation of about 10° in all directions. For that reason, it is important to place the antenna in the most open location available to you.

One error that no base station can easily correct for are multi-path reflections from buildings and trees. To avoid these, do not locate the antenna near trees and buildings, or other tall hard structures. It is also very important that the antenna does not move during the test. Ensure the supplied tripod is stable enough not to move in the wind and that no one can bump into it. When performing vehicle tests, consider gusts of wind that may be created by passing vehicles.

Figure 3. Choosing a location for the GNSS antenna



Choose a location for the GNSS antenna that is not close to buildings or trees, as these can both affect GNSS signals. The antenna needs to have a good view of the sky (not just above, but to the sides too).

If you intend to perform a test over several days, and will be packing the base-station away overnight, it is important to mark the location of the GNSS antenna. It will need to be placed in precisely the same location on each day. If possible, mount the antenna on a pole that has been fixed in the ground and can be left behind until the test has finished.

Setting up the tripod and antenna

1. The tripod legs use a friction lock to maintain their position. To extend each leg, twist each leg axially in an anti-clockwise direction (viewed from below) to unlock the leg. Ensure each section is re-locked in position by axially twisting it in a clockwise direction. It doesn't matter how high the GNSS antenna is located, as long as it has the best possible view of the sky.
2. Carefully remove the GNSS antenna from the GPS-Base case. The antenna is attached to the tripod via the threaded section. Do not apply excessive force when tightening the antenna.
3. Ensure the tripod and antenna are located in a safe position and there is no chance they can move or fall over.

Connecting the GNSS antenna and radio modem cables

Before powering up the GPS-Base, the GNSS antenna should be connected to the GNSS connector using the supplied GNSS cable.

Use the supplied user cable 14C0211D to connect to the GPS Base. This cable has a 5-pin power supply connection and a 26-way GPS base connector to connect to the GPS Base to enable connection to a radio modem.

The Power cable to connect to the GPS base is labelled “GPS base Power Com” and the power input can be connected to the connector labelled “10-28v in”. (A 4 pin power cable with the cigarette connection is also supplied.)

If radio modems are being used to transmit and receive DGNSS corrections, one of the supplied antennas should be connected to the Radio connector. The radio modem antenna should be placed as high up as possible (to ensure good range is achieved) but should be located at least 20 centimetres from the GNSS antenna.

To output corrections the 26-way plug will need to be connected to the GPS Base and the 15-way to the Radio modem to be used.

Powering up and monitoring the GPS-Base

Please note that a number of factors affect the time taken for the GPS-Base to acquire satellites. The process normally takes about 90 seconds, 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 first thing the GPS-Base loads as part of the boot process is a configuration file, which is held in its internal memory. The configuration file controls how the GPS-Base behaves. The first time an GPS-Base is powered up after delivery, the default settings are used. The default settings tell the GPS-Base to average its position over a three-minute period (once it computes a GNSS position) and to broadcast corrections in RTCMv3 format. The base station ID will be set to OxTS.

Creating custom configurations using our NAVbase software is covered in the next section.

Hardware LED descriptions

Table 11. Power LED Description

LED Label	LED State	Description
PWR	Green solid	Operational mode
	Yellow solid	In process of booting
	Red solid	Error, for example, invalid receiver AUTH code Firmware/Web UI update in progress

Table 12. GNSS LED Description

LED Label	LED State	Description
GNSS (indicates the position status of the receiver)	Green solid	PPP Solution
	Green slow blink	RTK integer ambiguity
	Green fast blink	Single point or SBAS position
	Yellow solid	No solution
	Yellow blink	User Accuracy Level (UAL) out of bounds (STEADYLINE)
	If PwrPak7 configured as Base	
	Green solid	Fixed position
	Yellow solid	Pending fixed position
	Yellow blink	Invalid fix

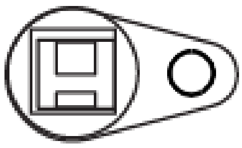
Table 13. INS LED Description

LED Label	LED State	Description
(INS indicates the INS status of the receiver (PwrPak7-E1 or PwrPak7 using an external IMU only)	Off	INS inactive
	Green solid	INS solution good
	Green slow blink	INS alignment complete
	Green fast blink	INS solution free
	Green/Yellow alternating blink	High variance
	Yellow solid	INS aligning/determining orientation
	Red solid	Error

Table 14.USB TRANSFER LED Description

LED State	Description
Green solid	Stick plugged in, no activity
Green slow blink	Logging to stick with lots of available memory
Green fast blink	Transferring files to stick with lots of available memory
Green/Yellow alternating blink	Logging to stick but low available memory
Yellow solid	Stick plugged in but low available memory
Yellow fast blink	Stick mounting or unmounting/busy
Red solid	Stick plugged in memory full
Red fast blink for 3 seconds then Red solid	Stick mount error: Stick plugged in but corrupt or unsupported format
Off	No connection to the TRANSFER port or stick is unmounted

Table 15.LOG LED and Button Description

LOG Button with LED	LED State	Description
 Logging	Green slow blink	Logging to Internal (lots of memory available)
	Green solid	Internal logging stopped (lots of memory available)
	Green/Yellow alternating blink	Logging to Internal (low memory)
	Yellow solid	Internal logging stopped (low memory)
	Yellow fast blink	Memory is mounting or unmounting/busy
	Off	PwrPak7 is connected to a PC as a mounted device
Push Button Error	Red fast blink for 3 seconds then Red solid	Not enabled, memory full or corrupt, unsupported file system

Communicating with the product

Our NAVbase software, which is supplied with the GPS-Base, is used to configure the product and monitor its operation. Using NAVbase you can:

- Average base-station location
- Enter base-station location, if known
- Restore a saved base-station location
- Program a location in to the GPS-Base so it will use it after power is removed and restored
- Set the base-station identifier GPS-Base
- Change the format of the corrections
- Monitor the status of the GPS-Base
- Save differential correction data to disk

To communicate with the GPS-Base the NAVbase software needs to know which "port" the GPS-Base is connected to. The GPS-Base connects using USB, but the USB drivers makes the GPS-Base appear as a serial COM port. Normally the driver will install three COM ports for the GPS-Base: COM5, COM6 and COM7. Any of these can be used. If these ports are taken by other software drivers then other ports will be used and it will be necessary to "search" until the correct port is found.

The GPS-Base automatically scans all the available ports on start up and only lists the ports where a valid GPS-Base has been detected.

The NAVbase interface

NAVbase can be started by clicking the Start button and typing navbase, or by clicking:

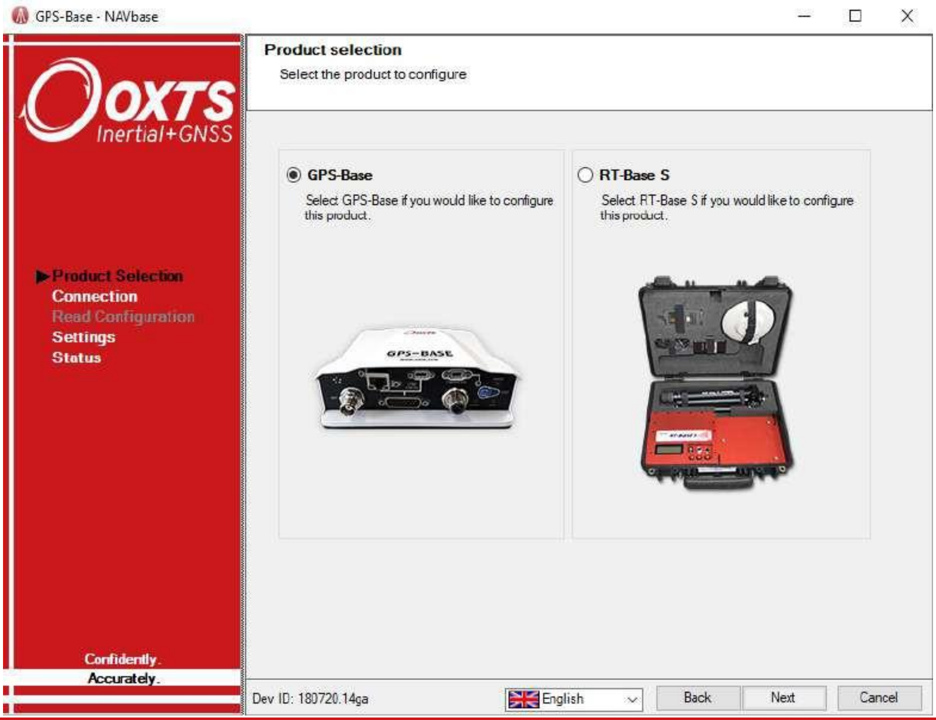
Start > All Programs > OxTS and selecting NAVbase

The initial launch screen is shown in Figure 4.

Product Selection

As NAVbase is our universal base station configuration tool, the first task is to tell the software which base station is about to configured. Simply select GPS-Base and click the Next button. You will notice that different options are available depending on the product selected.

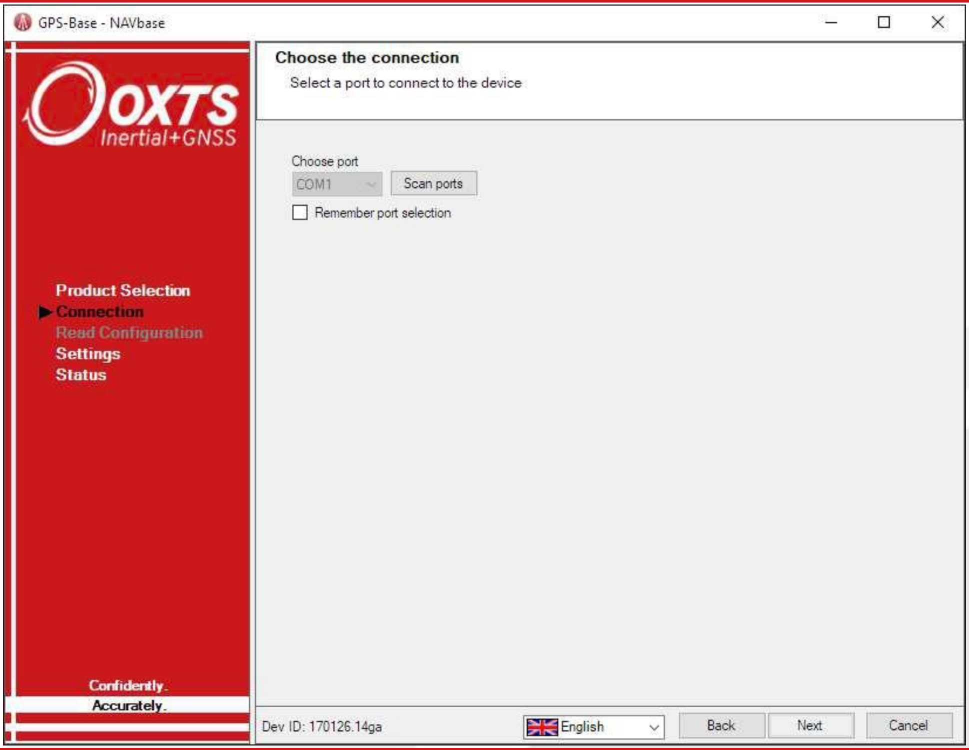
Figure 4. The initial screen presented by NAVbase



Select the GPS-Base and click Next.

Connection

Figure 5. NAVbase Connection page



The Connection page is used to specify which port NAVbase should use to communicate with the GPS-Base. If the GPS-Base was not connected when the software was run press the Scan Ports button to rescan the ports and find the GPS-Base.

Remember port selection

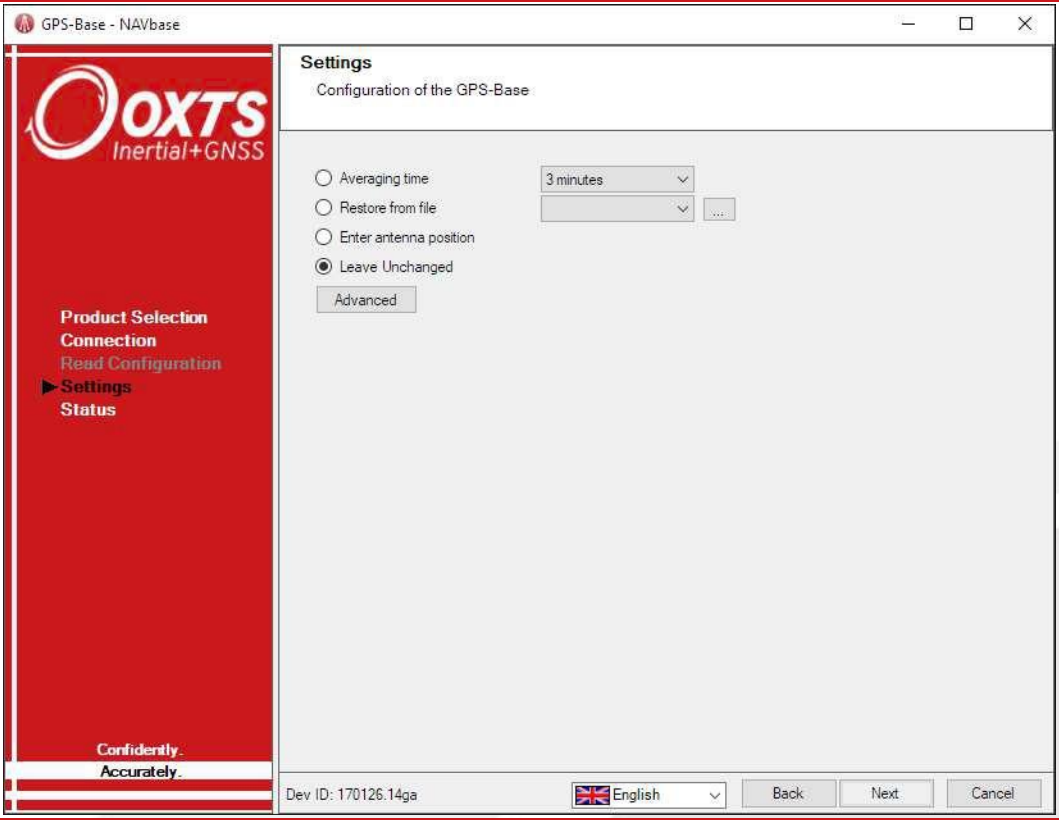
If the Remember port selection option is checked, then in future the software will skip the port scan. Normally the GPS-Base will remain on the same port so it is not necessary to visit this page each time. If the GPS-Base cannot be found on the saved port, NAVbase will scan all the ports, which can take time. It is best to have the GPS-Base on and connected before starting the software.

Settings

Before the GPS-Base will output corrections it needs to know the position of the GPS antenna. This can be restored from a file (i.e. using a position that has been saved), it can be restored from the GPS-Base, it can be entered by the user or the GPS-Base can average its position for a period of time to find an approximate location for the antenna.

There is some discussion at the end of the manual describing the benefits of each technique. In general it is sufficient to average for three minutes. For repeatable work, save the averaged location, and then restore this location using the Restore from file feature. To be accurate to a map it will be necessary to average for a long period of time (and hope that the person who made the map did this too, which they may not have).

Figure 6. NAVbase Settings page



Averaging time

Use this option to let the GPS-Base find its own position using GPS measurements. This is the most common option to use. For temporary installations, a three minute period is sufficient. Longer periods can be used to find the location of the antenna more precisely.

Note: if you average for three minutes then all the data for this average will be accurate to 2 cm compared to other data obtained during this average. If you re-average you will end up in a different location and the data from the new location will not overlay the old location. Use the Save/Restore features so that future data will overlay the current data.

Restore position from file

If you have saved the location of the GPS antenna to a file then you can restore that file using this option. This guarantees repeatable data if you can locate the GPS antenna in exactly the same location each time. The GPS-Base can also store an antenna location internally, this will be explained in the "Save Position To GPS Base" section.

Enter antenna position

If you know the position of the GPS antenna then you can enter it using this option. The position of the antenna might be known by writing down a previous location (rather than saving it to disk) or if a professional surveyor has measured the position of the GPS antenna.

Note that the altitude must be entered in EGM96, not WGS-84.

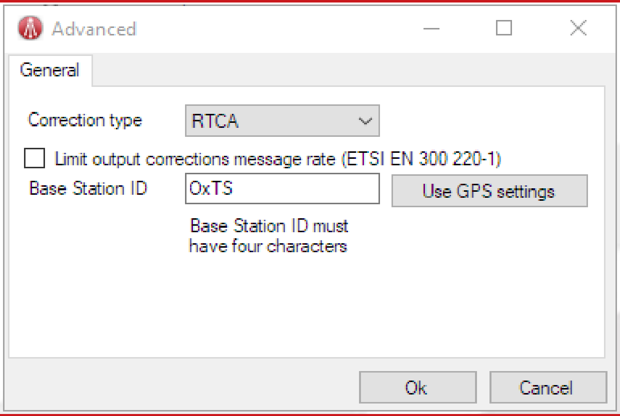
Leave unchanged

Use this option if the GPS-Base already knows its location and you do not want to change it. If the GPS-Base has a location stored internally, or a location has already been acquired during the session, this option will be selected automatically.

Advanced

Using Advanced, the correction type and the Base Station ID can be set. This is an identifier that is transmitted with the corrections so that the mobile GPS receiver knows which base- station is sending corrections. Figure 7 shows the Advanced page.

Figure 7. Advanced settings page



The GPS-Base supports RTCA, RTCA2 and RTCMv3 corrections (RTCMv3 is the default). More detailed information about these formats is available in the section called "Differential correction format details". Is there a differential correction section?

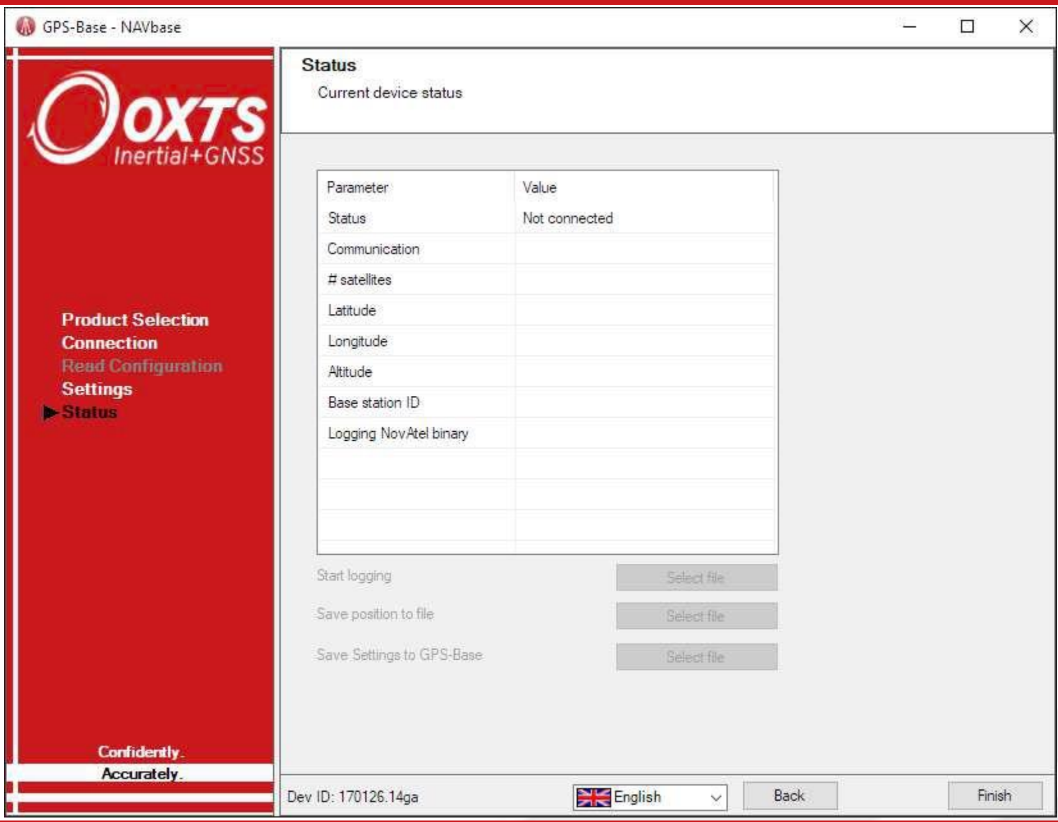
By default the GPS-Base will transmit "OxTS" as the Base Station Identifier.What does the Use GPS settings button do?

Limit output corrections message rate (ETSI EN 300 220-1): This option reduces the rate at which GPS-Base corrections are output to prevent overloading radio modems (such as the SATELLINE-EASy 896: firmware version 3.63.4 onwards) that comply to the 10% duty cycle restriction imposed by ETSI EN 300 220 1.

Status

The Status page is used to monitor the GPS-Base. The GPS-Base does not need the PC software to be running continuously, once the GPS-Base is configured then the PC can be disconnected (unless it is being used to log data). Figure 8 shows the Status Page.

Figure 8. GPS-Base status page



The status parameter shows the status of the GPS-Base and the software. Valid values for this parameter are listed in Table 16.

Table 16. Description of the status parameters

Value	Description
Not Connected	The GPS-Base software cannot find a GPS-Base to communicate with on the selected port. Return to the Connection page to select a different port or connect a GPS-Base to the computer
Averaging	The GPS-Base is averaging the GPS positions
RTCA OK	This is the normal mode for the GPS-Base when it is working correctly and outputting RTCA corrections
RTCA2 OK	This is the normal mode for the GPS-Base when it is working correctly andoutputting RTCA2 corrections
RTCMv3 OK	This is the normal mode for the GPS-Base when it is working correctly and outputting RTCMv3 corrections
Idle	The GPS-Base is idle. To change from this mode the GPS-Base needs to knowthe position of the GPS antenna. Return to the Configuration page to set the location of the GPS antenna
Interrogating	In this mode the software is trying to communicate and establish the mode of the GPS-Base. This mode should not last long
Integrity Warning	This occurs when the GPS receiver disagrees with the position that is being used.Check that the antenna location corresponds to the position that has been enteredor that the file used to save the GPS antenna location is correct
Error	There is some error. It is probably best to restart the software and the GPS-Base

Communication

The Communication value will change to show that the computer and the GPS-Base are communicating. In normal operation none of the other values change and this field is useful to show that the GPS-Base is still communicating correctly.

Latitude, longitude, altitude

These measurements show the location that the GPS-Base believes the antenna is at.

Base Station ID

This field shows the Base Station ID that the GPS-Base is currently transmitting. When this is blank then no ID has been set.

Logging Novatel binary

If the software is configured to log Novatel binary data to disk (for use with GPS post- processing software) then the value will show the size of the file. Otherwise, if logging is not active, it will show "Off".

Logging RTCMv3

If the software is configured to log RTCMv3 data to disk then the value will show the size of the file. Otherwise, if logging is not active, it will show "Off". Currently OxTS software does not support this format for post-processing but may use it in the future.

Save position to file

Use this option to save the current location of the GPS antenna to a file. The file can later be restored.

To use the save position feature it is also necessary to be able to replace the GPS antenna to exactly the same position each time. A 1 cm difference in the location of the GPS antenna will result in a 1 cm difference in the location of the remote measurements.

Save position to GPS-Base

Use this option to store the current antenna location internally on the GPS-Base. When a location is stored in the GPS-Base, there is no need to re-configure it every time it is used. Simply turn the GPS-Base on, without connecting it to a computer, and it will start transmitting corrections using the saved antenna location and differential correction format.

When using this feature it is necessary to replace the GPS antenna in exactly the same position each time. Only one antenna location can be stored on the GPS-Base, if a new location is stored it will overwrite the old one.

To find out which antenna location is stored in the GPS-Base, it must be connected to a computer and the software must be used. If there is a location stored on the GPS-Base, "Leave Unchanged" will automatically be selected on the Configuration page. This option will display the location stored in the GPS-Base on the Status page.

If the position of the antenna is re-averaged or if a new position is sent, any location stored on the GPS-Base will be erased. After averaging or sending a new position, it will be necessary to save the position to the GPS-Base.

Save setting to GPS-Base

While the GBS-Base is averaging the "Save Position To GPS-Base" function will change to "Save Setting To GPS-Base". Instead of saving the position to the GPS-Base this will instruct the GPS-Base to average a new position when it is turned on. This can be useful so that the GPS-Base works without a PC connected and averages its position when it is turned on. It will then output the differential corrections when it has finished averaging.

Start logging

Use this option to start logging the raw GPS measurements from the GPS-Base. Once started the "Start Logging" button will become "Stop Logging" which will stop the logging of the raw GPS measurements when pressed. While logging it is not possible to change page or quit.

LED status

Some of the radios provided with the GPS-Base have LEDs that show what the radio is doing.

SATEL radio status

This section only applies to the SATEL radio option. The GPS-Base will start outputting corrections when the antenna location has been found or entered. When transmitting corrections, the LEDs on the SATEL modem will be as shown in Table 17.

Table 17. Satel radio LED states and meanings

LEDs					Description
RTS	CTS	TD	RD	CD	
Off	Red	Off	Off	Off	Idle
Off	Red	Red	Off	Red	Transmitting a packet
Off	Red	Off	Off	Orange	Noise or other transmission on this frequency
Off	Red	Off	Green	Green	Receiving a packet

Freewave radio status

This section only applies to the Freewave radio option. When operating the radio modems, it is sensible to check that the signal is being transmitted correctly and received correctly.

The table below gives some combinations of the LEDs and describes their significance.

Table 18. Freewave radio LED states and meanings

Condition	Base-station modem			Mobile modem		
	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)
Powered no link	Red	Slow red flash		Red	Off	Red flash
Linked sending data	Red	Slow red flash		Green		Red
Setup mode	Green	Green	Green	Green	Green	Green

With the Freewave modems, if the "CD" LED is red then the radio has not detected any other radios and it will not transmit or receive from them. This can be seen on both the base and the mobile units since the Freewave radios use their bi-directional communication to form a more secure link. It can be difficult on the mobile unit to know if data is being received since only a transmit LED is available. If differential corrections are not being received by the INS/ GNSS product, then check that the differential correction format on the GPS-Base and on the INS/GNSS product are the same.

Differential correction message format

There are a number of different standards for the differential corrections which will improve the position accuracy of moving GNSS receivers. The GPS-Base supports several differential correction formats.

Please note: By default, the GPS-Base uses the RTCMv3 standard for transmitting its differential corrections. You do not need to change the differential correction format unless you have a GLONASS-capable equipment and a GLONASS base station.

Message output and frequency:

Table 19. RTCA message output

Message	Standard frequency	Limited frequency*
RTCA1 (pseudo-range corrections)	1 Hz	0.25 Hz
RTCAOBS (L1/L2 pseudo-range and carrier-phase)	1 Hz	0.25 Hz
RTCAREF (base station position)	0.2 Hz	0.2 Hz

*Used when the Limit output corrections message rate (ETSI EN 300 220-1) option is enabled.

Table 20. RTCAv2 message output

Message	Standard frequency	Limited frequency*
RTCA1 (pseudo-range corrections)	1 Hz	1 Hz
RTCAOBS2 (L1/L2 GNSS+GLONASS pseudo-range and carrier-phase)	1 Hz	0.25 Hz
RTCAREF (base station position)	0.2 Hz	0.1 Hz

*Used when the Limit output corrections message rate (ETSI EN 300 220-1) option is enabled

Table 21. RTCMv3 message output

Message	Standard frequency	Limited frequency*
RTCM1004 (extended L1/L2 GNSS pseudo-range and carrier-phase)	1 Hz	0.25 Hz
RTCM1005 (base station antenna position)	0.2 Hz	0.14 Hz
RTCM1007 (extended antenna descriptor and set-up information). The base station firmware always configures the base station antenna as a Novatel GNSS 702 GGL	0.1 Hz	0.1 Hz
RTCM1012 (extended L1/L2 GLONASS pseudo-range and carrier-phase)	1 Hz	0.25 Hz
RTCM1033 (base station and antenna descriptor)	0.1 Hz	0.1 Hz

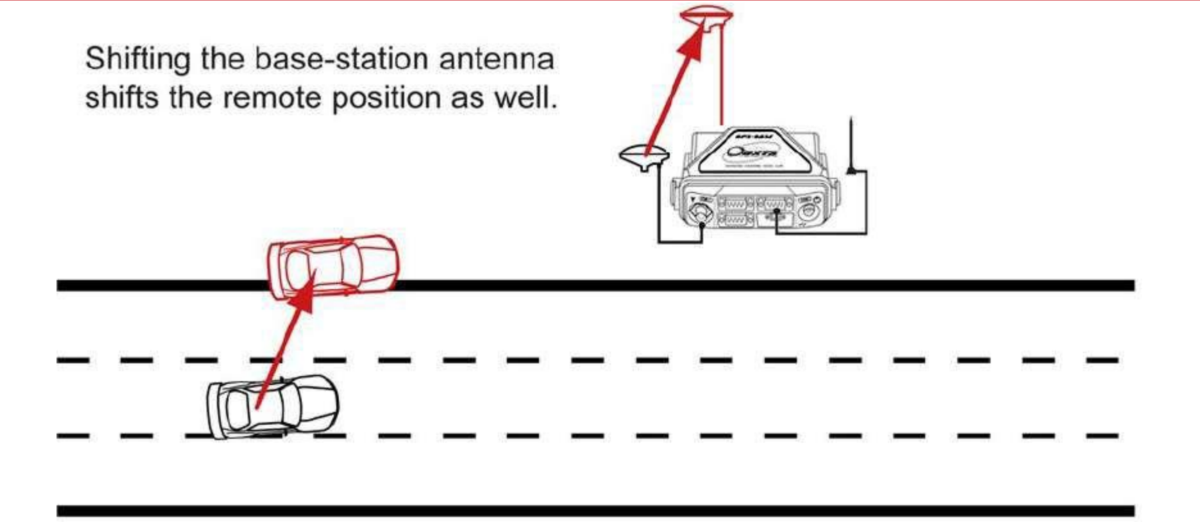
*Used when the Limit output corrections message rate (ETSI EN 300 220-1) option is enabled

Repeatability

Differential corrections change the way a GNSS receiver works. When using differential corrections, the GNSS 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 GNSS receivers move too. It is important to put the GNSS antenna in a location where it cannot move or be moved. See Figure 9.
2. The base station has to measure its own position. If the base station gets this position wrong, then the remote GNSS 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 GPS-Base off and on again. See Figure 10.

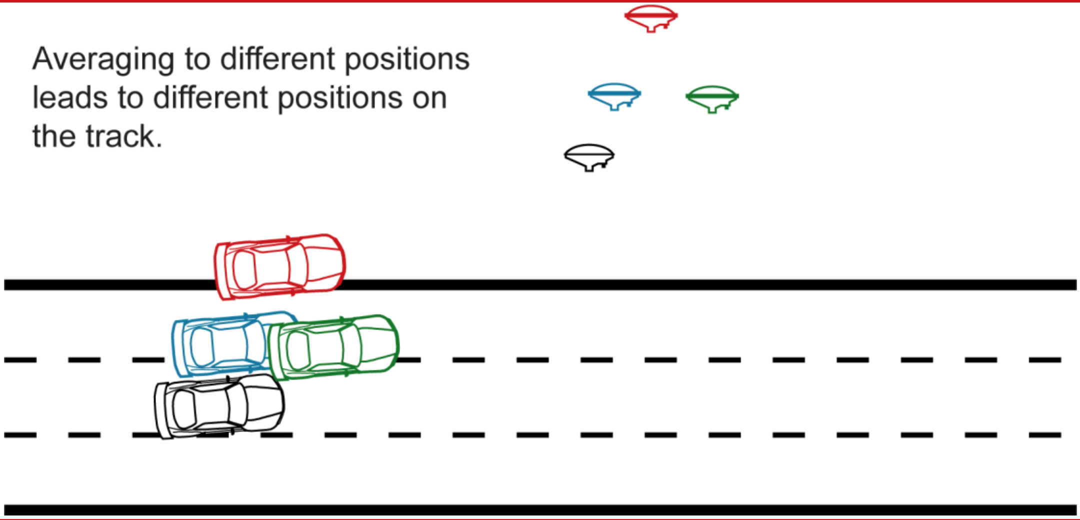
Figure 9. Shifting base station antenna example



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 1 cm.
- If the GPS-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 10. Averaging to a different position example



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

If the user is prepared to wait a long time (typically more than 24 hours) then GNSS is able to improve the accuracy of the base station antenna so it is accurate to 2 cm 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 surveyor's measurements and this is rarely required).

To overcome the problem of averaging, the save/restore feature of the GPS-Base should be used. When using the Save/Restore feature the GPS-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 1 cm or better, when using the Save/Restore feature.

Specifications

The technical specification for the GPS-Base unit is shown below.

Table 22. Technical specification (excluding radio modem)

Parameter	Specification
Power	9–36 V dc, 2 W
Operating temperature	-40°C to 75°C
Corrections	RTCA (Differential, L1, L2), RTCA2, RTCMv3
Frequency	1 Hz
Format	RS232

Revision history

Table 1. Revision history

Revision	Comments
070330	Initial version
071128	Software updates
080916	Software updates
090917	Added advanced settings for Base Station ID. Added GLONASS options
100812	Added RTCM V3 logging, RTCA2 and RTCM V3 correction outputs. Changed to new radio modem cable
120111	Updated images and drawings to match new enclosure and connectors. Added compatibility with RT2002 and RT2004
131025	Update image showing connections, minor formatting and new products
160628	Minor corrections
170217	Minor corrections, added option for EN 300 220-1 duty cycle limit
170731	Updated Freewave LED definitions
180928	Updated throughout
210219	Updated branding throughout
210825	Updated connecting the GNSS antenna and radio modem cable information