# User Manual


**RT1003 v2**
**GNSS-aided inertial navigation system**

Measure with confidence

OXTS

## Legal notices



## Copyright notice



## Revision

Document Revision: 220127 (See Revision History for detailed information).

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Any use of misuse of the RT in a manner not intended may impar the protection provided. Please contact OxTS if you believe any service or repair is required on your RT.

# Contents

# Introduction

The RT1003 v2 is a small and lightweight GNSS-aided inertial navigation system for use in automotive applications where space and payload are restricted. It is designed to measure position, velocity and orientation with high-accuracy and output those measurements in real- time as well as logging them internally.

Utilising dual antennas, DGPS corrections, tight-coupling and advanced gx/ix™ processing technology, the RT1003 v2 delivers up to 2 cm position and 0.1° heading accuracy (2 m antenna separation) with up to 250 Hz output for all measurements.

This manual covers the installation, configuration and basic operation of the RT1003 v2. Separate manuals are provided for the post-processing and graphing software installed with NAVsuite. We suggest reading the entire manual in order to become thoroughly familiar with the product before use. It is beyond the scope of this manual to provide details on service or repair. Contact OxTS support or your local representative for any customer service related inquiries.

# Scope of delivery

With the exception of a computer running Microsoft Windows, everything you need to utilise your RT1003 v2 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.

You may wish to make a note of your product's IP address (shown on the delivery note) as it will be useful to refer back to.

Date of purchase: ________________________________________

Product's serial number: ___________________________________

Product's IP address: ______________________________________

## RT1003 v2 Components

Table 1: Summary of standard components supplied with an RT1003 v2

| Quantity | Description |
|---|---|
| 1 | Mounting kit with screws |
| 1 | RT1003 v2 system unit |
| 1 | RT1003 v2 user manual |
| 1 | USB memory stick (software) |
| 1 | User cable |

## Accessory products

A number of accessory products are also compatible with your product. These are listed in Table 2. For more information on specific accessories, please see our website or speak to your OxTS representative.

Table 2: Accessory products

| Product | Description |
|---|---|
| GPS-Base | The GPS-Base is a small, portable GPS Base Station suitable for transmitting Differential corrections (DGPS) to our INS products or other products that use GPS.The position accuracy of differential and RTK capable receivers is improved when using the GPS-Base |
| RT-Backpack | The RT-Backpack is an additional component for the RT-Range systems where car-to-pedestrian tracking is required. It provides a wearable, self-contained and fully powered INS mounting platform |
| RT-Base S | The RT-Base S is a portable all-weather GNSS base station suitable for transmitting andlogging differential corrections (DGNSS). The position accuracy of differential and RTK capable receivers is improved when using the RT-Base S |
| RT-Strut | The RT-Base S is a portable all-weather GNSS base station suitable for transmitting andlogging differential corrections (DGNSS). The position accuracy of differential and RTK capable receivers is improved when using the RT-Base S |
| RT-UPS | An uninterruptible power supply capable of powering the INS for up to one minute afterpower is lost. Input 9–48 volts |
| RT-XLAN | The RT-XLAN is a high performance WLAN radio unit capable of providing a highly reliable >1 km vehicle-to-vehicle data communication link between multiple vehicles |

# Related documents

In addition to this hardware manual, documentation describing the software applications and protocols used in conjunction with this product are available. These manuals are copied to your PC as part of the NAVsuite installation, but more up-to-date versions may be available from our website. The table below lists the documents that may be of interest and where to find them.

Table 3: Supplementary documentation and software

| Manual | Description |
|---|---|
| NAVdisplay Manual | For viewing real-time information from an RT.<br>https://support.oxts.com/hc/en-us/articles/115002433285-NAVdisplay-Online-manual |
| NAVgraph Manual | For plotting and exporting captured data.<br>https://support.oxts.com/hc/en-us/articles/115002433465-NAVgraph-Online-manualv |
| NCOM Manual | For decoding and using the NCOM format.<br>https://support.oxts.com/hc/en-us/articles/360011890040-NCOM-Manual |
| NCOM C Code Drivers | A collection of C functions that can be used to decode the binary protocols from the RT.<br>https://github.com/OxfordTechnicalSolutions/NCOMdecoder |
| NMEA 0183 Description | NMEA description manual for the NMEA outputs.<br>https://support.oxts.com/hc/en-us/articles/360011890180-NMEA-Manual |
| NAVsolve Manual | Explains how to use our post-processing application.<br>https://support.oxts.com/hc/en-us/articles/360000225449-NAVsolve-manual |
| RT-Base S | Explains how to set-up and use the RT-Base S base station to achieve RTK integer operation mode.<br>https://support.oxts.com/hc/en-us/articles/115002407589-RT-Base-S-Online-manual |

# Conformance notices

The RT1003 v2 complies with the radiated emission limits for 47CFR15.109:2010 class A of Part 15 sub-part B of the FCC rules, and with the emission and immunity limits for class A of EN 55022. These limits are designed to provide reasonable protection against harmful interference in business, commercial and industrial uses.

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 RT1003 v2 incorporates a GNSS receiver. No GNSS receiver can track satellites in the presence of strong RF radiations within 70 MHz of the GNSS frequencies.

The RT1003 v2 conforms to the requirements for CE.

Any use or misuse of the RT1003 v2 in a manner not intended may impair the protection provided. OxTS is not liable for any damages caused by the misuse of the equipment.

Regulator testing standards

- 47CFR15.109:2010 class A (radiated emissions)
- EN 300 440-1 v1.6.1, test methods 8.3.4 (radiated emissions)
- EN 55022:2010
- EN 55024:2010
- EN 61326-2-1:2006 according to the requirements of EN 61326-1:2006
- EN 61326-1-1:2013 according to the requirements of EN 61326-1:2013
- EN 301 489-3 v1.4.1 according to the requirements of EN 301 489-1 v1.9.2
- IEC 61010-1:2010 3rd Ed. (safety)

# Getting to know your product

This section covers some basic information required for the operation of the RT1003 v2. Before operating an RT1003 v2 for the first time, we recommend thoroughly reading all of the documentation provided.

## Handling precautions

The RT1003 v2 is a precision instrument. While designed to operate and survive real-world use, care should be taken to avoid excessive impact, extreme temperature and water.

The product housing is designed to dissipate heat, and after periods of extended operation it may be hot. The product should be allowed to cool before handling and care should be taken. If the product is used in high-temperature environments, forced convection may be required.

## Connector panel layout

The layout of the RT1003 v2's connector panel is shown below and the function of each connector is described.

Figure 1. Connector panel of the RT1003 v2


Table 4. RT1003 v2 front panel descriptions

| Label Number | Description |
|---|---|
| 1 | GNSS LED |
| 2 | Status LED |
| 3 | Power LED |
| 4 | User cable main connector |
| 5 | Secondary antenna connector |
| 6 | Primary antenna connector |

## LED definitions

The LEDs on the connector panel provide information about the current system state, but it is not possible for the LEDs to communicate everything the product is capable of measuring. Instead, they provide a snapshot of the current status and are useful for at-a-glance checks without the need for a portable PC. The tables below describe the behaviour of each LED.

Table 5. GNSS LED states

| Colour | Description |
|---|---|
| Off | GNSS receiver fault (valid only after start-up) |
| Red flash | GNSS receiver is active, but has been unable to determine heading |
| Red | GNSS had a different heading lock |
| Orange | GNSS receiver has a floating (poor) calibrated heading lock |
| Green | GNSS receiver has an integer (good) calibrated heading lock |

Table 6. Status LED states

| Colour | Description |
|---|---|
| Off | The operating system has not yet booted and the program is not yet running. This occurs at start-up |
| Red-green flash | The RT1003 v2 is asleep. Contact OxTS support for further information |
| Red flash | The operating system has booted and the programme is running. The GNSS receiver has not yet output a valid time, position, or velocity |
| Red | The GNSS receiver has locked on to satellites and has adjusted its clock to valid time (the 1 PPS output will now be valid). The strapdown navigator is ready to initialise. If the vehicle is travelling faster than the value set for 'Initialisation speed' during configuration then the strapdown navigator will initialise and the system will become active. On dual antenna systems the system will initialise once the GNSS receiver has determined heading, even if the vehicle is stationary or moving slowly |
| Orange | The strapdown navigation has initialised data is being output, but the system is not real-time yet. It takes 10 seconds for the system to become real-time after start up |
| Green | The strapdown navigator is running and the system is real-time[a] |

In the current versions of the software the strapdown navigator will not leave green and return to any other state. This may change in future releases.

Table 7. Power (PWR) LED states

| Colour | Description |
|---|---|
| Off | There is no power to the system or the system power supply has failed |
| Green | Power is applied to the system |
| Orange | The system is powered and Ethernet traffic is present |

# Inputs and outputs

The RT1003 v2 is capable of transmitting and monitoring a number of digital signals for the purpose of synchronisation and event marking. The following section describes the inputs and outputs available on the RT1003 v2.

Table 8 describes each of the signals on the digital I/O connector J5 of the user cable.

Table 8. User cable digital I/O connector J5

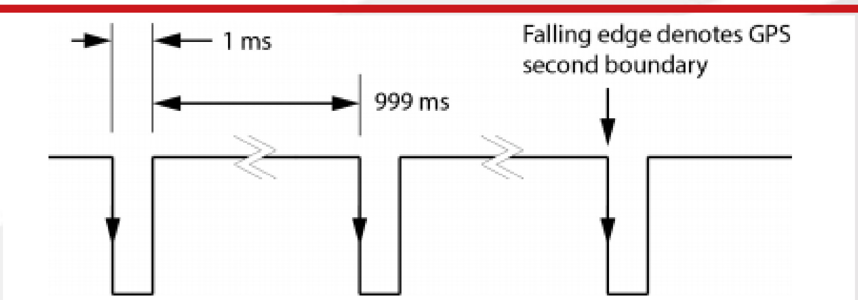
| Pin# | Name (function) | Description |
|---|---|---|
| J5-1 | Digital 1 (1 PPS output) | Pulsed output from primary GNSS receiver, synchronised with the transition of GPS seconds |
| J5-2 | Digital 2 (Trigger 1) | User-selectable I/O (input/distance output/IMU sync output) |
| J5-3 | Digital 3 (Wheel speed 1A) | Input for Hall-effect wheel speed sensor. When connecting a quadrature sensor, this input is the A-channel |
| J5-4 | Digital 4 (Trigger 2) | User-selectable I/O (input/distance output/IMU sync output) |
| J5-5 | Digital 5 (Wheel speed 1B) | When connecting a quadrature wheel speed sensor, this input is for the B-channel |
| J5-6 | Digital ground | |
| J5-7 | Digital ground | |
| J5-8 | Digital ground | |
| J5-9 | Digital ground | |

## 1PPS output

The 1PPS (J5-1) output is a pulse generated by the GNSS receiver. On RT1003 v2 products, the output is active even when the GNSS receiver has no valid position measurement. The falling edge of the pulse is the exact transition from one second to the next in GPS time. The pulse is low for 1 ms, then high for 999 ms and repeats every second.

The output is a low-voltage CMOS output, with 0.8 V or less representing a low and 2.4 V or more representing a high. No more than 10 mA should be drawn from this output.

Figure 2. 1PPS waveform



### Trigger 1 and 2

Trigger 1 (J5-2) and Trigger 2 (J5-4) can be used to generate events within the RT1003 v2 for purposes of identifying external events, or to output a time/distance-based signal for the purpose of driving external events. Both Triggers are independently configurable in the Options page of NAVconfig.

In input mode, the trigger waits for a signal from an external device such as a camera or switch. When a signal is detected, a time-stamped measurement is generated by the INS in addition to the normal measurements being generated. The trigger inputs have a pull-up resistor so they can be used with a switch or as a CMOS input.

Input signal characteristics:

- 0 V and 5 V input
- low < 0.6 V
- high > 2.6 V

The default maximum detection rate for input signals is 1 Hz for 100 Hz products and 4 Hz for 250 Hz products. The detection rate for both products increases to 50 Hz by when **Output on falling edge of trigger** or **Output on rising edge of trigger** is selected in the Ethernet Output window in NAVconfig

Trigger information is contained within status message 24 and 43 (output over NCOM and CAN) for the low-rate triggers (1 Hz). The fast trigger information (50 Hz) can only be output over NCOM.

In **output mode**, the trigger generates pulses based on distance or in synchronisation with the IMU clock rate. The pulse width of the distance-based signal is 1 ms, whereas the IMU sync signal has a duty cycle of approximately 50%.Output signal characteristics:

- 0 V and 5 V output
- low <= 0.8 V
- high >= 2.4 V

Camera mode is a software condition that is automatically entered when the PPM distance output is configured as less than 1 PPM. It exists in order to generate time-stamped INS measurements synchronised with distance-based output triggers. The output is called camera mode as it’s often used to trigger image recording equipment, which can then be matched to the position measurements at the precise moment of the trigger. Camera mode provides a method of achieving this.

To enter camera mode, configure a trigger as an output, and set the distance to less than one pulse per metre. A signal will be generated according to the specifications above at the distance interval defined by the PPM settings. At the same moment the trigger signal is output, a position measurement will be internally generated and logged alongside the regular measurement data. To generate a real-time message in relation to the camera trigger, it is necessary to select the **Output on camera trigger** option on the Ethernet configuration window.

### Wheel speed input

The wheel speed 1A input (J5-3) accepts TTL pulses from an encoder on a single wheel. An encoder from a gearbox should not be used, and simulated TTL pulses (e.g. converted from the CAN bus) should not be used either. The timing of the wheel speed input pulses is critical and nothing should cause any delay to them.

The RT1003 v2 also accepts signals from quadrature wheel speed sensors. When using quadrature sensors, connect one channel from the quadrature sensor to wheel speed 1A, and the other to wheel speed 1B input (J5-5). The odometer input should be configured as per a normal wheel speed sensor – the RT will automatically detect the use of the quadrature sensor.

The wheel speed input requires less than 0.8 V for a low pulse and more than 2.4 V for a high pulse. Limited protection is provided on this port, however the input voltage should not exceed 12 V.

Wheel speed input signal characteristics:

- 0 V to 12 V
- low < 0.8 V
- high > 2.4 V

The wheel that is used should not steer the vehicle. The RT1003 v2 will assume the wheel travels straight.

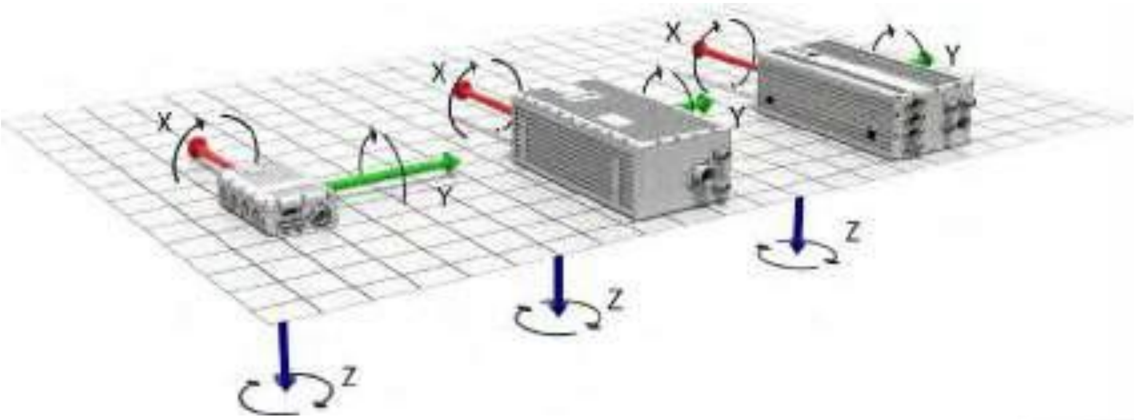
## Co-ordinate frame conventions

An inertial navigation system is capable of making very precise measurements, but without context those measurements are just meaningless numbers. In order to make sense of the world, and to output measurements in way that describes position, orientation and velocity, an INS such as the RT1003 v2 uses a number of different reference frames and co-ordinate systems.

This section describes those frames and co-ordinate systems.

### *IMU frame*

Figure 3. IMU frame




The arrows indicate the positive direction, and the direction of positive rotation about each axis. The origin of the IMU frame is marked on the casing of each product or described in the technical drawings at the end of the user manual.

All of our inertial navigation systems share a common IMU reference frame. The orientation of that frame is popular among navigation systems. The positive direction of each axis, and the direction of positive rotation about those axes is shown in Figure 3.

When looking at the connector panel of your product, the positive X-axis points forward, the positive Y-axis points right and the positive Z-axis points down. The exact origin of the IMU frame is marked on the product casing and is also described in the technical drawings at the end of the product manual.

During the configuration process, you will need to enter several measurements in order for the INS to know where it is mounted in relation to other components or objects. When making those measurements, always measure between the IMU frame origin and the point of interest.

### OxTS NED navigation frame

Figure 4. OxTS navigation frame


The OxTS navigation frame is attached to the IMU frame origin but does not rotate with it. The down axis is always aligned to the gravity vector and north always points north.

The OxTS navigation frame uses an earth-fixed, earth-centred reference frame, and employs a NED (north, east, down) orientation. It is shown in Figure 4. The down axis is always aligned to the gravity vector, while the north axis always points north. As long as the displaced output function in NAVconfig is not enabled, the OxTS navigation frame is centred on the IMU frame origin.

Table 9. OxTS navigation frame definition

| Axis | Description |
|---|---|
| North | The north axis (N) is perpendicular to the gravity vector and in the direction of the North Pole along the earth's surface |
| East | The east axis (E) is perpendicular to gravity, perpendicular to the north axis and is in the east direction |
| Down | The down axis (D) is along the gravity vector |

### *ISO 8855 ENU earth-fixed system*

Figure 5. ISO 8855 earth-fixed system


The ISO earth-fixed system is attached to the IMU frame origin but does not rotate with it. The north and east axes are perpendicular to the gravity vector and north always points north.

The ISO 8855 earth-fixed system uses an earth-fixed, earth-centred reference frame, and employs an ENU (east, north, up) orientation. It is shown in Figure 5. The east and north axes are always perpendicular to the gravity vector. As long as the displaced output function in NAVconfig is not enabled, the ISO 8855 earth-fixed system is centred to the IMU frame origin.

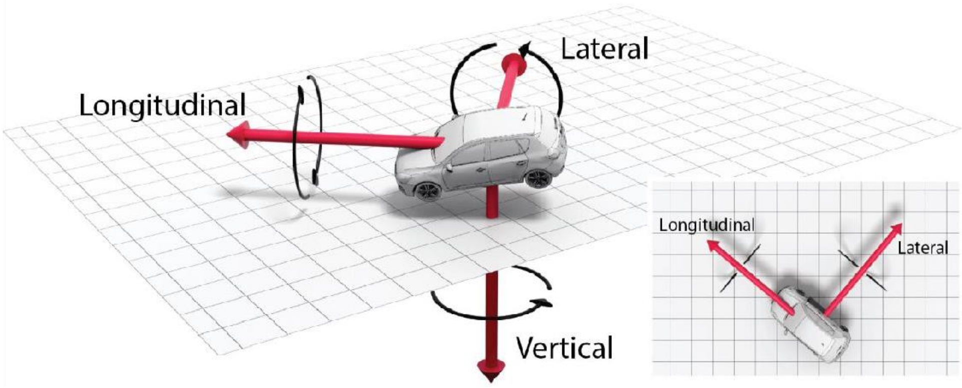
Table 10. ISO 8855 ENU earth-fixed system

| Axis | Description |
|---|---|
| East | The east axis (E) is perpendicular to gravity, perpendicular to the north axis and is in the east direction |
| North | The north axis (N) is perpendicular to the gravity vector and in the direction of the North Pole along the earth's surface |
| Up | The up axis (U) is co-axial with the gravity vector, and positive in the up direction |

### *OxTS horizontal frame*

The OxTS horizontal frame (sometimes called the level frame) is attached to the vehicle but does not rotate with the roll and pitch of the vehicle. It rotates by the heading of the vehicle. The definition of the OxTS Horizontal frame is listed in Table 11 and shown Figure 6.

Figure 6. OxTS Horizontal frame definition




The OxTS horizontal frame is attached to the vehicle. The longitudinal and lateral axes remain parallel to a horizontal plane. The longitudinal axis is also parallel to the vehicle's heading when viewed from above.

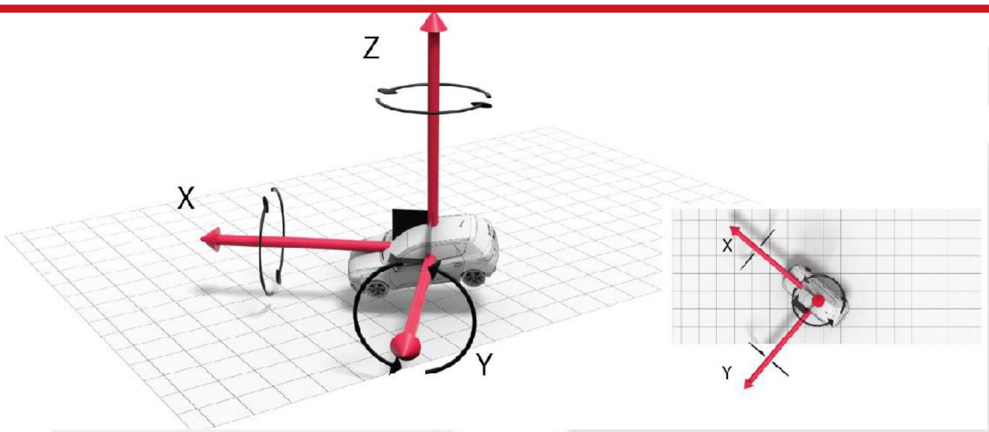
Table 11. OxTS Horizontal frame definition

| Axis | Description |
|---|---|
| Longitudinal / Forward | This is the longitudinal (forward) direction of the vehicle, projected in to the horizontal plane |
| Lateral | This is the lateral direction of the vehicle, pointing to the right, projected in to the horizontal plane |
| Vertical / Down | This is the vertical (down) direction of the vehicle, along the gravity vector |

### *ISO 8855 intermediate system*

The ISO 8855 intermediate system is attached to the vehicle but the X- and Y-axis both remain parallel to the ground plane. The X-axis is also aligned with the vertical projection of the vehicle heading. The definition of the ISO 8855 intermediate system is listed in Table 12**Error! Reference source not found.** and shown in Figure 7.

Figure 7. ISO 8855 intermediate system



The ISO intermediate system is attached to the vehicle. The X- and Y-axes remain parallel to a horizontal plane. The X-axis is also parallel to the vehicle's heading when viewed from above.

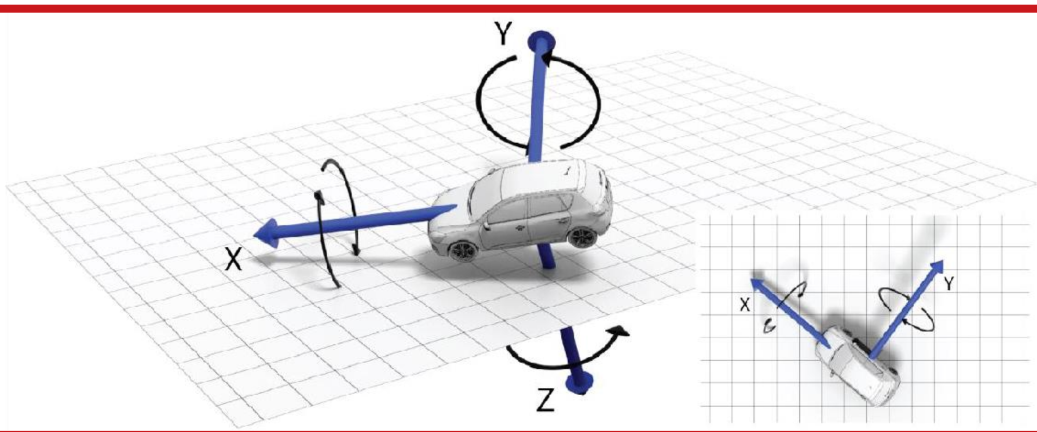
Table 12. ISO 8855 intermediate system

| Axis | Description |
|---|---|
| X | This is the forward direction of the vehicle, projected into the horizontal plane |
| Y | This is the lateral direction of the vehicle, pointing to the left, projected in to the horizontal plane |
| Z | This is the vertical direction of the vehicle, pointing up |

## *OxTS vehicle frame*

The OxTS vehicle frame is attached to the body of the vehicle. It is related to the INS through the rotations in the Orientation page of NAVconfig. It can be changed while the INS is running using the Quick Config tool in NAVdisplay. The definitions of the vehicle frame are listed in Table 13 and shown in Figure 8.

Figure 8. Vehicle frame definition




The OxTS vehicle frame is attached to the vehicle and rotates with it in all three axes. The Y-axis points to the vehicle's right and is perpendicular to its vertical plane of symmetry. The Z-axis (when the vehicle is level), is essentially aligned to the gravity vector and points down.

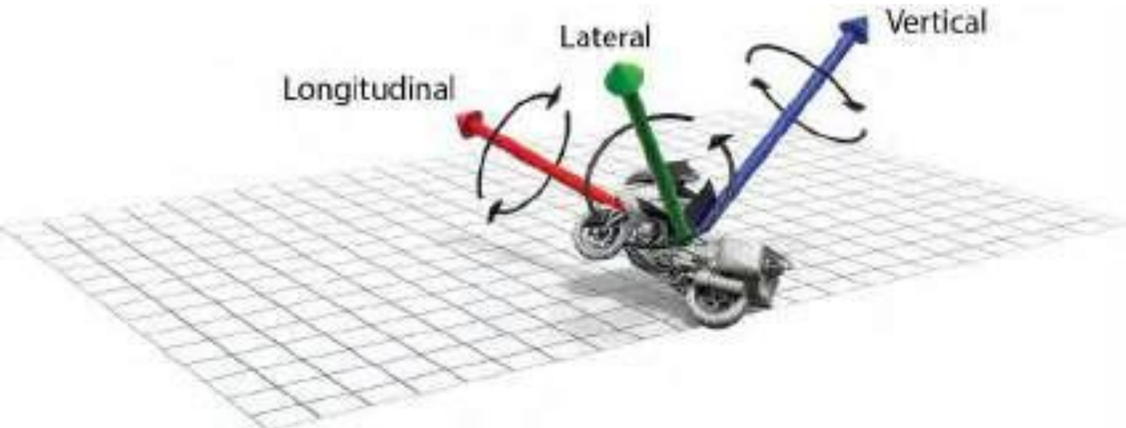
Table 13. OxTS vehicle frame definition

| Axis | Description |
|---|---|
| X | This is the forward direction of the vehicle |
| Y | This is the right direction of the vehicle |
| Z | This is the down direction of the vehicle |

## *ISO 8855 vehicle system*

The ISO 8855 vehicle system is attached to the body of the vehicle. At rest, the longitudinal axis points forwards horizontally and is parallel to the vehicle's longitudinal axis. The lateral axis is perpendicular to the longitudinal axis and points left. The vertical axis is orthogonal to the longitudinal and lateral axes. Definitions are listed in Table 14 and shown in Figure 9.

Figure 9. ISO 8855 vehicle system




The ISO vehicle frame is attached to the vehicle and rotates with it in all three axes. The lateral axis points to the vehicle's left and is perpendicular to its vertical plane of symmetry. The longitudinal axis and vertical axis (when the vehicle is level), is essentially aligned to the gravity vector and points up.

Table 14. ISO 8855 vehicle system

| Axis | Description |
|---|---|
| Longitudinal | This is the forward direction of the vehicle |
| Lateral | This is the left direction of the vehicle |
| Vertical | This is the up direction of the vehicle |

## Local co-ordinates

As well as the reference frames already mentioned, the software supplied with your INS makes it possible to define a new frame of reference called local co-ordinates. A local co- ordinate frame is shown in Figure 10.

Figure 10. Local co-ordinate frame


To define a new local co-ordinate reference frame, the INS needs to know several things. First, it needs an origin. This is defined using latitude and longitude to at least six decimal places. It then needs an altitude offset for the frame (positive or negative), which is applied to the WGS 84 altitude at the assigned lat/lon co-ordinates. The offset is applied parallel to the gravity vector at the defined origin.

Finally, the X-axis angle must be defined relative to north. A value of 0° causes the X-axis to point north while the Y-axis points east. A value of 90° causes the X-axis to point west while the Y-axis points north. The Z-axis always points down, perpendicular to the plane and is only aligned to the gravity vector at the local co-ordinate origin. Because the local co- ordinate frame is planar, it is not suitable for measurements over large distances.

Table 15. Local coordinate frame

| Axis | Description |
|---|---|
| X | The X-axis is offset anti-clockwise from the north vector by the angle specified in the localco-ordinate settings panel. It is perpendicular to the gravity vector at the origin |
| Y | The Y-axis is perpendicular the X- and Z-axis |
| Z | The Z-axis is parallel to the gravity vector and centred on the latitude and longitude entered in the local co-ordinate settings panel |

# Software installation

Included with every RT1003 v2 is a USB stick containing the software package, NAVsuite. This package contains several programs required to take full advantage of the RT's capabilities Table 16 lists the contents of NAVsuite.

Table 16. NAVsuite components

| Icon | Software | Description |
|---|---|---|
| | NAVdisplay | Used to view real-time data from OxTS products via Ethernet or a serial port. It can also be used to transmit special commands and replay logged data. |
| | NAVstart | A menu from which you can navigate between OxTS applications. This opens automatically when you are connected to a unit. |
| | NAVconfig | Used to create, send, and receive configurations from OxTS products. As configurations vary between products there is no manual for NAVconfig. |
| | NAVsolve | Used to download raw data files from the RT and post-process the data. The configuration can be changed and differential corrections can be applied before the data is reprocessed. It can export NCOM, XCOM and CSV file formats. |
| | NAVgraph | Used to graph NCOM, XCOM and RCOM files created in post-process. It can display graphs, cursor tables and map plots and data can be exported in CSV or KML (Google Earth) format. |
| | NAVbase | Used to configure and manage RT-Base S and GPS-Base base stations, which can be used to achieve RTK integer level position accuracy. |
| | Manuals | This folder contains PDF versions of relevant OxTS manuals. Other manuals can be downloaded from the OxTS website. |

In addition to the main applications, the NAVsuite installer also copies a number PDF manuals and help documents to the computer's disk. The documents are located in C:\Program Files (x86)\OxTS\Manuals and can be accessed via the OxTS folder in the Start menu.

To install NAVsuite, insert the USB stick and run **NAVsetup.exe**. Follow the onscreen instructions to install the software. By default, the installer creates the program files in *C:\Program Files (x86)\OxTS* on 64 bit operating systems or *C:\Program Files\OxTS* on 32 bit operating systems.

# System requirements

NAVsuite installs and runs on PCs running Microsoft Windows 7, 8, 10 or 11 (either 32- and 64- bit versions). Please ensure the latest operating system service packs are installed. The following components are also required to run NAVsuite and will be automatically installed if not detected.

- Microsoft .NET Framework 4.6.1 or newer
- Microsoft Visual C++ 2010 x86 Redistributable, 10.0.30319.1 or newer
- Microsoft Visual C++ 2015 Redistributable (x86) 14.0.23026 or newer

While an Ethernet port is not required to launch NAVsuite applications, some features of programs that communicate with products will be unavailable or restricted without one.

### *Admin rights*

For successful installation, administrative rights are required to configure the firewall for the FTP and UDP port, so you may need to contact your system administrator. Write access is also required for the following system folders:

- Common Files
- Program Files or Program Files (x86) depending on operating system
- Program Data
- Users\<current user>\Documents

### *To uninstall NAVsuite*

NAVsuite can be removed from the PC by navigating to Control Panel > Programs > Programs and Features then selecting NAVsuite from the list and clicking Uninstall. It will then remove all files and applications for NAVsuite. The uninstall feature will not touch the data folder at the path C:\Users\<user name>\Documents\OxTS\NAVsolve.

# Communicating with the product

In order to send and receive real-time measurements, differential GNSS corrections, raw data files and configuration files, the RT1003 v2 employs three different communication interfaces:

- Ethernet
- Serial RS232
- CAN bus

# Ethernet

Ethernet is the main interface by which the RT1003 v2 communicates. Whenever the manual instructs you to connect a PC to the product, it can be assumed that Ethernet is the interface to use.

The Ethernet port is used to send and receive configuration files, transmit and monitor real- time measurements and finally, it is used to FTP the internally logged raw data onto your PC. Real-time measurements are transmitted using a UDP broadcast (at 100/250 Hz depending on the core system speed of your product), using a proprietary format called NCOM. The use of a UDP broadcast allows everyone on the network to receive the real-time data. OxTS offers free C and C++ code that will interpret the NCOM packet (See Related documents on page 10.).

To ensure high-speed transmission, each RT1003 v2 is fitted with a 10/100 Base-T Ethernet adaptor and is configured with a static IP address. The IP address of your product can be found on your delivery note. If the delivery note is unavailable, the default IP address assigned by OxTS takes the form 195.0.0.sn; where sn are the last two digits of the product's serial number. The serial number is normally displayed on the product's connector panel.

Knowing the static IP address of the product is important because to successfully transmit data between the product and a computer, both IP addresses must be in the same range. Changing the IP address of your PC is quick and easy. We suggest configuring the PC with a static IP address in the range 195.0.0.1 to 195.0.0.10, and with a subnet mask of 255.255.255.0. Instructions on how to do this are shown below.

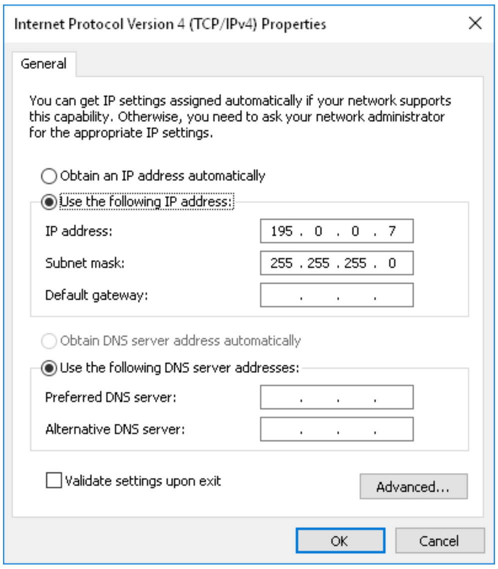
To change the IP address of a computer running Windows Vista/7/8:

1. Open the Control Panel from the Start menu.
2. In category view, select Network and Internet and then Network and Sharing Center.
3. Select Change adapter settings in the side panel.
4. Right-click the Ethernet option and select Properties.
5. In the window that opens, navigate the list to find Internet Protocol Version 4 (TCP/IPv4). Select it and click Properties.
6. In the TCP/IPv4 Properties window (Figure 11), select Use the following IP address and enter the IP address and subnet mask to use.
7. Click OK when finished.

To change the IP address of a computer running Windows 10 or 11:

1. Right-click on the Windows Start icon in the Taskbar, then select Network Connections.
2. In the window that opens, right-click on the network adapter you want to configure, and select Properties.
3. In the window that opens, navigate the list to find Internet Protocol Version 4 (TCP/IPv4). Select it and then click Properties.
4. In the TCP/IPv4 Properties window (Figure 11), select Use the following IP address and enter the IP address and subnet mask to use.
5. Click OK when finished.

Figure 11. Configuring the computer's IP address




Once the computer is configured, the IP address of an RT1003 v2 can be found by running NAVdisplay software; this will display the IP address of any connected system.

Note that it is possible to change the IP address of RT1003 v2 systems. If the IP address has been changed, NAVdisplay should still be able to identify the address that the RT1003 v2 is using as long as the PC has a valid IP address in the same range and this is not the same as the RT1003 v2's.

While the sending of configuration files and downloading of data is handled automatically by software like NAVconfig and NAVsolve, it is also possible to manually move files to and from the product using Windows File Explorer or another FTP application. The user- name and password required to manually connect to the RT1003 v2 are:

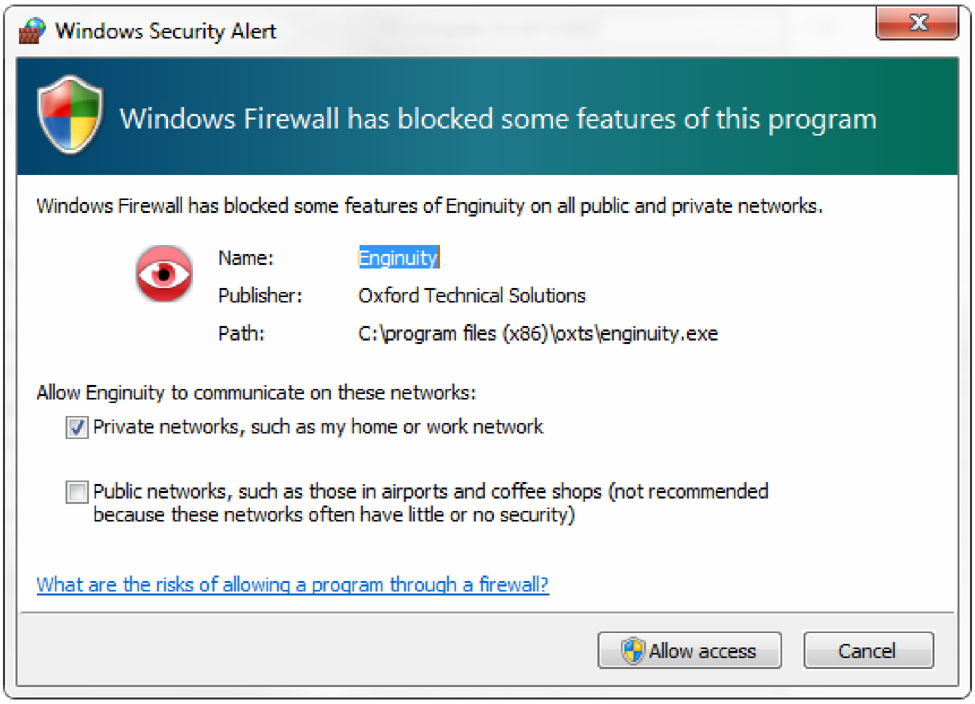
- Username: “user”
- Password: “user”

## Firewall warning

The first time some OxTS applications are run, a firewall warning message similar to that shown in Figure 12 may be triggered. This is because the program is attempting to listen for, and communicate with, OxTS products on the network. The firewall must be configured to allow each program to talk on the network, or programs will not work as intended.

Sometimes a warning will not be triggered, but the firewall may still block certain functions. If a program fails to display the IP address of a connected product, check the firewall settings for that connection. Ensure both Private and Public networks are selected to ensure the software can continue functioning when moving from one network type to another.

Figure 12. Windows Firewall warning message




## Ethernet connection details

The Ethernet connector on the user cable is designed to be connected directly to a network hub. To extend the cable it is necessary to use an in-line coupler. This is two RJ-45 sockets wired together in a straight-through configuration. Following the in-line coupler, a normal, straight UDP Cat 5e cable can be used to connect the coupler to the hub.

To connect directly to an Ethernet card in a computer a crossed in-line coupler must be used. The connections in the crossed coupler are given in Table 17. Note that this is not the normal configuration sold and it may be necessary to modify an existing coupler to suit.

Table 17. Ethernet in-line couple connections

| Socket 1 | Straight socket 2 | Crossed socket 2 |
|---|---|---|
| Pin 1 | Pin 1 | Pin 6 |
| Pin 2 | Pin 2 | Pin 3 |
| Pin 3 | Pin 3 | Pin 2 |
| Pin 4 | Pin 4 | - |
| Pin 5 | Pin 5 | - |
| Pin 6 | Pin 6 | Pin 1 |
| Pin 7 | Pin 7 | - |
| Pin 8 | Pin 8 | - |

A typical in-line coupler is shown in Figure 13.

Figure 13. In-line RJ-45 coupler


## Serial RS232

The RT1003 v2 has two RS232 serial ports. One is reserved as an input for DGNSS corrections from a radio modem while the other can be configured to output data in a number of different formats including NMEA strings and NCOM. Both ports are configured from the Options page of NAVconfig.

## CAN bus

The RT1003 v2 features user configurable CAN bus that operates at 250 Kb/s, 500 Kb/s or 1 Mb/s. As well as transmitting its measurement data via CAN, the RT1003 v2 can also be configured to log 12 signals from the CAN bus. This functionality allows measurements (from a vehicle CAN bus for example), to be logged inside the INS along with the navigation measurements.

Please note that a termination resistor is not built into the RT1003 v2. It is therefore essential to include a 120 ohm resistor at each end of your CAN bus wiring—otherwise the CAN bus will not work. Signals sent from the RT1003 v2 are encoded in little-endian format (Intel-style).

In its default configuration, the CAN bus uses the following identifiers:

- 500h to 5FFh for INS status information
- 600h to 60Fh for navigation information
- 610h to 613h for RT-ANA messages
- 620h to 623h for the additional slip points

Only one status message is output per cycle (100 Hz or 250 Hz output rate) you do not get each status message at the specified rate.

# Hardware installation

It is essential to install the RT1003 v2 rigidly in the vehicle. The INS should not be able to move or rotate compared to either of the GNSS antennas or the vehicle itself, otherwise the performance will be reduced. When used with additional mounting brackets, the RT1003 v2 is compatible with the RT-Strut mounting product. The RT-Strut can be used to provide a quick and secure vehicle mounting option.

Installing the RT1003 v2 is not difficult, but it is a precision instrument and care should be taken not to subject it to extreme shock, vibration or temperature. While the RT1003 v2 does not need to be located at the precise point you wish to measure, try to keep any displacement to a minimum.

For ease of use, it is best to try and mount the RT1003 v2 so the IMU frame is aligned squarely to the vehicle frame (±5° in each axis). If the system must be mounted in a misaligned way, then those angle offsets must be measured and entered into NAVconfig.

## Antenna placement and orientation

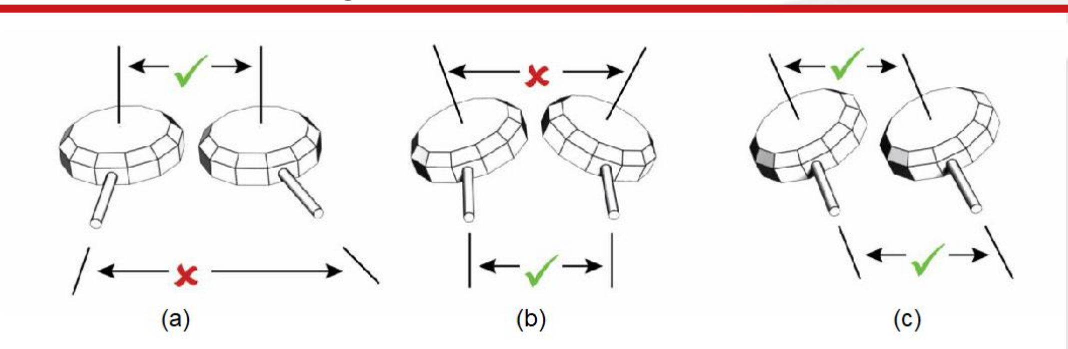
The placement and orientation of the GNSS antennas is important to the system accuracy. For optimal performance it is essential to mount the antennas where they have a clear, uninterrupted view of the sky and on a suitable ground plane, such as the roof of a vehicle if made of a ferrous material. It is possible to mount one antenna on the roof and one on the bonnet (hood), although in reality, the multipath reflections from the windscreen will degrade the performance of the system.

For good multipath rejection the antennas should be mounted on a metal surface using the magnetic mounts provided; no additional gap should be used. Multipath affects dual antenna systems on stationary vehicles more than moving vehicles and it can lead to heading errors of more than 0.5° RMS if the antennas are mounted poorly.

The antennas should not be mounted on non-conducting materials or near the edges of conducting materials. If the antennas are to be mounted without a conductor below them, then different antennas should be used. It is recommended to mount the antennas at least 30 cm from any edge where possible.

Antennas should be spaced between 1 and 5 metres apart, and the antenna baseline should be aligned with the vehicle's longitudinal or lateral axes where possible. It is possible to use a shorter antenna separation but the heading accuracy will be degraded. When mounting the antennas, the secondary antenna should be mounted in the same orientation as the primary, as shown in Figure 14. The direction the cable exits the antennas does not matter as long as it is the same for both.

Figure 14. Antenna orientation and alignment



a) The bases of the antennas are parallel, but the cables exit in different directions.

b) The cables exit in the same direction but the bases of the antennas are not parallel.

c) The bases of the antennas are parallel and the cables exit in the same direction. This configuration will achieve the best results.

When measuring the antenna separation, if the antennas are level (i.e. within ±15° of horizontal) then the separation should be measured to within 50 mm. If the antennas are not level, then the separation must be measured to 5 mm.

For both single and dual antenna systems it is essential that the supplied GNSS antenna cables are used and not extended, shortened or replaced. This is even more critical for dual antenna systems and the two antenna cables must be of the same specification. Do not, for example, use a 5 m antenna cable for one antenna and a 15 m antenna cable for the other. Do not extend the cable, even using special GNSS signal repeaters that are designed to accurately repeat the GNSS signal. Cable length options are available in 5 m and 15 m lengths.

## Configuring the RT1003 v2

To obtain the best results from an RT1003 v2 it is necessary to configure it to suit the installation and application before using it for the first time. The program NAVconfig is used to do this. This section describes how to use NAVconfig and gives additional explanations on the meanings of some of the terms used.

It is only possible to change the RT1003 v2 configuration via Ethernet. In order to do this, the Ethernet adapter on your computer must be correctly configured. See Communicating with the product on page 29 for detailed information on how to do this.

Once uploaded, the configuration file tells the RT1003 v2 how it is positioned and orientated in relation to the vehicle it is installed in. It also specifies which options to use while processing the data- such as DGNSS corrections.

Configuration files are stored in the product's memory and loaded each time the product is powered up. There is no need to upload a new configuration unless the RT1003 v2 is installed in another vehicle, or something about the existing installation changes—an antenna is moved for example.

## Overview

In order to give the best possible performance, the RT1003 v2 needs to know the following things:

- Its orientation relative to the vehicle it is mounted in.
- The position of the primary GNSS antenna compared to the RT1003 v2 IMU frame origin.
- The position of the secondary antenna (if applicable) compared to the primary antenna.
- The position of the non-steering wheels compared to the RT1003 v2.
- Some environment parameters.

The RT1003 v2 can work out many of these parameters by itself, but this takes time. Measuring the parameters yourself and configuring the RT1003 v2 reduces the time taken to achieve full specification.

## Language selection

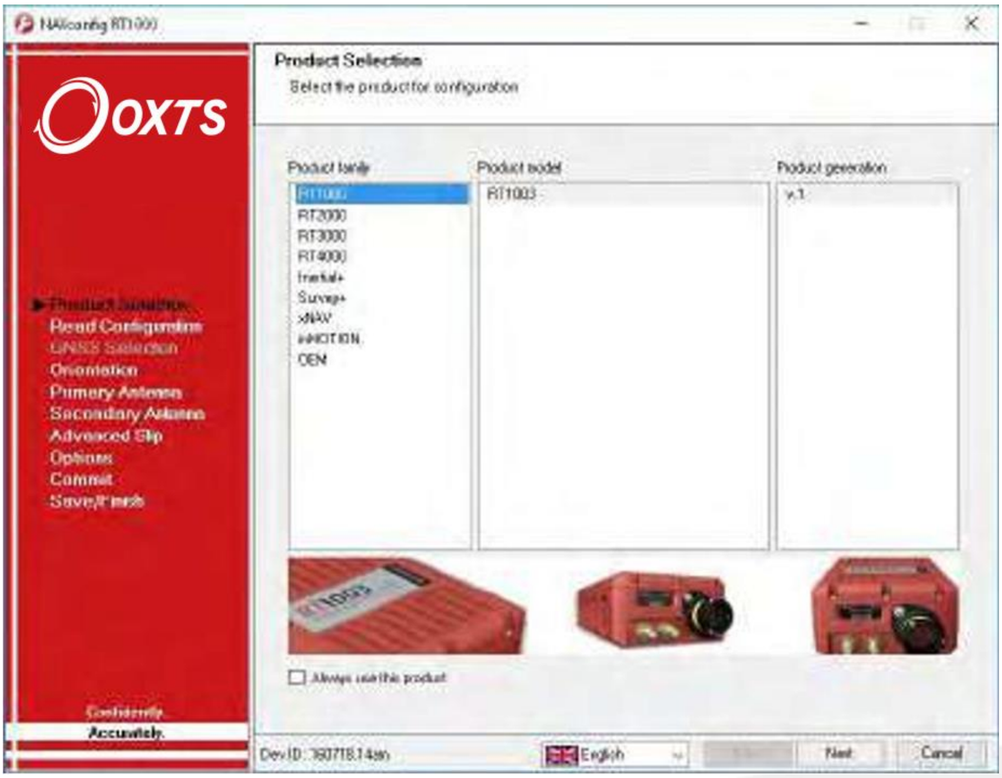
The NAVconfig software can operate in several languages. To change the language, open the settings located at the bottom left of the screen and select a language from the menu at the top of that page. The language can be changed at any time without affecting the current configuration.

The software will use the regional settings of the computer to choose whether numbers are represented in the English or European format (dot or comma for the decimal separator). The selected language does not change the format used for numbers.

Measurement units can also be displayed in metric, imperial, or both using the option setting below the language selection window.

## Product selection

Figure 15. Product selection



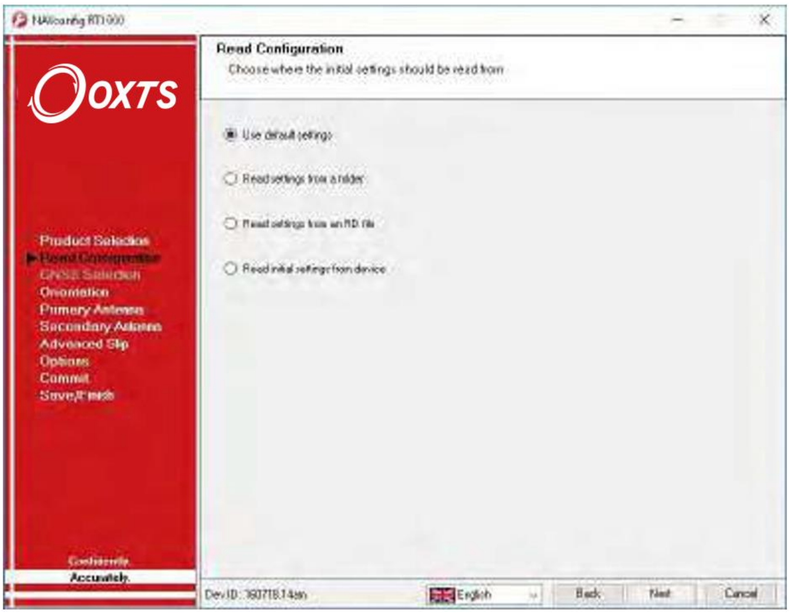

NAVconfig is a universal tool that is used to configure many different devices, so the first step in most configurations is to choose the product that will be configured, as shown in Figure 15.

The configuration wizard can be run without a product connected, so it is necessary to select the correct product for configuration. Some configuration pages are not available with some of the products. These will be displayed as grey in the sidebar.

In instances where the same product type will be used each time, the Product Selection page can be skipped in the future by selecting Always use this product. If a different product needs configuring, the selection page can be returned to by clicking Product Selection in the sidebar

# Read configuration

Figure 16. NAVconfig Read Configuration page




The Read Configuration page tells NAVconfig where to read the initial configuration from (see Figure 16).

**Use default settings**: NAVconfig loads the default settings the RT1003 v2 was delivered with.

**Note**: Choosing Use default settings overwrites any advance settings that may have been sent with prior configurations. To maintain those advanced settings, the Read initial settings from device option must be used.

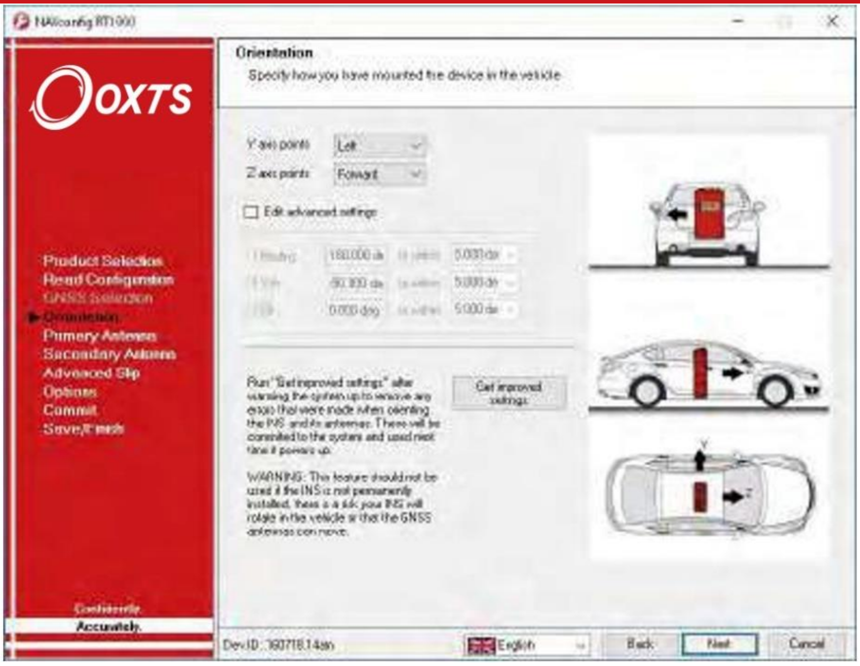
**Read settings from a folder**: It is possible to store a configuration in a folder. The configuration comprises several files, so it is tidier to keep it in a folder by itself. To read the configuration from a folder, select this option and then specify a folder by clicking the Browse… button.

**Read settings from an RD file**: The RT1003 v2 writes the configuration it is using to the internally stored RD file. This option extracts the configuration used and loads it into the configuration wizard. Specify an RD file by clicking the Browse… button.

**Read initial settings from device**: If the RT1003 v2 is connected to the computer via Ethernet it is possible to read the initial settings directly from the RT1003 v2. The settings loaded are the settings that were last committed to the RT1003 v2 using NAVconfig. Select this option and enter the correct IP address of your RT1003 v2, or select it from the drop-down list. The list will show all systems that are connected to the network, so if more than one system is connected ensure you select the correct system.

**Note**: The list will not function correctly if NAVdisplay or other software is using the UDP port unless the OxTS UDP Server is running.

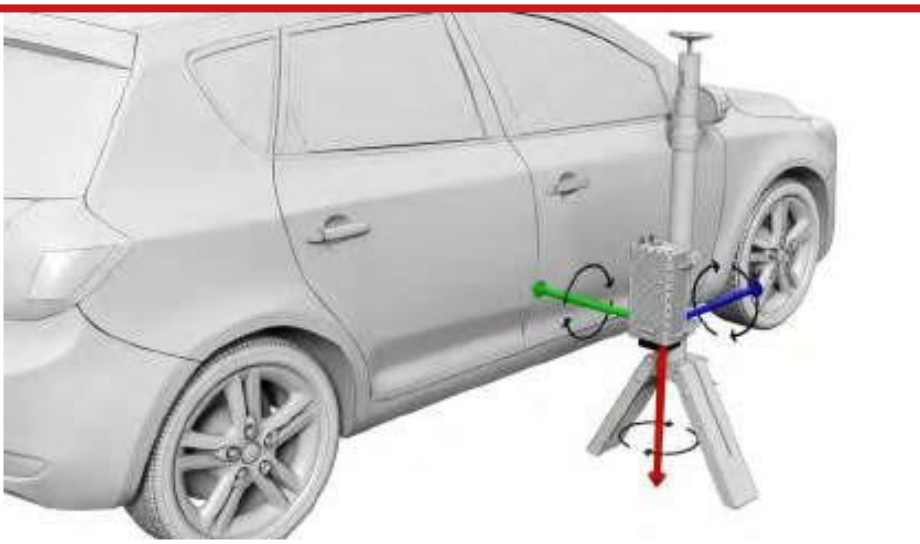
Figure 17. NAVconfig Orientation page




The Orientation page is used to tell the product how its IMU co-ordinate frame is orientated relative to the vehicle co-ordinate frame. Unless the RT1003 v2 happens to be installed in the default orientation, it will need to be told which way the IMU's Y- and Z-axis point.

Figure 17 illustrates this by showing an INS (with its IMU frame shown) mounted on our RT- Strut system. If the RT-Strut was installed in the vehicle as shown, the settings on NAVconfig's Orientation page would need to be set to: Y-axis points left; Z-axis points forward.

Figure 18. An INS device mounted on our RT-Strut system



The image shows an INS (with its IMU axes clearly visible) mounted on an RT-Strut. It the RT-Strut was mounted in the vehicle as shown, the settings on the Orientation page of NAVconfig would need to be set to Y- axis (green) points Left; Z-axis (blue) points forward. The INS will then convert measurements into the vehicle frame.

If it is not possible to mount the RT1003 v2 squarely within the vehicle, select **Use advanced settings** and define the RT1003 v2's orientation using these values.

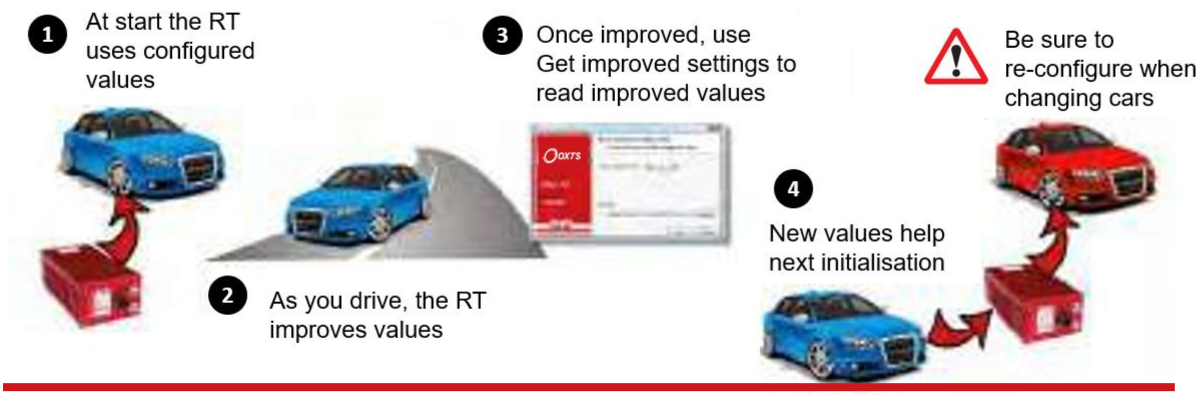
For correct initialisation it is necessary to get the heading orientation correct. The product gets its initial heading by assuming that the vehicle is travelling forwards and in a straight line. If the definition of the vehicle's X-axis (forward direction) is incorrect, the system will not initialise correctly when the vehicle moves forwards.

### *Get improved settings*

The **Get improved settings** button provides the ability to read the configuration settings from a warmed up system. While the RT1003 v2 is running it tries to improve some of its configured parameters. This option is useful if a calibration run has been done and the Kalman filter's values are known to be good.

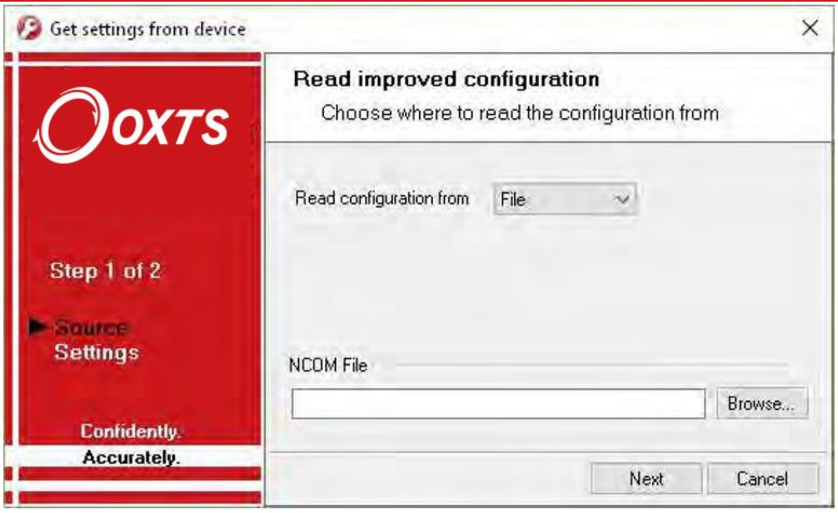
In particular the system will try to improve the GNSS antenna position measurements, the orientation of the dual antennas, the yaw orientation of the INS in the vehicle and, if one is being used, the wheel speed calibration values. In applications where the product is permanently installed in a vehicle, it can be beneficial to import these improved values into the configuration file to be used next time. It can make the results more consistent. Figure 18 shows this process. The Get improved settings feature should not be used if there is a risk the INS will rotate in the vehicle or that the GNSS antennas can move — even by a few millimetres.

Figure 19. Proccess of using Get improved settings




To read the improved values from the RT1003 v2, click **Get improved settings** on the Orientation page. This opens the Get settings from device window shown in Figure 20.

Figure 20. Source selection page for Get improved settings

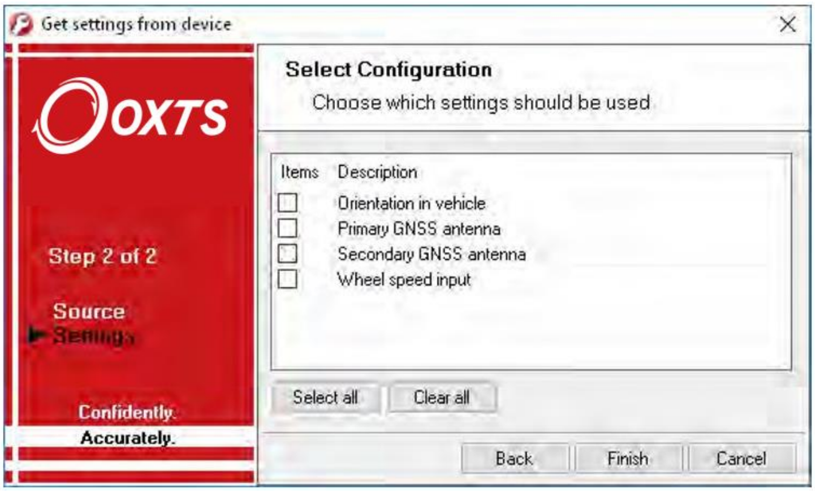



In the Read configuration from box, select the source for the improved settings. The options are:

- **File**: If an NCOM file has already been saved to disk or processed using the post-process utility, it can be read and the required settings extracted from it. Use this setting if you have an NCOM file. Click **Browse**… and select the NCOM file you wish to read the configuration from. Do not use an NCOM file that has been combined from forward and backwards processing of the inertial data.
- **Ethernet**: This will get the information that the product is currently using. Use this setting if the RT1003 v2 is running, has initialised and has warmed-up. Select the correct IP address for the product in the drop-down list.
- **Note**: The list will not function correctly if NAVdisplay or other software is using the UDP port unless the OxTS UDP Server is running.

Once a source has been selected, click **Next** and the software will check which settings can be obtained from the source. Settings that cannot be obtained will be shown in grey; this may be because the product is not calculating these values at present. Figure 21 shows the Settings page with the parameters available to improve in the configuration. You may update several parameters at once. Select the settings you want to be updated and uncheck the ones that you do not want to update.

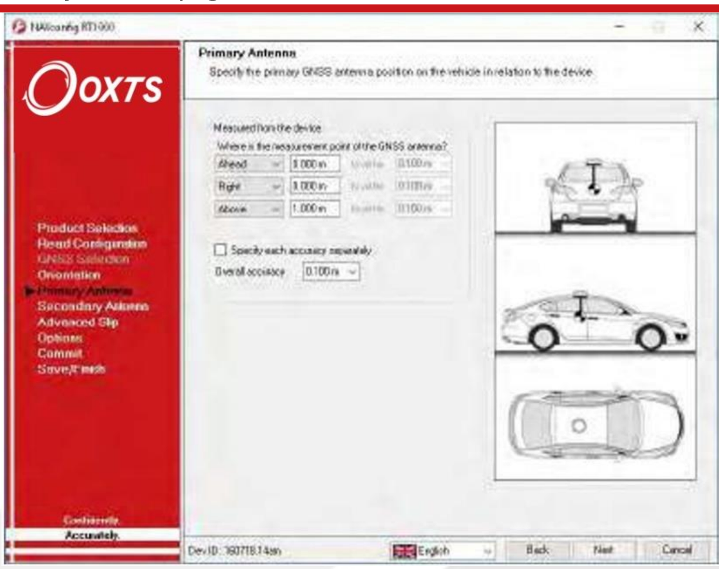
Figure 21. Settings page of the Get improved settings




**Note**: If Orientation in vehicle is selected, the improvement to orientation should only be applied if the change in the orientation is small (less than 5°). If the change in orientation is large then it is likely that the original configuration was wrong or has not been loaded into NAVconfig. You are very likely to get poor results if the orientation is changed by a large amount.

## Primary antenna

Figure 22. NAVconfig Primary Antenna page



Accurately defining the position of the primary antenna in NAVconfig helps achieve better results sooner. It is recommended to measure the GNSS antenna position to an accuracy of 10 cm.

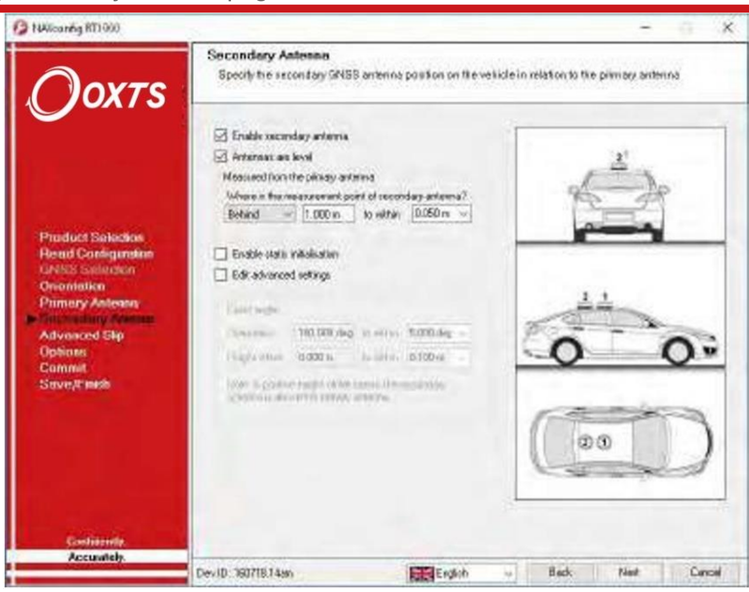
Measure the distances from the RT1003 v2 to the GNSS antenna along each of the axes in the vehicle's co-ordinate frame. On the Primary Antenna page, shown in Figure 22, select the directions (Ahead/Behind, Right/Left, and Above/Below) and enter each of the measurements. For visual confirmation the position of the antenna in the image will change to reflect the specified configuration.

The Overall accuracy can be specified by choosing a value from the drop-down list or typing one in. Alternatively, the accuracy of each measurement can be specified separately by clicking the check box to unlock the greyed out drop-down boxes.

The default accuracy is 10 cm, which is sufficient for the RT1003 v2 to refine itself to specification during the warm-up period. Care should be taken if specifying a greater accuracy. Do not overstate the accuracy as doing so may cause the RT1003 v2 to look in the wrong place, increasing the time taken to find the correct solution.

## Secondary antenna

Figure 23. NAVconfig Secondary Antenna page




The Secondary Antenna page, shown in Figure 23, is used to define the position of the GNSS antenna connected to the secondary receiver, relative to the primary one. The secondary antenna should be placed in accordance with the information given in the antenna installation section of this manual.

Select the Enable secondary antenna check box to allow the configuration to be entered. If it is not enabled, the RT1003 v2 will ignore the secondary antenna and will not use it to compute a heading solution.

By default, the **Antennas are level** box is checked. This means the antenna baseline should be within ±5° of horizontal. When the antennas are level the separation should be measured to within 50 mm. If the antennas are not level, i.e. mounted with height offsets or on an incline, then the box should be unchecked. In this case, the separation should be measured to within 5 mm.

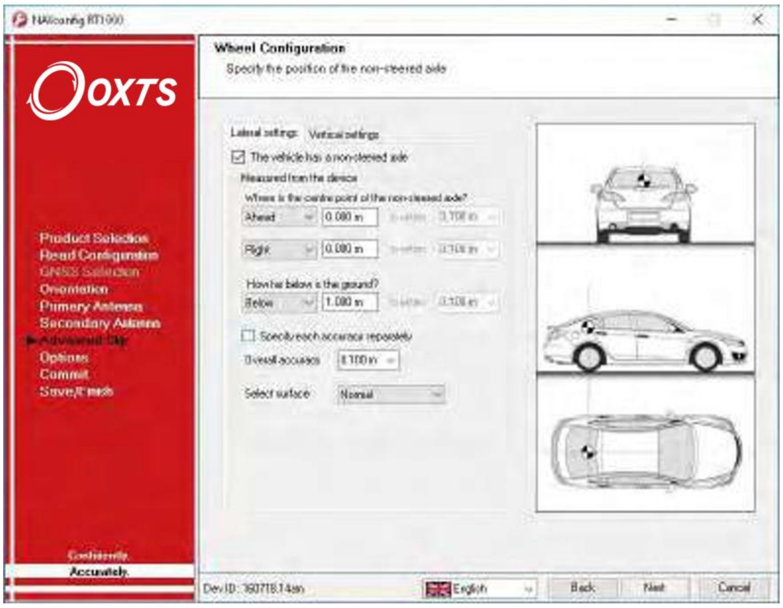
Enter the antenna separation and select the position of the secondary antenna relative to the primary antenna from the drop-down list. The measurement accuracy can also be specified with the to within drop-down box. The illustrations will change according to the settings you choose to help visualise the configuration of the antennas.

It is important to measure between the same point on each antenna, e.g. centre to centre, or from cable to cable.If the antennas are mounted at significantly different heights, or if the mounting angle is not directly along a vehicle axis (forward or right), then click **Edit** advanced settings to enable **advanced settings** and specify the orientation and height offset.

The Enable static initialisation option is useful for slow moving vehicles or when dynamic initialisation may be difficult. Static initialisation is 99% reliable in open sky, but the reliability decreases in environments where obstructions to GNSS signals are present. Static initialisation is also faster when the antenna separation is smaller and the Antennas are level check box is ticked.

## Advanced slip

Figure 24. NAVconfig Advanced Slip page




The Advanced Slip feature uses characteristics of land vehicle motion to improve heading and reduce drift. Specifying the position of the non-steered wheels makes a huge difference to the lateral drift performance of the RT1003 v2 when GNSS is not available. The vertical drift performance can also be improved by specifying some additional measurements.

This feature must be disabled for airborne and marine applications where the lateral velocity can be significant. It is also not suitable for land vehicles that have no non-steered wheels. The vertical settings should not be used if the vehicle can perform wheelies (motorcycles).

The advanced slip feature applies heading correction when the vehicle is not slipping; when the vehicle is slipping the lateral acceleration is usually large enough that the normal heading corrections provide excellent results. When combined with a wheel speed input the drift of the RT1003 v2 during GNSS blackout is drastically reduced.

For the Lateral settings, the system needs to know the position of the non-steered axle (the rear wheels on a front-wheel steering vehicle and vice versa). Vehicles with all wheels steering cannot use this feature reliably, although minor steering of the rear-wheels does not significantly affect the results. The measurements entered are from the RT1003 v2 measurement origin, to the point shown in Figure 25.

Figure 25. Measurement point for advanced slip

Measure the distance to the non-steered axle position in each axis of the vehicle co-ordinate frame. Select the direction from the drop-down lists and enter the distances.

Typically, the measurements should all be made to an accuracy of 10 cm. Selecting an accuracy better than 10 cm does not improve results. Using an accuracy figure worse than 20 cm will increase the drift of the RT1003 v2. Use the accuracy fields to select or specify the accuracy of the measurements.

The Advanced Slip feature also requires some knowledge of the road surface. Select one of the predefined options from the drop-down list, Normal or Low friction (ice).

For the Vertical settings, the system needs to know the position of the front axle. A position at road height, mid-way between the wheels should be used, like for the rear axle.

Measure the distances again from the RT1003 v2 and enter them into the cells, selecting the appropriate directions from the drop-down lists.

## Options

Figure 26. NAVconfig Options page


The Options page includes some optional settings that can be configured to tailor the RT1003 v2 to specific applications. Figure 26 shows the available options. To adjust the settings, click the default value in the Setting column to activate the cell. A description on each option and how to adjust it is found below.

### *IMU output rate*

The standard output rate of the RT1003 v2 is 100 Hz, however this can be increased to 250 Hz with the application of a special IMU high-rate feature code. On devices where the feature code has been applied, the IMU output rate option allows the output rate to be set to 100, 200 or 250 Hz. On devices where the IMU high-rate feature code has not been applied, this option is ignored, regardless of its setting.

### *Vehicle starts*

If the vehicle being measured will be level during initialisation (to within about 5°) select Level. This reduces the initialisation time by about 40 seconds as an initial roll and pitch value does not have to be computed. In high vibration environments Not level may not work and so the RT1003 v2 can only start if the vehicle is level and the Level option has been specified.

### *Vibration*

There are three options available to describe the level of vibration the system will be exposed to. In most cases Normal, will work correctly. If the RT1003 v2 is installed using vibration mounts allowing some movement independent of the GNSS antennas, High or Very high settings should be considered. Select the appropriate option from the drop-down list.

### GNSS weighting

The RT1003 v2 can place different emphasis on the GNSS receiver's measurements. The default setting is High, placing more weight on the GNSS receiver's measurements than those of the inertial sensors. Selecting Low will make the RT1003 v2 rely more on the inertial sensors.

In obstructed environments it is better to believe the inertial sensors more, whereas in open sky the GNSS receiver should be believed more.

### Differential

Differential GNSS corrections can either be received via Ethernet (using a device such as the RT-XLAN), or via the serial port when connected to a radio modem. If another device on the network is transmitting differential corrections, the Differential option should be set to Network correction receiver.

When receiving corrections via the serial port, the Differential option should be set to Disabled. Once the serial port has been correctly configured to receive corrections, it is possible to set the Differential option to Network correction transmitter. In this state, the RT1003 v2 will output the corrections it is receiving on the serial port via the Ethernet port (which can be shared via Wi-Fi when suitable equipment is attached).

### SBAS

In Europe, North America, and Japan, SBAS can be used for differential corrections. When operating in regions with a satellite based augmentation service (SBAS), enabling this option will improve the GNSS performance compared to the standard positioning service (SPS). In North America, the SBAS service is known as WAAS, in Europe it is known as EGNOS and in Japan it is known as MSAS. When enabled, the system scans for SBAS services and automatically selects the appropriate service.

**Note**: SBAS correction is automatically enabled/disabled when gx/ix is being used as they two technologies are incompatible.

### Terrastar corrections

Select either Automatic or Manual from the corrections drop-down list in the properties window to enable corrections. When manual is used, the correct satellite should be selected for the region where you are operating.

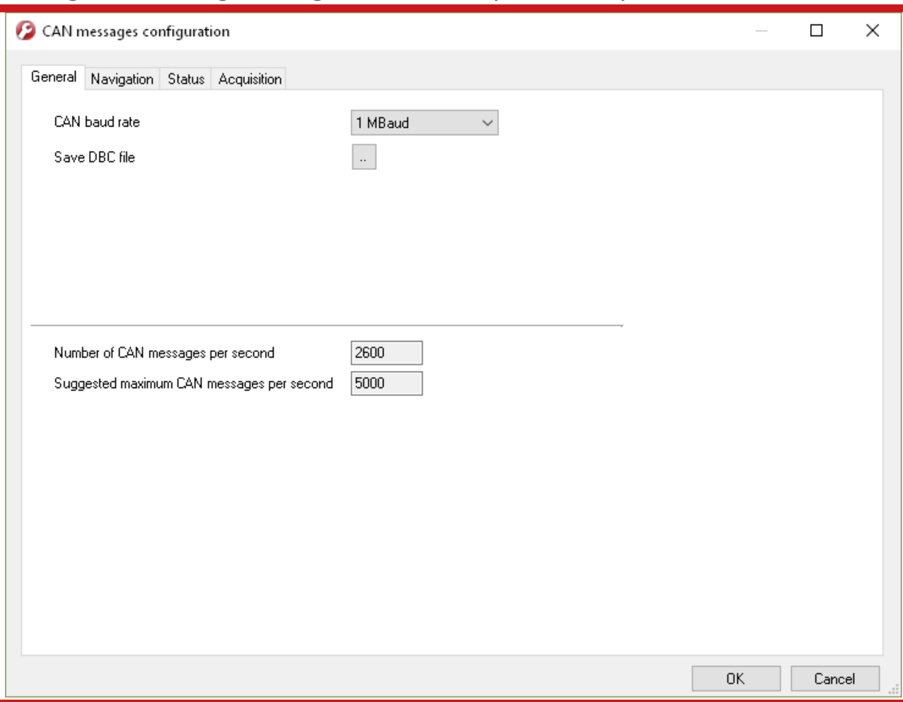
Several satellites have been pre-programmed into the software. In the future more satellites may exist, or their properties may change. In this case it is necessary to select Use advanced settings to set the satellite's Frequency and Baud rate.

### CAN

RT1003 v2 systems can be configured to send and receive data via a CAN bus. This allows measurements to be sent to external logging devices, and signals from a test vehicle's CAN bus to be logged alongside navigation data inside an RT1003 v2.

By default, CAN communication is disabled. It is enabled by selecting an option from the drop-down list for CAN baud rate on the General tab of the properties window, shown in Figure 27.

Figure 27. NAVconfig CAN messages configuration window (General tab)

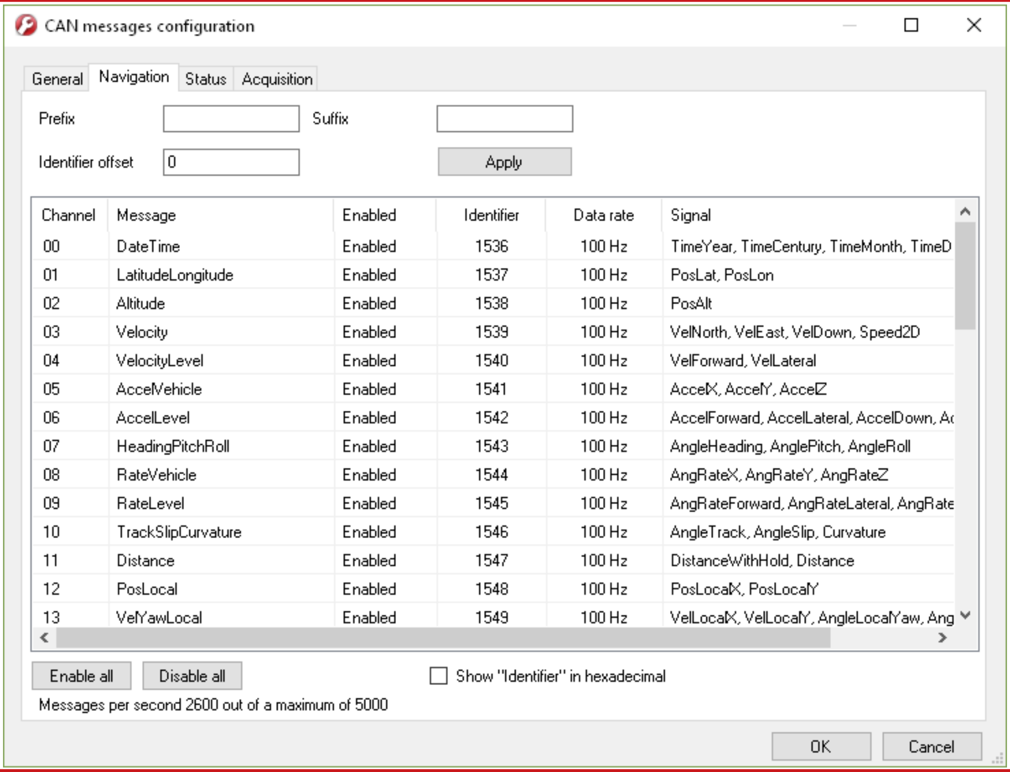



Depending on the baud rate selected, the suggested maximum CAN messages per second will change. A warning message will appear if the combined rate of all current navigation and status messages will overload the CAN bus at the selected baud rate. Disabling or reducing the frequency of navigation or status messages will remove the warning and ensure reliable operation of the CAN bus. Increasing the baud also works, but the baud rate must be common to all devices on the bus. When using an RT ANA, the default baud rate is 1 MBaud.

The **Save DBC file** button generates a CAN DBC library listing all navigation and status messages that are enabled (not greyed-out). The DBC file does not include channels defined under the acquisition tab. The status message binary format is the same as the NCOM status message binary format as described in the NCOM Description manual. Those status messages that do not have signals listed against them are not described at the signal level in the DBC file. The binary format of these messages is quite complex and as such the DBC file it not sufficient to describe the decoding process.

The Navigation tab (Figure 28) is where navigation-related CAN messages are configured for output. The table can be sorted in ascending or descending order by clicking any column header. This is particularly useful when checking for enabled/disabled messages.

Figure 28. NAVconfig CAN messages configuration window (Navigation tab)




The Prefix and Suffix boxes can be used to quickly add alpha-numeric strings to the beginning and end of all message names, while the Identifier offset box allows users to quickly apply an offset to all CAN IDs. These tools are useful when IDs conflict with other equipment and changes need to be made to many channels.

Positive and negative integer values can be entered into the Identifier offset box in both decimal and hexadecimal formats. Data entered in hexadecimal format should end with a "h". To remove the offset, type 0 in the identifier offset box and click **Apply**.

Each message can be enabled/disabled by clicking in the appropriate cell and selecting from the drop-down menu. The message Identifier is also changed by clicking in the cell. The identifier number should be defined in either hexadecimal or decimal format. Decimal values can be entered as normal. Hexadecimal values should have a letter 'h' be appended.

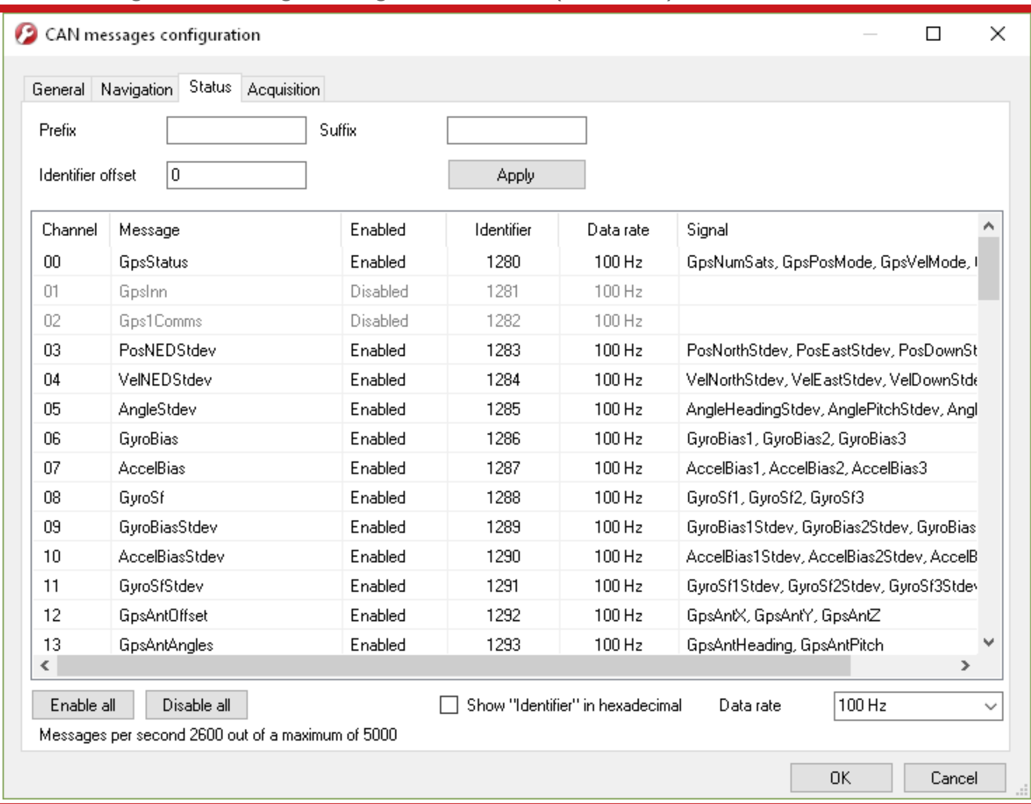
The Data rate can be set using the drop-down list that appears after clicking in each data rate cell. When a message's data rate changes or it is enabled or disabled, the caption at the bottom of the window displaying messages per second updates to reflect the new settings.

On RT1003 v2 systems the default set of CAN messages may overload the CAN bus (depending on how many slip points are used and whether local co-ordinates are configured). It may be necessary to reduce the number of messages that are output on an RT1003 v2 system.

The Status tab (Figure 29) lists all status messages, which are sent one after another in a repeating loop. Although 80 messages are shown in the list, 100 are actually used internally. If the data rate is set to 100 Hz, a status message will be sent every 10 ms. Some messages are transmitted more frequently than others because they appear in the list more than once. At a data rate of 100 Hz, each message in the Status tab will be transmitted on the CAN bus once per second.

Messages shown in grey are not included in the CAN DBC file.

Figure 29. NAVconfig CAN messages configuration window (Status tab)

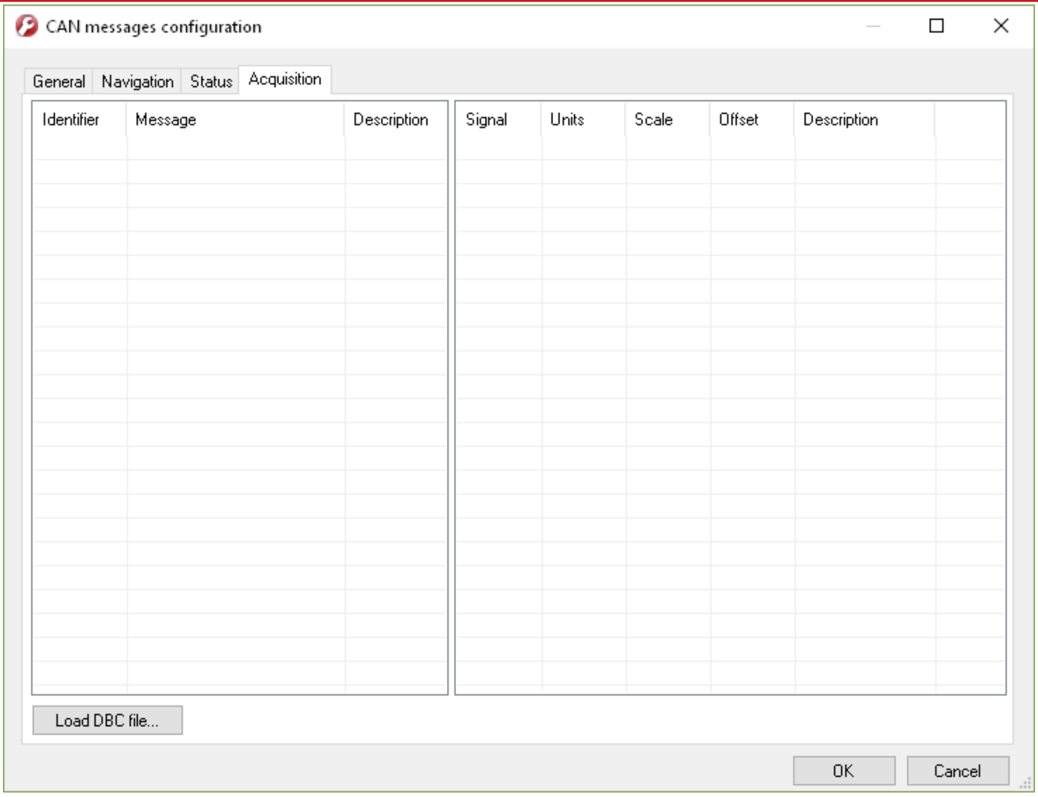



The Acquisition tab (Figure 30) is where incoming CAN signals are defined. These signals can be viewed in real-time along with the RT1003 v2's native data using NAVdisplay, or at a later time using NAVgraph.

Channels are added to the acquisition list by clicking on the Load DBC file button and selecting a valid CAN DBC file. The top 12 messages in the list acquisition list are logged at the INS update speed of 100 Hz or 250 Hz. This is not adjustable.

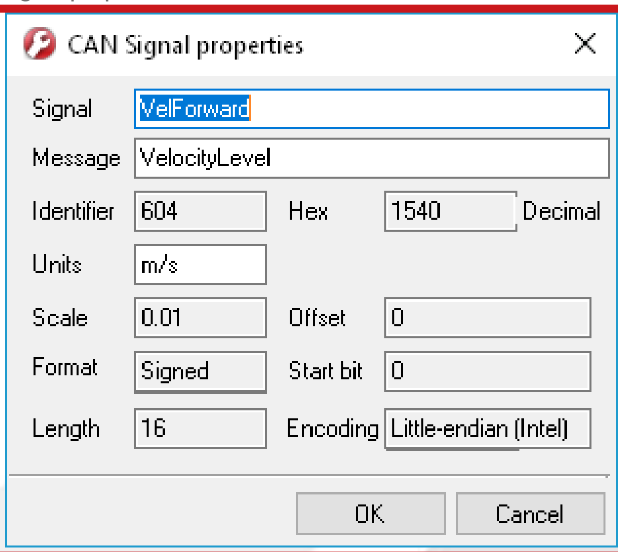
Extra CAN messages (those on the grey background) do not need deleting from the list but will not be logged. To move a message up into the top 12 area for logging, right-click on messages above and delete them from the list. To remove individual signals from a message, right-click on the signal in the right-hand window to bring up the delete option.

Figure 30. NAVconfig CAN messages configuration window (Acquisition tab)




The Message name, Signal name and Units can be edited in the CAN Signal Properties window (Figure 31). This is opened by double-clicking any signal. Changes made using NAVconfig are independent of the DBC file, and will not affect it or be saved.

Figure 31. NAVconfig CAN signal properties window



## Heading lock

When stationary for extended periods of time, the heading of systems using only one GNSS antenna can drift. The heading lock option solves this by locking the heading to a fixed value while the system is stationary. Using both antennas with a dual antenna system will also keep the heading stable in which case heading lock is not necessary.

Heading lock cannot be used with host vehicles that can turn on the spot (i.e. without longitudinal velocity). Note that simply turning the steering wheel while stationary is often enough to change the heading on most road vehicles.

Select an option from the drop-down list. Table 18 gives a description on each of the heading lock options.

Table 18. NAVconfig heading lock options

| Heading lock | Description |
|---|---|
| Disabled | Disables heading lock. Should be used if the vehicle can turn on the spot |
| Normal | Best for most applications. Assumes that the heading of the vehicle does not change by more than 2° while the vehicle is stationary. The heading accuracy recovers quickly when the vehicle moves |
| Tight | Assumes that the heading of the vehicle does not change by more than 0.5° while the vehicle is stationary. The recovery is fast if the heading of the vehicle does not change but will be slow if the vehicle turns before it moves |
| Very tight | Assumes that the heading of the vehicle does not change by more than 0.3° while the vehicle is stationary. The recovery is fast if the heading of the vehicle does not change but will be slow if the vehicle turns before it moves. This option can cause problems during the warm-up period if the vehicle remains stationary for a long time and then drives suddenly |

## Garage mode

Garage mode is used to stabilise the outputs when GNSS is not available. For example, GNSS signals can be blocked when the vehicle returns to a garage for modifications to be made. If the modifications take a long time, the system may drift too far and struggle to recover.

When Garage mode is active, a gentle velocity update is applied the system assumes the vehicle is stationary. This keeps the roll, pitch and velocity within acceptable limits while there are no GNSS signals. With heading lock enabled as well, the RT1003 v2 can also maintain an accurate heading while stationary.

When using the garage mode option, try to keep the vehicle's movement inside the garage to a minimum and exit the garage through the same door the car entered.

## Initialisation speed

The initialisation speed defines the threshold that must be crossed to trigger dynamic initialisation (for static initialisation see the Secondary antenna section of this manual). The default value of 5 m/s works well in most situations.

When changing the initialisation speed, be aware that the product makes some assumptions during initialisation. First, it assumes the vehicle is travelling forwards; and second, it assumes its travelling in a straight line. For this reason, the initialisation speed should be set sufficiently high that initialisation is not accidentally triggered while reversing out of a parking space for example. A higher speed also means there is more time for the steering to self-centre after any manoeuvres that were performed in order to get to the initialisation area.

### *Displace output*

The RT1003 v2 can displace its outputs to another location in the vehicle reference frame. Output measurements will then appear to be from the new location, the location of a sensor for example, rather than the real-world location of the INS. This option displaces all outputs (position, velocity, acceleration) to this new location.

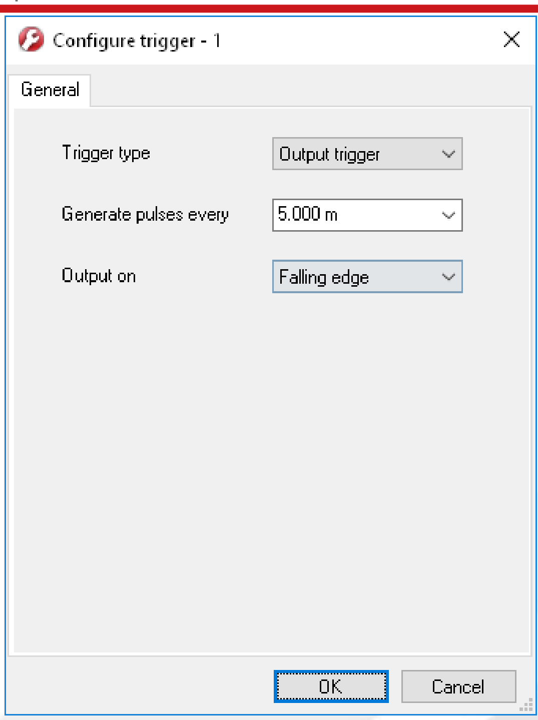
To enable the output displacement option, click the check box in the properties window and enter the offsets from the IMU origin, to the new displaced location. Offsets are given in the vehicle reference frame.

**Note**: Any noise in the acceleration outputs will be multiplied when output displacement is used. Typical installations in land-based vehicles have angular vibrations of about 2 rad/s². This equates to 2 m/s² of additional vibration with a 1 m output displacement. It will be necessary to filter the data if output displacement is used.

### *Trigger 1 and Trigger 2*

The RT1003 v2 has two triggers, each of which can be configured as an input trigger, output trigger or an IMU sync pulse. To define a trigger, click in the Settings column, then select the [...] button to open the properties window, shown in Figure 32. Select the trigger type from the drop-down list.

Figure 32. NAVconfig trigger properties window



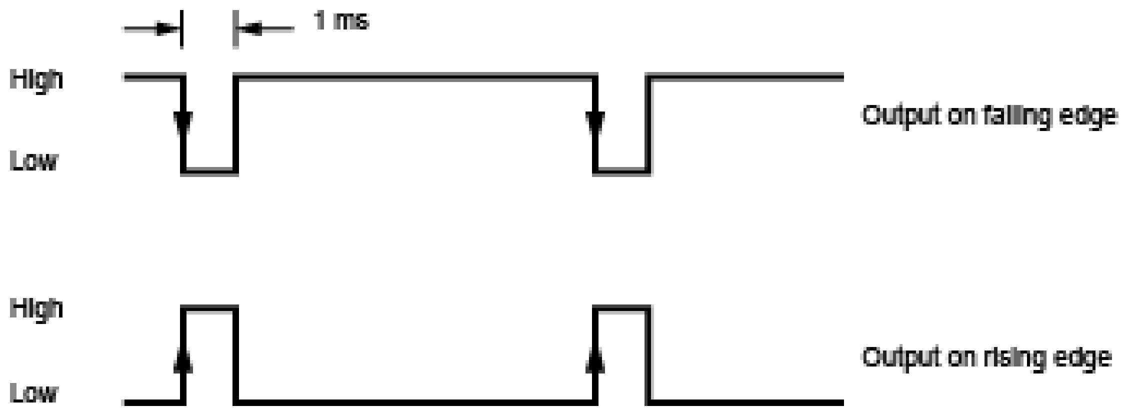

The NMEA tab is enabled when the Packet is set to NMEA.

**Input trigger**: Accepts a trigger input from an external device, such as a camera, to generate a data point with all measurements at the exact timestamp of the trigger. The event input has a pull-up resistor so it can be used with a switch or as a CMOS input. The input sees less than 0.6 V as low and more than 2.6 V as high. The input range should be kept between 0 V and 5 V.

**Output trigger:** Generates a pulse based on distance. Select the distance interval to generate the pulses on from the drop-down list, or type in a value. The output has 0.8 V or less for a low and 2.4 V or more for a high. The pulse width is 1 ms. By selecting Rising edge or Falling edge from the drop-down box the trigger can be configured as a low or high, as illustrated in Figure 33.

**IMU sync:** Generates an output pulse at the same frequency as the data rate of the system, synchronised to the IMU sample time. The output has a duty cycle of approximately 50% and the falling edge is synchronised to the sample file of the data from the IMU.

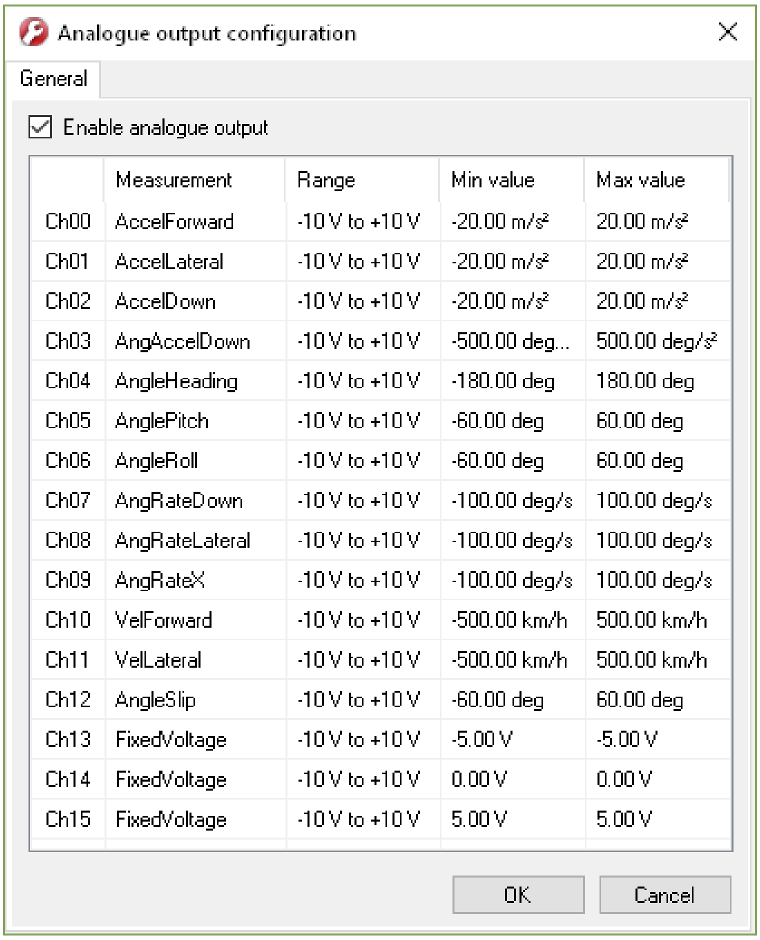
Figure 33. Output trigger settings




### *Analogue output*

The Analogue output option is used for configuring the RT-ANA companion product. There are 16 channels in the RT-ANA, numbered from 0 to 15. The Measurement, Range, and Min and Max values for all 16 channels can be configured. Click on a specific cell to change the settings.

Figure 34. NAVconfig Analogue outputs configuration window


Analogue output configuration

General

Enable analogue output

| | Measurement | Range | Min value | Max value |
|---|---|---|---|---|
| Ch00 | AccelForward | -10 V to +10 V | -20.00 m/s² | 20.00 m/s² |
| Ch01 | AccelLateral | -10 V to +10 V | -20.00 m/s² | 20.00 m/s² |
| Ch02 | AccelDown | -10 V to +10 V | -20.00 m/s² | 20.00 m/s² |
| Ch03 | AngAccelDown | -10 V to +10 V | -500.00 deg... | 500.00 deg/s² |
| Ch04 | AngleHeading | -10 V to +10 V | -180.00 deg | 180.00 deg |
| Ch05 | AnglePitch | -10 V to +10 V | -60.00 deg | 60.00 deg |
| Ch06 | AngleRoll | -10 V to +10 V | -60.00 deg | 60.00 deg |
| Ch07 | AngRateDown | -10 V to +10 V | -100.00 deg/s | 100.00 deg/s |
| Ch08 | AngRateLateral | -10 V to +10 V | -100.00 deg/s | 100.00 deg/s |
| Ch09 | AngRateX | -10 V to +10 V | -100.00 deg/s | 100.00 deg/s |
| Ch10 | VelForward | -10 V to +10 V | -500.00 km/h | 500.00 km/h |
| Ch11 | VelLateral | -10 V to +10 V | -500.00 km/h | 500.00 km/h |
| Ch12 | AngleSlip | -10 V to +10 V | -60.00 deg | 60.00 deg |
| Ch13 | FixedVoltage | -10 V to +10 V | -5.00 V | -5.00 V |
| Ch14 | FixedVoltage | -10 V to +10 V | 0.00 V | 0.00 V |
| Ch15 | FixedVoltage | -10 V to +10 V | 5.00 V | 5.00 V |

OK Cancel

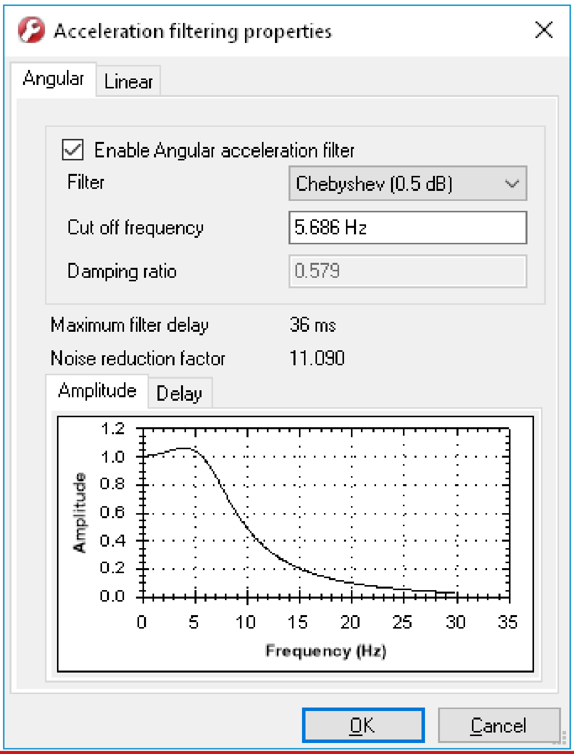
### *Acceleration filter*

The RT1003 v2 is able to filter the linear acceleration and the angular acceleration before they are output. These filters affect the outputs on the CAN bus. On the NCOM output the non- filtered values are output together with the filter characteristics and the NCOM decoders provided by OxTS will implement the chosen filter. The linear acceleration and the angular acceleration can be configured separately.

Due to vibration the accelerations (both linear and angular) are noisy. In particular, angular acceleration is normally filtered when it is used. The RT1003 v2 can filter the acceleration outputs using a second order low-pass filter. The characteristics of the filter can be set and viewed in the Acceleration filtering properties window (Figure 35).

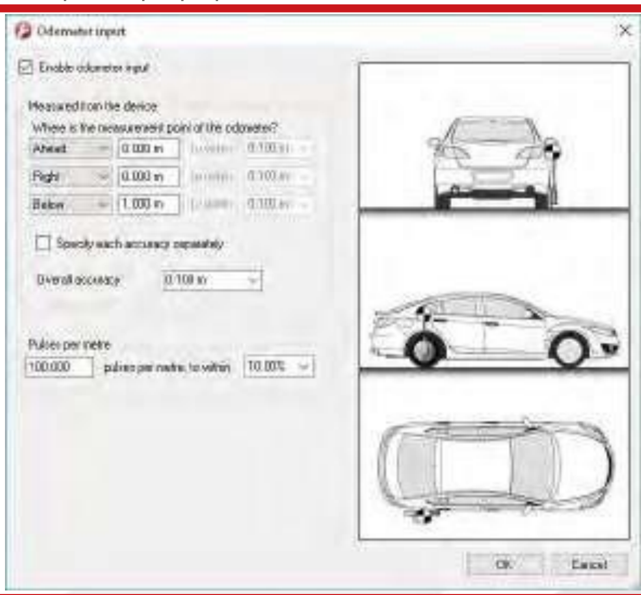
Designing the right filter is always a compromise between the noise reduction and the filter delay. To help choose the filter, the software will compute the maximum delay over the 0 to 5 Hz interval and the Noise Reduction Factor over the full bandwidth. The Noise Reduction Factor is the ratio of the filtered noise compared to the unfiltered noise assuming the vibration is white (i.e. same amplitude across the frequency spectrum). A graph showing the delay with respect to frequency can also be plotted. The delay is the additional delay of the filter and not the total delay of the acceleration output. The RT1003 v2 has other delays, like calculation delay, too.

Figure 35. NAVconfig acceleration filter properties window




### *Wheel speed input*

Figure 36. NAVconfig Wheel speed input properties window



When measuring land-based vehicles, accuracy can be maintained for longer periods during GNSS blackout if an independent wheel speed odometer is fed into the system. In most instances the Advanced Slip feature should be used in conjunction with an odometer input.

The odometer signal must not be sourced from a steered wheel—the odometer signal should only measure in the vehicle's longitudinal axis. As odometer pulses from driven wheels are less accurate, the best results are achieved when the odometer input is fitted to the rear wheel of a front wheel drive vehicle.

To work correctly, the system needs to know where the measurement point (the centre of the wheel being measured) is in relation to the IMU origin. The directions can be selected from the drop-down lists. If the odometer signal is being sourced from a prop shaft, then the measurement point entered should be half way between the two wheels. The illustrations in the window will change depending on the settings you choose, to help visualise the position of the RT1003 v2 in relation the odometer.

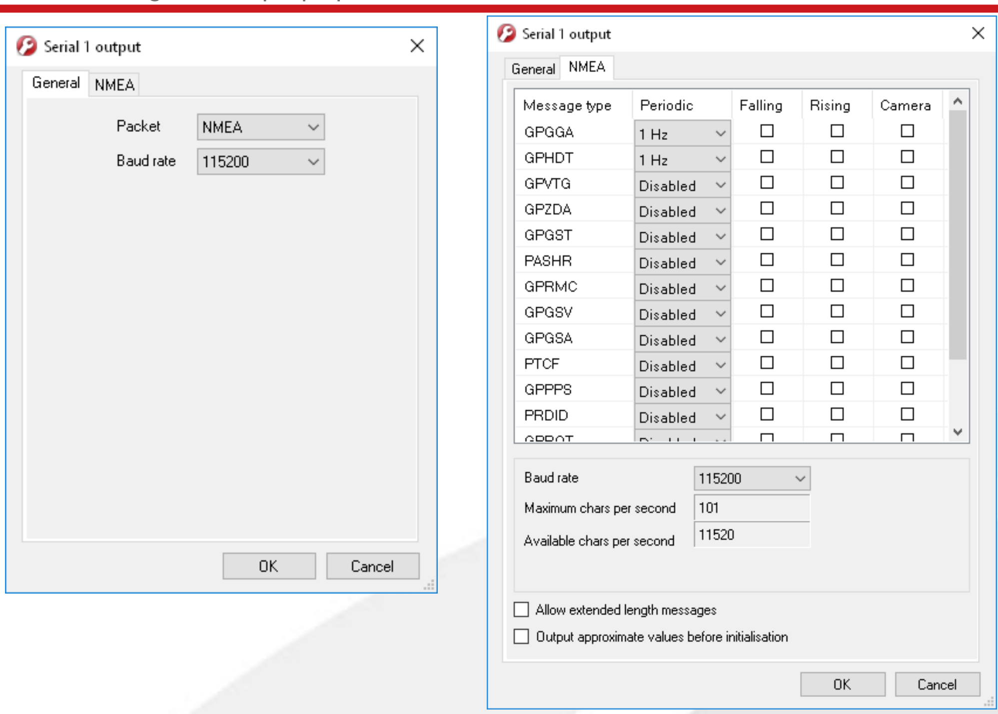
The pulses per metre should also be specified. A value that is accurate to 10% is sufficient unless the figure is known more accurately. The RT1003 v2 will improve this scaling factor itself when GNSS is available.

### Local co-ordinates

The RT1003 v2 can output the displacement from an origin in a local co-ordinate grid. To use this option, a new origin must be defined; the latitude, longitude and altitude for the origin must be entered along with an angular offset for the X-axis. Local co-ordinates are fully explained earlier in this manual.

### Serial 1 output

Figure 37. NAVconfig serial output properties




The NMEA tab is enabled when Packet is set to NMEA.

The serial port can be configured to output different types of message (see Table 18). To enabled serial output, click in the Setting column, then click the [...] button to open the properties window, shown in Figure 37.

Select a **Packet type** and **Baud rate**. By default, data on the serial port is output using 8-N-1, although odd/even parity and two stop bits are available by using Advanced commands. Please contact support@oxts.com for details on this.

If the NMEA packet type is selected, the NMEA tab will appear in the properties window (see Figure 37). In this tab the NMEA messages to output on the serial port are selected by choosing the data rate for each message type from the drop-down lists and clicking the check box for when to generate the message.

NMEA messages can also be generated in response to event input triggers. Check the falling or rising edge check box to compute the message when the event occurs. The RT1003 v2 can also generate NMEA messages from pulses on the output trigger. These messages use interpolation to compute the values at the exact time of the event but may be output on the serial port up to 30 ms late and out of order compared to the normal messages. To enable these messages check the appropriate check box.

Table 19. Serial output options

| Option | Description |
|---|---|
| Disabled | The serial output is disabled. This option can be used to reduce the computational load and ensure that the Kalman filter runs quicker |
| NCOM | Normal output of the RT1003 v2. NCOM data is transmitted at up to 125 Hz over serial. The format is described in the NCOM Description Manual. Software drivers exist for decoding the NCOM data |
| IPAQ | NCOM output at a reduced rate. The baud rate of the serial port is set to 19200 and the update rate is 25 Hz. It is used because the IPAQ cannot manage to receive the data reliably above 25 Hz |
| IPAQ+ | NCOM output at a reduced rate and polled. Windows Mobile 5 on IPAQs crashes if the inMOTIONx is sending data when the IPAQ is turned on. Using IPAQ+ the IPAQ will poll the RT1003 v2; the RT1003 v2 will not send data while the IPAQ is off, pre venting the turn-on crash of the IPAQ |
| NMEA | The NMEA outputs conform to the National Marine Electronics Association Standard (NMEA 0183 version 3.01 The NMEA sentences available are GPGGA, GPHDT, GPVTG, GPZDA, GPGST, PASHR, GPRMC, GPGSV, GPGSA, PTCF, GPPPS, PRDID, GPROT, GPGGK, and GPUTC. The NMEA 0183 description manual gives details of the fields output in the NMEA sentences |
| Javad I+RTK | A special set of messages output in GREIS format to be used with Javad receivers. For assistance please contact OxTS for support |
| MCOM | Used for marine applications. Identical to NCOM output but with the addition of heave measurements |
| TSS1 | TSS I format outputting acceleration, heave, roll and pitch |
| TSSHHRP | TSSHHRP format |
| Simrad EM3000 | Suitable for use with Simrad EM3000 multibeam sounders |
| Simrad EM1000 | Suitable for use with Simrad EM1000 multilbeam sounders |

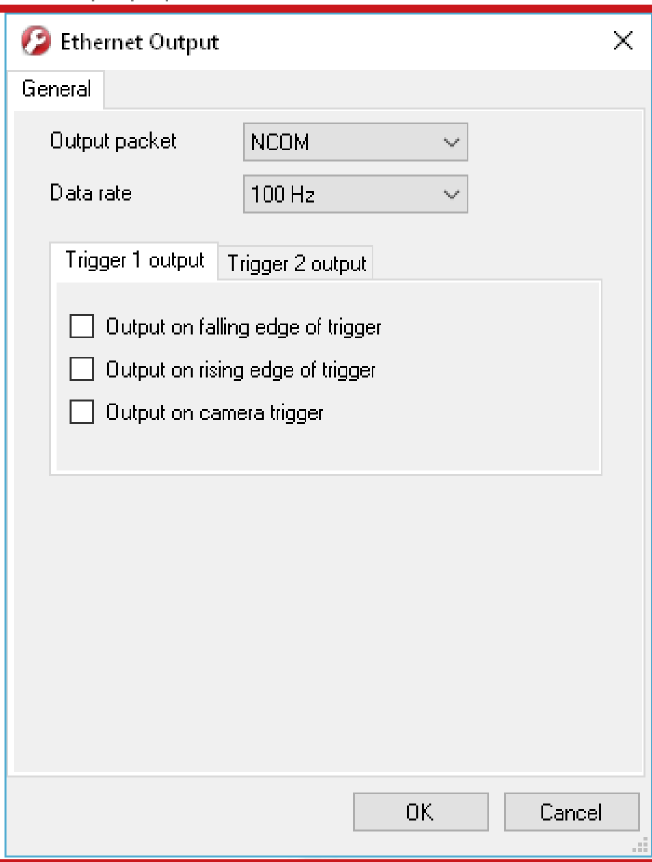
Note that it is easy to overload the serial port if there are too many events. The software computes the number of characters that will be output each second and displays this at the bottom of the window. A serial port data overflow warning message will appear if the data rate is too high for the selected baud rate; to fix this it is necessary to lower the data rate of the selected NMEA sentences or increase the baud rate.

Selecting Allow extended length messages enables the full GGA and RMC messages to be output, which are longer than the NMEA specification allows. Please see the NMEA 0183 Description manual for more details.

Selecting Output approximate values before initialisation forces output of the raw GNSS measurements before the RT1003 v2 is initialised. Currently just the position is output and this is the position of the antenna, not the inertial measurement unit. Note that there will be a jump (from the antenna to the inertial measurement unit) when initialisation occurs.

### *Ethernet output*

Figure 38. NAVconfig Ethernet output properties window




Ethernet is the default setting to output measurements. It can be configured for different data rates and to output extra data packets based on triggers. Click in the Settings column, the select the ... button to open the properties window, shown in Figure 38.

The Ethernet output can either output NCOM or MCOM, or be disabled by using the **Output packet** drop-down list. When NCOM or MCOM is selected, the **Data rate** can be selected by using the drop-down list.

If a trigger has been configured as an event input, click the **Output on falling edge of trigger** or **Output on rising edge of trigger** check boxes to choose when the extra data packet is generated. If a trigger has been configured as an output trigger, click the Output on camera trigger to generate extra data packets based on the output trigger settings configured earlier.

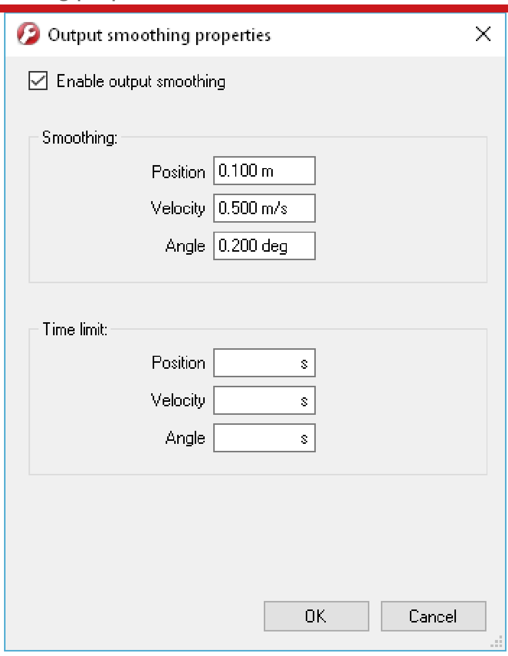
These packets are interpolated to the time when the event occurred and may be output up to 30 ms late and out of order compared to the normal messages. It is essential to enable these options in order to see trigger information in NCOM, or if the events have a rate higher than 1 Hz otherwise the output cannot communicate all of the events and some will be lost.

### *Driving robot IP*

The IP address can be entered here alongside the current version of PCOM firmware being used.

### *Output smoothing*

Figure 39. NAVconfig output smoothing properties window




When the Kalman filter in the RT1003 v2 determines that there is some error to correct, this error correction is applied smoothly rather than as a jump. The output smoothing controls how fast the correction is applied to the outputs.

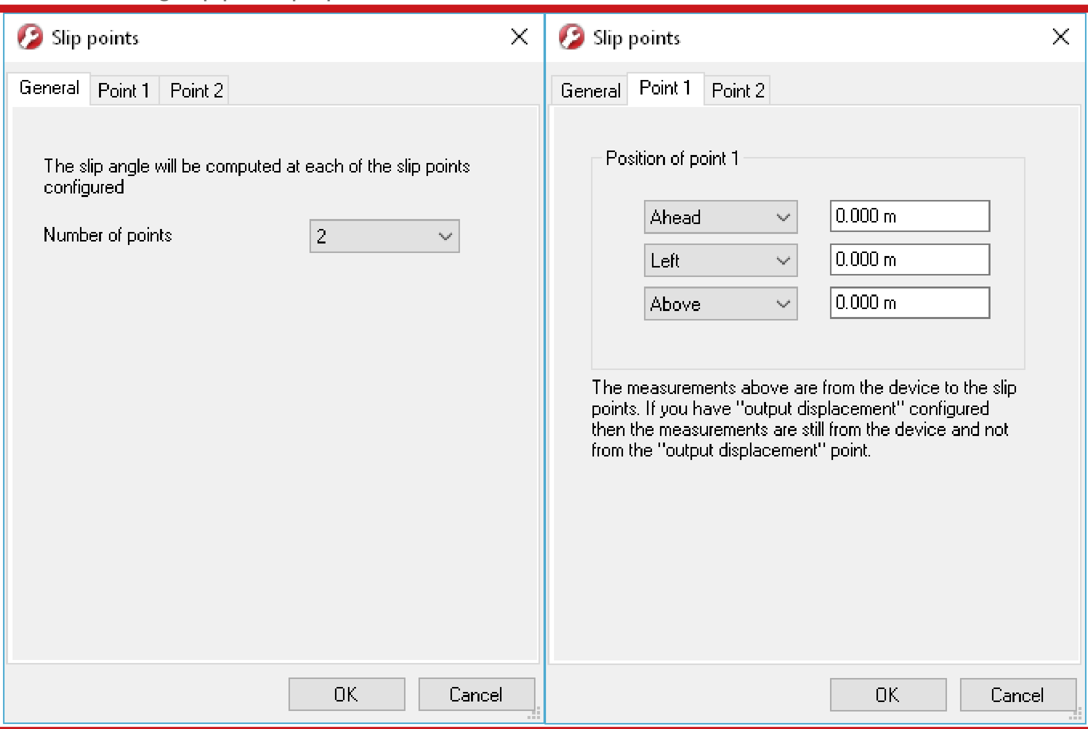
Click the [...] button to open the properties window and click the check box to enable output smoothing. The smoothing of the position, velocity and orientation corrections can be controlled independently. The Smoothing parameters define the maximum amount of correction applied per second. The Time limit forces a correction if the correction will take more than the specified time.

Care should be taken not to make the smoothing too small. If these parameters are too small then the RT1003 v2 will not be able to make suitable corrections to the outputs and it will not work correctly.

**Note**: This function is designed to improve the data in real-time. When post-processing the data using the forwards-backwards combined option, output smoothing should not be used as it may give unexpected results.

## *Slip points*

Figure 40. NAVconfig Slip points properties window



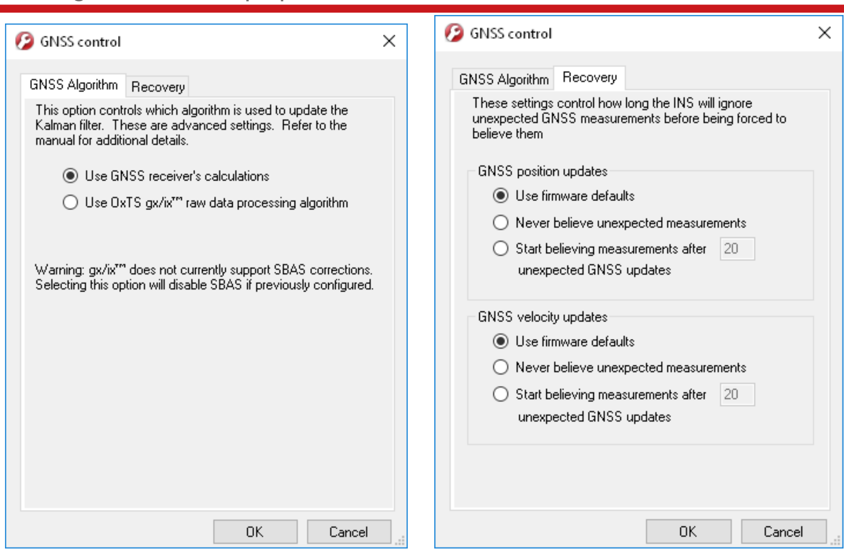

The RT1003 v2 can output slip angle measurements (slip angle, track angle and curvature) at up to eight additional points in the NCOM stream. The data is also logged in the RD file. Figure 40 shows the properties windows for slip point configuration.

On the General tab select the additional Number of points from the drop-down list. A number of additional tabs corresponding to the number of points selected will appear. Click on the Point 1 and subsequent tabs to configure the position of each additional slip point. Enter the distances and directions from the RT1003 v2 to each slip point.

If you have Output displacement enabled, then the measurements are still from the RT1003 v2 and not from the output displacement point.

## *GNSS control*

Figure 41. NAVconfig GNSS control properties window




The GNSS control option (Figure 41) contains advanced options that control how the GNSS information is managed in the RT1003 v2. To adjust the feature, click in the Settings column, then click the … button to open the properties window.

The GNSS algorithm tab can be used to select the algorithm used for blending the GNSS and the inertial data in the Kalman filter. The Recovery tab can be used to decide how to begin using GNSS measurements if they have been rejected or ignored for a period of time.

The Use GNSS receiver's calculations option turns off gx/ix™ mode and uses the receiver's default algorithms for calculating a GNSS solution.

Use OxTS gx/ix raw data processing algorithm enables gx/ix mode. The gx/ix processing uses the raw data from the GNSS and custom algorithms to compute position and velocity tailored to the needs of the Kalman filter. It also improves performance in poor GNSS environments using single satellite aiding technology and tightly coupled GNSS and inertial measurements. In environments where signal lock may be difficult to maintain (e.g. urban canyons), gx/ix mode is recommended to achieve the highest accuracy.

Currently, not all GNSS modes are compatible with gx/ix. Table 20 details the current compatibilities of gx/ix mode.

Table 20. gx/ix™ compatibility

| GNSS mode | Real time | Post-process |
|---|---|---|
| GPS SPS | a | a |
| SBAS | X | X |
| GPS DGPS | a | a |
| RTK | a | a |
| GLONASS SPS & DGPS | a | a |
| GLONASS RTK | a | a |

## GNSS Recovery tab

The Recovery tab controls how the RT1003 v2 will accept or reject GNSS measurements. The GNSS control determines how many updates the RT1003 v2 should ignore before forcing the GNSS to be accepted. Both the velocity and the position can be controlled separately.

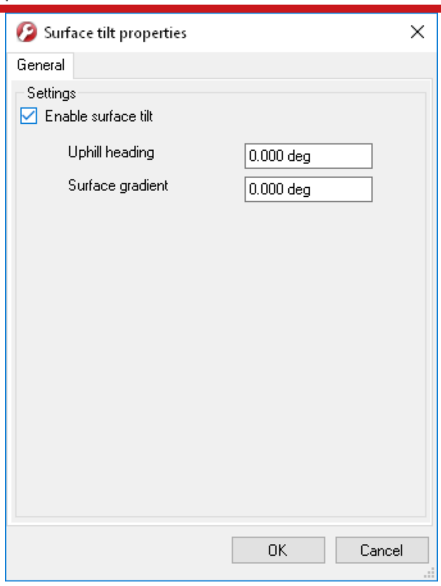
In the default state the RT1003 v2 will reject up to 20 GNSS measurements before it forces the GNSS to be accepted. However, in high multipath environments or when wheel speed measurements are used, it may be desirable to reject more GNSS measurements. Select the Start believing measurements after option and enter the number of GNSS measurements to reject before the system starts believing it again.

The RT1003 v2 GNSS receivers update both position and velocity at a rate of 5 Hz. Therefore, to ignore updates for 60 seconds for example, the number to enter to start believing measurements again would be 300.

The gx/ix processing algorithm makes its own decisions about when to trust and how to recover from GNSS errors, so Use firmware defaults should be selected when using gx/ix mode.

## Surface tilt

Figure 42. NAVconfig Surface tilt properties window



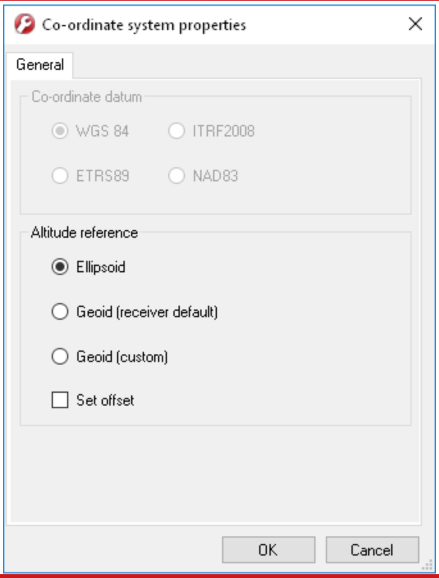

The surface tilt settings are used to compute the roll, pitch (and heading) compared to a planar inclined surface. The roll and pitch from the RT1003 v2 are measured compared to gravity. Most test tracks are built at an angle so rain water runs off and the track dries faster. As the vehicle drives up the incline, the pitch shows a positive value; as the vehicle drives down the incline the pitch shows a negative value; the value changes with a sinusoidal pattern as you drive round a circle. The roll angle shows a similar effect.

Using the surface tilt option, the roll and pitch compared to the inclined surface can be output as well. The NAVdisplay software contains a tool for working out the surface angles. NAVconfig can be used to configure the surface's angle if it has been measured already. Figure 41 shows the Surface tilt properties window. Enter the heading (compared to true north) of the uphill direction and the gradient of the surface.

The RT1003 v2 does not change the roll and pitch outputs because of these settings. Instead, there are additional outputs, surface roll, surface pitch and surface heading that are output and the transformation is applied to these outputs. Note that for surfaces with a small gradient the surface heading is almost the same as heading.

### *Global Coordinate system*

Figure 43. NAVconfig coordinate system properties window




The RT1003 v2 can output position relative to different coordinate frames. Click the  button to open the properties window, shown in Figure 43.

From the Coordinate datum section you can choose which reference datum to output latitude and longitude relative to. The default system and the standard for GPS is the WGS 84 datum.

**Note**: Currently outputs will only reference datums other than WGS 84 in post-processing. Real-time outputs will still be referenced to WGS 84 even if another option is selected.

The Altitude reference can be compared to either ellipsoidal or geoidal height. If Ellipsoid is selected, the altitude will be output with respect to the reference ellipsoid selected in the coordinate datum section. If Geoid (receiver default) is selected, the altitude will be relative to the geoid used in the GNSS receivers. A Custom geoid file can be used for local variations. To download supported geoid files, go to http://support.oxts.com/local-geoid-files/. The UGF file must be saved in C:\Users\username\Documents\OXTS\Shared\Custom geoid files. Once the file is downloaded and saved in this location, it can be selected from the drop down box.

A constant offset to the specified altitude reference can be applied by checking the offset box and typing in a value into the cell.

### *1PPS*

A one-pulse-per-second signal from the primary GNSS receiver is output when a valid GNSS solution is found. The output is a low-voltage CMOS output where 0.8 V or less represents low and 2.4 V or more represent high. No more than 10 mA should be sourced from the output. The GNSS time crossing boundary can be configured to coincide with the rising or falling edge of the signal.

### Advanced

Clicking the ... button opens the Advanced settings window. This can be used to set special commands for the RT1003 v2. This should only be done with special instructions from OxTS.

### Committing the configuration

Figure 44. NAVconfig Commit page


NAVconfig is an off-line configuration tool, so configurations must be explicitly uploaded to the RT1003 v2 via Ethernet when finished. On the Commit page (Figure 44) enter the IP address of the RT1003 v2 that you want to configure or select it from the drop-down list. The drop-down box will list all of the systems that are connected to the computer's network so ensure to select the correct system if there are multiple listed. The list will not work if NAVdisplay or other software is using the RT1003 v2 UDP port unless the OxTS UDP server is running.

Click **Commit** to save the configuration to the RT1003 v2. This will automatically reset the RT1003 v2 so the changes take effect.

**Note**: It will be necessary to initialise and warm-up the system again after the changes have been applied.

### *Saving the configuration and finishing*

Figure 45. NAVconfig Save/Finish page


Before finishing, it is possible to save a copy of the configuration in a folder on your computer. This can then be easily loaded back into the system if using the same configuration again. The Save/Finish page also lets you know if the settings have been committed successfully or not. Figure 45 shows the Save/Finish page.

To save a copy of the configuration in a local folder check the Save settings in the following folder box and use **Browse**… to select a folder. The configuration has a number of files associated with it so it is recommended to create a new folder. Click **Finish** to save the configuration to the selected folder and close NAVconfig.

## Setting up the base station

For correct operation of the higher accuracy systems it is necessary to use a base station GNSS receiver. All of the systems can be successfully used without a base station, however, the specification will only be met if a base station is used.

The base station is a separate GNSS receiver that monitors signals from the GNSS satellites. Using its knowledge of position it works out the errors in each satellite's signal. It also measures the carrier-phase of the signal for kinematic corrections. The carrier-phase observations and the satellite signal errors are sent from the base station GNSS to the RT1003 v2 via a radio modem (available separately).

The position of the base station GNSS antenna can either be determined by the base station GNSS receiver or can be surveyed in by a chartered surveyor. If the base station GNSS receiver determines its own position, through position averaging, then any error in the base station receiver will also result in error at the RT1003 v2. In order to relate the RT1003 v2 signals to maps, or other items on the world, it is necessary to have a surveyor measure the position of the GNSS antenna and then tell the base station GNSS receiver what position to use.

For many applications it is not necessary to survey in the base station antenna since an absolute world-reference is not required and relative position is more important.

### *Initialisation*

Each time an inertial navigation system or GNSS receiver is powered-up, it has no way of knowing where it is or how it's orientated. So the first thing all INS or GNSS receivers do before they output useful measurements is to calculate some initial values. In the case of this product; which uses both inertial and GNSS measurement technology, the process of establishing these start values is called initialisation.

In order to complete the initialisation process, the INS must assign start values to the following variables:

- Time
- Position
- Velocity
- Pitch
- Roll
- Heading

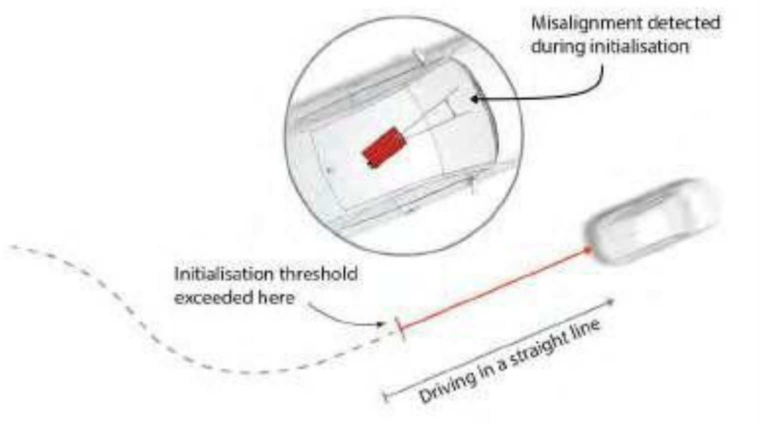
Initial values for time, position and velocity are taken from the GNSS receiver once it has correctly computed a valid GNSS solution. Initial values for pitch and roll are also quite easy to discover by filtering out other accelerations over a period of time to separate out a gravity vector. Heading is the most difficult variable to initialise. There are two different methods of calculating an initial heading value: dynamic initialisation and static initialisation.

### *Dynamic initialisation*

Dynamic initialisation is the default, and preferred, method of initialisation. It is suitable for nearly all applications.

Successful dynamic initialisation requires 10 consecutive measurements from the primary GNSS receiver at a velocity above the initialisation speed, and with some acceleration. The system then searches for a solution to align the IMU's acceleration vector (measured in the IMU frame) with the acceleration vector calculated from the GNSS measurements (measured in an earth-fixed, earth-centred reference frame). During dynamic initialisation it is important that the vehicle under test travels in a straight line — otherwise the system will not be able to accurately align the acceleration vectors.

Figure 46. Illustration of dynamic initialisation




As the INS assumes the vehicle is travelling straight during initialisation, any misalignment can be estimated.

## *Static initialisation*

Static initialisation — which is only possible on dual antenna systems — requires both primary and secondary antennas to be configured. When static initialisation is selected, the system will attempt to calculate an initial heading based on the position of the two GNSS antennas relative to the IMU, as defined in the configuration.

The time required to statically initialise depends entirely on the GNSS environment, however, in good GNSS environments it typically takes less than 30 seconds. Once static initialisation is successful, the LEDs on the connector panel will change to reflect the current state of the strapdown navigator.

Static initialisation is 99% reliable in open sky, but the reliability decreases in environments with high multipath. Static initialisation is also faster when the antenna separation is smaller, but bear in mind that heading accuracy is also reduced with a smaller separation. We recommend a minimum separation of one metre.

Static initialisation is only intended to be used:

- Where an initial heading value is required prior to the vehicle moving (i.e. autonomous vehicles).
- On slow moving vehicles, where a lack of speed means errors in the GPS velocity are relatively large in proportion to the vehicle speed.
- On heavy vehicles like trains and plant equipment that can't accelerate quickly enough (while above the initialisation threshold) to trigger dynamic initialisation.
- Where it is difficult to ensure the vehicle travels in straight line during dynamic initialisation — airborne and waterborne applications.

## *Real-time output during initialisation*

During the initialisation process the INS does not output measurements in real-time. Instead, the system runs one second behind, allowing GNSS information to be compared to information from the inertial sensors. However, once initialisation occurs, the system reduces this lag to zero. It does this in a linear way over a period of 10 seconds after initialisation. The Status LED indicates whether the system is outputting in real-time or not.

## Warm-up

For the first 15 minutes after power-up, the system will not conform to specification. During this period the Kalman Filter runs a more relaxed model for the sensors. By running a more relaxed model, the system is able to:

- Make better estimates of the errors in the long term (if it does not get these correct then they become more difficult to correct as time goes on).
- Track the errors in the inertial sensor during their warm-up period (when their errors change more quickly than normal).

As part of the warm-up procedure, it is necessary to drive the vehicle or the errors will not be estimated and the specification will not be reached. The NCOM output message (and CAN outputs) include status information that can be used to identify when the required specification has been met. These are plotted in the example below.

Below is an example of a good warm-up procedure (conducted with an RT3000 INS) that did not involve a lot of work for the user. In this example the key features are:

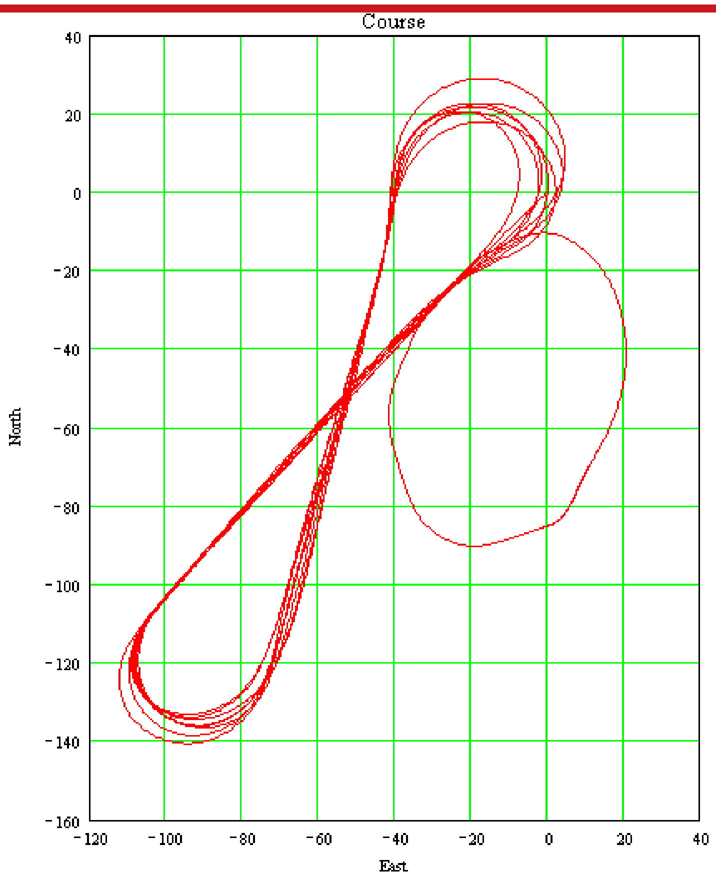
1. The INS was configured well-the GNSS antenna position, Advanced slip options and dual-antenna separation were measured accurately in advance.
2. The INS was turned on as soon as possible. In this case it took us 15 minutes to get all the other equipment sorted out. The INS was stationary for most of this period-which is not a problem.
3. Although in this example the INS was receiving corrections from a base station while stationary, it is not necessary. The base station should be working before the dynamic driving starts so the INS can use the best information to self- calibrate (if a base station is not being use this does not apply).
4. There are six minutes during which the car was driven in figures of eight. From the graphs you can see the INS is accurate almost after the first figure of eight, after that the improvement is very small.

The trick is to turn the INS on early, do not reconfigure it (which resets it) or cycle the power.

Figure 47 shows the route driven while Figure 48 shows the accuracy estimated by the Kalman filter for various output parameters during the first 25 minutes. The quality of initialisation would have been the same if the stationary period was 10 minutes, followed by five minutes of driving.

The time on the graphs is the time from initialisation. In this example the INS was initialised 25 seconds after starting up; the quality of initialisation would be the same if it had been not been initialised for the first 10 minutes, then initialised and driven for five minutes.

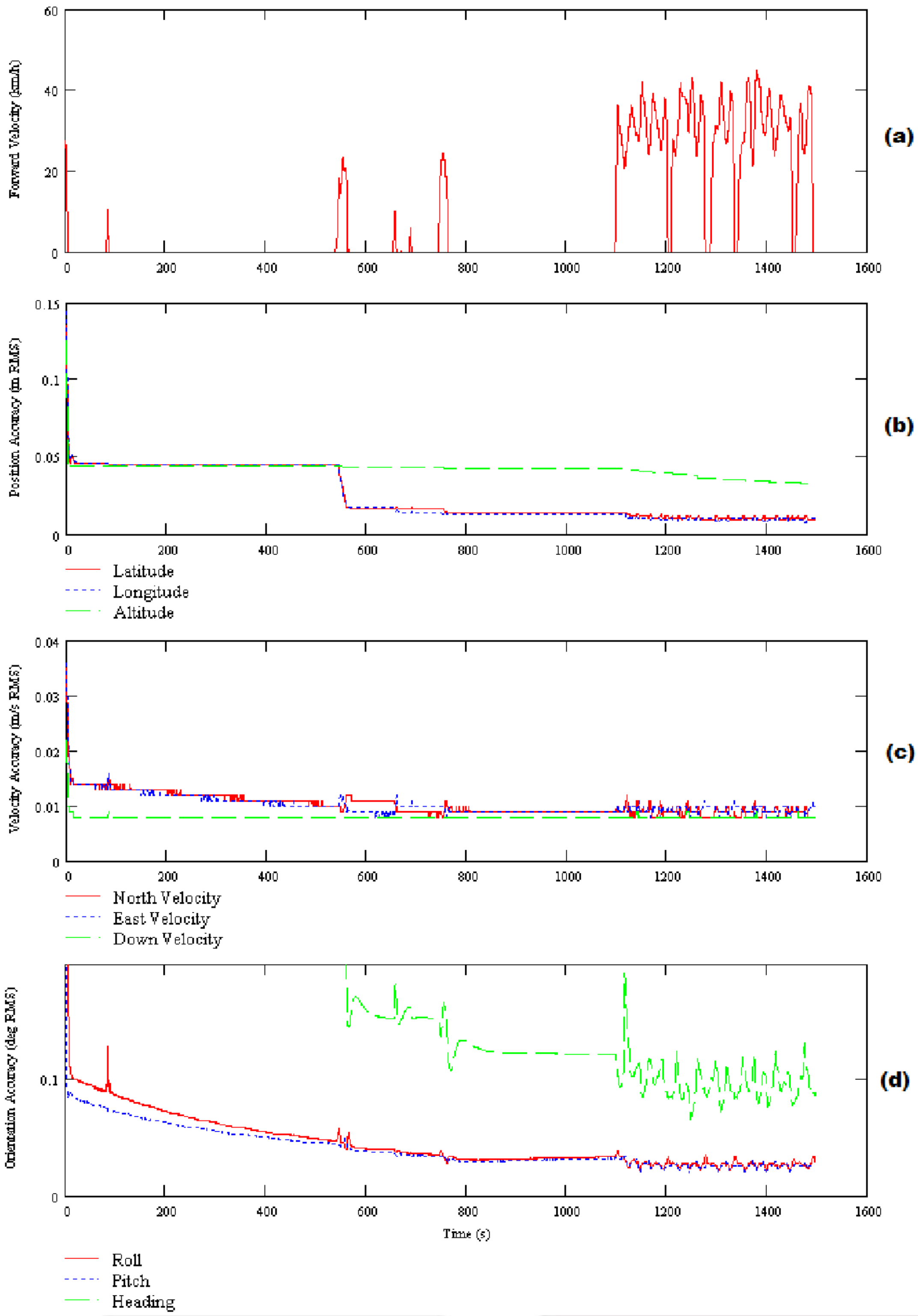
Figure 47. Example warm-up driving route




At the start there is just a small amount of motion to get the RT1003 v2 initialised. During this time the Kalman filter cannot improve the position accuracy because the position of the GNSS antenna is not known accurately and cannot be estimated without motion. The accuracy of the velocity, roll and pitch steadily improves as the Kalman filter places more and more weight on the inertial sensors. At this point the heading accuracy is worse than the scale of the graph ((d) in Figure 48**Error! Reference source not found.**); the heading is not accurate and the dual antenna system cannot measure the angle of the GNSS antennas compared to the inertial sensors, so the dual antenna cannot provide accurate information.

Just after 500 seconds the RT1003 v2 is driven (it is the small loop on the east side in Figure 47, not the figures of eight). This small amount of driving is sufficient for the Kalman filter to gain confidence in the antenna position and to improve the alignment of the two GNSS antennas compared to the inertial sensors. After this period the position accuracy is better than 1 cm and the heading is better than 0.2°.

Figure 48. Example warm-up accuracy estimates




(a) Forward velocity. (b) Position accuracies. (c) Velocity accuracies. (d) Orientation accuracies.

You can see the INS is nearly at specification after just this small amount of driving. However, experience tells us the Kalman filter will continue to make some improvements (not obvious) during the first few figures of eight. The main part of the motion occurs after 1100 seconds when the vehicle was driven in figures of eight for six minutes.

These are fairly large figures of eight driven at relatively low speeds. Notice the brake stops in the velocity graph ((a) in Figure 48) where the speed falls to zero. These are important parts of the warm-up-so as many states in the Kalman filter as possible can be updated.

Notice how close to the specification the INS is even without the figure of eight manoeuvres. A proper warm-up is recommended in order to achieve the highest level of accuracy. However the effect is small and only significant when you need the full performance of the INS.

### *Post-processing data*

Data is stored on the RT1003 v2 in a raw, unprocessed format; these raw data files have an RD extension. The advantage of storing data in a raw format is that it can be reprocessed at a later time using different configuration settings. For example, if the configuration created in NAVconfig was incorrect when running in real-time, the configuration can be changed and the data can be reprocessed post-mission using a new configuration.

The software suite provided with the RT1003 v2 includes the NAVsolve software which can be used to process the data. The NAVsolve Wizard also gives the user the ability to change the NCOM binary output format to text.

A full explanation of NAVsolve is given in the NAVsolve manual, which can be downloaded from the OxTS website.

# CAN messages and signals

## CAN-DB file

NAVconfig can output a CAN DBC file that contains all the measurements the RT1003 v2 is configured to output.

## CAN bus messages

Table 20 lists all the messages the RT outputs on the CAN bus and the identifiers that are used for each message. The signals in each message are listed in the tables that follow.

Table 21. CAN bus messages

| Default identifier | Message name | Data contents | See table |
|---|---|---|---|
| 1536 (600h) | DateTime | Date and time | Table 22 |
| 1537 (601h) | LatitudeLongitude | Latitude and longitude | Table 23 |
| 1538 (602h) | Altitude | Altitude | Table 24 |
| 1539 (603h) | Velocity | OxTS NED frame velocity | Table 25 |
| 1540 (604h) | VelocityLevel | OxTS horizontal frame velocity | Table 26 |
| 1541 (605h) | AccelVehicle | OxTS output frame IMU acceleration | Table 27 |
| 1542 (606h) | AccelLevel | OxTS horizontal frame IMU acceleration | Table 28 |
| 1543 (607h) | HeadingPitchRoll | OxTS orientation | Table 29 |
| 1544 (608h) | RateVehicle | OxTS output frame IMU angular rate | Table 30 |
| 1545 (609h) | RateLevel | OxTS horizontal frame IMU angular rate | Table 31 |
| 1546 (60Ah) | TrackSlipCurvature | Track, slip and curvature | Table 32 |
| 1547 (60Bh) | Distance | Distance | Table 33 |
| 1548 (60Ch) | PosLocal | Position in local co-ordinates | Table 34 |
| 1549 (60Dh) | VelYawLocal | Velocity and yaw angle in local co-ordinates | Table 35 |
| 1550 (60Eh) | AngAccelVehicle | OxTS output frame IMU angular acceleration | Table 36 |
| 1551 (60Fh) | AngAccelLevel | OxTS horizontal frame IMU angular acceleration | Table 37 |
| 1552..1555 (620h…613h) | | Reserved for RT-ANA signals | -- |
| 1568 (620h) | TrackSlipCurvaturePoint1 | Measurement point 1 track, slip and curvature | Table 38 |
| 1569 (621h) | TrackSlipCurvaturePoint2 | Measurement point 2 track, slip and curvature | Table 39 |
| 1570 (622h) | TrackSlipCurvaturePoint3 | Measurement point 3 track, slip and curvature | Table 40 |

| | | | |
|---|---|---|---|
| 1571 (623h) | TrackSlipCurvaturePoint4 | Measurement point 4 track, slip and curvature | Table 41 |
| 1572 (624h) | HeadingPitchRollFromSurf | Level surface orientation | Table 42 |
| 1573 (625h) | TrackSlipCurvaturePoint5 | Measurement point 5 track, slip and curvature | Table 43 |
| 1574 (626h) | TrackSlipCurvaturePoint6 | Measurement point 6 track, slip and curvature | Table 44 |
| 1574 (627h) | TrackSlipCurvaturePoint7 | Measurement point 7 track, slip and curvature | Table 45 |
| 1576 (628h) | TrackSlipCurvaturePoint8 | Measurement point 8 track, slip and curvature | Table 46 |
| 1577 (629h) | ApproxLatitudeLongitude | Approximate latitude and longitude | Table 47 |
| 1578 (62Ah) | ApproxAltitude | Approximate altitude | Table 48 |
| 1579 (62Bh) | ApproxVelocity | Approximate OxTS NED frame velocity | Table 49 |
| 1580 (62Ch) | Reserved | | -- |
| 1581 (62Dh) | FallingTrigger | Trigger 1 falling edge | Table 50 |
| 1582 (62Eh) | RisingTrigger | Trigger 1 rising edge | Table 51 |
| 1583 (62Fh) | PosLocalNE | Northing and easting in local co-ordinates | Table 52 |
| 1584 (630h) | MilliTime | Absolute GPS time | Table 53 |
| 1585 (631h) | Reserved | | -- |
| 1586 (632h) | Reserved | | -- |
| 1587 (633h) | IsoOrientation | ISO 8855 orientation | Table 54 |
| 1588 (634h) | IsoVsVelocity | ISO 8855 vehicle system velocity | Table 55 |
| 1589 (635h) | IsoVsAcceleration | ISO 8855 vehicle system acceleration | Table 56 |
| 1590 (636h) | IsoVsAngularVelocity | ISO 8855 vehicle system angular velocity | Table 57 |
| 1591 (637h) | IsoVsAngularAcceleration | ISO 8855 vehicle system angular acceleration | Table 58 |
| 1592 (638h) | IsoIsVElocity | ISO 8855 intermediate system velocity | Table 59 |
| 1593 (639h) | IsoIsAcceleration | ISO 8855 intermediate system | Table 60 |
| 1594 (63Ah) | IsoAngularVelocity | ISO 8855 intermediate system angular velocity | Table 61 |
| 1595 (63Bh) | IsoIsAngularAcceleration | ISO 8855 intermediate system angular acceleration | Table 62 |
| 1596 (63Ch) | IsoEfsVelocity | ISO 8855 earth-fixed system velocity | Table 63 |
| 1597 (63Dh) | IsoEfsAcceleration | ISO 8855 earth-fixed system acceleration | Table 64 |

The status information in NCOM is output over the CAN bus on Identifiers 500h to 5FFh. The offset from 500h is the same as the Channel number in the NCOM message definition. The bytes 0 to 7 are the same in the CAN message as in the NCOM packet.

## Table heading definitions

The fields in the tables have the following meanings.

**Offset (bits).** This is the offset into the message where the signal starts. To compute the offset in bytes divide the value by 8.

**Length (bits).** This is the length of the signal in bits. To compute the length of the signal in bytes, divide the value by 8.

**Type.** This specifies either an unsigned value (U) or a signed value (S).

**Units.** This is the units for the signal.

**Factor.** This is the factor that the integer unit should be multiplied by to get the signal into the units given in the table.

**Offset.** This is the value of the signal when the integer value in the CAN message is zero. It is zero for all the RT signals and can usually be discarded.

## Signals

The following tables describe the signals in each of the messages.

Table 22. Identifier 600h (1536), DateTime

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 8 | U | year | 1 | 0 | Year within century (e.g. '16' during year 2016) | TimeYear |
| 8 | 8 | U | year | 100 | 0 | Century (e.g. '20' during 2016) | TimeCentury |
| 16 | 8 | U | month | 1 | 0 | Month | TimeMonth |
| 24 | 8 | U | day | 1 | 0 | Day | TimeDay |
| 32 | 8 | U | S | 0.01 | 0 | Hundredths of current second | TimeHSecond |
| 40 | 8 | U | S | 1 | 0 | Seconds | TimeSecond |
| 48 | 8 | U | min | 1 | 0 | Minutes | TimeMinute |
| 56 | 8 | U | hour | 1 | 0 | Hours | TimeHour |

**Note**: time is always reported as GPS time. Currently this is 16 s different from UTC.

Table 23. Identifier 601h (1537), LatitudeLongitude

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 32 | S | ° | 1e-7 | 0 | Latitude | PosLat |
| 32 | 32 | S | ° | 1e-7 | 0 | Longitude | PosLon |

Table 24. Identifier 602h (1538), Altitude

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 32 | S | m | 0.001 | 0 | Altitude | Altitude |

By default the altitude is output relative to mean sea level, not WGS 84. The datum can be changed using NAVconfig.

Table 25. Identifier 603h (1539), Velocity

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | m/s | 0.01 | 0 | OxTS NED frame north velocity | VelNorth |
| 16 | 16 | S | m/s | 0.01 | 0 | OxTS NED frame east velocity | VelEast |
| 32 | 16 | S | m/s | 0.01 | 0 | OxTS NED frame vertical (down) velocity | VelDown |
| 48 | 16 | S | m/s | 0.01 | 0 | Horizontal speed | Speed2D |

The horizontal speed is the vector addition of north and east velocities. For forward speed (which can go negative) see message 604h.

Table 26. Identifier 604h (1540), Velocity level

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | m/s | 0.01 | 0 | OxTS horizontal frame longitudinal (forward) velocity | VelForward |
| 16 | 16 | S | m/s | 0.01 | 0 | OxTS horizontal frame lateral (right) velocity | VelLateral |

The forward velocity can go negative when driving backwards.

Table 27. Identifier 605h (1541), AccelVehicle

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | $m/s^2$ | 0.01 | 0 | OxTS output frame longitudinal (forward) IMU acceleration | AccelX |
| 16 | 16 | S | $m/s^2$ | 0.01 | 0 | OxTS output frame lateral (right) IMU acceleration | AccelY |
| 32 | 16 | S | $m/s^2$ | 0.01 | 0 | OxTS output frame vertical (down) IMU acceleration | AccelZ |

Table 28. Identifier 606h (1542), AccelLevel

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | m/s | 0.01 | 0 | OxTS horizontal frame longitudinal (forward) IMU acceleration | AccelForward |
| 16 | 16 | S | m/s | 0.01 | 0 | OxTS horizontal frame lateral (right) IMU acceleration | AccelLateral |
| 32 | 16 | S | m/s | 0.01 | 0 | OxTS horizontal frame vertical (down) IMU acceleration | AccelDown |
| 48 | 16 | S | m/s | 0.01 | 0 | Slip rate | AccelSlip |

Table 29. Identifier 607h (1543), HeadingPitchRoll

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Heading angle | AngleHeading |
| 16 | 16 | S | ° | 0.01 | 0 | Pitch angle | AnglePitch |
| 32 | 16 | S | ° | 0.01 | 0 | Roll angle | AngleRoll |

**Note**: the range of the heading angle is 0 to 359.99, the range of the pitch angle is ±90° and the range of the roll angle is ±180°.

Table 30. Identifier 608h (1544), RateVehicle

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | °/s | 0.01 | 0 | OxTS output frame longitudinal (forward) IMU angular rate | AngRateX |
| 16 | 16 | S | °/s | 0.01 | 0 | OxTS output frame lateral (right) IMU angular rate | AngRateY |
| 32 | 16 | S | °/s | 0.01 | 0 | OxTS output frame vertical (down) IMU angular rate | AngRateZ |

Table 31. Identifier 609h (1545), RateLevel

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | °/s | 0.01 | 0 | OxTS horizontal frame longitudinal (forward) IMU angular rate | AngRateForward |
| 16 | 16 | S | °/s | 0.01 | 0 | OxTS horizontal frame lateral (right) IMU angular rate | AngRateLateral |
| 32 | 16 | S | °/s | 0.01 | 0 | OxTS horizontal frame vertical (down) IMU angular rate | AngRateDown |

See message 608h for roll angular rate. The definition of roll rate used in this manual is consistent with the Euler angles used to output roll, pitch and heading; therefore the roll angular rate is the same as the pitched x-angular rate or the body x-angular rate. The forward angular rate is the rotation about the axis which is horizontal.

Table 32. Identifier 60Ah (1546), TrackSlipCurvature

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Track angle | AngleTrack |
| 16 | 16 | S | ° | 0.01 | 0 | Slip angle | AngleSlip |
| 32 | 16 | S | 1/m | 0.0001 | 0 | Curvature | Curvature |

Note that the slip angle will be close to 180° when driving backwards.

Table 33. Identifier 60Bh (1547), Distance

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 32 | U | m | 0.001 | 0 | Horizontal distance with hold | DistanceWithHold |
| 32 | 32 | U | m | 0.001 | 0 | Horizontal distance without hold | Distance |

**Note**: Distance with hold will not increase when the RT measures a speed less than 0.2 m/s whereas the Distance field will drift by the noise of the RT when stationary. The distances start from zero when the RT-CAN unit is powered up.

Table 34. Identifier 60Ch (1548), PosLocal

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 32 | S | m | 0.0001 | 0 | Distance from origin along x-axis | PosLocalX |
| 32 | 32 | S | m | 0.0001 | 0 | Distance from origin along y-axis | PosLocalY |

**Note**: The origin is set using the local co-ordinates option in NAVconfig. The convention used for the local co-ordinates uses a right-handed set with the z-axis up.

Table 35. Identifier 60Dh (1549), VelYawLocal

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | m/s | 0.01 | 0 | Velocity along the x-axis | VelLocalX |
| 16 | 16 | S | m/s | 0.01 | 0 | Velocity along the y-axis | VelLocalY |
| 32 | 16 | S | ° | 0.01 | 0 | Yaw angle | AngleLocalYaw |
| 48 | 16 | S | ° | 0.01 | 0 | Track angle in local coordinates | AngleLocalTrack |

**Note**: The convention used for the local co-ordinates uses a right-handed set with the z-axis up.

Table 36. Identifier 60Eh (1550), AngAccelVehicle

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | o/s$^2$ | 0.1 | 0 | OxTS output frame longitudinal (forward) IMU angular acceleration | AngAccelX |
| 16 | 16 | S | o/s$^2$ | 0.1 | 0 | OxTS output frame lateral (right) IMU angular acceleration | AngAccelY |
| 32 | 16 | S | o/s$^2$ | 0.1 | 0 | OxTS output frame vertical (down) IMU angular acceleration | AngAccelZ |

Table 37. Identifier 60Fh (1551), AngAccelLevel

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | o/s$^2$ | 0.1 | 0 | OxTS horizontal frame longitudinal (forward) IMU angular acceleration | AngAccelForward |
| 16 | 16 | S | o/s$^2$ | 0.1 | 0 | OxTS horizontal frame lateral (right) IMU angular acceleration | AngAccelLateral |
| 32 | 16 | S | o/s$^2$ | 0.1 | 0 | OxTS horizontal frame vertical (down) IMU angular acceleration | AngAccelDown |

Table 38. Identifier 620h (1568), TrackSlipCurvaturePoint1

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Measurement point 1 track angle | AngleTrackPoint1 |
| 16 | 16 | S | ° | 0.01 | 0 | Measurement point 1 slip angle | AngleSlipPoint1 |
| 32 | 16 | S | 1/m | 0.0001 | 0 | Measurement point 1 curvature | CurvaturePoint1 |

**Note**: The slip angle of point 1 will be close to 180° when driving backwards.

Table 39. Identifier 621h (1569), TrackSlipCurvaturePoint2

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Measurement point 2 track angle | AngleTrackPoint2 |
| 16 | 16 | S | ° | 0.01 | 0 | Measurement point 2 slip angle | AngleSlipPoint2 |
| 32 | 16 | S | 1/m | 0.0001 | 0 | Measurement point 2 curvature | CurvaturePoint2 |

**Note**: The slip angle of point 2 will be close to 180° when driving backwards.

Table 40. Identifier 622h (1570), TrackSlipCurvaturePoint3

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Measurement point 3 track angle | AngleTrackPoint3 |
| 16 | 16 | S | ° | 0.01 | 0 | Measurement point 3 slip angle | AngleSlipPoint3 |
| 32 | 16 | S | 1/m | 0.0001 | 0 | Measurement point 3 curvature | CurvaturePoint3 |

**Note:** The slip angle of point 3 will be close to 180° when driving backwards.

Table 41. Identifier 623h (1571), TrackSlipCurvaturePoint4

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Measurement point 4 track angle | AngleTrackPoint4 |
| 16 | 16 | S | ° | 0.01 | 0 | Measurement point 4 slip angle | AngleSlipPoint4 |
| 32 | 16 | S | 1/m | 0.0001 | 0 | Measurement point 4 curvature | CurvaturePoint4 |

**Note**: The slip angle of point 4 will be close to 180° when driving backwards.

Table 42. Identifier 624h (1572), HeadingPitchRollFromSurf

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Heading relative to the road surface | AngleHeadingFromSurf |
| 16 | 16 | S | ° | 0.01 | 0 | Pitch relative to the road surface | AnglePitchFromSurf |
| 32 | 16 | S | ° | 0.01 | 0 | Roll relative to the road surface | AngleRollFromSurf |

**Note**: The range of heading is 0 to 360°; the range of pitch is ±90°; the range of roll is ±180°. The road surface angle needs to be defined in order for these measurements to be active.

Table 43. Identifier 625h (1573), TrackSlipCurvaturePoint5

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Measurement point 5 track angle | AngleTrackPoint5 |
| 16 | 16 | S | ° | 0.01 | 0 | Measurement point 5 slip angle | AngleSlipPoint5 |
| 32 | 16 | S | 1/m | 0.0001 | 0 | Measurement point 5 curvature | CurvaturePoint5 |

**Note:** The slip angle of point 5 will be close to 180° when driving backwards.

Table 44. Identifier 626h (1574), TrackSlipCurvaturePoint6

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Measurement point 6 track angle | AngleTrackPoint6 |
| 16 | 16 | S | ° | 0.01 | 0 | Measurement point 6 slip angle | AngleSlipPoint6 |
| 32 | 16 | S | 1/m | 0.0001 | 0 | Measurement point 6 curvature | CurvaturePoint6 |

**Note:** The slip angle of point 6 will be close to 180° when driving backwards.

Table 45. Identifier 627h (1575), TrackSlipCurvaturePoint7

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Measurement point 7 track angle | AngleTrackPoint7 |
| 16 | 16 | S | ° | 0.01 | 0 | Measurement point 7 slip angle | AngleSlipPoint7 |
| 32 | 16 | S | 1/m | 0.0001 | 0 | Measurement point 7 curvature | CurvaturePoint7 |

**Note:** The slip angle of point 7 will be close to 180° when driving backwards.

Table 46. Identifier 628h (1576), TrackSlipCurvaturePoint8

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | U | ° | 0.01 | 0 | Measurement point 8 track angle | AngleTrackPoint8 |
| 16 | 16 | S | ° | 0.01 | 0 | Measurement point 8 slip angle | AngleSlipPoint8 |
| 32 | 16 | S | 1/m | 0.0001 | 0 | Measurement point 8 curvature | CurvaturePoint8 |

**Note:** The slip angle of point 8 will be close to 180° when driving backwards.

Table 47. Identifier 629h (1577), ApproxLatitudeLongitude

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 32 | S | ° | le-7 | 0 | Approximate latitude | ApproxPosLat |
| 32 | 32 | S | ° | le-7 | 0 | Approximate longitude | ApproxPosLon |

**Note**: Before initialisation the approximate latitude and longitude message will have the GNSS measurement of latitude and longitude (at the GNSS antenna location). After initialisation it will contain the same latitude and longitude as message 601h.

Table 48. Identifier 62Ah (1578), ApproxAltitude

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 32 | S | m | 0.001 | 0 | Approximate altitude | ApproxPosAlt |

**Note**: By default, the altitude is output relative to mean sea level, not WGS 84. See altitude in the NCOM description for information on how to change this. Before initialisation the approximate altitude message will have the GNSS measurement of altitude (at the GNSS antenna location). After initialisation it will contain the same altitude as message 602h.

Table 49. Identifier 62Bh (1579), ApproxVelocity

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | m/s | 0.01 | 0 | Approximate OxTS NED frame north velocity | ApproxVelNorth |
| 16 | 16 | S | m/s | 0.01 | 0 | Approximate OxTS NED frame east velocity | ApproxVelEast |
| 32 | 16 | S | m/s | 0.01 | 0 | Approximate OxTS NED vertical (down) velocity | ApproxVelDown |
| 48 | 16 | U | m/s | 0.01 | 0 | Approximate horizontal speed | ApproxSpeed2D |

**Note**: Before initialisation, the approximate velocity message will have the GNSS measurement of velocity (at the GNSS antenna location). After initialisation it will contain the same altitude as message 603h.

Table 50. Identifier 62Dh (1581), FallingTrigger

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 8 | U | | 1 | 0 | TTL signal level (0 low, 1 high, 255 unknown) | SignalLevelFalling |
| 8 | 8 | U | | 1 | 0 | Trigger count, increments with each new trigger | TriggerCountFalling |
| 16 | 16 | U | s | 0.0002 | 0 | Time since last trigger | TriggerTimeFalling |
| 32 | 32 | U | m | 0.001 | 0 | Distance with hold since last trigger | TriggerDistanceFalling |

Table 51. Identifier 62Eh (1582), RisingTrigger

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 8 | U | | 1 | 0 | TTL signal level (0 low, 1 high, 255 unknown) | SignalLevelRising |
| 8 | 8 | U | | 1 | 0 | Trigger count, increments with each new trigger | TriggerCountRising |
| 16 | 16 | U | s | 0.0002 | 0 | Time since last trigger | TriggerTimeRising |
| 32 | 32 | U | m | 0.001 | 0 | Distance with hold since last trigger | TriggerDistanceRising |

Table 52. Identifier 62Fh (1583), PosLocalNE

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 32 | S | m | 0.0001 | 0 | Northing | PosLocalNorth |
| 32 | 32 | S | m | 0.0001 | 0 | Easting | PosLocalEast |

Table 53. Identifier 630h (1584), MilliTime

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 48 | S | ms | 1 | 0 | Milliseconds since the start of GPS time | MilliTime |
| 0 | 48 | S | s | 0.001 | 0 | Seconds since the start of GPS time | MilliTimeSeconds |
| 48 | 8 | S | s | 1 | 0 | GPS UTC offset | UtcOffset |

**Note**: MilliTime and MilliTimeSeonds both refer to the same bits on the CAN bus—however they are decoded twice with a different scale in the DBC file. MilliTime needs to be stored as a signed 64-bit integer value as the current value already exceeds the limits of a 32-bit integer, however this is not supported by all CAN software. To overcome that problem MilliTimeSeconds can be stored as a 32-bit double-precision value, however limitations in the double-precision format mean there may be an error of up to 5 ms and the resulting decimal numbers may contain rounding errors. Where possible MilliTime should be used, otherwise use MilliTimeSeconds with care.

Table 54. Identifier 633h (1587), IsoOrientation

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | ° | 0.01 | 0 | ISO 8855 yaw angle | IsoYawAngle |
| 16 | 16 | S | ° | 0.01 | 0 | ISO 8855 pitch angle | IsoPitchAngle |
| 32 | 16 | S | ° | 0.01 | 0 | ISO 8855 roll angle | IsoRollAngle |

Table 55. Identifier 634h (1588), IsoVsVelocity

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | m/s | 0.01 | 0 | ISO 8855 vehicle system longitudinal (forward) velocity | IsoVsLongitudinalVelocity |
| 16 | 16 | S | m/s | 0.01 | 0 | ISO 8855 vehicle system lateral (left) velocity | IsoVsLateralVelocity |
| 32 | 16 | S | m/s | 0.01 | 0 | ISO 8855 vehicle system vertical (up) velocity | IsoVsVerticalVelocity |

Table 56. Identifier 635h (1589), IsoVsAcceleration

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | $m/s^2$ | 0.01 | 0 | ISO 8855 vehicle system longitudinal (forward) velocity | IsoVsLongitudinalAcceleration |
| 16 | 16 | S | $m/s^2$ | 0.01 | 0 | ISO 8855 vehicle system lateral (left) velocity | IsoVsLateralAcceleration |
| 32 | 16 | S | $m/s^2$ | 0.01 | 0 | ISO 8855 vehicle system vertical (up) velocity | IsoVsVerticalAcceleration |

Table 57. Identifier 636h (1590), IsoVsAgularVelocity

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | °/s | 0.01 | 0 | ISO 8855 vehicle system roll (longitudinal angular) velocity | IsoVsRollVelocity |
| 16 | 16 | S | °/s | 0.01 | 0 | ISO 8855 vehicle system pitch (lateral angular) velocity | IsoVsPitchVelocity |
| 32 | 16 | S | °/s | 0.01 | 0 | ISO 8855 vehicle system yaw (vertical angular) velocity | IsoVsYawVelocity |

Table 58. Identifier 637h (1591), IsoVsAgularAcceleration

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | °/s$^2$ | 0.1 | 0 | ISO 8855 vehicle system roll (longitudinal angular) velocity | IsoVsRollAcceleration |
| 16 | 16 | S | °/s$^2$ | 0.1 | 0 | ISO 8855 vehicle system pitch (lateral angular) velocity | IsoVsPitchAcceleration |
| 32 | 16 | S | °/s$^2$ | 0.1 | 0 | ISO 8855 vehicle system yaw (vertical angular) velocity | IsoVsYawAcceleration |

Table 59. Identifier 638h (1592), IsoIsVelocity

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | m/s | 0.1 | 0 | ISO 8855 intermediate system longitudinal (forward) velocity | IsoIsLongitudinalVelocity |
| 16 | 16 | S | m/s | 0.1 | 0 | ISO 8855 intermediate system pitch lateral (left) velocity | IsoIsLateralVelocity |
| 32 | 16 | S | m/s | 0.1 | 0 | ISO 8855 ISO 8855 intermediate system vertical (up) velocity | IsoIsVerticalVelocity |

Table 60. Identifier 639h (1593), IsoIsAcceleration

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | $m/s^2$ | 0.01 | 0 | ISO 8855 intermediate system longitudinal (forward) acceleration | IsoIsLongitudinalAcceleration |
| 16 | 16 | S | $m/s^2$ | 0.01 | 0 | ISO 8855 intermediate system pitch lateral (left) acceleration | IsoIsLateralAcceleration |
| 32 | 16 | S | $m/s^2$ | 0.01 | 0 | ISO 8855 ISO 8855 intermediate system vertical (up) acceleration | IsoIsVerticalAcceleration |

Table 61. Identifier 63Ah (1594), IsoIsAngularVelocity

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | °/s | 0.01 | 0 | ISO 8855 intermediate system roll (longitudinal angular) velocity | IsoIsRollVelocity |
| 16 | 16 | S | °/s | 0.01 | 0 | ISO 8855 intermediate system pitch (lateral angular) velocity | IsoIsPitchVelocity |
| 32 | 16 | S | °/s | 0.01 | 0 | ISO 8855 ISO 8855 intermediate system yaw (vertical angular) velocity | IsoIsYawVelocity |

Table 62. Identifier 63Bh (1595), IsoIsAngularAcceleration

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | $°/s^2$ | 0.1 | 0 | ISO 8855 intermediate system roll (longitudinal angular) acceleration | IsoIsRollAcceleration |
| 16 | 16 | S | $°/s^2$ | 0.1 | 0 | ISO 8855 intermediate system pitch (lateral angular) acceleration | IsoIsPitchAcceleration |
| 32 | 16 | S | $°/s^2$ | 0.1 | 0 | ISO 8855 ISO 8855 intermediate system yaw (vertical angular) acceleration | IsoIsYawAcceleration |

Table 63. Identifier 63Ch (1596), IsoEfsVelocity

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | m/s | 0.01 | 0 | ISO 8855 earth-fixed system east velocity | IsoEfsEastVelocity |
| 16 | 16 | S | m/s | 0.01 | 0 | ISO 8855 earth-fixed system north velocity | IsoEfsNorthVelocity |
| 32 | 16 | S | m/s | 0.01 | 0 | ISO 8855 earth-fixed system vertical (up) velocity | IsoEfsVerticalVelocity |

Table 64. Identifier 63Dh (1597), IsoEfsAcceleration

| Offset (bits) | Length (bits) | Type | Units | Factor | Offset | Description | Signal name |
|---|---|---|---|---|---|---|---|
| 0 | 16 | S | $m/s^2$ | 0.01 | 0 | ISO 8855 earth-fixed system east acceleration | IsoEfsEastAcceleration |
| 16 | 16 | S | $m/s^2$ | 0.01 | 0 | ISO 8855 earth-fixed system north acceleration | IsoEfsNorthAcceleration |
| 32 | 16 | S | $m/s^2$ | 0.01 | 0 | ISO 8855 earth-fixed system vertical (up) acceleration | IsoEfsVerticalAcceleration |

# Specifications

Table 65. RT1003 v2 specification[a]

| Parameter (unit) | RT1003 v2 |
|---|---|
| Positioning | |
| GPS | L1, L2C |
| GLONASS | L1, L2 |
| BeiDou | B1 B2 |
| Galileo | E1, E5 |
| Position accuracy (m) [CEP] | |
| ▪ SPS | 1.6 |
| ▪ L1/L2 RTK | 0.02 |
| Drift (m) [RMS] 60 s GNSS outage[b] | <5 |
| Velocity accuracy (km/h) [RMS] | 0.1 |
| Roll/pitch (°) [1σ] | 0.05 |
| Heading (°) [1σ] 2 m antenna baseline | 0.1 |
| Accelerometers | |
| ▪ Bias stability (mg) | 0.08 |
| ▪ Scale factor (%) | 0.08 |
| ▪ Range (g) | ±8 |
| Gyros | |
| ▪ Bias stability (°/hr) | 5 |
| ▪ Scale factor (%) | 0.3 |
| ▪ Range (°/s) | 480 |
| Slip angle (°) [1s] at 50 km/h | 0.25 |
| Update rate (Hz) | 100 (200/250 optional) |
| Input voltage (V dc) | 10–31 |
| Power consumption (W) | 9 |
| Dimensions (mm) | 142 × 77 × 41 |
| Mass (kg) | 0.435 |
| Operating temperature (°C) | -40–70 |
| Vibration | 10-500 Hz 1.42 g RMS |
| Shock survival (g) | 15 g, 11 ms |
| Environmental protection | IP65 |
| Internal storage (GB) | 32 |

| | |
|---|---|
| Input/output | RS232 serial, CAN (up to 1 Mb/s), 10/100 Base-T Ethernet, 2 × IO ports, wheel speed input (quadrature) |
| DGNSS types | RTCM, RTCMV3 |
| Recommended recalibration period (Years) | 2 |

a. Valid for open-sky conditions.

b. With wheelspeed Sensor

# Appendix: Troubleshooting

There are several checks that can be performed in the laboratory to ensure the system is working correctly. The most fragile items in the system are the accelerometers, the other items are not subject to shock and do not need to be tested as thoroughly.

## Accelerometer test procedure

To check the accelerometers are working correctly, follow this procedure.

1. Connect power and a laptop to the system.
2. Commit a default setting to the RT1003 v2 using NAVconfig, then run NAVdisplay.
3. Click the Calibration button, then select the Navigation tab and ensure the X, Y, and Z accelerations (values 19 to 21) are within specification when the RT1003 v2 is placed on a level surface in the orientations according to Table 66.

Table 66. Acceleration measurement specifications

| Orientations | | | Acceleration measurement |
|---|---|---|---|
| **X** | **Y** | **Z** | |
| Flat | Flat | Down | Z-acceleration between -9.7 and -9.9 m/s$^2$ |
| Flat | Flat | Up | Z-acceleration between 9.7 and 9.9 m/s$^2$ |
| Down | Flat | Flat | X-acceleration between -9.7 and -9.9 m/s$^2$ |
| Up | Flat | Flat | X-acceleration between 9.7 and 9.9 m/s$^2$ |
| Flat | Down | Flat | Y-acceleration between -9.7 and -9.9 m/s$^2$ |
| Flat | Up | Flat | Y-acceleration between 9.7 and 9.9 m/s$^2$ |

This test is sufficient to ensure the accelerometers have not been damaged.

## Gyro test procedure

To check that the gyros (angular rate sensors) are working correctly, follow this procedure:

1. Connect power and a computer to the system.
2. Commit a default setting to the RT1003 v2 using NAVconfig, then run NAVdisplay.
3. Click the Calibration button, then select the Navigation tab and scroll to view the X, Y, and Z angular rates (values 30 to 32).
4. Rotate the RT1003 v2 according to Table 66 and check the angular rate measurements occur.
5. With the unit stationary, check all the angular rates are within ±5 °/s. (In general they will be within ±0.5 °/s, but the algorithm in the RT1003 v2 will work to specification with biases up to ±5 °/s).

Table 67. Angular rate measurement specifications

| Orientations | | | Acceleration measurement |
|---|---|---|---|
| X | Y | Z | |
| +ve | Zero | Zero | The x-axis should indicate positive rotation, others are small |
| -ve | Zero | Zero | The x-axis should indicate negative rotation, others are small |
| Zero | +ve | Zero | The y-axis should indicate positive rotation, others are small |
| Zero | -ve | Zero | The y-axis should indicate negative rotation, others are small |
| Zero | Zero | +ve | The z-axis should indicate positive rotation, others are small |
| Zero | Zero | -ve | The z-axis should indicate negative rotation, others are small |

It is hard to do a more exhaustive test using the angular rate sensors without specialised software and equipment. For further calibration testing it is necessary to return the unit to OxTS.

Note that the RT1003 v2 is capable of correcting the error in the angular rate sensors very accurately. It is not necessary to have very small values for the angular rates when stationary since they will be estimated during the initialisation process and warm-up period.

## Testing the internal GNSS and other circuitry

To check all the internal circuits in the RT1003 v2 are working correctly and the navigation computer has booted correctly, use the following procedure:

1. Connect power to the system, connect the system to a computer and run the visual display software (NAVdisplay).
2. Use Table 68, below, to check the status fields are changing.

Table 68. Status field checks

| Field | Incriment rate |
|---|---|
| IMU packets | 100 per second, 200 or 250 per second, depending on IMU speed |
| IMU chars skipped | Not changing (but not necessarily zero) |
| GPS packets | Between 2 and 20 per second (depending on system) |
| GPS chars skipped | Not changing (but not necessarily zero) |
| GPS2 packets[a] | Between 2 and 20 per second (depending on system) |
| GPS2 char skipped[a] | Not changing (but not necessarily zero) |

a. The GPS2 related fields will only increase for dual antenna systems.

These checks will ensure the signals from the GNSS and from the inertial sensors are being correctly received at the navigation computer.

# Revision history

Table 69. Revision history

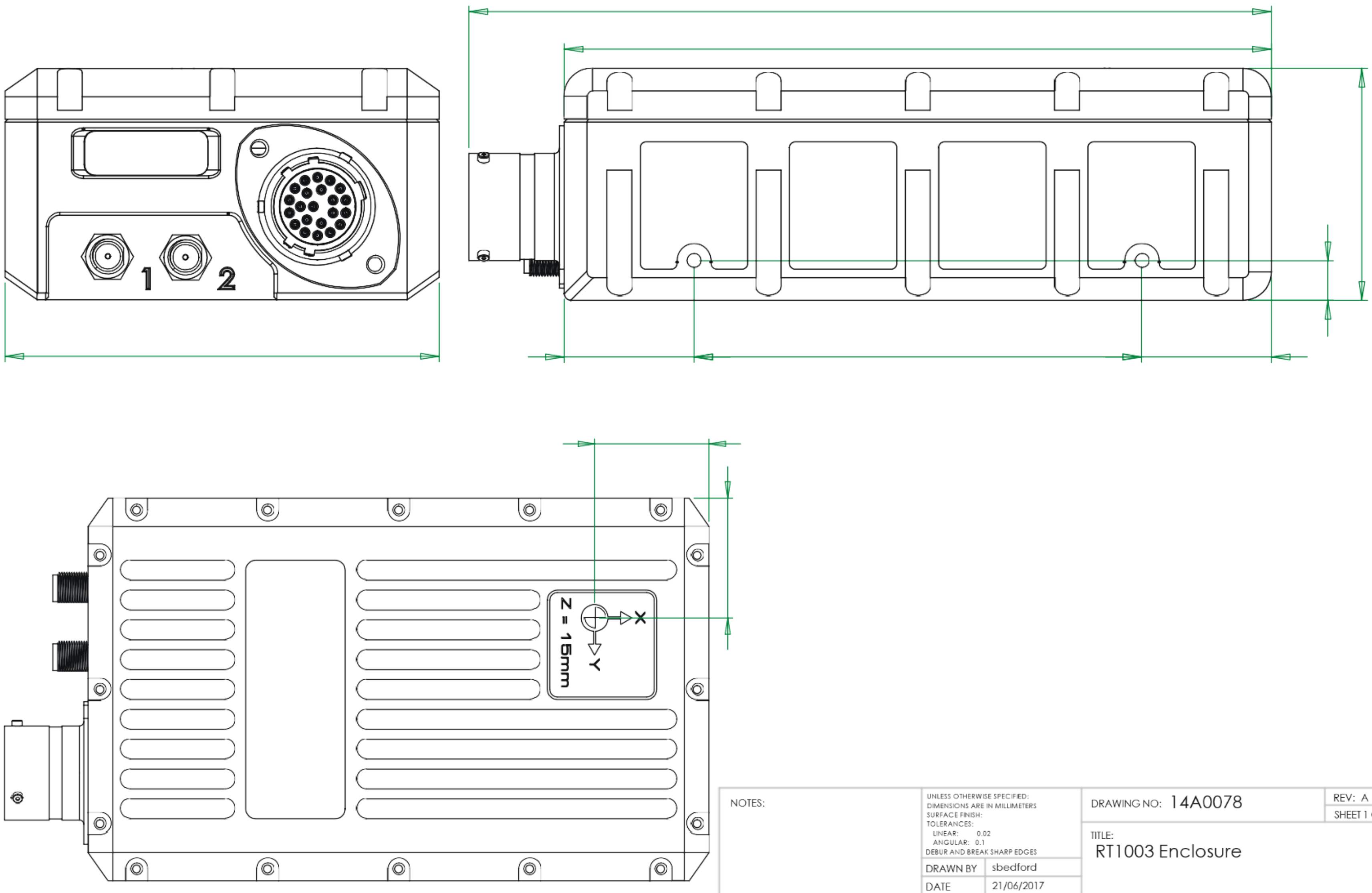
| Revision | Comments |
|---|---|
| 161214 | Original version |
| 170925 | CAN messages and drawings updated |
| 180122 | Antennas updated |
| 190628 | GNSS and accelerometers updated |
| 211209 | Rebranded throughout |
| 220127 | Updated for RT1003 v2 |

# Drawing list

Table 70 lists the available drawings that describe components of the RT system. If you require a drawing, or different revision of a drawing, that is not here then contact Oxford Technical Solutions.

Table 70. List of available drawings

| Revision | Description |
|---|---|
| 14A0078A | RT1003 v2 Enclosure |
| 14C0038B | RT1003 v2 User Cable |
| 77C0002B | Power cable |
| 14A0078A | Unit Fitting Bracket Customer Drawing |




NOTES:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR: 0.02
ANGULAR: 0.1
DEBUR AND BREAK SHARP EDGES

| | |
|---|---|
| DRAWN BY | sbedford |
| DATE | 21/06/2017 |
| MATERIAL | Various |
| WEIGHT | 435 g |
| A3 | Not to scale |

THIRD ANGLE PROJECTION

Confidential Information
The information in this document is confidential and must not be disclosed to other parties or used to build the described components without the written permission of Oxford Technical Solutions.

DRAWING NO: 14A0078

REV: A

SHEET 1 OF 1

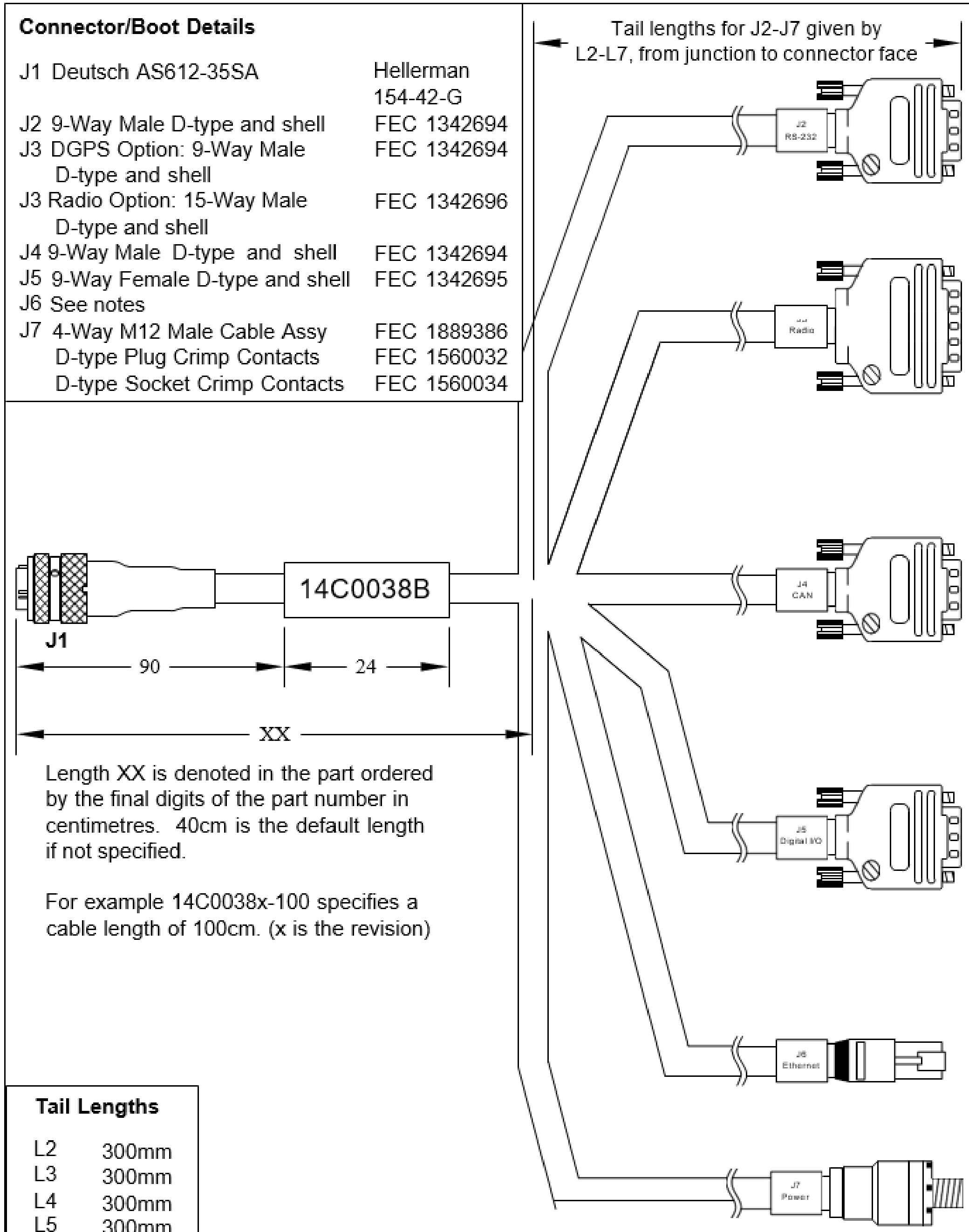
TITLE:
RT1003 Enclosure

Oxford Technical Solutions
77 Heyford Park
Upper Heyford
Oxfordshire
OX25 5HD
www.oxts.co.uk

OXTS

**Connector/Boot Details**

| | | |
|---|---|---|
| J1 | Deutsch AS612-35SA | Hellerman 154-42-G |
| J2 | 9-Way Male D-type and shell | FEC 1342694 |
| J3 | DGPS Option: 9-Way Male D-type and shell | FEC 1342694 |
| J3 | Radio Option: 15-Way Male D-type and shell | FEC 1342696 |
| J4 | 9-Way Male D-type and shell | FEC 1342694 |
| J5 | 9-Way Female D-type and shell | FEC 1342695 |
| J6 | See notes | |
| J7 | 4-Way M12 Male Cable Assy | FEC 1889386 |
| | D-type Plug Crimp Contacts | FEC 1560032 |
| | D-type Socket Crimp Contacts | FEC 1560034 |




| Pin | Function | Conn |
|---|---|---|
| 2 | Nav Data RS232 RX | J1-4 |
| 3 | Nav Data RS232 TX | J1-3 |
| 5 | RS232 Common | J1-12 |

**Radio**

| Pin | Function | Conn |
|---|---|---|
| 1 | +Supply | J3-14 |
| 7 | RS232 Common | J1-16 |
| 8 | Supply Return | J7-3 |
| 9 | Radio Data RX | J1-7 |
| 11 | Radio Data TX | J1-6 |
| 14 | +Supply | J7-1 |
| 15 | +Supply | J7-1 |

**CAN**

| Pin | Function | Conn |
|---|---|---|
| 2 | CAN - | J1-10 |
| 3 | CAN Ground | J1-17 |
| 6 | CAN Ground | J4-3 |
| 7 | CAN + | J1-9 |

**Digital I/O**

| Pin | Function | Conn |
|---|---|---|
| 1 | Digital 1 | J1-11 |
| 2 | Digital 2 | J1-8 |
| 3 | Digital 3 | J1-15 |
| 4 | Digital 4 | J1-19 |
| 5 | Digital 5 | J1-5 |
| 6 | Digital Ground | J1-18 |
| 7 | Digital Ground | J1-18 |
| 8 | Digital Ground | J1-18 |
| 9 | Digital Ground | J1-18 |

See manual for details of the signals on Digital 1 to Digital 5

| Pin | Function | Conn |
|---|---|---|
| 1 | Ethernet (ETX +) | J1-20 |
| 2 | Ethernet (ETX -) | J1-13 |
| 3 | Ethernet (ERX +) | J1-21 |
| 6 | Ethernet (ERX -) | J1-14 |

| Pin | Colour | Function | Conn |
|---|---|---|---|
| 1 | Brown | +Supply (10-25 Volts DC) | J1-1 |
| 2 | White | Sleeved and made safe | |
| 3 | Blue | Supply Return | J1-2 |
| 4 | Black | Sleeved and made safe | |

Length XX is denoted in the part ordered by the final digits of the part number in centimetres. 40cm is the default length if not specified.

For example 14C0038x-100 specifies a cable length of 100cm. (x is the revision)

**Tail Lengths**

| | |
|---|---|
| L2 | 300mm |
| L3 | 300mm |
| L4 | 300mm |
| L5 | 300mm |
| L6 | 300mm |
| L7 | 300mm |

**Oxford Technical Solutions**
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Oxfordshire
OX25 5HD
www.oxts.com


0 10 20 30

| | |
|---|---|
| **Print Size:** | A4 |
| **Scale:** | Not to scale |
| **Units:** | mm |
| **Tolerances:** | 5mm |
| **Projection:** | N/A |

**Notes:**

J6 is a RJ45 UTP patch lead which is cut to length and terminated at J1.

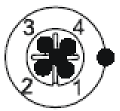
Wire Types:
J7-1, J7-3 16/0.2
All others 7/0.2
J1-13 & J1-20 Twisted pair
J1-14 & J1-21 Twisted pair

Cables outers braided and connected to J1-22, J1 shell and J7 shell (through cable assembly braiding).

Please populate all unused pins with empty crimps.

Ensure that the cable legend text precisely matches that given in diagram.

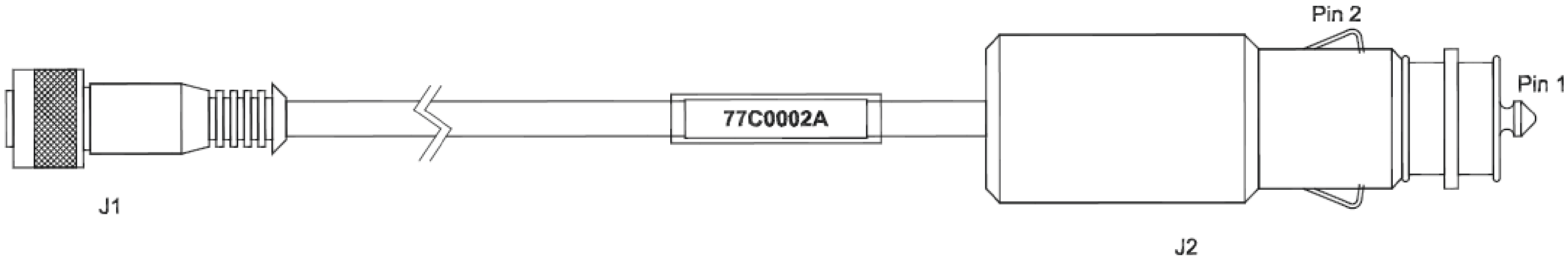
| | |
|---|---|
| **Date:** | 14/09/17 |
| **Part #:** | 14C0038B |
| **Document:** | RT1000 User Cable |
| **Sheet:** | 1 of 1 |




View from front of socket

Pin Definitions

J1-1 (Brown) Positive 12V Power supply (9–18V d.c.)
J1-2 (White) Positive 12V Power/Charger supply (11–18V d.c.)
J1-3 (Blue) 0V/GND
J1-4 (Black) 0V/GND




Parts

RS291-5881 M12 4w 5m PVC straight Connector
RS 266-0250 Car Cigarette Lighter Plug 8A fused)

Connections

J1-1 (Brown) – J2-1
J1-2 (White) – J2-1
J1-3 (Blue) – J2-2
J1-4 (Black) – J2-2

**Oxford Technical Solutions**
77 Heyford Park
Upper Heyford
Oxfordshire
OX25 5HD
www.ots.ndirect.co.uk


0 10 20 30

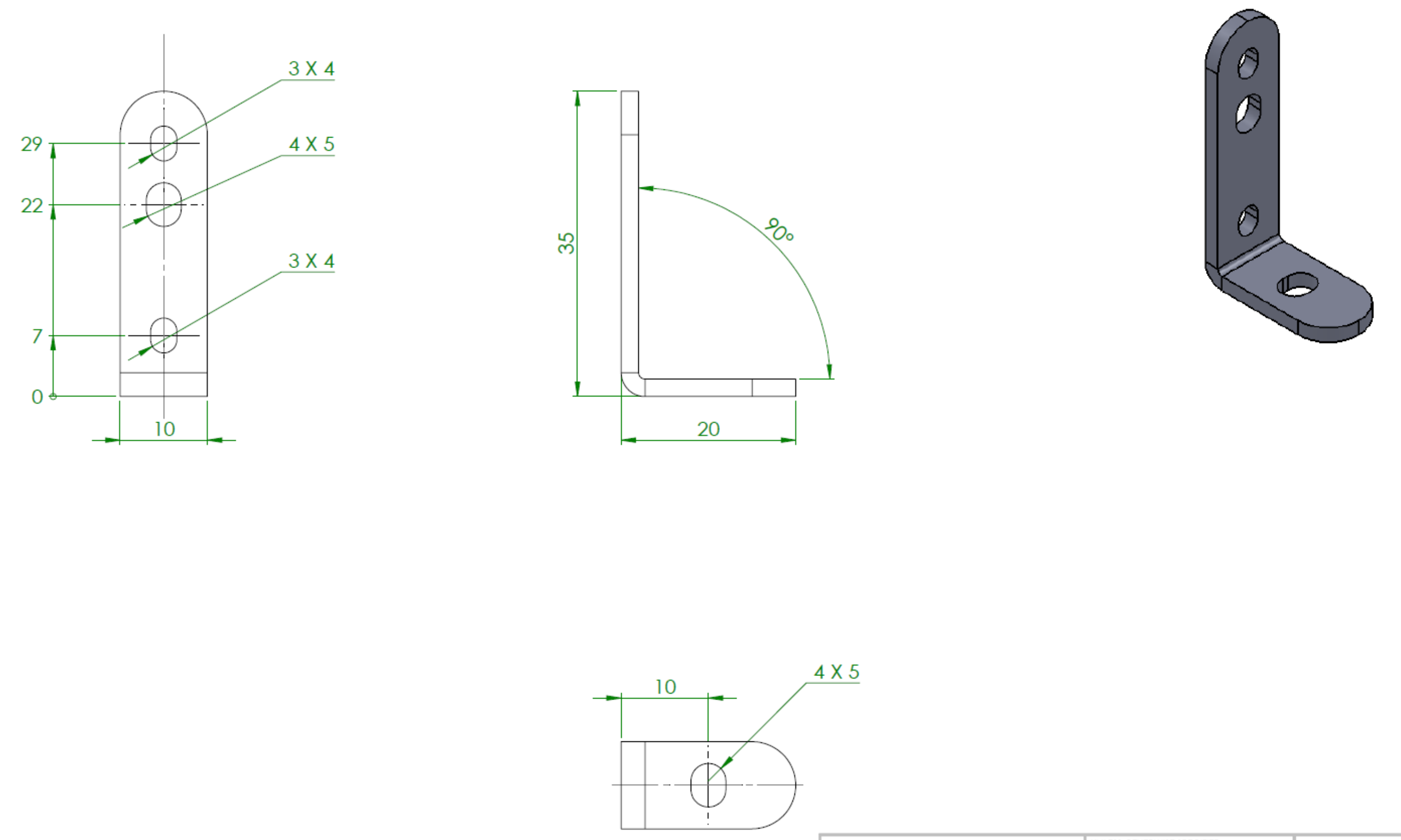
| | |
|---|---|
| **Print Size:** | A4 |
| **Scale:** | 1:1 |
| **Units:** | mm |
| **Tolerances:** | 1mm |
| **Projection:** | N/A |

**Notes:**

10/04/02
Alternative Part Number added

22/05/15
Fit 5A fuse in Cigar Plug

| | |
|---|---|
| **Date:** | 22/05/15 |
| **Part #:** | 77C0002B |
| **Document:** | Power Cable |
| **Sheet:** | 1 of 1 |




| | | | |
|---|---|---|---|
| NOTES: MRP Number 110-00203-002 | UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: 0.1 ANGULAR: 0.5 DEBUR AND BREAK SHARP EDGES | DRAWING NO: 14M0098B | SHEET 1 OF 1 |
| | DRAWN BY: S Whelan | TITLE: Unit Fitting Bracket Customer Drawing | |
| | DATE: 06/07/2015 | | |
| THIRD ANGLE PROJECTION | MATERIAL: 304 S/S 2mm | Oxford Technical Solutions, 77 Heyford Park, Upper Heyford, Oxfordshire, OX25 5HD, www.oxts.com | OXTS |
| Confidential Information. The information in this document is confidential and must not be disclosed to other parties or used to build the described components without the written permission of Oxford Technical Solutions. | WEIGHT | | |
| | A3 — SCALE:2:1 | | |
| | DO NOT SCALE DRAWING | | |

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