ADVANCED NAVIGATION

Boreas D90
Boreas D70

Reference Manual

Contents

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For more information, contact technical support via email at **support@advancednavigation.com**.

1 Revision History

Version	Date	Changes
1.7	13 Mar 2024	Updated firmware changelog, see **2.1 Firmware Changelog** ANPP packets 70 (Raw DVL Data Packet) and 185 (Installation Alignment Packet) updated Minor editorial changes
1.6	15 Nov 2023	Updated weight and improved detail of **6.2 Hardware Specifications** Expanded **9.2 Using Boreas Manager** to include all features Updated software changelog, see **9.2.1 Boreas Manager Software Changelog**
1.5	17 Feb 2023	Updated software changelog, see **9.2.1 Boreas Manager Software Changelog** Updated software installation information to include Java 11 requirement, see **9.2.3 Installation and Starting** and **7.1 Installation Checklist** Updated instructions for running manager on MacOS, see **9.2.3 Installation and Starting**
1.4	22 Dec 2022	Updated firmware changelog, see **2.1 Firmware Changelog**
1.3	05 Dec 2022	Updated to include D70 variant, see **6.1 Navigation Specifications**, **5 Part Numbers and Ordering** and **3 Evaluation Kit** Added further information on temporary accuracy degradation under high vibration, see **7.12 Vibration**
1.2	11 Oct 2022	Updated firmware changelog, see **2.1 Firmware Changelog** Updated hardware changelog, see **2.2 Hardware Changelog** Updated software changelog, see **9.2 Using Boreas Manager** Updated Logging information as per Manager v6.2, see **9.2.8.4 Log Converter** Added a link to the product page to find the SDK, see **9.4 Using ANPP** Added information on disabling dual antenna heading for single antenna configurations, see **11.5.5 Filter Options Packet** and **9.1.3 Configuration Menu** Updated External Time Packet to show it is Read only, see **11.4.31 External Time Packet** Updated specifications to include hw v1.1 changes, see **6.2 Hardware Specifications** Added note that higher precision oscillator for time accuracy is available, see **8.3 Time**
1.1	01 Jun 2022	Updated Device ID table, see **11.3.4 Device Information Packet** Added Device Discovery section for Boreas Manager, see **9.2.8.1 Device Discovery** Updated Logging information, see **9.2.8.4 Log Converter** Added Basestation Packet, see **11.4.46 Basestation Packet** Reformatted 1PPS output information, see **10.6.1.2 1PPS Output** Added System temperature Packet, see **11.4.50 System Temperature Packet**

Version	Date	Changes
		Breakout cable diagrams updated to show connector types, see **6.6 IO Connection**
		Clarified geoid, ellipsoid and orthometric heights, see **12.5 Geodetic Co-ordinate System**
		Added information on Boreas variant with BD992 GNSS Receiver, see **5 Part Numbers and Ordering**, **6.1 Navigation Specifications**, **11.4.41 GNSS Receiver Information Packet**, **9.1.3 Configuration Menu**, and **3 Evaluation Kit**
		Added disclaimer than Antenna Status Flags are only applicable to Aries GNSS Receivers, see **9.1.2.4 Status**, **11.4.1 System State Packet** and **11.4.10 Raw GNSS Packet**
1.0	17 June 2021	Initial Release

Table 1: Revision History

2 Introduction

Boreas D90/D70 is an ultra high accuracy DFOG GNSS/INS that provides accurate position, velocity, acceleration and orientation under the most demanding conditions. It combines cutting edge Fibre Optic Gyroscopes (FOG) technology with closed loop accelerometers and a dual antenna RTK GNSS receiver. These are coupled in a sophisticated fusion algorithm to deliver accurate and reliable navigation and orientation. The system features ultra fast gyrocompassing heading that works under all conditions.

Boreas is equipped with an Advanced Navigation Aries GNSS receiver as standard. A Trimble BD992 variant is also available. See **5 Part Numbers and Ordering** for more information.

Figure 1: Boreas

Boreas is a compact, light-weight GNSS/INS system that:

- Provides unparalleled accuracy, stability and reliability with its use of the revolutionary Digital FOG (DFOG) technology
- Provides continuously reliable data throughout extended GNSS outages and periods of interference
- Rapidly acquires accurate heading information using Digital FOG (DFOG) gyroscopes in conjunction with an innovative north-seeking algorithm
- Extracts greater usable information from sensor data using Advanced Navigation's AI-based sensor filter
- Is designed and built to be tough, tested to high safety standards and resistant to shock and vibration, allowing it to be used in extreme conditions
- Features multiple interfaces including Ethernet, CAN, RS232, RS422 and general-purpose IO
- Supports all industry-standard protocols including NMEA 0183 and NMEA 2000 and a wide variety of proprietary protocols.

Note: For information about Global Navigation Satellite Systems (GNSS), Inertial Navigation Systems (INS) and related concepts explained in simple terms, see **12 Reference Information**.

Use the links below for detailed information about Boreas.

2.1 Firmware Changelog

Version	Date	Changes
1.70 (D90 only)	06 December 2023	Various UI improvements Implemented adaptive noise filtering algorithm for navigation Implemented coarse alignment on gyro-overrange Improved state orientation during turns Output larger orientation standard deviation when heading is not yet available Improved navigation performance when GNSS is denied Fixed periodic heading resets in the stationary vehicle profile Extended external GNSS lever arm offset range to 50 m horizontal and 100 m vertical Added sub types to Extended Device Information Packet Added support to input the Raw DVL Data Packet (packet 70) Updated DVL input to use Odometer Offset Fixed intermittent IP address misconfiguration when using DHCP Fixed malformed CANOpen packets Added UTM grid position output to the CANopen protocol Added ability to configure packet timer period in multiples of 1000 Fixed intermittent web UI not accessible on boot up after firmware update Fixed PTP performance impacted by web server load Fixed CRC mismatch for bootloader packet acknowledgement Fixed intermittent reboot when updating firmware via application bootloader Implemented common mDNS address prefix for all Boreas variants Improved saving of configuration, eliminating potential for corruption Updated Aries GNSS receiver firmware - Improved GNSS operation when transitioning between Fix to No Fix - Improved ANPP29 packet timing - Reduced erroneous reporting of GNSS Fix
1.40 (D90 only)	09 December 2022	Improved factory accelerometer calibration over temperature Improved gyrocompass heading drift when stationary Fixed PTP clock syncing when using hardware timestamp
1.30 (D90 only)	18 August 2022	Added support for Trimble BD992 receiver Allowed firmware update using any ANPP dataport. Previously only available via Primary Serial or Web UI. Fixed unable to apply GNSS configuration
1.20 (D90 only)	10 June 2022	Added ability to operate as single antenna configuration by disabling dual antenna heading, see **9.1.3 Configuration Menu** Report a gyroscope failure if a gyroscope temperature is out of range Fixed satellite tracking information display and ANPP84 for BD992 Fixed CANopen PDO objects stop transmitting if the bus is broken then restored Fixed Manual Initialisation from Web UI Fixed intermittent restart due to NMEA0183 sentences Fixed CANopen external odometer input General performance improvements
1.10 (D90 only)	25 October 2021	Improved gyrocompass fine alignment Fixed NMEA 0183 GPGSV output missing

Version	Date	Changes
1.0 (D90 only)	10 September 2021	Initial release

Table 2: Firmware Changelog

Note: To upgrade the firmware to the latest version, see **8.18 Upgrading the Boreas Firmware**.

2.2 Hardware Changelog

Version	Date	Changes
1.1	12 July 2022	Component changes to increase maximum operating temperature
1.0	25 May 2021	Initial release

Table 3: Hardware Changelog

3 Evaluation Kit

The Evaluation Kit provides the necessary parts and accessories to set up and connect a Boreas unit. It is supplied in a rugged transport case to protect the equipment during transit.

Figure 2: Boreas Evaluation Kit Transport Case

3.1 Evaluation Kit Contents

Figure 3: Boreas Evaluation Kit Contents

Part Number	Quantity	Description	Notes
BOREAS-D90 or BOREAS-D90-BD992 or BOREAS-D70 or BOREAS-D90-BD992	1	Boreas INS Unit	Boreas unit in rugged enclosure with Aries Dual GNSS Receiver or Trimble BD992 GNSS Receiver
VSP6337L	2	VeroStar GNSS Antenna	VeroStar GNSS Antenna - L1/L2/L5 plus L band, pole mount, TNC Female Connector
BF046WS210224-01	2	GNSS antenna cable TNC to TNC 4 m	4 metre RG-58A/U antenna cable with TNC connectors
CABLE-FTDI	1	RS232/422 Adaptor to USB	FTDI USB to RS232 / RS422 (selectable) 1 metre cable
CABLE-38999-RJ45-3M	1	Ethernet MIL-DTL-38999 Series III RJ45 to RJ45 3 m	Ethernet cable 3 m industrial MIL-DTL-38999 Series III RJF TV RJ45 male to RJ45 male See **6.5 Ethernet Connection**.
CABLE-38999-19-32-BREAKOUT	1	Breakout cable for IO connection	Breakout cable for IO connection 2 m MIL-DTL-38999 Series III Size 19, 32-pin connector Connectors for Primary, Auxiliary, CAN, GPIO, 1PPS, Alert and Power. See **6.6.2 IO Breakout Cable**.
SUPPLY-24V	1	24 V DC power supply	100-240 V AC Mains to 24 V DC Power Supply (DC jack) Includes 2-pin plug types A/C/G/I
38999-19-CAP	1	Waterproof cap for Size 19 MIL-DTL-38999 Series III socket connector	Used to maintain IP67 rating when not using an Ethernet connection
BOREAS90-KIT-CASE	1	Boreas Evaluation Kit case	Rugged transport case

Table 4: Evaluation Kit Contents

4 Getting Started

To get started with Boreas for the first time, it is recommended that you begin by establishing communications to the device, either before or after the unit is installed in its final location. These instructions assume the use of components provided in the **3 Evaluation Kit**, or purchased as Advanced Navigation supplied optional **5.4 Accessories**.

1. Plug the power supply into the power connector on the breakout cable and then into the wall socket. See **7.6 Power Supply**.

2. Plug the IO breakout cable into the IO connector on the Boreas unit. See **6.6 IO Connection**.

3. Connect either the MIL-DTL-38999 Series III terminated cable or a standard Ethernet cable from the Ethernet socket on the Boreas unit to your network or switch. See **6.5 Ethernet Connection**.

4. If using Windows, download and install the Bonjour ZeroConf networking utility from the link **https://www.advancednavigation.com/Bonjour64.msi**.

5. In a web browser, type the address: **http://boreas.local.**

There are additional factors that you must review **before** you proceed with the installation. For more information, see **7 Installing Boreas**.

5 Part Numbers and Ordering

This topic covers information about:

- **5.1 Evaluation Kit**
- **5.2 Standalone Units**
- **5.4 Accessories**

5.1 Evaluation Kit

Part Number	Description
BOREAS-D90-EK	Boreas D90 INS Evaluation Kit Includes the items listed in **3.1 Evaluation Kit Contents**
BOREAS-D90-BD992-EK	Boreas D90 BD992 Receiver Evaluation Kit Includes the items listed in **3.1 Evaluation Kit Contents**
BOREAS-D70-EK	Boreas D70 INS Evaluation Kit Includes the items listed in **3.1 Evaluation Kit Contents**
BOREAS-D70-BD992-EK	Boreas D70 BD992 Receiver Evaluation Kit Includes the items listed in **3.1 Evaluation Kit Contents**

Table 5: Evaluation Kit Part Numbers

5.2 Standalone Units

Part Number	Description	Notes
BOREAS-D90	Boreas D90 Unit	Boreas D90 unit in rugged enclosure Aries Dual GNSS Receiver No cables or blanking caps included
BOREAS-D90-BD992	Boreas D90 BD992 Unit	Boreas D90 unit in rugged enclosure Trimble BD992 GNSS Receiver No cables or blanking caps included
BOREAS-D70	Boreas D70 Unit	Boreas D70 unit in rugged enclosure Aries Dual GNSS Receiver No cables or blanking caps included
BOREAS-D70-BD992	Boreas D70 BD992 Unit	Boreas D70 unit in rugged enclosure Trimble BD992 GNSS Receiver No cables or blanking caps included

Table 6: Standalone Unit Part Numbers

5.3 GNSS Receiver Licence Upgrades

These licenses are only applicable to Boreas units with a Trimble BD992 GNSS Receiver.

Part Number	Description	Notes
BD992-LIC-10CM	Upgrade Boreas BD992 to 10 cm RTK	Applicable for Trimble BD992 GNSS Receiver variant. Upgrades BD992 GNSS Receiver from 30 cm to 10 cm RTK accuracy
BD992-LIC-8MM	Upgrade Boreas BD992 to full RTK (8 mm) with Galileo and BeiDou	Applicable for Trimble BD992 GNSS Receiver variant Upgrades BD992 GNSS Receiver from 30 cm to 8 mm RTK accuracy Adds Galileo and BeiDou constellations

Table 7: Ordering Part Numbers for GNSS Receiver Licence Upgrades

5.4 Accessories

Part Number	Description	Notes
CABLE-38999-RJ45-3M	Ethernet MIL-DTL-38999 Series III RJ45 to RJ45 3 m	3 m industrial Ethernet cable MIL-DTL-38999 Series III RJF TV See **6.5 Ethernet Connection**
CABLE-38999-RJ45-10M	Ethernet MIL-DTL-38999 Series III RJ45 to RJ45 10 m	10 m industrial Ethernet cable MIL-DTL-38999 Series III RJF TV See **6.5 Ethernet Connection**
CABLE-38999-19-32-BREAKOUT	Breakout cable for IO connection	2 m breakout cable for IO connection MIL-DTL-38999 Series III Size 19, 32-pin connector Connectors for Primary, Auxiliary, CAN, GPIO, 1PPS, Alert and Power See **6.6 IO Connection**.
CABLE-38999-19-32-UNT-5M	IO MIL-DTL-38999 Series III 5 m unterminated cable	MIL-DTL-38999 Series III 32-pin connector 5 m 26 core cable unterminated. See **6.6 IO Connection**.
38999-19-CAP	Waterproof cap for Size 19 MIL-DTL-38999 Series III socket connector	Used to maintain IP67 rating when not using an Ethernet connection
CABLE-FTDI	USB to RS232 / RS422 cable 1 m	1 m FTDI USB to RS232 / RS422 (selectable) cable
SUPPLY-24V	24 V DC Power Supply	100-240 V AC Mains to 24 V DC Power Supply (DC jack) Includes 2-pin plug types A/C/G/I
CAR12VPWR	Car auxiliary power outlet supply	Car auxiliary power supply to DC jack power supply
BF046WS210224-01	TNC to TNC 4 m GNSS antenna cable	4 m RG-58A/U antenna cable with TNC connectors
VSP6337L	VeroStar GNSS Antenna	VeroStar GNSS Antenna - L1/L2/L5 plus L band, pole mount (1"-14 thread with adapter included for 5/8"-11 thread), TNC Female Connector
G5ANT-53A4T1	Antcom GNSS Antenna	Antcom G5 L1/L2 GNSS antenna with optional survey mount (5/8"-11 thread)
OBDII-ODOMETER	OBDII Odometer	Allows vehicle-mounted units access to accurate odometer data. See **7.10.2 OBDII Odometer Interface**
Various Air Data Units	Air Data Unit	Air data units provide pitot and static air velocity data aiding for Boreas in fixed wing aircraft
MOUNT-SUCT	Suction Cup Antenna Mount	Suction cup 5/8" GNSS antenna survey mount for easy installation of GNSS antenna on vehicles. See **7.8.2 Antenna Suction Cup Mount**.
BOREAS90-KIT-CASE	Boreas Kit Case	Rugged transport case suitable for storing a single Boreas unit, 2 antennas, standard cables and power

Part Number	Description	Notes
		supply accessories.

Table 8: Ordering Part Numbers for Accessories

6 Specifications

Review the following specifications for Boreas:

6.1 Navigation Specifications

Specification	
Horizontal Position Accuracy	1.2 m
Vertical Position Accuracy	2.0 m
Horizontal Position Accuracy (SBAS)	0.5 m
Vertical Position Accuracy (SBAS)	0.8 m
Horizontal Position Accuracy (with RTK or Kinematica Post Processing)	0.01 m
Vertical Position Accuracy (with RTK or Kinematica Post Processing)	0.015 m
Accuracy with Odometer without GNSS (% of distance travelled)	0.01%
Accuracy with DVL without GNSS (% of distance travelled)	0.01%
Velocity Accuracy	0.005 m/s
Roll & Pitch Accuracy	0.005 °
Roll & Pitch Accuracy (Kinematica post processing)	0.005 °
Heading Accuracy with Dual GNSS (1.0 m antenna separation)	0.006 °
Heading Accuracy without GNSS (Secant Latitude RMS)	0.01 °
Heading Accuracy (Kinematica post processing)	0.006 °
Gyrocompassing Coarse Alignment	2 min
Gyrocompassing Fine Alignment (typical)	10 min
Heave Accuracy (whichever is greater)	2 % or 0.02 m
Rotation Range	Unlimited
Hot Start Time	2 s
Internal Filter Rate	1000 Hz
Output Data Rate	1000 Hz

Table 9: Boreas Navigation Specifications

6.1.1 Dual Antenna Heading Accuracy

Antenna Separation	
0.5 m	0.01 °
1 m	0.006 °
2 m	0.005 °
5 m	0.004 °
10 m	0.003 °

Table 10: Heading Accuracy based on Antenna Separation

6.1.2 Sensor Specifications

Parameter	Accelerometers	Gyroscopes	Pressure
Range	± 15 g	± 490 °/s	10 to 130 kPa
Bias Instability	7 ug	0.001 °/hr	8 Pa
Initial Bias	< 100 ug	< 0.01 °/hr	< 50 Pa
Initial Scaling Error	340 ppm	80 ppm	-
Scale Factor Stability	100 ppm	10 ppm	-
Non-linearity	150 ppm	10 ppm	-
Cross-axis Alignment Error	< 0.001 °	< 0.001 °	-
Noise Density	30 ug/√Hz	0.06 °/h/√Hz	0.4 Pa/√Hz
Random Walk	17 mm/s/√hr VRW	0.001 °/√h ARW	-
Bandwidth	300 Hz	400 Hz	50 Hz

Table 11: Boreas D90 Sensor Specifications

Note: Boreas sensors are calibrated for bias, sensitivity, misalignment, cross-axis sensitivity, non-linearity and gyroscope linear acceleration sensitivity across the full operating temperature range.

6.1.3 GNSS Specifications

Parameter	Specification	
	Aries GNSS Receiver	**Trimble BD992 Receiver**
Supported Navigation Systems	GPS L1, L2 GLONASS L1, L2 Galileo E1, E5b BeiDou B1, B2	GPS L1, L2, L5 GLONASS L1, L2 Galileo E1, E5b, E5a [2] BeiDou B1, B2, B3 [2]
Supported SBAS Systems	WAAS EGNOS MSAS GAGAN QZSS	WAAS EGNOS MSAS GAGAN QZSS Omnistar [1] Trimble RTX [1]
RTCM Input	Version 3.3	Version 3.2
Update Rate	Up to 20 Hz [3]	20 Hz
Hot Start First Fix	2 s	2 s
Cold Start First Fix	30 s	30 s
Horizontal Position Accuracy	1.2 m	1.2 m
Horizontal Position Accuracy (with SBAS)	0.5 m	0.5 m
Horizontal Position Accuracy (with RTK)	0.010 m	0.008 m [2]
Velocity Accuracy	0.05 m/s	0.007 m/s
Timing Accuracy	20 ns	20 ns
Acceleration Limit	4 g	11 g

Table 12: GNSS Specifications

[1] Requires purchase of Omnistar or Trimble RTX subscription

[2] Requires purchase of additional software license, see **5.3 GNSS Receiver Licence Upgrades**

[3] See **9.1.3.15 GNSS Configuration** for update rate relevant to particular constellation configurations

6.2 Hardware Specifications

Specification	Value
Hot Start Battery Capacity	> 48 hours
Hot Start Battery Charge Time	30 minutes
Hot Start Battery Endurance	> 10 years
Mean Time between Failure (MTBF)	> 70,000 hours

Specification	Value
Dimensions (depth x width x height) excluding connectors	160 mm x 140 mm x 115.5 mm
Weight	2.8 kg

Table 13: Hardware Specifications for Boreas

6.2.1 Environmental Specifications

Parameter	Specification	Standard
Operating and Storage Temperature	-40 °C to 65 °C (v1.0) -40 °C to 75 °C (All D70, v1.1 D90 and later)	MIL-STD-810H Method 501.7 & 502.7
Humidity	Natural Cycle B1	MIL-STD-810H Method 507.6
Salt Fog	48 hours	MIL-STD-810H Method 509.7
Ingress Protection	IP67	IEC 60529 MIL-STD-810H Method 512.6
Vibration	7.7 g rms	MIL-STD-810H Method 514.8E-1 & 514.8C-3
Shock	50 g 11 ms	MIL-STD-810H Method 516.8

Table 14: Environmental specifications for Boreas

6.2.2 Mechanical Drawings
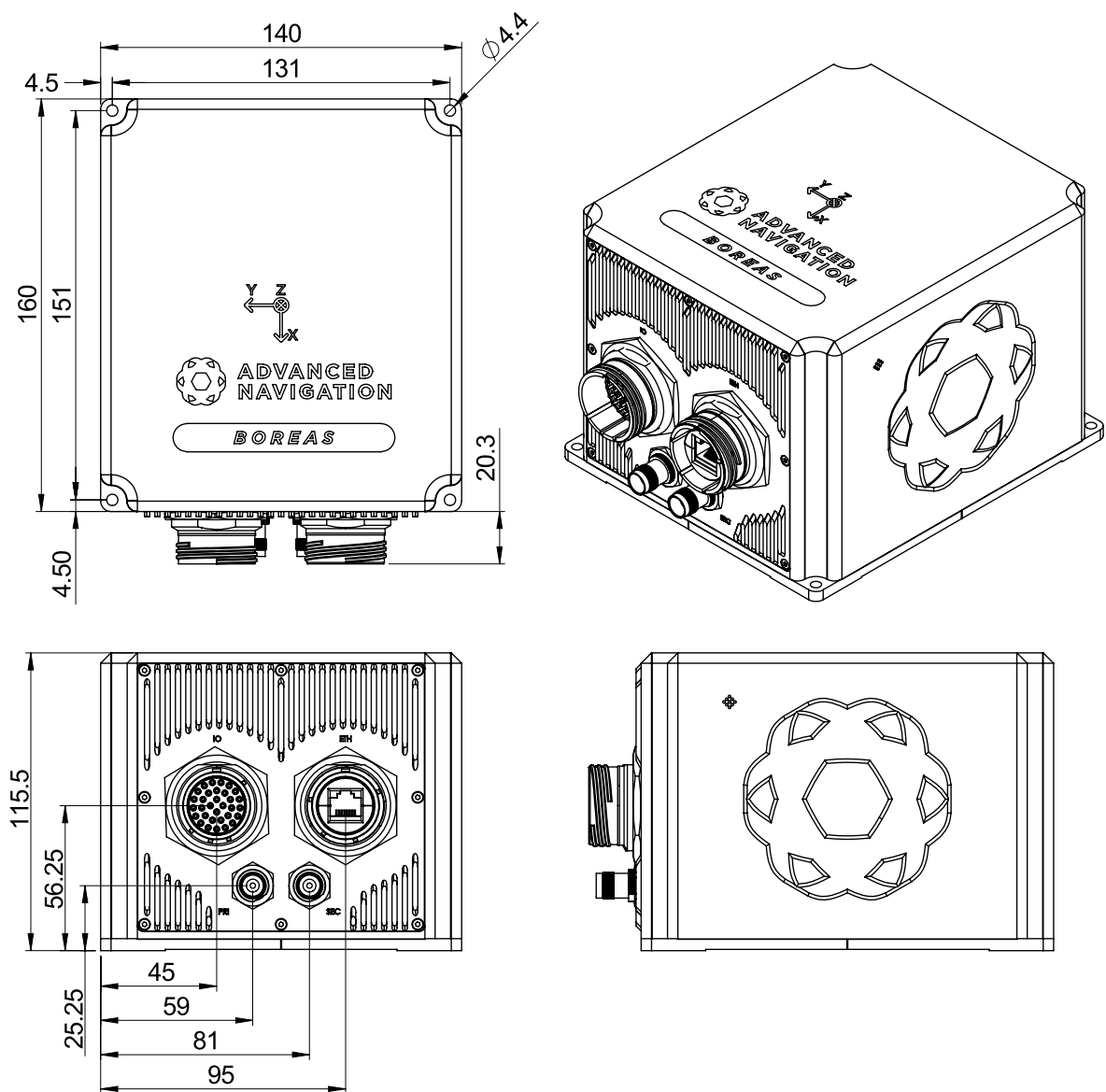
Figure 4: Mechanical Drawings of Boreas D90 and D70

6.2.3 Cable Bend Radius
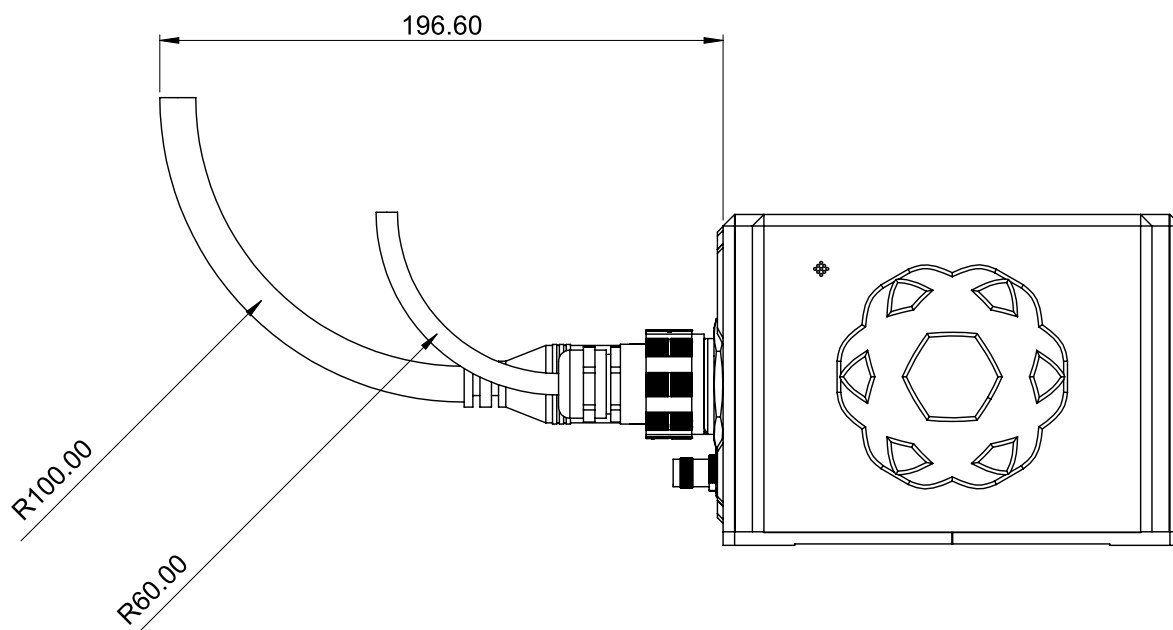
Figure 5: Recommended Minimum Bend Radius for Advanced Navigation Supplied Cables

6.2.3.1 Centre of Gravity Location for Boreas D90 and D70
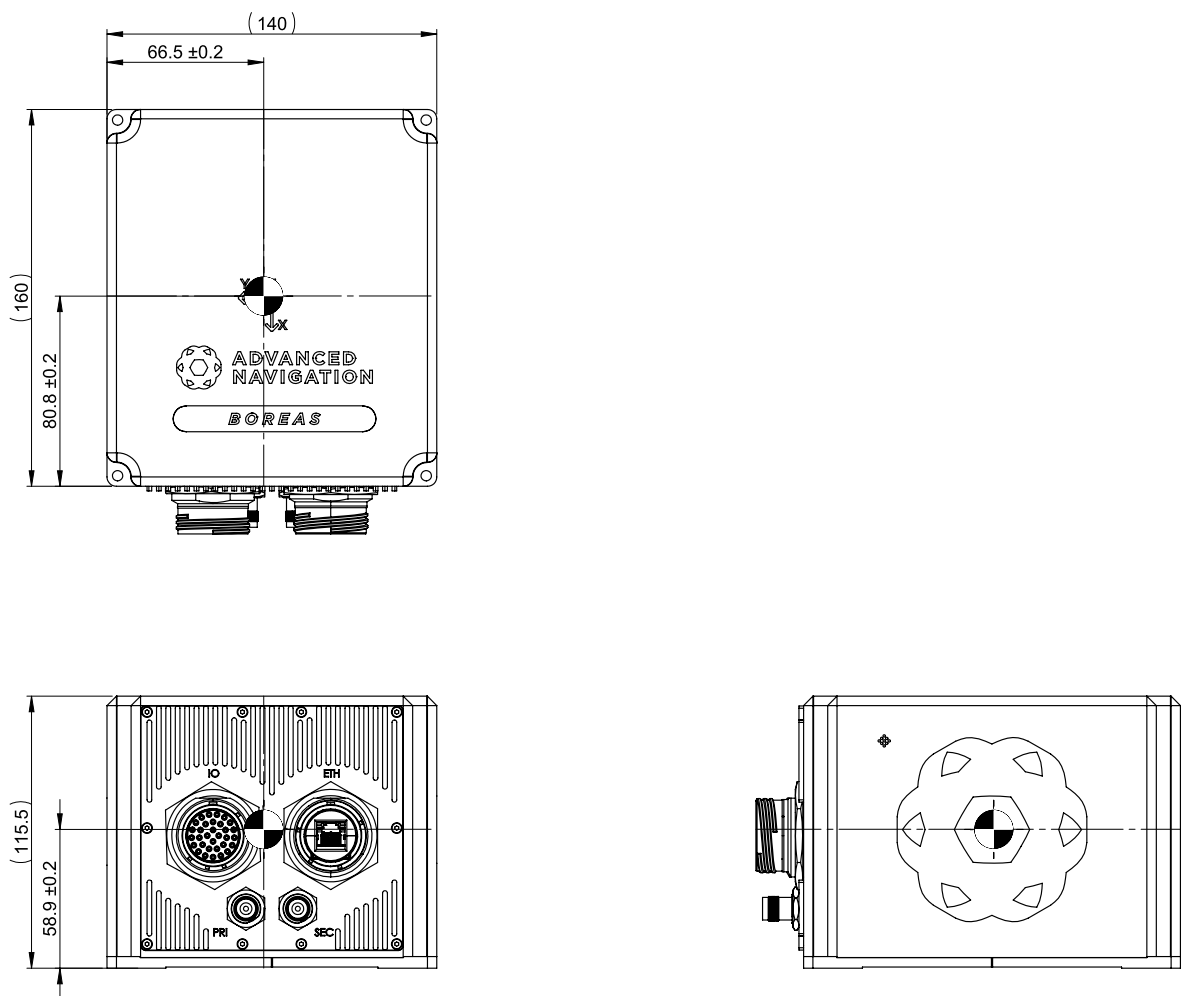
Figure 6: Centre of Gravity Location of Boreas D90 and D70

6.2.4 Serial Number

The device serial number can be inspected by using the Device Information page in the web interface (see **9.1 Using the Web User Interface**) or with the Manager application (see **9.2 Using Boreas Manager**). The serial number label is located on the outside rear of the enclosure with the serial number encoded in a 2D data matrix bar code to assist customers in tracking their units. The label also contains the hardware version and build date. Applications are available for most smartphones that can scan the 2D data matrix bar code to display the serial number.

Figure 7: Boreas External Serial Number Sticker

6.3 Communication Specifications

Specification	Value
Interfaces	Ethernet RS232/RS422 CAN 1PPS
Speed	100 Mbit Ethernet 4800 to 4 M baud serial
Protocols	Advanced Navigation Packet Protocol, NMEA or CANopen
Peripheral Interface	2 x GPIO 1 x 1PPS Output 1 x Auxiliary RS232 1 x Alarm Output
GPIO Operating Voltage Levels	5 V 3.3 V RS232
GPIO Functions	1PPS input/output Odometer input DVL/USBL input Air Data input Zero velocity input NMEA input/output Novatel GNSS input Trimble GNSS input Advanced Navigation Packet Protocol CAN/CANopen

Table 15: Communication Specifications

6.4 Electrical Specifications

Parameter	Minimum	Typical	Maximum
Operating Voltage	9 V		36 V
Input Protection	-200 V		+200 V
Power Consumption		10 W without GNSS 12 W with GNSS	15 W
Inrush Current		1.67 A at 12 V 0.79 A at 24 V	
RS232			
Tx Voltage Low		-5.4 V	-5 V
Tx Voltage High	5 V	5.4 V	
Tx Short Circuit Current			±60 mA

Parameter	Minimum	Typical	Maximum
Rx Threshold Low	0.6 V	1.2 V	
Rx Threshold High		1.5 V	2.0 V
RS422			
Tx Differential Output	1.5 V		
Tx Short Circuit Current			±250 mA
Rx Differential Threshold	-0.2 V		-0.05 V
GPIO when set to 5 V			
Output Voltage Low	0 V		0.3 V
Output Voltage High	4.8 V		5 V
Input Voltage	-20 V		20 V
Input Threshold Low			1.5 V
Input Threshold High	3.5 V		
Output Current			5 mA
1PPS when set to 5 V			
Output Voltage Low	0 V		0.3 V
Output Voltage High	4.5 V		5 V
Output Current			50 mA
GPIO when set to 3.3 V			
Output Voltage Low	0 V		0.3 V
Output Voltage High	3 V		3.3 V
Output Current			5 mA
Input Voltage	-5 V		5 V
Input Threshold Low			0.8 V
Input Threshold High	2 V		
1PPS when set to 3.3 V			
Output Voltage Low	0 V		0.1 V
Output Voltage High	3 V		3.3 V
Output Current			50 mA
GNSS Antenna			
Active Antenna Supply Voltage	4.5 V		4.6 V
Antenna Supply Current			200 mA
Alarm Output			
Voltage			36 V
Current			0.5 A

Parameter	Minimum	Typical	Maximum
On Resistance			2.5 ohms

Table 16: Electrical Specifications

6.5 Ethernet Connection

Advanced Navigation offers a 3 m industrial Ethernet cable with a MIL-DTL-38999 Series III connector to create a rugged connection to the unit. This is supplied as part of the **3 Evaluation Kit**, and also a recommended accessory with the standalone unit. The MIL-DTL-38999 Series III RJ45 end is IP67 rated in mated position.
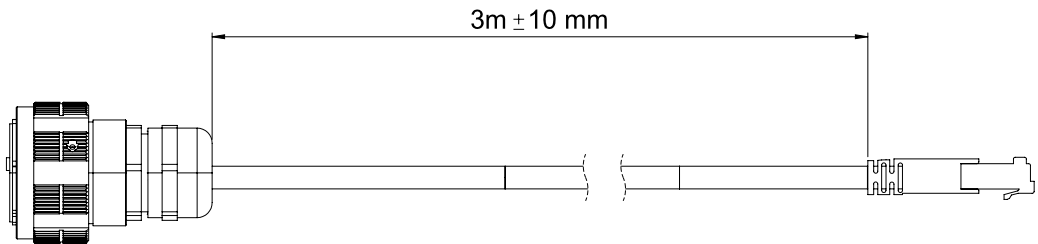
Figure 8: Ethernet Cable

There are several alternatives and options for differing application needs:

- If a shorter cable is required, it can be either coiled or cut and re-terminated.

- For evaluation purposes, a standard Cat5e or better Ethernet cable can be used directly into the unit.

- If a longer cable is required, a standard Cat5e or better cable can be used with an Amphenol RJF-TV series connector. This connector uses a MIL-DTL-38999 Series III mating connection in a size 19. The connector has a normal Orientation Key, and is finished in an RoHS-compliant Black Zinc Nickel finish for high corrosion resistance. Refer to Amphenol documentation for instructions on how to correctly terminate these connectors.

Connector	Manufacturer and Series	Part Number	Notes	Finish
Cable side Ethernet connector	Amphenol Socapex	RJF TV 6M ZN	Aluminium, Straight Plug with metal gland, Size 19	Black Zinc Nickel

Table 17: Ethernet Connector

6.6 IO Connection

The IO connection is used to provide the power supply and access to a range of interface connections. It can be achieved with an **6.6.1 IO Unterminated Cable**, an **6.6.2 IO Breakout Cable** or by building your own cable (see **6.6.3 Custom IO Termination**). Connection is made through MIL-DTL-38999 Series III connectors, which provide reliable and rugged connection under demanding conditions and are rated to IP67 in the mated position (see **7.5 MIL-DTL-38999 Series III Connector Mating**).

6.6.1 IO Unterminated Cable

An optional 5 m unterminated cable is available for custom connections. Each individual wire in the unterminated cable is a colour-coded FEP coated wire. See **Pin** for details on pin out functions. Custom cable lengths for unterminated types are available subject to minimum order quantities and lead times; contact the **Sales** team for more information
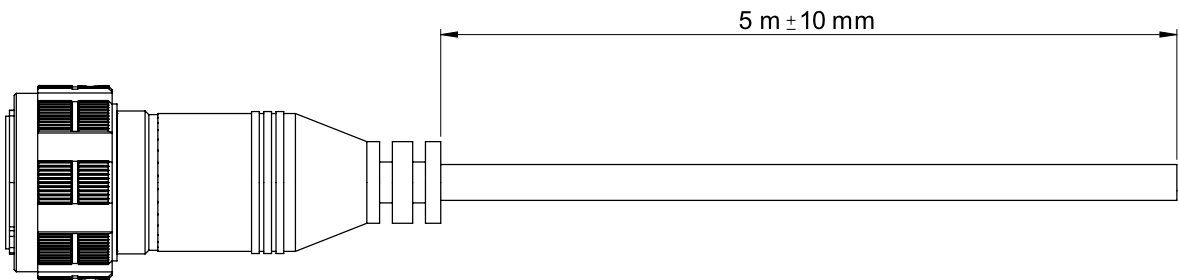
Figure 9: IO Unterminated Cable

Pin	Colour	Function
A	Black	Power Ground
B	Red	Power Supply
C	Orange	1PPS
D	Blue	GPIO1
E	Brown	GPIO2
F		
G	Violet	RS422-TX(+)/RS232-TX PRI
H	Yellow	RS422-RX(+)/RS232-RX PRI
J	White	Serial Ground 1
K	Light Blue	RS422-TX(+)/RS232-TX AUX
L	Light Green	RS422-RX(+)/RS232-RX AUX
M	White/Red Stripe	Serial Ground 3
N	Light Brown/Black Stripe	CAN H
P		
R		
S	Pink	Alert H
T	Pink/Black Stripe	Alert L

Pin	Colour	Function
U		
V	Grey	GPIO Ground 1
W	Grey/Black Stripe	GPIO Ground 2
X	Grey/Red Stripe	GPIO Ground 3
Y	Violet/Black Stripe	RS422-TX(-) PRI
Z	Yellow/Black Stripe	RS422-RX(-) PRI
a	Light Blue/Black Stripe	RS422-TX(-) AUX
b	Light Green/Black Stripe	RS422-RX(-) AUX
c	Light Brown	CAN L
d		
e		
f	Brown/White Stripe	NA
g	Blue/White Stripe	NA
h	White/Black Stripe	Serial Ground 2
j	Orange/Black Stripe	NA

Table 18: Pin Allocation Table

6.6.2 IO Breakout Cable

Advanced Navigation offers a 2 metre long pre-terminated IO cable that is supplied as part of the Boreas **3 Evaluation Kit**. Custom cable lengths are not available for pre-terminated cables.
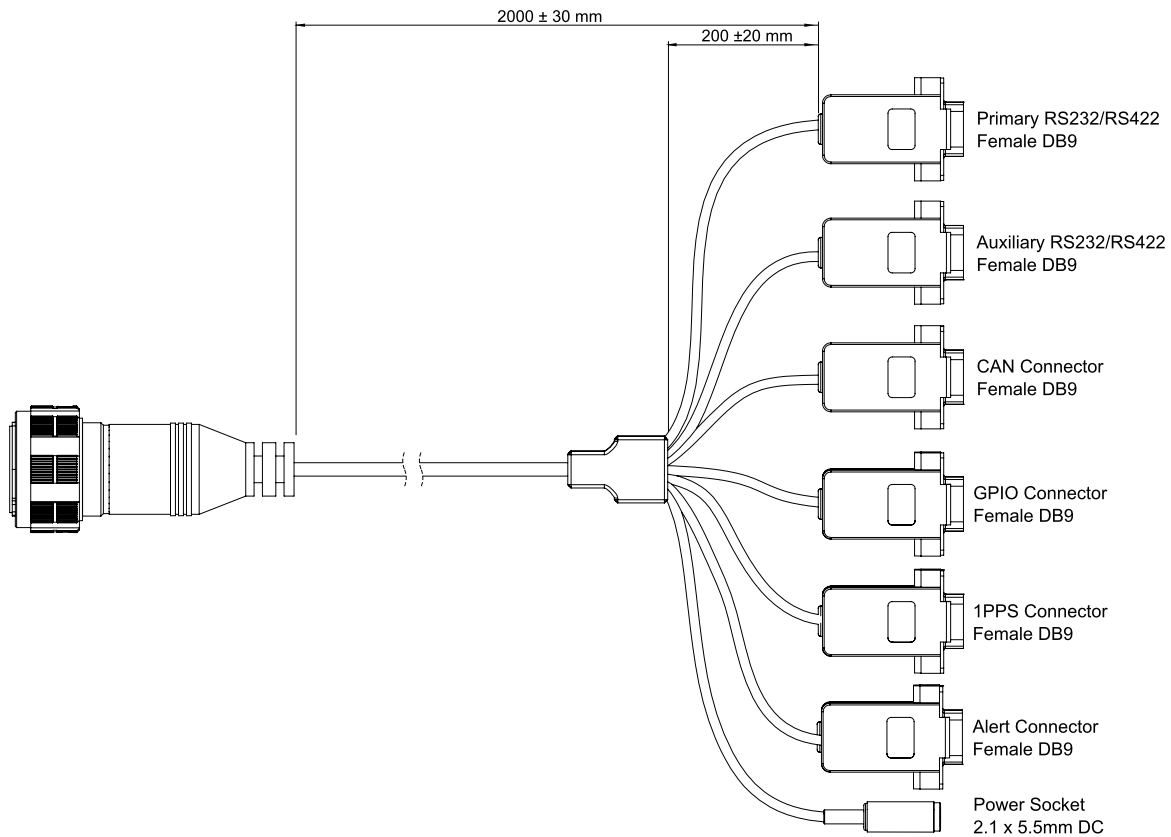
Figure 10: IO Breakout Cable

The IO breakout cable comprises one DC barrel plug for power, and six DB9 connectors that allow connecting to:

- Primary RS232/RS422
- Auxiliary RS232/RS422
- CAN Connector
- GPIO Connector
- 1PPS Connector
- Alert Connector

Given below are details of the IO breakout cable connections.

Pin	Function	Primary	Auxiliary	CAN	GPIO	1PPS	Alert	Power
A	Power Ground							Ring
B	Power Supply							Tip
C	1PPS					2		
D	GPIO1				2			
E	GPIO2				3			
F								
G	RS422-TX (+)/RS232-TX PRI	2						
H	RS422-RX (+)/RS232-RX PRI	3						
J	Serial Ground 1	5						
K	RS422-TX (+)/RS232-TX AUX		2					
L	RS422-RX (+)/RS232-RX AUX		3					
M	Serial Ground 3			6				
N	CAN H			7				
P								
R								
S	Alert H						2	
T	Alert L						3	
U								
V	GPIO Ground 1					5		
W	GPIO Ground 2				5			
X	GPIO Ground 3							
Y	RS422-TX(-) PRI	8						
Z	RS422-RX(-) PRI	7						
a	RS422-TX(-) AUX		8					
b	RS422-RX(-) AUX		7					
c	CAN L			2				
d								
e								
f	NA							

Pin	Function	Primary	Auxiliary	CAN	GPIO	1PPS	Alert	Power
g	NA							
h	Serial Ground 2		5					
j	NA							

Table 19: IO Breakout Cable Connector Pin-out

6.6.3 Custom IO Termination

Whilst it is recommended to use either a breakout cable or an unterminated cable from Advanced Navigation, you can also source and build your own custom IO cable.

A suitable IO MIL-DTL-38999 Series III connector is available from several manufacturers with a variety of different cable boot and strain relief options. The table below specifies suitable example connectors.

Connector	Manufacturer and Series	Part Number	Notes	Finish
TV-CTV MIL-DTL-38999 Series III, Size 19 connector with 32 size 20 contacts	Amphenol	TV O6 ZNCI 19-32 S A F472	Aluminium, Plug with integrated Backshell, Size 19-32 (32 x 20 gauge contacts), Socket contact, A orientation key	Black Zinc Nickel
	Souriau	8DA519Z32SA	Aluminium, Plug with integrated Backshell, Size 19-32 (32 x 20 gauge contacts), Socket contact, A orientation key	

Table 20: Cable Side IO Connector

7 Installing Boreas

To install and quickly get started with Boreas, follow the instructions provided in **7.1 Installation Checklist**

Additional information related to installing Boreas is provided in the following sections:

See	For
7.2 Mounting Boreas	Guidelines for selecting the mounting location for the unit.
7.3 Mounting Alignment	Guidelines on setting the alignment with respect to the vehicle and antennas.
7.4 Cable Bend Radius	Recommendation on the bend radius of Advanced Navigation supplied cables.
7.5 MIL-DTL-38999 Series III Connector Mating	Information on correctly mating a connector
7.6 Power Supply	Recommendations for setting up power supply.
7.7 Electrical Domains	Information on how to minimise interference due to noise.
7.8 GNSS Antennas	Guidelines on how to install GNSS antennas and route cables.
7.9 Networking	Information about changing Boreas to a fixed IP address system after establishing a connection.
7.10 Odometer	Different options using an odometer to improve the navigation and orientation.
7.11 Magnetics	Information on the effects of magnetic interference.
7.12 Vibration	Steps to mitigate the adverse effects of vibration on the performance.

Table 21: Additional Information

Note: For ordering an evaluation kit, a standalone kit or accessories for Boreas, see **5 Part Numbers and Ordering**.

7.1 Installation Checklist

The following checklist provides the basic steps for connecting, mounting and configuring a Boreas unit.

1. Plug the power supply into the power connector on the IO breakout cable and then into the wall socket. See **7.6 Power Supply**.
2. Plug the IO breakout cable into the IO connector on the Boreas unit. See **6.6 IO Connection** and **7.4 Cable Bend Radius**.
3. Connect to Boreas using one of the following methods:
   a. **Ethernet**
      i. Connect either the MIL-DTL-38999 Series III terminated cable or a standard Cat5e Ethernet cable from the Ethernet socket on the Boreas unit to your network or switch.

A standard Ethernet cable will not be IP67 rated, and using the cable may cause damage to the unit due to environmental factors. See **6.5 Ethernet Connection** and **7.4 Cable Bend Radius**

ii. If using Windows, download and install the Bonjour ZeroConf networking utility from the link **https://www.advancednavigation.com/Bonjour64.msi**.

iii. In a web browser, navigate to **http://boreas.local**.

b. **RS232**

i. Connect the USB to RS232 / RS422 adaptor cable to the Primary port and your computer. The factory default setting is RS232. Check that the mode switch is at the correct setting.

ii. **Java 11 is required** to run Boreas Manager. Adoptium JRE 11 is the recommended Java installer to be used on all platforms. Install the latest version of Java 11 from **Adoptium**, selecting the correct operating system and architecture for your computer.

iii. Download Boreas Manager from the **Boreas** product page of the Advanced Navigation website.

> **Note**: Boreas Manager is only available for systems with x64 architecture

iv. Double click Boreas Manager to start the application. See **Using Boreas Manager** for specific notes for different platforms

v. Select the correct COM port.

vi. Select the Baud Rate. The default baud rate is 115200 bps.

vii. Click **Connect**. If you are unable to connect, see **9.2.4 Troubleshooting**.

4. Mount the unit in the standard alignment of X+ pointing forward and Z+ pointing down. For more information, see **7.3 Mounting Alignment**.

5. Mount the two GNSS antennas in a level orientation with a clear view of the sky. The primary antenna should be positioned directly forwards of the secondary antenna with separation of at least 0.5 metres. See **7.8 GNSS Antennas** .

6. Connect the coaxial antenna cables between the antennas and Boreas. The antenna cables should not be coiled.

7. Accurately measure the GNSS antenna offset from the centre of the Boreas unit to the central base of the primary antenna in the body co-ordinate frame (X+ forward and Z+ down, see **12.3 The Body Co-ordinate Frame**) and enter these values into the **9.1.3.3 Alignment** screen under the **Configuration** menu. See **7.8 GNSS Antennas** for more details.

8. Choose a Vehicle Profile in the **9.1.3.1 Filter Options** screen under the **Configuration** menu. This should be the closest available match to your vehicle type. If you need more information, contact Support at support@advancednavigation.com.

9. Check that all filters are initialised. See **8.1 Filter Initialisation**.

The system is now ready for use.

7.2 Mounting Boreas

When installing Boreas into a vehicle, the mounting position and **alignment** of the unit are essential for achieving optimal performance. Position refers to the physical location within the vehicle where the unit is installed while alignment refers to the orientation of the unit with respect to the orientation of the vehicle.

When planning a mounting location for Boreas, be mindful of the following recommendations.

- Mount the unit in an area that will not exceed the rated temperature range, and with minimal temperature fluctuations.

- Mount the unit away from high levels of vibration where possible.

- Mount the unit within several metres of the GNSS antennas where possible.

- Mount close to the centre of gravity of the vehicle where possible.

- Mount the unit at least 10 cm away (and preferably as far as possible) from sources of dynamic magnetic interference such as high current wiring or large motors for best performance.

- Do not obstruct the two vents on the side of the enclosure unless **8.7 Atmospheric Altitude** will be disabled.

Boreas is mounted using the four 4.4 mm diameter mounting holes on the base of the enclosure (see **Figure 11: Bottom View of Boreas Mounting Plate** below for mounting plate and hole guide).
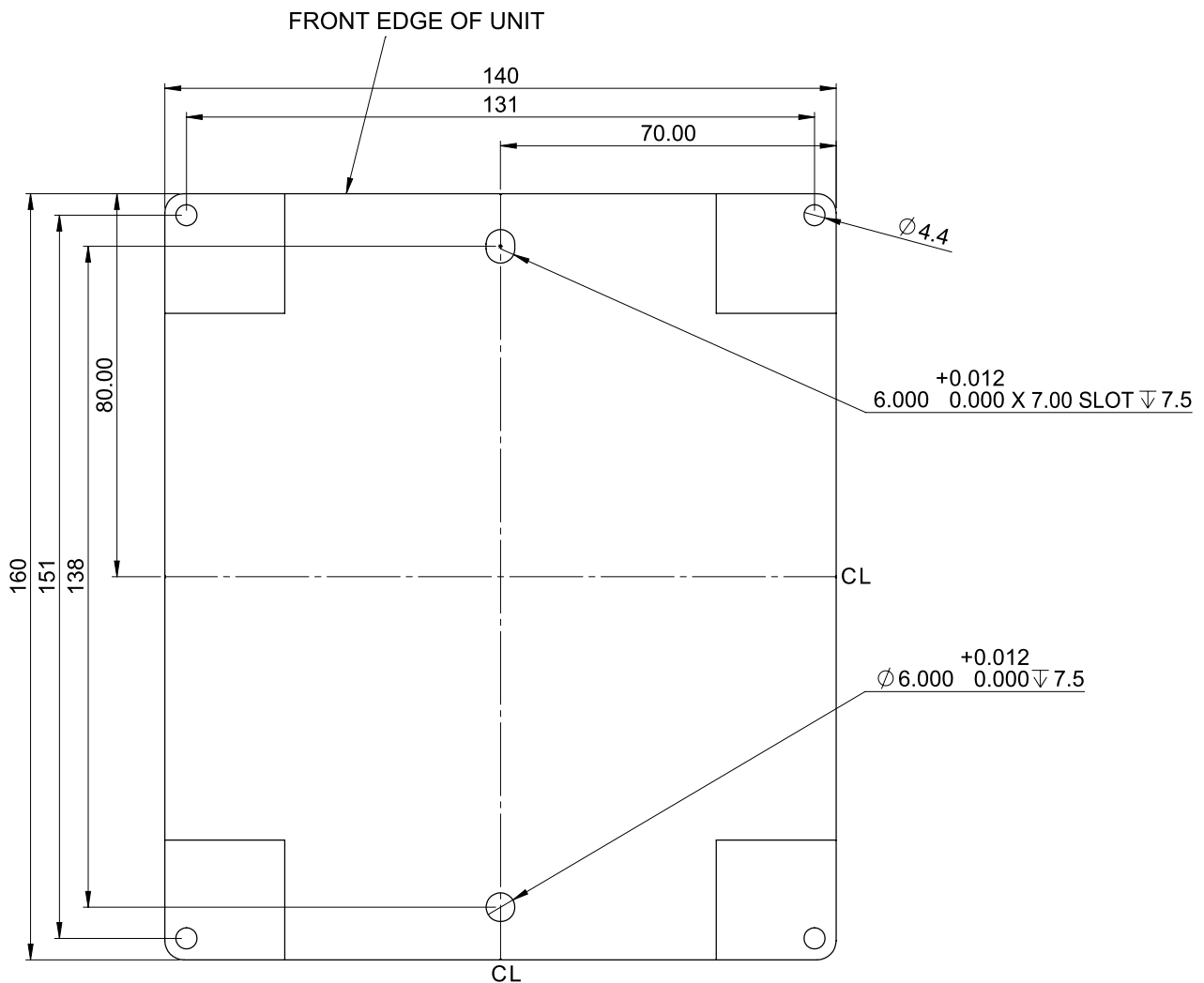
Figure 11: Bottom View of Boreas Mounting Plate

For precision mounting, an alignment hole 6 mm and an alignment slot 6 mm x 7 mm are provided at the middle edge of the enclosure. They are designed for 6 mm dowel pins. Suitable alignment dowel pins based on DIN 6321 are Norelem Locating Pin 02020-206 or equivalent.
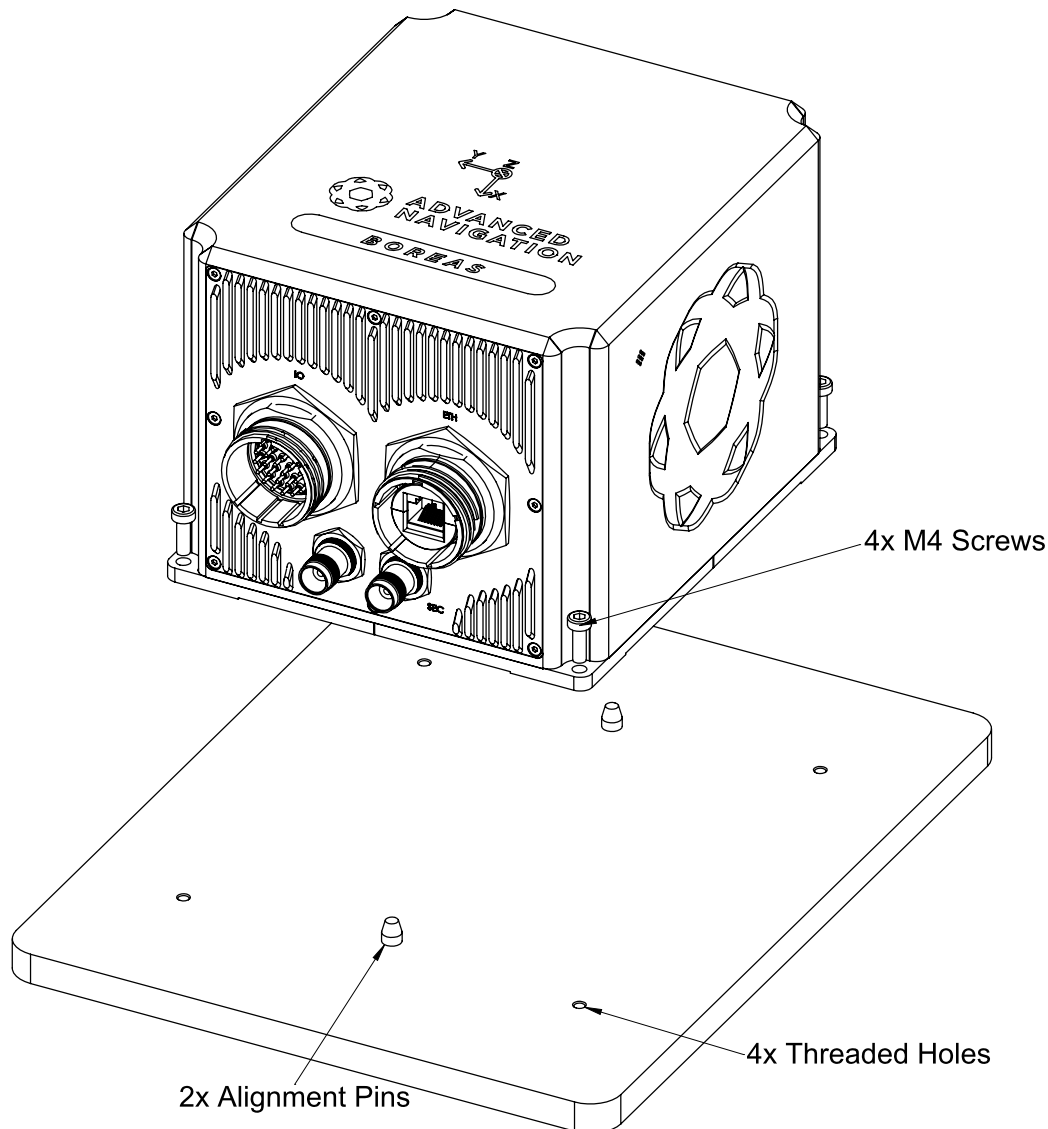
Figure 12: Boreas Mounting Holes and Alignment Pins

It is recommended that M4 stainless steel washers with an outside diameter of 9 mm are used under the bolts. Blue loctite can also be used to prevent the screws from loosening over time.

To ensure precision mounting repeatability,

1. Place the unit in position on the alignment pins and apply gentle pressure in the positive y-axis direction.

2. Install the M4 mounting screws.

3. Tighten the stainless steel bolts in a clockwise direction to a torque of 1 Nm.

For instructions on alignment of the unit within a vehicle, see **7.3 Mounting Alignment**.

7.3 Mounting Alignment

The easiest way to align Boreas is by installing the unit with its sensor axes aligned with the vehicle axes. There are notches marked on the unit to indicate the X and Y axes to assist with alignment.

Install the unit such that the X+ axis points forward towards the front of the vehicle and the Z+ axis points straight down towards the ground as shown below.
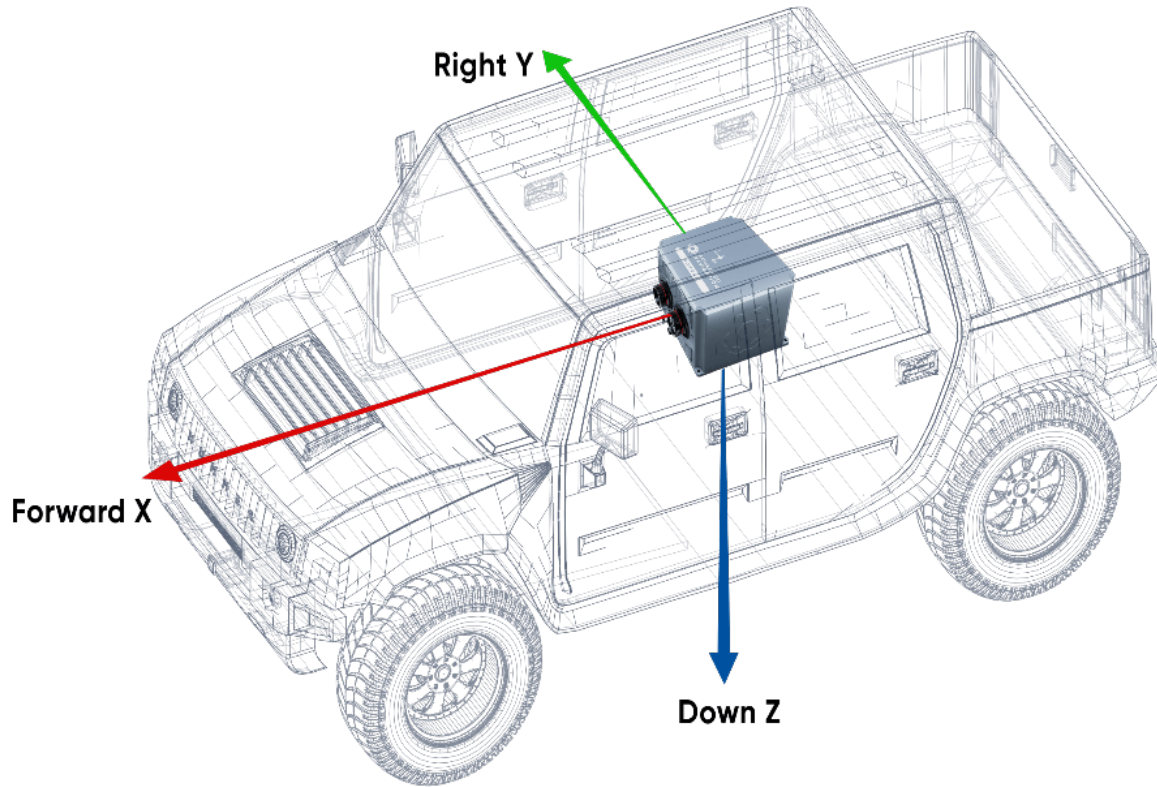
Figure 13: Recommended Mounting Location and Alignment

If aligning Boreas with the vehicle axes is not possible within vehicle size or shape constraints, it may be mounted in a different alignment and the alignment offset can be configured **9.1 Using the Web User Interface** or **9.2 Using Boreas Manager**.

7.4 Cable Bend Radius

During installation, be mindful that cables must not be flexed beyond their specified bending radius. For Advanced Navigation supplied cables, these specifications can be found in **6.2.3 Cable Bend Radius**.

A figure of the bend radius for Advanced Navigation supplied cables is shown below.

Figure 14: Bend Radius Using Advanced Navigation Supplied Cables

For space-constrained applications, it may be necessary to use single-insulated wires with a customer-supplied plug.

See **7.8 GNSS Antennas** for information about the bend radius of antenna cables.

7.5 MIL-DTL-38999 Series III Connector Mating

In order to maintain proper ingress protection, it is important that a proper connection is made to the MIL-DTL-38999 Series III IO and Ethernet connectors.

Figure 15: Unmated Connector

Figure 16: Correctly Mated Connector

The connector should be mated using its correct keying position and orientation. The screw thread should be tightened to fully mated position. If using an Advanced Navigation supplied cable, a visible red band indicates that the connector is not mated correctly. See **8.17 Environmental Exposure**

7.6 Power Supply

A high level of power supply filtering has been built into Boreas to allow for reliable operation in demanding environments. However, a power supply with low noise and ripple levels, and adequate transient response is still recommended. Boreas contains a fully isolated power supply and has separate grounds for power and signals to ensure that power supply noise does not corrupt communications or cause ground loops with other equipment. See **7.7 Electrical Domains** for more details about isolation.

The power supply must be able to reliably provide the maximum current at the chosen voltage, especially in systems with substantial load variations. Make sure that all system components are rated (including safety factors) for the anticipated environmental operating conditions and stressors of the system. Refer to section **6.2 Hardware Specifications** for further information.

Boreas contains an active protection circuit on the power supply input that protects the unit from under-voltage, over-voltage and reverse polarity events. It is recommended to always operate the unit at a voltage higher than the minimum mentioned in the Boreas **6.4 Electrical Specifications**. Take caution when using a supply voltage close to the minimum voltage as minor voltage fluctuations could trigger under-voltage protection, leading to unexpected oscillations between the on and off states.

7.7 Electrical Domains

Boreas contains separate electrically isolated domains. Each domain is isolated from the others to minimise noise injection and avoid ground loops. Where possible, this isolation should be preserved by externally connected devices. We recommend connecting the enclosure to your vehicle ground where possible for the best electrical noise performance.

Domain Name	Affected Components and Ports
Chassis	Enclosure, GNSS receiver, GNSS antennas
Power	Power Supply
Serial	Primary port, Auxiliary port, CAN port
GPIO	GPIO 1 port, GPIO 2 port, 1PPS port
Ethernet	Ethernet port

Table 22: Boreas Electrical Domains

7.8 GNSS Antennas

The GNSS antennas should be installed level with respect to each other, with a clear unobstructed view of the sky, away from reflective surfaces and with the shortest cable run to the Boreas unit permitted by the application. The antennas should be mounted away from any RF emitters such as radars, high‑powered communication links, etc. It is important to have a ground plane (flat conductive surface such as a piece of plate aluminium) under the antenna with a minimum radius of 60mm or as recommended by the antenna supplier. Correct antenna positioning is critical for Boreas's dual-antenna heading function.

The primary GNSS antenna position offset should be configured in the Boreas unit by using the Alignment page in the web UI or Boreas Manager. See **9.1 Using the Web User Interface** or **9.2 Using Boreas Manager**.The antenna offset is measured from the physical centre of the Boreas unit to the central base (ARP) of the primary GNSS antenna in the body co-ordinate frame (X+ forward, Z+ down).

Note: The Z axis is positive downwards, mounting the antenna above the Boreas unit will require a negative Z offset. It is very important to set this antenna offset accurately as Boreas corrects for lever arm velocities. An incorrect GNSS antenna offset will lead to performance degradation under turning and angular rotations.

An example installation with the body co-ordinate frame axes marked is shown below in Boreas antenna offset isometric view and Boreas antenna offset front view. In this installation below with an antenna mounted on the right-hand side of the vehicle roof, further forward from the Boreas unit, there would be a positive X antenna offset value, a positive Y antenna offset value and a negative Z offset value.
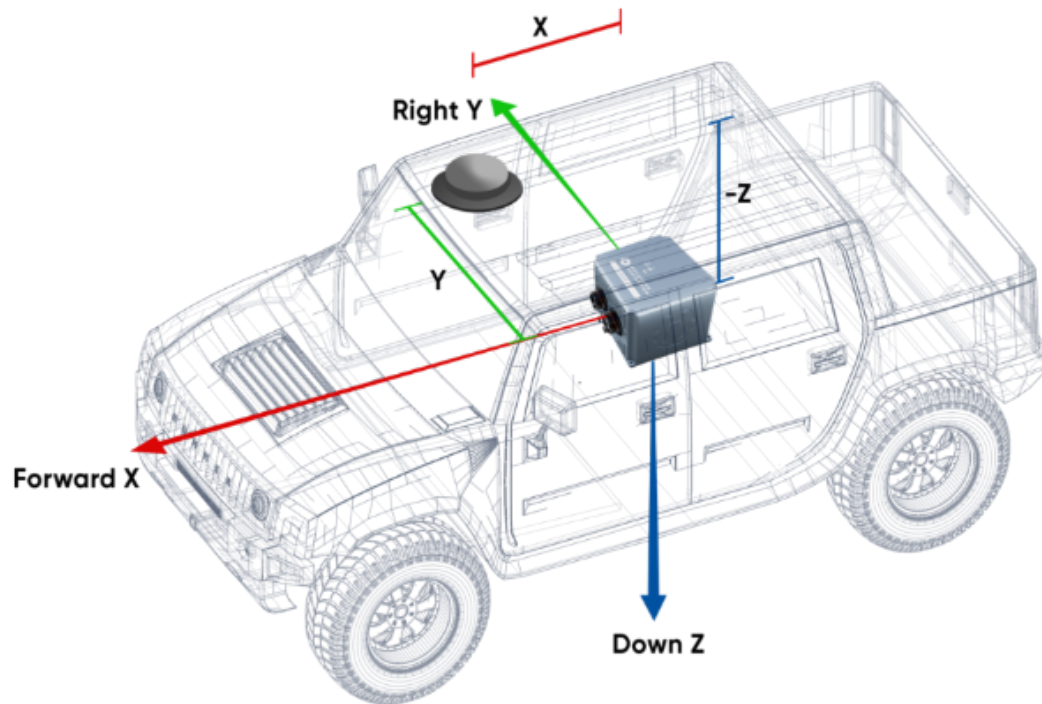
Figure 17: Antenna Offset Isometric View
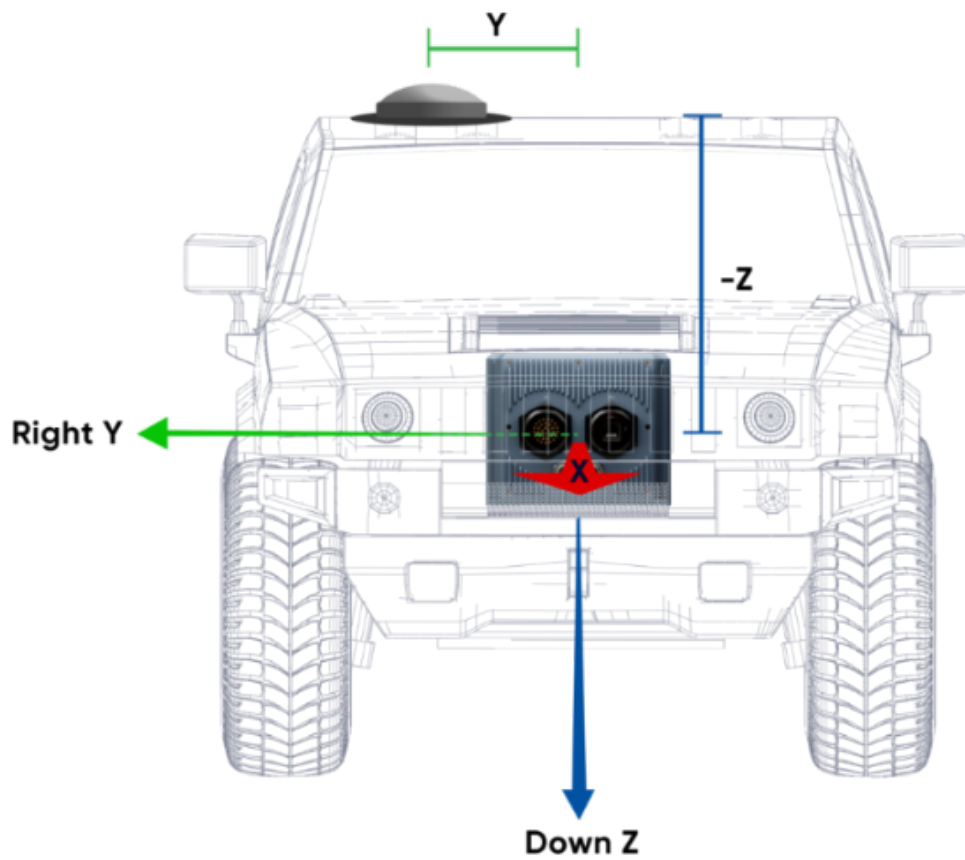
Figure 18: Antenna Offset Front View

The secondary antenna should be mounted behind the primary antenna with as much separation as possible, and in line with the long axis of the vehicle, in the direction of travel, with as much separation as practically possible. The heading accuracy can be improved by increasing the antenna separation. See **6.1.1 Dual Antenna Heading Accuracy** specifications.

If GNSS signals are interrupted resulting in the loss of the dual antenna heading, the accuracy of the heading will gradually degrade to 0.01° secant latitude over a period of time, depending upon the motion of the vehicle and other conditions.

If it is impractical to mount the secondary antenna directly behind the primary antenna due to physical constraints, it can be mounted in another position. In this case the secondary antenna configuration must be entered into the Dual Antenna page in the web UI or Boreas Manager. See **9.1 Using the Web User Interface** or **9.2 Using Boreas Manager**.
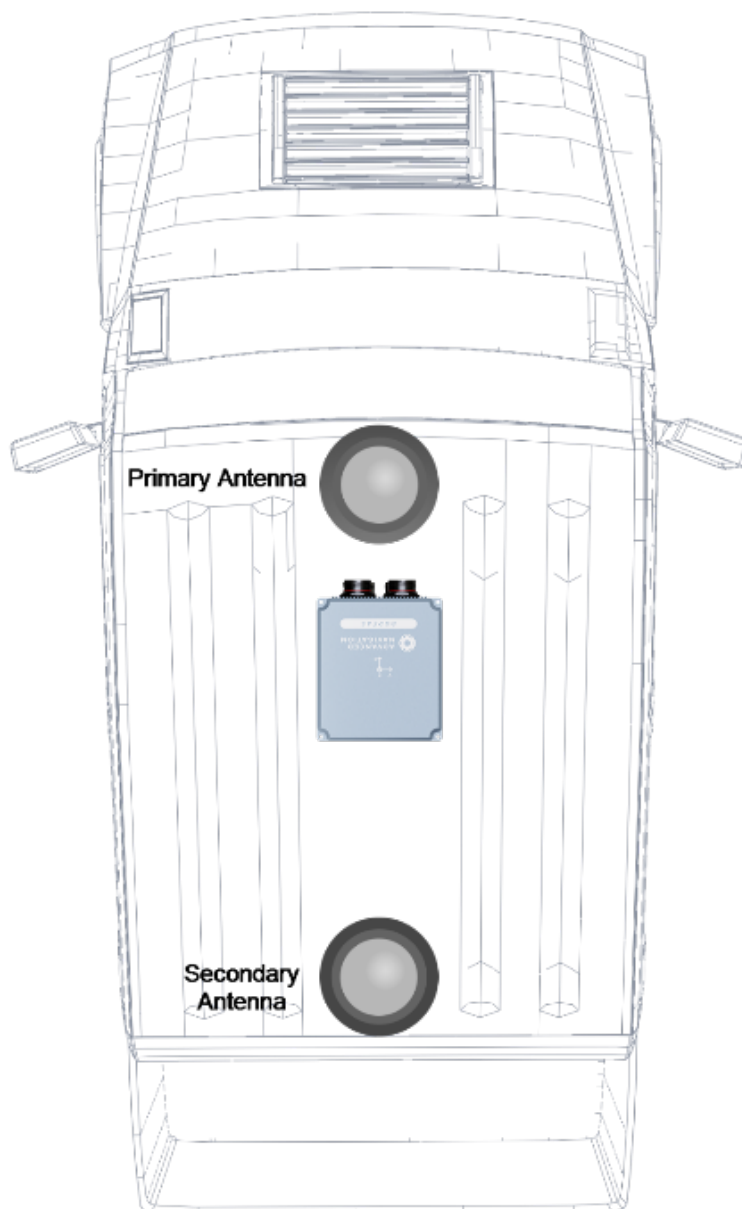
Figure 19: Recommended Second Antenna Placement

The standard antennas supplied in the Boreas Evaluation Kit are the VeroStar VSP6337L. They are an L1/L2/L5 RTK antenna that support GPS, GLONASS, BeiDou, Galileo, and SBAS. They are environmentally sealed to the IP69k standard.

If you are sourcing your own antennas, note the following antenna guidelines:

- The antenna should be capable of receiving both L1 and L2. Heading performance will be significantly degraded with an L1-only antenna.

- Active antennas should have sufficient LNA gain, which when accounting for cable losses, provides at least 33 dB of gain at the connector of the unit.

- The antenna needs to have an accurate phase centre to be RTK capable. This is also required for the dual antenna heading to function correctly. Low performance (low cost) antennas are typically not able to achieve good heading performance.

- The antenna should support GPS, GLONASS, BeiDou, and Galileo.

- The antenna should be environmentally sealed, including connectors.

7.8.1 Antenna Cables

The antenna cables should be routed away from powerful RF emitters, high current wiring, high temperatures and any rotating or reciprocating machinery. It is very important not to bend the antenna cable tighter than its minimum bend radius, or to allow it to be dented. It is recommended to use wide cable ties, loosely fixed in order to avoid damaging the insulation or shielding. The cables should not be coiled. Advanced Navigation recommends:

- Keeping the antenna cables the same length, and as short as possible.

- Using either RG58 low loss or LMR240 coaxial cable combined with high quality connectors. LMR300 and LMR400 can also be used to minimise loss for very long antenna cables.

Cable Type	Minimum Bend Radius	Signal Loss
RG-58/U Low Loss	20 mm	~0.92 dB/m
LMR240	20 mm	~0.33 dB/m
LMR300	22.2 mm	~0.26 dB/m
LMR400	25.4 mm	~0.17 dB/m

Table 23: GNSS antenna co-axial cable properties

The Boreas end of the antenna cables must have standard male TNC connectors.

If you are sourcing your own antenna cables it is important to ensure that the antenna has enough gain to support the signal loss over the cable. Boreas requires a minimum of 33 dB of gain at the connector. With the standard 4 metre RG-58A/U antenna cables supplied by Advanced Navigation, the minimum antenna gain required is 36.5 dB.

7.8.2 Antenna Suction Cup Mount

A suction cup mount can be used when antennas need to be mounted at any angle or on a smooth, non-porous surface such as a window or on vehicles with aluminium or fibreglass bodies. A suction cup mount can be attached and removed quickly and can easily be moved from one location to another. See **5.4 Accessories**.

7.8.3 Antcom Antenna Survey Mount Assembly

If using the optional Antcom G5ANT-53A4T1 antenna, mount it to a panel or mount to a standard 5/8"-11 survey mount with the included survey mount kit. See the figure below for assembly of each antenna with the survey mount kit.

Note: The ground planes are not optional.
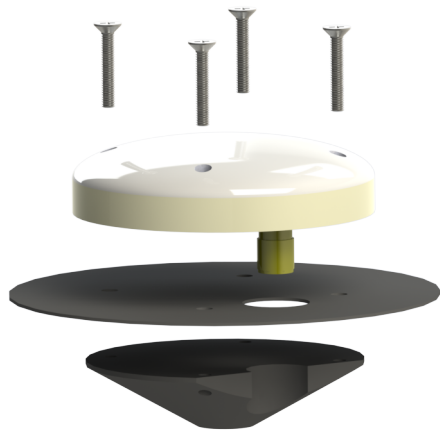
Figure 20: Antenna Survey Mount

7.9 Networking

The default configuration for Boreas is for the DHCP Client to be Enabled. This makes it a plug-and-play solution for most users. It is possible to change Boreas to a fixed IP address system once a connection has been established.

Boreas supports the Zero Configuration (Zeroconf) networking feature. On Linux and MacOS systems no additional software is required. If you are using Microsoft Windows, install the Apple Bonjour software from **https://www.advancednavigation.com/Bonjour64.msi** if it's not already installed. Open a web browser and type in the address **http://boreas.local/** to discover the device and access the web interface.

If you cannot establish a connection using a DHCP-capable network, you can connect to and configure the Boreas using the Primary port RS232 serial interface and the Boreas Manager application.

Note: A factory reset will re-enable the DHCP Client and lose any static IP address settings.

7.10 Odometer

On ground vehicles, the use of an odometer input will greatly improve the Boreas navigation and orientation solution during GNSS outages.

There are several different options for odometer that are explained as follows.

7.10.1 Factory VSS Signal

Most mass-market vehicles since 1980 contain a VSS (vehicle speed sensor) signal that can be wired directly into one of the Boreas GPIO pins. Any voltage limits on this pin that must be taken into consideration.

To set up the odometer, the appropriate GPIO pin should be set to Odometer Input using Boreas Manager. The odometer pulse length must then be set either manually or automatically, see **8.8 Odometer Pulse Length** for more information.

For more information on the GPIO signals and their requirements see **10.6 GPIO Pins and the Auxiliary Port**.

7.10.2 OBDII Odometer Interface

For applications where it is undesirable to modify the vehicle or the system needs to be used with multiple vehicles, the OBDII odometer interface may be a better solution. OBDII is a vehicle diagnostic port standard and most vehicles from the mid 1990s onwards contain an OBDII port in the drivers side foot well. Advanced Navigation produces an inexpensive OBDII Odometer Interface that plugs into this OBDII port and feeds Boreas with odometer data over the Auxiliary RS232 port. See the figure below. Contact the Advanced Navigation sales team at **sales@advancednavigation.com** for more information.

Figure 21: Advanced Navigation OBDII Odometer

7.10.3 Aftermarket Wheel Speed Sensor

Applications requiring very high performance without GNSS for any length of time are recommended to use a high precision aftermarket wheel speed sensor. Advanced Navigation recommends aftermarket wheel speed sensors from Kistler, Pegasem or GMH Engineering.

Figure 22: Aftermarket Wheel Speed Sensor

7.10.4 Radar Speed Sensor

For applications requiring high performance in harsh conditions where aftermarket wheel speed sensors are not feasible, a radar speed sensor is recommended. Advanced Navigation recommends radar speed sensors from Stalker or GMH Engineering.

Figure 23: Radar Speed Sensor

7.11 Magnetics

Boreas uses FOG sensors to calculate heading; therefore, its heading is not corrupted by stray and changing magnetic fields. However, FOG sensors can still be affected by magnetic fields, which are strong and in close proximity. It is recommended that Boreas is not mounted directly on or closely adjacent to electric motors, solenoids and high current pulsed wiring. Magnetic Fields stronger than 2 Gauss at the surface of the unit will effect performance.

7.12 Vibration

Boreas is able to tolerate a high level of vibration compared to other inertial systems. This is due to a unique gyroscope design and a special filtering algorithm among other things. There is, however, a limit to the amount of vibration that a unit can tolerate — temporary degradation in accuracy may occur while operating under high vibration.

When mounting Boreas to a platform with vibration present, there are several options to mitigate the negative performance effects. It is recommended to conduct a brief operating check to confirm performance is within specification before conducting longer runs. The Raw Sensor view in the web UI or Boreas Manager can give you a good idea of how bad the vibrations are.

If there are persistent issues:

- Try to find a mounting point with less vibration.
- Mount Boreas to a plate which is then mounted to the platform through vibration isolation mounts. Be mindful that a plate with very soft mounts may also cause problems with shifts in orientation over time.

8 Using Boreas

This section covers the following topics:

8.1 Filter Initialisation

There are four different levels of filter initialisation on Boreas. These are orientation, navigation, heading and time.

The initialisation of each can be monitored by inspecting the **9.1.2.4 Status** view in the web UI or **9.2.6 View Menu** in the Boreas Manager.

Initialisation

🟢 Orientation

🟢 Navigation

🟢 Heading

🟢 Time
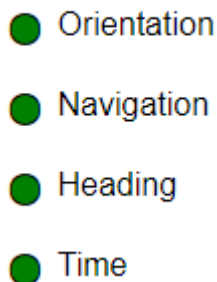
Figure 24: Initialisation Levels

After all four levels of initialisation, the Boreas INS filter takes several minutes to achieve its full accuracy. It is recommended to wait two minutes after initialisation for applications requiring high accuracy.

8.1.1 Orientation Initialisation

Orientation initialisation occurs automatically upon power on and typically completes within seconds. To determine its orientation it uses the accelerometers to measure the gravity vector. Random accelerations from environmental sources can disturb this process, which can introduce minor orientation errors that will be corrected within several seconds. To prevent this, Boreas monitors the accelerometers and gyroscopes and restarts the orientation detection if there are sudden movements. It is however still possible under some circumstances for it to miss minor movements and start with a small orientation error. Boreas will progressively correct the orientation error over a period of several seconds.

Once orientation initialisation is complete, the roll, pitch and angular velocity values will be valid.

8.1.2 Navigation Initialisation

Navigation initialisation completes once the system has determined a starting absolute position. The most common method of navigation initialisation is for the system to get a 3D GNSS fix or better. If the system is hot-starting it will remember its position at the time it was switched off and use this as the starting position. The other possibility for navigation initialisation is an external position source to be used, see **11.4.25 External Position Packet** for more information. In a situation where a GNSS fix is not available to initialise navigation, it can be initialised manually by entering a position into the **9.1.3.9 Manual Initialisation** page in the web UI or the **9.2.7.11 Manual Initialisation** dialogue in the Boreas Manager.

Once navigation initialisation is complete, the position, velocity and acceleration values will be valid.

8.1.3 Heading Initialisation

Heading initialisation completes once the system has determined a heading using one of its several methods. The conditions required to determine a heading depend upon the heading source being used, see **8.4 Heading Sources**. The default heading source is dual antenna, which will initialise the heading to a high accuracy within several minutes of power on assuming that both antennas are connected with an unobstructed view of the sky.

The system can be stationary or moving during this initialisation. If velocity heading is enabled and the vehicle is moving, this will be very fast. If the system hot-starts, the last known heading value will be used. However, in order for the Heading Filter to initialise, the system must have a valid heading source.

Until the heading has been initialised, the system will not be able to navigate without a GNSS fix, and the roll and pitch values will not reach full accuracy.

8.1.4 Time Initialisation

Time initialisation completes once the system has determined time accurately. This occurs as soon as the GNSS receiver obtains its first fix. For this to occur the system must receive rough time as well as a 1PPS signal on one of the GPIO pins. It is also possible to acquire time from an external source, see **11.4.31 External Time Packet** for more information.

Until the time has initialised, the Unix or formatted time that Boreas outputs will be flagged as invalid.

8.2 Hot Start

Advanced Navigation devices were the first on the market with hot-start functionality. This hot-start functionality allows Boreas to start inertial navigation within 500 ms to 2s , and obtain a GNSS fix in as little as 2 seconds, The hot-start functionality is always on and fully automatic. See **6.1 Navigation Specifications** for details.

A next generation backup battery system within Boreas provides the hot-start ability for more than 48 hours without power. When Boreas hot-starts, it assumes that it is in the same state it was when it lost power and begins navigating from that position. The hot-start also provides ephemeris, almanac and time information to the GNSS receiver which allows it to achieve a GNSS fix far more quickly than it otherwise could. When the GNSS achieves its first fix, Boreas will jump to the new position without disturbing the filter.

Whenever Boreas is without power it continues to accurately keep time so that it is immediately valid for a hot-start.

The hot-start functionality is of particular benefit to vehicle tracking and robotics applications. The primary benefits are immunity and fast recovery from power failure as well as fast start up time.

8.3 Time

Boreas has been designed to provide a highly accurate time reference. It contains a temperature compensated disciplined oscillator that corrects itself very precisely using GNSS time. When a GNSS fix is available, the Boreas time is accurate to within 20 nanoseconds.

When the GNSS fix is lost, the Boreas time will slowly lose accuracy at a rate of approximately 3 microseconds per hour.

If greater accuracy is required for your application, Advanced Navigation may be able to offer Boreas with a temperature compensated disciplined oscillator that has greater time accuracy than 20 nanoseconds and less than 3 µs/hr of drift. Contact Advanced Navigation's sales department at sales@advancednavigation.com for more information.

When Boreas hot-starts the time accuracy is typically within 1-2 seconds immediately on startup and corrected to within 50 nanoseconds as soon as a GNSS fix is achieved.

The time can be accessed via the following means:

- A dedicated **10.3 1PPS Signal**. This is the preferred means to obtaining the most accurate timing output.

- A 1PPS output over GPIO or the Auxiliary port, see **10.6.1.2 1PPS Output** of the Dynamic Pin Functions.

- A built-in Precision Time Protocol (PTP) version 2 server for synchronisation with network-connected devices which require high accuracy time. The PTP server broadcasts PTP messages (Sync, Follow Up, Announce) to multicast IP address 224.0.1.129. The PTP broadcasts are sent whenever an Ethernet connection is established and cannot be disabled.

- A built-in Network Time Protocol (NTP) server.

8.4 Heading Sources

There are several different heading sources available for Boreas. The heading sources can be configured using the **Filter Options** page in the Web UI (see **9.1 Using the Web User Interface**) or in the Manager application (see **9.2 Using Boreas Manager**). It is possible to use multiple heading sources and this can provide performance benefits.

8.4.1 North Seeking Gyrocompass Heading

Boreas contains high accuracy gyroscopes allowing it to detect the rotation of Earth to determine North with a high degree of accuracy. Gyrocompass heading is fully automatic and always enabled.

Coarse alignment takes two minutes to complete, during which time some movement is acceptable, however it is best to keep the unit as stationary as possible. The **9.1.2.12 Coarse Heading Alignment** Status dialogue in the Web UI provides feedback on the initialisation process.

Fine alignment will occur after coarse alignment is complete. Fine alignment is automatic, and the time taken to reach full accuracy will depend upon operating conditions. Some movement, ideally including 90 degree turns will speed up the time required to reach full accuracy.

For all applications, the gyrocompass heading requires an approximate position that is within a 50 km range. The position can come from the GNSS, **9.1.3.9 Manual Initialisation**, or the last good position that is stored in flash memory.

8.4.2 Dual Antenna Heading

This is the default heading source and provides the most accurate heading while GNSS is available. Dual antenna heading only works when a good GNSS fix is available to both antennas. It requires a clear view of the sky with minimal nearby sources of interference or multipath. The greater the antenna separation, the higher the accuracy (see **6.1.1 Dual Antenna Heading Accuracy**). A minimum antenna separation of 0.5 metres is required.

Boreas will operate with a single primary antenna connected, but this will prevent dual-antenna heading being used, although velocity heading will still be possible.

8.4.3 Velocity Heading

Velocity heading works by deriving heading from the direction of velocity and acceleration. Velocity heading works well with cars, fixed wing aircraft and other vehicles that don't move sideways. Velocity heading cannot work for helicopters and other vehicles where the vehicle is pointed somewhere other than the direction of travel. Velocity heading requires a horizontal speed of over 1.15 m/s with a GNSS fix. Velocity heading is disabled by default.

8.4.4 External Heading

This can be used if there is some other way to derive heading that is external to Boreas. The heading must be supplied to Boreas using the **11.4.28 External Heading Packet** or an NMEA message, see **10.6.1.28 NMEA Input**.

8.4.5 External Magnetometers Packet

Heading can derived using the magnetometers of an additional external Advanced Navigation product to input external magnetometer values. See **External Magnetometers Packet** for details.

8.5 Data Anti-aliasing

Internally the Boreas filters update at 1,000 Hz. When Boreas outputs data, most applications require the data at a much lower rate (typically less than 100 Hz). This causes a problem for time-based data such as velocities and accelerations where aliasing will occur at the lower rate. To prevent this problem, if the output rate is lower than 1000 Hz, Boreas will low-pass filter the values of the time dependent data between packets to prevent aliasing. This is only the case when a packet is set up to output at a certain rate. If the packet is simply requested, no anti-aliasing will occur. Additionally there is no anti-aliasing for non time-dependent fields such as position.

8.6 Vehicle Profiles

Boreas supports a number of different pre-configured vehicle profiles. These vehicle profiles impose constraints upon the filter to increase performance. If your application matches one of the available vehicle profiles, it is required that you select it for use in the **Filter Options** page in the Web UI or Boreas Manager. For a list of the different vehicle profiles, see **11.5.5.1 Vehicle Types**. If the wrong vehicle profile is selected, it can cause a significant decrease in performance. It is recommended to Reset the unit after changing vehicle profiles to ensure that any relevant setting are updated in the GNSS receiver.

8.7 Atmospheric Altitude

Boreas contains an internal atmospheric pressure sensor. This is used as an altitude aid in the filter. If Boreas is mounted in an area subject to unusual pressure waves, for example helicopters, or is mounted inside an enclosure that is not exposed to atmospheric pressure, the pressure sensor input should be disabled. This can be done by disabling Atmospheric Altitude in the **9.1.3.1 Filter Options** page in the web UI or the **9.2.7.2 Filter Options** dialogue in the Boreas Manager.

8.8 Odometer Pulse Length

For Boreas to use a wheel speed sensor or odometer input, it must know the pulse length of the signal. The pulse length is the distance in metres between low to high transitions of the signal. By default, the odometer will automatically calibrate itself. To automatically calibrate the odometer pulse length, see **8.8.1 Calibrating Odometer Automatic Pulse Length**.

8.8.1 Calibrating Odometer Automatic Pulse Length

1. Ensure that the signal is connected correctly and that the GPIO pin is configured as an odometer input using the **9.1.3.5 GPIO** page in the web UI or the **9.2.7.6 GPIO** dialogue in the Boreas Manager.

2. Open Boreas Manager, connect to Boreas and open the Odometer Configuration dialogue. In the **Odometer Configuration** dialogue select the **Automatic pulse length calibration** check box and click **Save**.

3. Wait until Boreas has a continuous GNSS fix and then conduct the test in an area with no obstructions over the test circuit.

4. If Boreas loses a GNSS fix for any extended period of time during the calibration, the distance travelled will be reset. The distance travelled can be checked in the Odometer Configuration dialogue to ensure that it has passed 1,000 metres.

5. Once 1000 metres has been driven, check that the automatic pulse length check box has become unticked and the Pulse Length value has changed. This indicates a successfully completed calibration.

Note: To enter the pulse length manually, use the **Odometer** page in the Configuration menu in the **Boreas Manager**.

8.9 Reversing Detection

Reversing detection is an algorithm that can detect when the vehicle is travelling backwards. Knowledge of reverse motion is important when using velocity heading or odometer input to provide correct results. If Boreas is fitted to a vehicle that does not reverse or doesn't use velocity heading or an odometer, this function should be disabled. Reversing detection is enabled by default and it can be disabled using the Filter Options page in the web UI or Boreas Manager. See **9.1 Using the Web User Interface** or **9.2 Using Boreas Manager**.

8.10 Motion Analysis

Motion analysis is an artificial intelligence algorithm that associates patterns in high frequency inertial data with the speed of the vehicle. After power on it takes some time to match patterns with speed before it will become active. Motion analysis only activates when dead reckoning and is most effective when the vehicle is near stationary. Motion analysis does not work in all situations and its primary benefit is for ground vehicles. It should be enabled in any car application. Motion analysis is enabled by default and can be disabled using the **9.1.3.1 Filter Options** page in the web UI or the **9.2.7.2 Filter Options** dialogue in the Boreas Manager.

8.11 RTK

The Boreas internal GNSS receiver supports RTK GNSS which uses correction data (RTCM messages) from a nearby base station to provide accuracy of up to 0.01 m in real time. An RTK system requires additional infrastructure equipment to generate and receive corrections data, and is not practical for all applications. Customers who require this level of accuracy but do not need it in real time should consider using **Kinematica**.

There are two different methods for receiving RTK corrections:

- Network
- Radio modem

For applications where Boreas can achieve internet access, network RTK corrections (NTRIP) are recommended.

For applications that are unable to access the internet, radio modems can be used to communicate between Boreas and the base station, see **8.11 RTK**.

> **Note**: If you do not need high accuracy positioning in real time, for example if you are planning to use Kinematica to post-process log files, an RTK system may not be necessary at all.

8.11.1 Network RTK Corrections (NTRIP)

NTRIP can be configured in three ways:

1. Using the Boreas Web UI **9.1.3.12 NTRIP Client** in the Configuration Menu.
2. Using the Boreas Manager application, select **9.2.8.5 NTRIP Client** under the Tools menu.
3. Using the Spatial Manager for Android application. This is convenient for field testing or when temporary RTK corrections are required, for example for performance trials. Download from the **Google Play** store.

Any of these NTRIP clients can connect to a network RTK service to stream RTK corrections to Boreas. This requires that the client is connected to the internet, and a valid subscription with a local network RTK service. Contact **Support** if you need assistance in setting up for network RTK corrections.

8.11.2 Radio Modem RTK Corrections

Figure 25: Trimble R4 Base Station

Figure 26: Trimble TDL 450L Radio Modem

Base station radio modem RTK corrections require both a base station and a radio modem receiver. The base station is set up at a fixed location and transmits corrections to the radio modem receiver that is connected to the mobile Boreas unit (the "rover"). The radio modem receiver and Boreas unit must remain within radio range of the base station to receive these corrections. The base station should be located no more than 50 km from the Boreas, and ideally closer. Advanced Navigation recommends contacting a local surveying company for assistance setting up a base station.

8.11.3 Supported RTCM Messages

The internal GNSS receiver in Boreas supports receiving the following RTCM v3 messages.

Message Number		
1002	1010	1045
1004	1012	MSM4

Message Number		
1005	1019	MSM5
1006	1020	MSM6
1007	1033	MSM7
1008	1044	

Table 24: Supported RTCM v3 messages

8.12 Raw Satellite Data

Boreas supports the output of raw satellite data. This data can be used by post-processing software to achieve high-accuracy kinematic positioning.

The maximum output rate for raw satellite data is 20 Hz, subject to the **9.1.3.15 GNSS Configuration**.

It can be enabled by turning on the **11.4.37 Raw Satellite Data Packet** (ID 60) in the **9.1.3.2 Data Ports** page in the Web UI, or via the Packet Rates dialog in the **Configuration** menu of the Boreas Manager, see the figure below.

This packet will be automatically converted to RINEX v3.02 by the **9.2.8.4 Log Converter** utility in the **Tools** menu of the Boreas Manager.
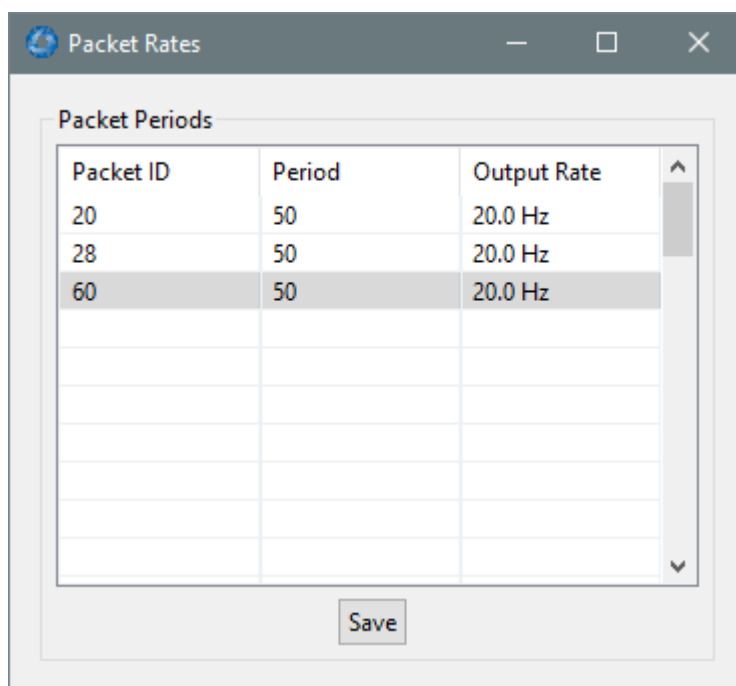
Figure 27: Enabling Packet 60

8.13 Kinematica Post Processing

Boreas can be used with Advanced Navigation's post-processing platform Kinematica to achieve high-accuracy positioning of as low as 10 mm and significantly improved dead reckoning performance. You need to record a ANPP-format log file with certain packets enabled.

Refer to the Kinematica documentation found at **www.advancednavigation.com/solutions/kinematica** for details.

8.14 Vents

Boreas contains a sophisticated venting system that allows it to measure air pressure whilst preventing water ingress. There are two sets of vent holes on either side of the enclosure. It is very important that these remain clear of debris and blockages. Should debris get into the vents they should be gently rinsed with fresh water. Foreign bodies should never be poked into the vent holes, as this will break the environmental seal and void the warranty on the unit. The vents are not resistance to high-pressure jet washing or to waves. Do not direct streams of water directly at the unit.

8.15 RAIM

RAIM stands for Receiver Autonomous Integrity Monitoring. It allows a GNSS receiver to detect and exclude both faulty and fraudulent satellite signals. The Boreas internal GNSS receiver is equipped with RAIM and it is enabled by default.

An improved class of RAIM, Fault Detection and Exclusion (FDE), is used in some GNSS receivers. The objective of FDE is to detect positioning failure and exclude the source of failure; however, it may not identify the specific source. FDE uses a minimum of six satellites to detect and exclude a possible faulty satellite from the navigation solution to ensure that the navigation function remains uninterrupted.

The availability of RAIM and FDE might be slightly lower for mid-latitude operations and slightly higher for equatorial and high-latitude regions because of the nature of the orbits. The availability of RAIM and FDE can be enhanced by using satellites from multiple GNSS constellations or using SBAS satellites as additional ranging sources.

8.16 Heave

Boreas can provide vertical heave position at four different points on a ship. The Boreas heave filter is always on and fully automatic. After power on, Boreas requires approximately 5 minutes for its heave filter to converge upon an accurate solution. Heave works without a GNSS fix, however best heave performance is achieved when Boreas has a GNSS fix .

By default Boreas provides heave from the point at which the Boreas unit is mounted, however it can provide heave at four different offset points on the ship. To configure Heave, see the **9.1.3.8 Reference Point Offsets** page in the web UI or use the **9.2.7.9 Reference Position Offsets** dialogue in the Boreas Manager.

8.17 Environmental Exposure

Whilst Boreas is environmentally protected, there are limits to this protection that must be observed to avoid damaging the device.

Boreas is only IP67-protected when its connectors are mated (or sealed with the blanking caps) and two IP67 GNSS antennas are attached to it (or the antenna ports are sealed). If any of these connections are not tightened to the recommended torque, the unit will not achieve its rated protection.

Spanners or tools should never be used to tighten the connectors. Use your fingers to firmly tighten the connectors. The Boreas seals the top of the enclosure to the base using screws and an o-ring. This o-ring is not field serviceable, and attempting to open the housing will invalidate the calibration.

8.17.1 Temperature

Boreas should not be subjected to temperatures outside of its operating range. Subjecting Boreas to temperatures outside of the operating range can affect the factory sensor calibration, potentially causing a

permanent reduction in performance or premature failure. For information about the operating temperature range, see **6.2 Hardware Specifications**.

8.17.2 Water

Boreas complies with IP67 standard, which means that it can be submersed in water to a depth of up to 1 m deep for a maximum of 30 minutes. Submersion to depths beyond 1 metre can cause water entry and destruction of the internal electronics, and the sealing is not designed for prolonged or repetitive immersion. Do not direct streams of water directly at the unit even at low pressure. For cleaning the unit, ensure that no pressure is used.

Note: Connectors must be installed or blanking caps must be used if the unit is likely to be exposed to water.

8.17.3 Salt

The Boreas housing is made from hard-anodized marine-grade aluminium and stainless fittings to provide good corrosion resistance, however cannot tolerate extended periods of time in salt water environments. After any contact with salt water or salt spray, Boreas should be rinsed with distilled or RO water.

8.17.4 Dirt and Dust

Boreas is completely sealed against dirt and dust entry whenever all connectors are mated. When disconnecting the connectors, any dirt or dust should be rinsed or wiped off with fresh water and then dried to minimise the chance of contaminants entering the connectors or plugs.

8.17.5 pH Level

Environments with acidic or alkaline water or atmospheres can cause the Boreas enclosure to corrode or discolor. If Boreas comes into contact with these environments it should be rinsed in fresh water as soon as possible. It is not recommended to operate Boreas in non-neutral pH environments.

8.17.6 Shocks

Boreas is a rugged piece of equipment that can withstand reasonable amounts of shock. However, continuous shocks may cause premature failure as a result of materials fatigue, and may also affect the sensor calibration resulting in degraded performance.

Shocks applied directly to the Boreas enclosure can affect the unit. Therefore, care should be taken when handling the unit prior to mounting. When mounted in a vehicle, the effect of most operating shocks is negligible.

8.17.7 Atmospheres

Hydrogen-rich atmospheres may damage the MEMS. Boreas is not rated for use where explosive gases or dust may be present.

8.18 Upgrading the Boreas Firmware

Boreas contains firmware which is regularly updated to improve performance and add features. Advanced Navigation recommends that you upgrade to the latest version whenever available. The firmware update function is robust, such that power loss, file corruption or other issues cannot cause problems with units. Check the **Boreas** product page of the Advanced Navigation website periodically for updates.

Note: Advanced Navigation device firmware files have the extension .anfw.

See **9.2.8.2 Firmware Update** for instructions on how to upgrade the firmware using the Boreas Manager or see **Firmware Update** for instructions to update the firmware using the web UI.

9 Configuring and Monitoring Boreas

Boreas can be configured and monitored through:

- the **web user interface**, accessed on a connected computer via Ethernet
- Boreas **Manager**, accessed on a computer via a serial adaptor
- the **Android App**
- the Advanced Navigation Packet Protocol (**9.4 Using ANPP**)

The Boreas Web UI is the recommended interface to configure as it is designed to be simple and easy to use without any software or system requirements. The Web UI is compatible with all modern web browsers.

9.1 Using the Web User Interface

The web user interface allows you to manage Boreas through the following:

- **9.1.1 Main View**
- **9.1.2 View Menu**
- **9.1.3 Configuration Menu**
- **9.1.4 Tools Menu**

9.1.1 Main View

The Main View is accessible from other pages via the **Map** menu item under the **View** menu.
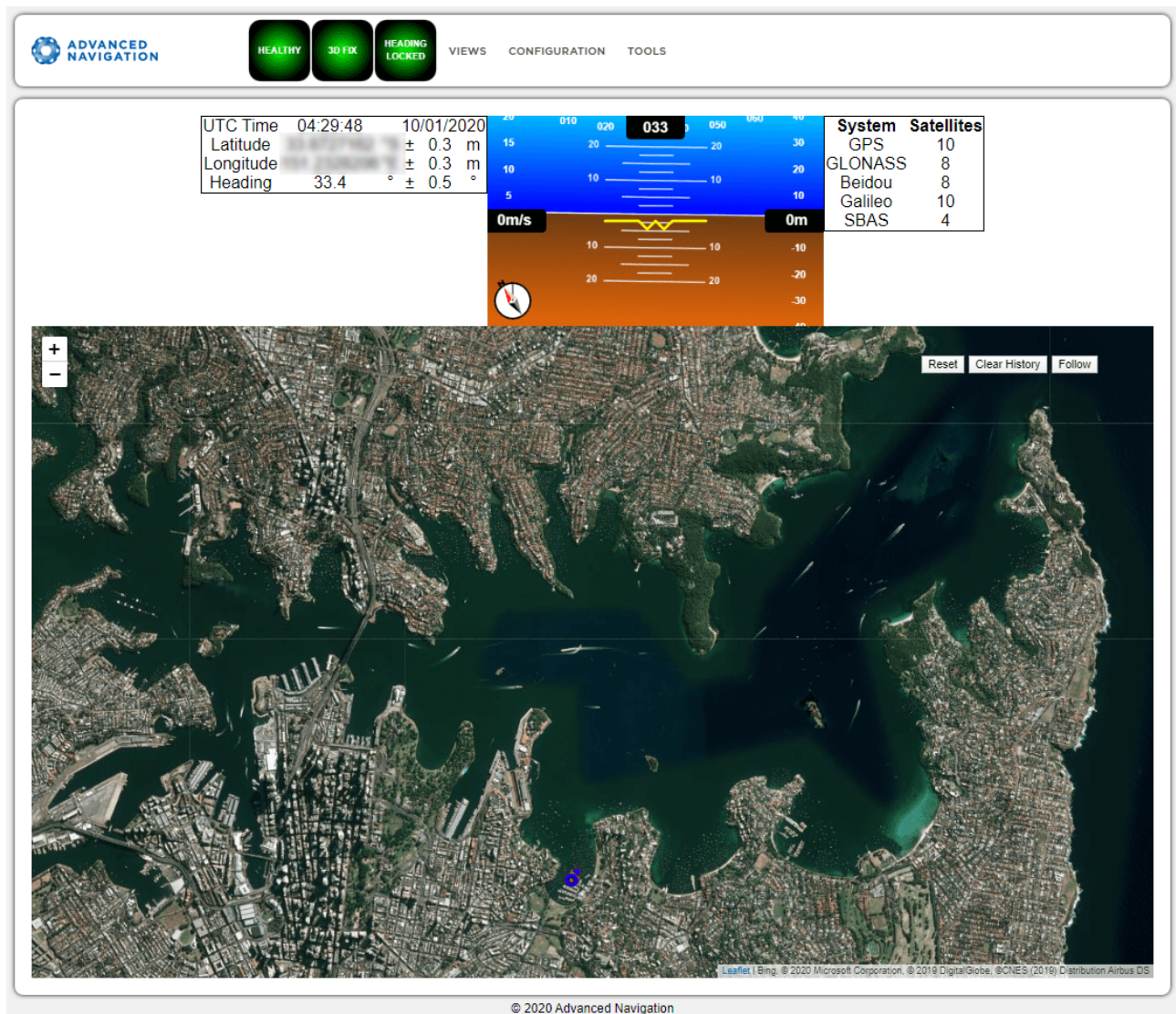
Figure 28: Boreas Web UI Home Page

9.1.1.1 Status Indicator

The Status Indicator section contains the current Boreas status, the GNSS fix type indicator, and the heading status. These are visible on every page.

- Status Indicator: This indicator shows any problems with Boreas. Once the filter has initialised it will show "HEALTHY".

- GNSS Fix: This indicator shows the status of the GNSS fix. Under normal operating conditions it should show "3D FIX". When satellite visibility is poor it may show either "2D FIX" or "NO FIX".

- Heading Status: This indicator shows the current status of the heading filter. When there is a valid source of heading it will show "HEADING LOCKED".

9.1.1.2 Current Time, Position and Heading

This section displays the current UTC time, position, and heading. The data will only be valid if Boreas has a HEALTHY status, there is a 3D GNSS fix or better, and the Heading is initialised.

9.1.1.3 Altitude Indicator

The Attitude Indicator visualises roll and pitch using a standard artificial horizon. Heading, velocity and height are shown to the side. All units are SI (metric) and degrees.

9.1.1.4 Satellites Table

The Satellites table shows the number of satellites visible by the primary antenna. More detailed information can be found in the Satellites screen under the **View** menu.

9.1.1.5 Map

The map shows the Boreas position on Earth as well as a red trail showing position history since the last reset. When the filter initialises the map will automatically reset the view to the Boreas position. To move the camera click and drag on the map. To zoom in and out, use the mouse scroll wheel.

Use **Reset** to reset the map view to the current position of Boreas.

Clear History clears the current red trail showing the position history. This will immediately restart from the current position. Note that this does not affect any logging currently active.

9.1.1.6 Map Controls

Reset

This resets the map view to the current position of Boreas.

Clear History

This clears the current red trail showing the position history. This will immediately restart from the current position. Note that this does not affect any logging currently active.

Follow

This button makes the map follow the device.

9.1.2 View Menu

The View menu contains the options for viewing pages of data from Boreas.

9.1.2.1 Map

This takes the user back to the home page of the web UI with the map display.

9.1.2.2 Device Information

The Device Information page is useful for users when requesting technical support and for tracking their serial number, firmware version, and hardware version.

Figure 29: Boreas Web UI Device Information Page

9.1.2.3 Subcomponent Information

The Subcomponent Information page shows the serial numbers and hardware version information for the Boreas subcomponents. This will be useful information to include when contacting our support team.

9.1.2.4 Status

The Status shows the current status of Boreas as reported by sections **11.4.1 System State Packet** (ID#20) and **11.4.10 Raw GNSS Packet**. (ID#29).

> **Note**: The following Status flags do not update for Boreas units with a Trimble BD992 GNSS Receiver. These flags are only applicable to Aries GNSS Receivers: GNSS 2, Antenna 1 disconnected, Antenna 2 disconnected, Antenna 1 short, Antenna 2 short
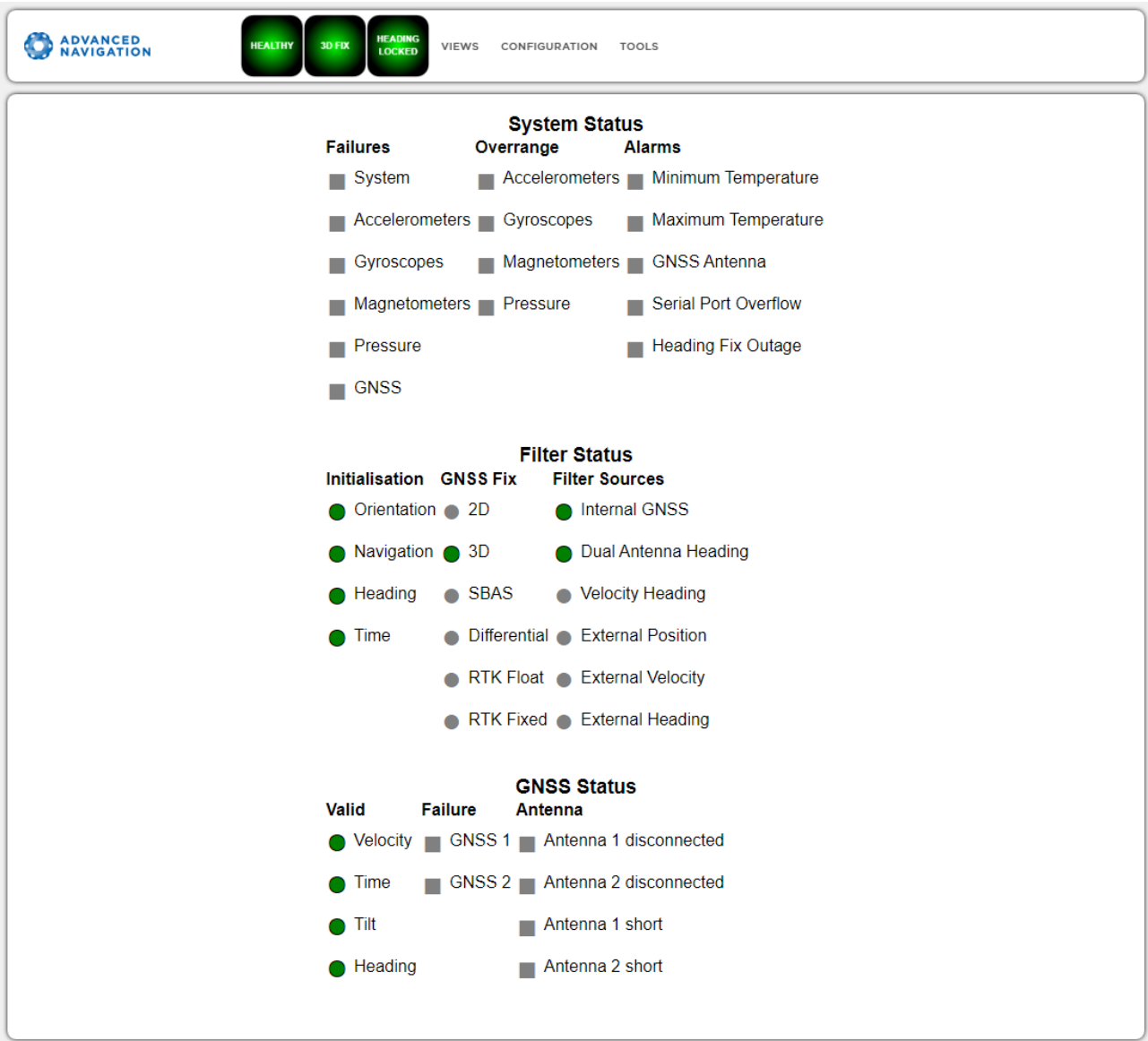
Figure 30: Boreas Web UI Status Page

9.1.2.5 Satellites

The Satellites page shows detailed information on the satellites that are visible to both antennas of the Boreas GNSS receiver.

The information is displayed as a satellite skyplot, a table and an SNR graph. A maximum of 28 satellites will be displayed, even if more are accessible. This plot shows the SNR of each satellite at the primary and secondary antenna. As a guideline, these should be within 5-10 dB of each other in the absence of cable or antenna faults

System	PRN	Frequency	Elevation	Azimuth	Primary SNR	Secondary SNR
GPS	5	L1C	20	136	41	43
GPS	10	L1C	11	319	37	42
GPS	13	L1C	23	97	41	40
GPS	15	L1C	37	63	46	46
GPS	16	L1C	11	219	35	39
GPS	20	L1C	42	311	46	45
GPS	21	L1C	46	237	45	46
GPS	25	L1C	23	347	39	40
GPS	26	L1C	27	242	40	41
GPS	29	L1C	73	87	50	50
GLONASS	2	L1C	33	141	49	47
GLONASS	3	L1C	65	59	52	51
GLONASS	4	L1C	26	356	45	46
GLONASS	9	L1C	11	226	33	40
GLONASS	16	L1C	14	285	39	35
GLONASS	17	L1C	34	96	50	50
GLONASS	18	L1C	53	170	50	49
GLONASS	19	L1C	22	223	36	36
GALILEO	1		27	265	38	35
GALILEO	7		43	32	44	43
GALILEO	8		40	107	45	44
GALILEO	13		52	122	46	46
GALILEO	15		9	88	37	36
GALILEO	18		19	231	39	38
GALILEO	21		22	321	39	39
GALILEO	26		50	219	46	47
GALILEO	31		6	218	30	38
GALILEO	33		7	250	39	36

Figure 31: Boreas Web UI Satellites Page

9.1.2.6 Raw Sensors

The Raw Sensors page shows the temperature-calibrated raw IMU sensor values.

In the lower plot only the air pressure is plotted. The current value from the internal temperature sensors are given on the right. These do not provide general environmental temperature.
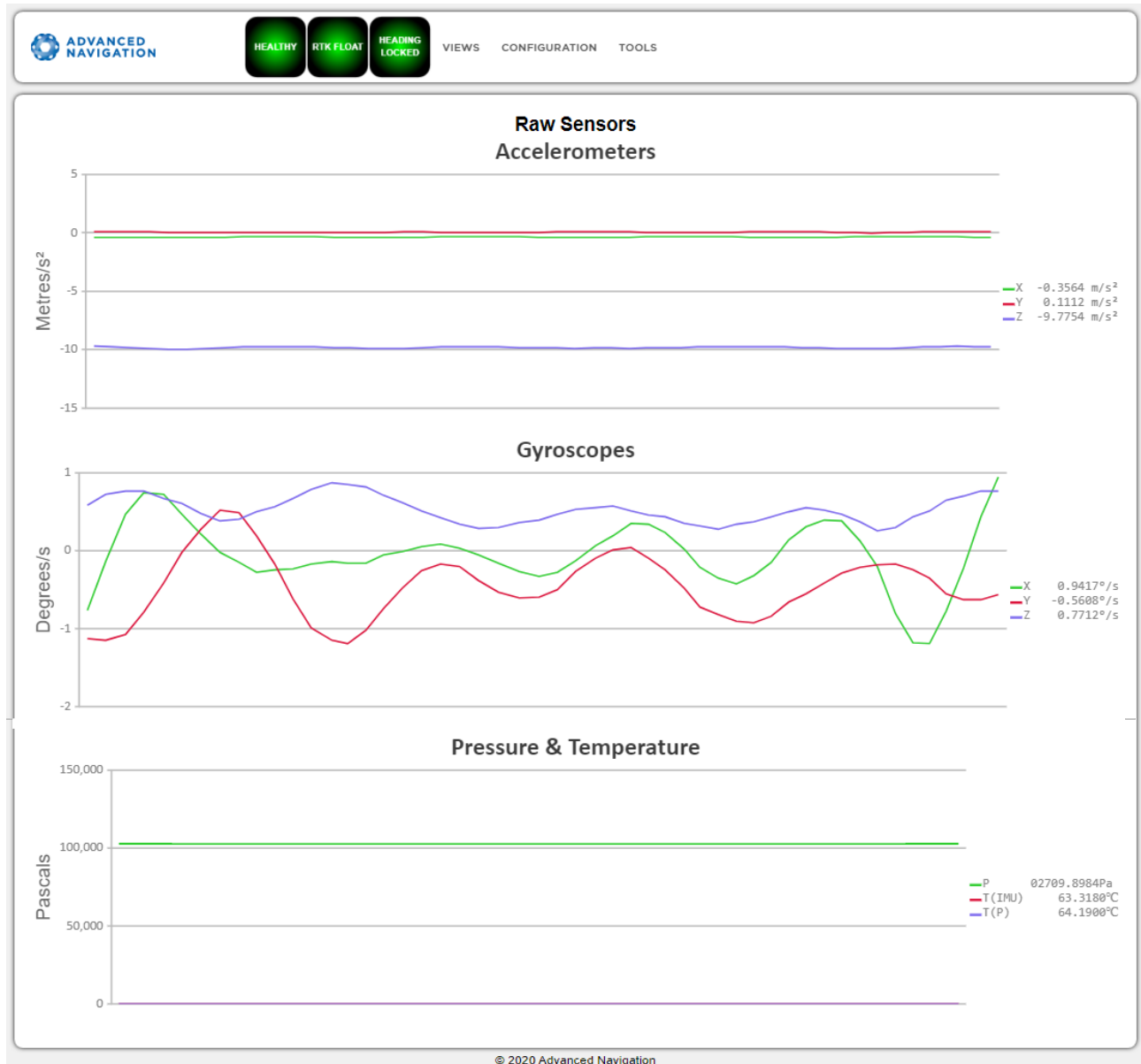
Figure 32: Web UI Raw Sensors Page

9.1.2.7 Orientation

The Orientation page shows the Boreas orientation and angular velocity. Course is determined by measuring sequential positions. Slip is the difference between the heading and the course.
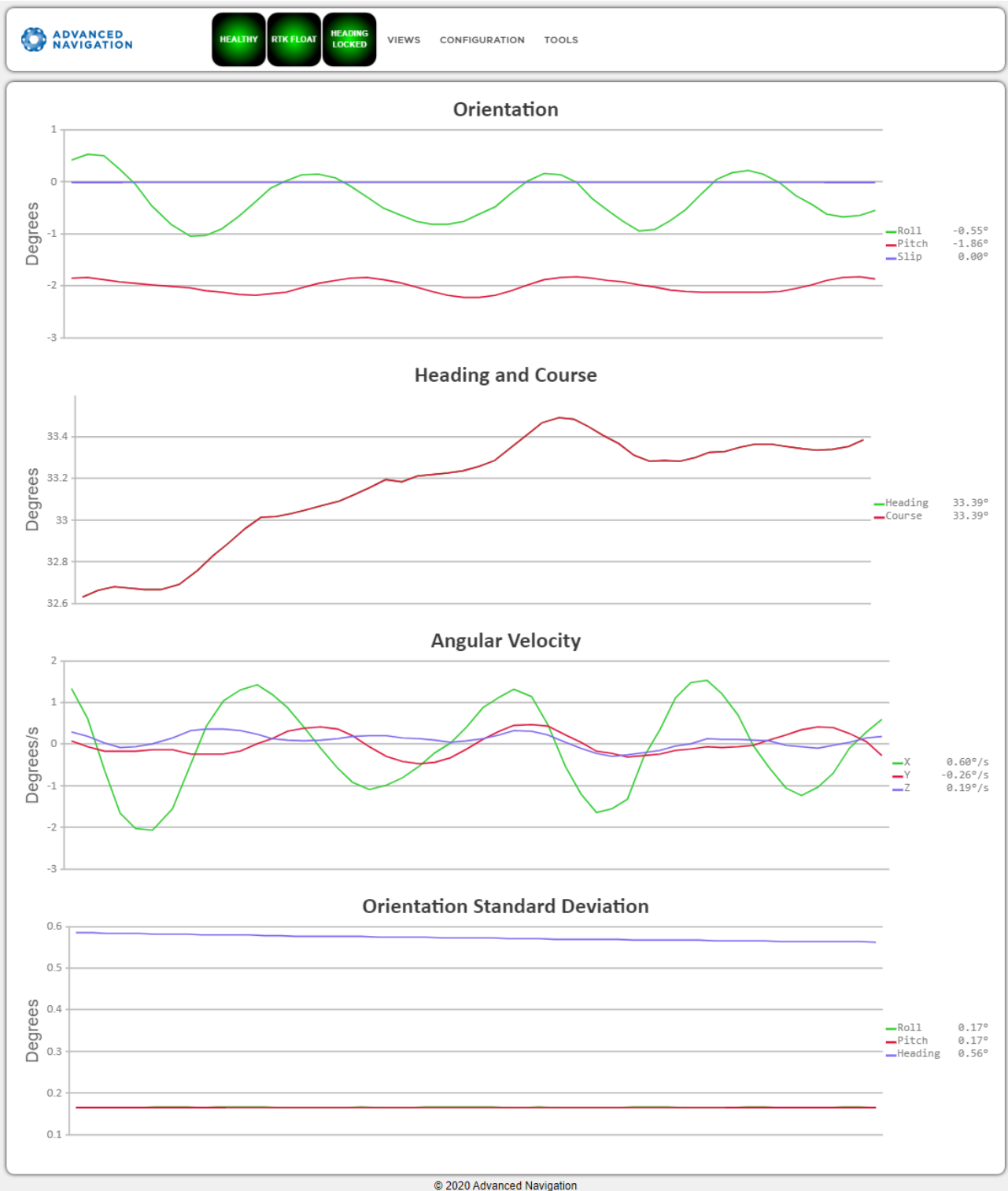
Figure 33: Boreas Web UI Orientation Page

9.1.2.8 Position

The Position page shows the Boreas position and position standard deviation. Latitude and longitude are converted to North and East metres from a reference point that can be reset by refreshing the web page in your browser.
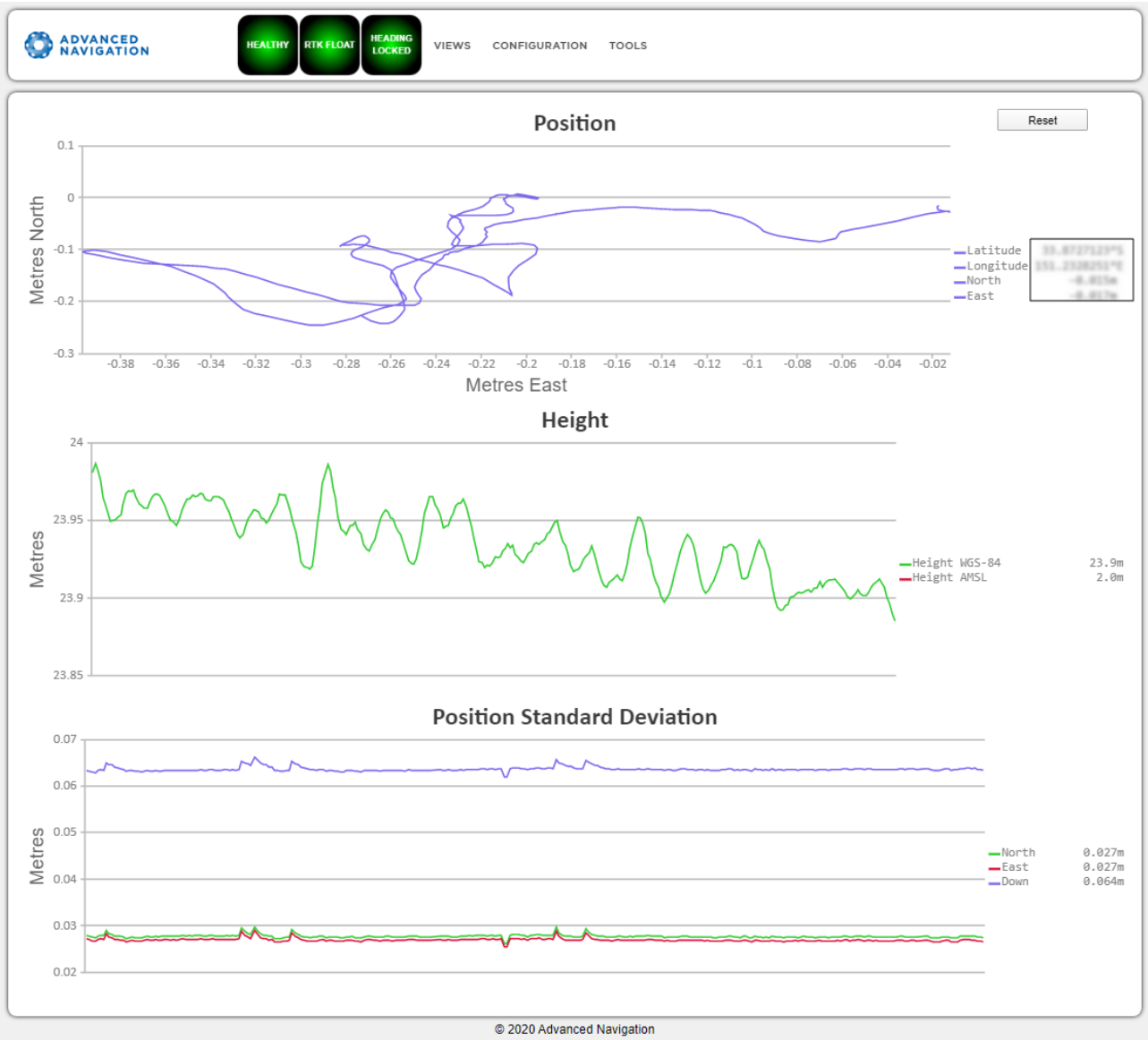
Figure 34: Boreas Web UI Position Page

9.1.2.9 Velocity and Acceleration

The Velocity and Acceleration page shows the Boreas velocity, acceleration and g-force.
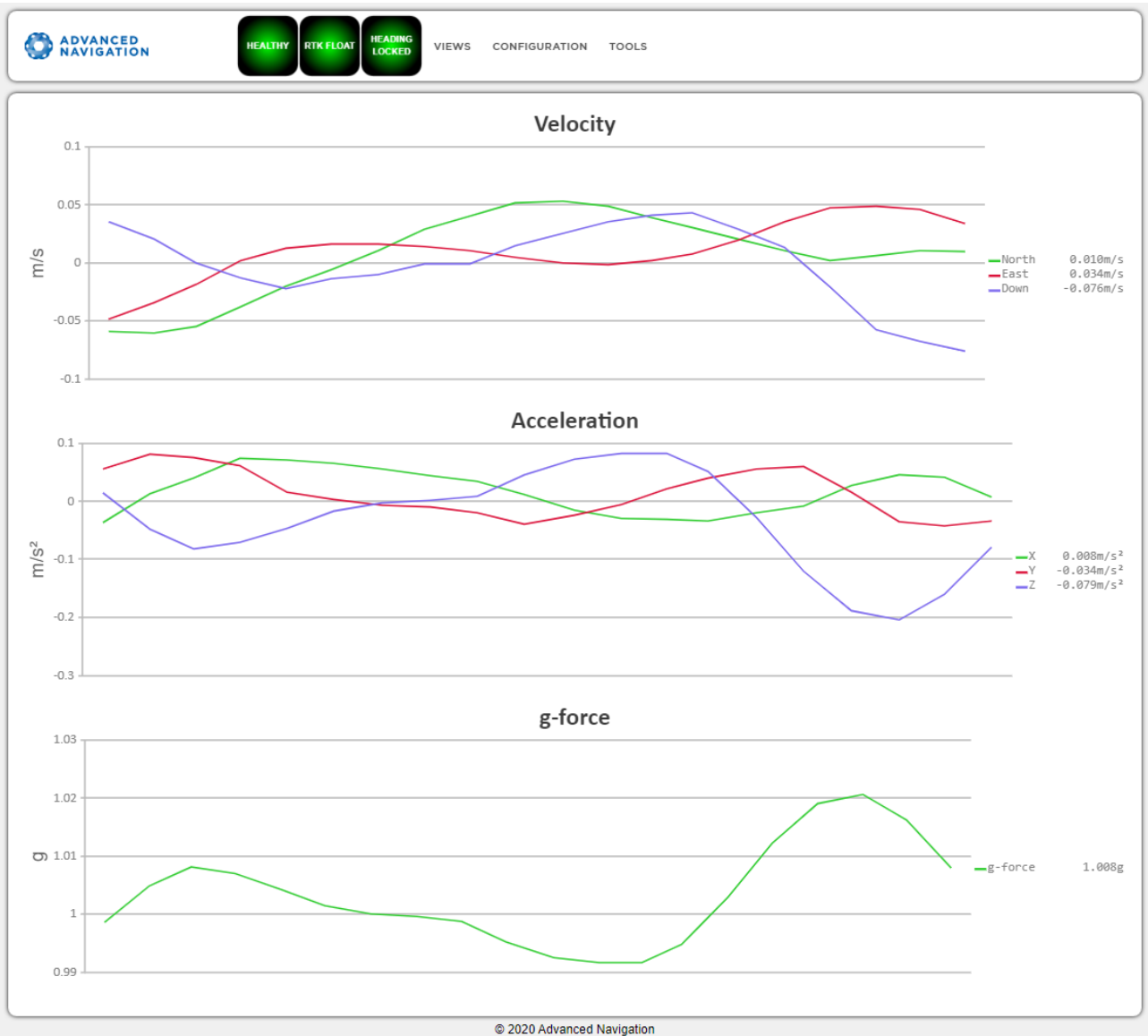
Figure 35: Boreas Web UI Velocity and Acceleration Page

9.1.2.10 GNSS Receiver Information

This page shows information about the GNSS receiver fitted to Boreas.
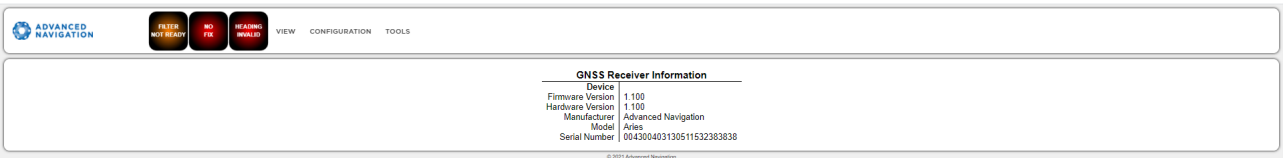
Figure 36: Boreas Web UI GNSS Receiver Information Page

9.1.2.11 Heave

This page displays the heave at up to 4 reference points.
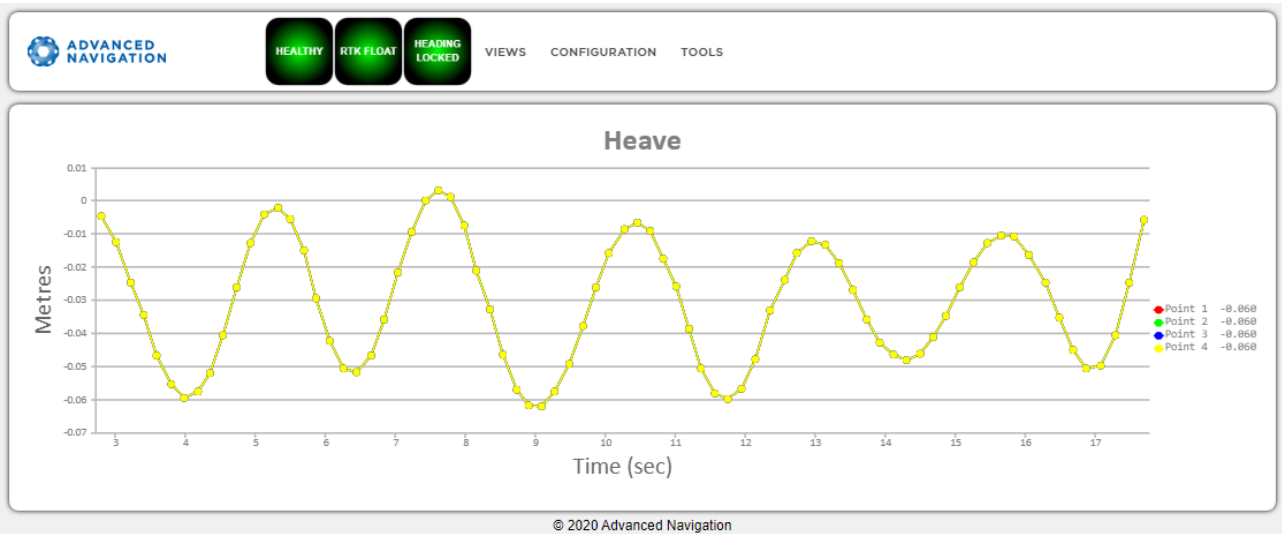
Figure 37: Boreas Web UI Heave Page

9.1.2.12 Coarse Heading Alignment

Coarse Alignment is used to derive the heading based on a gyrocompass' estimation of true North. For more information, see **8.4 Heading Sources**. Coarse alignment is necessary to establish an approximate heading when a dual antenna GNSS heading or alternate source is unavailable, such as in a GNSS denied environment. Once coarse alignment is complete, a heading is established, after which the gyrocompass will be used for fine alignment.

The Coarse Heading Alignment page displays the current status of the initialisation process. Given below is a list statuses and warnings that may be displayed during this process:

Status Messages	Description
Awaiting position via GNSS or manual initialisation	An approximate position is required to complete coarse alignment. Initialisation will commence as soon as the position is available. If GNSS positioning is not available, provide the position details manually on the **9.1.3.9 Manual Initialisation** page.
Initialising, please wait	With the position known, the process of determining the coarse heading alignment has commenced. This process will take 2 minutes, unless it is restarted due to excessive motion or a significant change in latitude.
Alignment initialised via alternate source	Coarse alignment is not required as heading has been initialised via an alternate source, such as **dual antenna** , **velocity** or **external input**. If heading is available from one of these sources, coarse alignment is not required.
Heading coarse alignment complete	The system has successfully determined an approximate heading.

Table 25: Coarse Heading Alignment - Status Messages

Warning Messages	Description
Initialisation restarted - excessive motion detected	Initialisation has been automatically restarted due to excessive motion.
Initialisation restarted - change in latitude detected	Initialisation has been automatically restarted due to a significant change in latitude.
Initialisation restarted - Change in COG lever arm detected	Initialisation has been automatically restarted due to a change in the Centre of Gravity (COG) lever arm **configuration**.
Warning - Check latitude, value out of range	A discrepancy between the current latitude and the coarse alignment algorithm has been detected. Check the current latitude is correct.

Table 26: Coarse Heading Alignment - Warning Messages

9.1.3 Configuration Menu

These menus contain the set of configuration settings for Boreas.

9.1.3.1 Filter Options

Ensure that the Vehicle Type filter option is selected for all applications. For most standard applications, the other filter options can be left as their defaults.

See **8.1 Filter Initialisation** for more information on these specific settings. If you require assistance, contact **support@advancednavigation.com**.

Figure 38: Boreas Web UI Filter Options Page

9.1.3.2 Data Ports

The Data Ports page allows you to specify which data packets or messages are output on a periodic basis and at what rate via a range of serial and Ethernet ports.

Note: The GPIOs and auxiliary port are configured in the Data Ports page only if they are being used as serial transmit and receive lines. To configure GPIOs as digital or frequency inputs or outputs, use the **9.1.3.5 GPIO** page.

The default ANPP format packets enabled for the primary port are the **11.4.1 System State Packet** (ID #20) and the **11.4.9 Raw Sensors Packet** (ID #28) at 20 Hz and these typically provide all the data that a user will require. Other ANPP format state packets can be enabled as required.

Other data formats available include NMEA0183, GNSS, TSS1, SIMRAD and other formats. For more information see **10.1.2 Ethernet Functions** and **10.2 Serial Interface**.

Figure 39: Boreas Web UI Data Ports Page

9.1.3.3 Alignment

The Alignment page is used to set the alignment offsets of the system installation. It is important to set the values on this page correctly to avoid degrading performance.

Figure 40: Boreas Web UI Alignment Page

Alignment Offset

If Boreas is installed into the vehicle with the positive X axis pointing forwards and the positive Z axis pointing down, then no alignment offset is required and the roll, pitch and heading offset values can remain at the factory defaults of zero.

If the unit is installed in a different orientation then the roll, pitch and heading offset must be entered. For example, if the unit is installed on its side with the X axis pointing up and the Z axis pointing forwards and no change to the Y axis, then this would result in a pitch offset of +90 degrees with roll and heading remaining zero.

If there is a small misalignment due to mechanical mounting error this can be compensated for by setting the vehicle stationary on a level surface and clicking the **Zero Current Orientation** button.

Note: Zero Current Orientation will only correct for roll and pitch offsets, the Heading offset must be entered manually and saved after using this function.

GNSS Antenna Offset

The GNSS antenna offset is measured from the centre of the Boreas unit to the phase centre of the primary antenna in the orientation of the **12.3 The Body Co-ordinate Frame** (X positive forward, Z positive down).
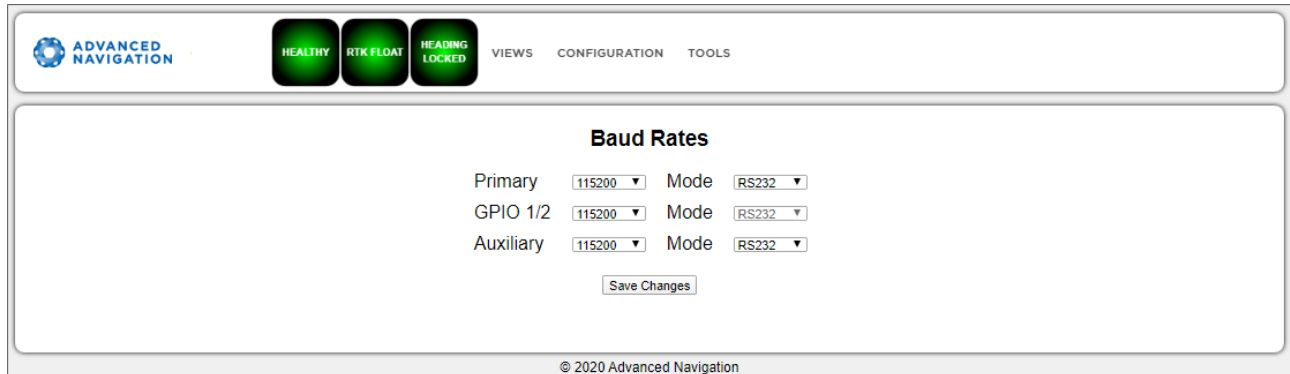
External Data Offset

These values are only required for speciality applications operating with an external source of velocity and position data. The offsets are used when providing NMEA Input, External GNSS, or with an Air Data Unit. When using a DVL, use the odometer offset. Please contact **support@advancednavigation.com** for further assistance.

9.1.3.4 Baud Rates

This page is for setting the baud rates for the GPIO, primary and auxiliary ports. The factory default baud rate value for these ports is 115200 bps.

The primary and auxiliary ports can be set to RS232 or RS422. The factory default is RS232 for both ports.

Figure 41: Boreas Web UI Baud Rates Page

9.1.3.5 GPIO

This page allows the user to select the input and output functions of the GPIO and Auxiliary ports. These functions are described in detail in **10.6.1 Dynamic Pin Functions**. These functions change dynamically and are effective immediately upon clicking **Save Changes**.

> **Note**: The GPIO port functions at RS232 levels for data functions and 0 to 5 volt (or 0 to 3.3 V) levels for all other functions. The auxiliary port functions at RS232 or RS422 levels for data functions and 0 to 5 volt (or 0 to 3.3 V) levels for all other functions. The internal hardware automatically reconfigures based upon the selected function.

The default values for these settings are Inactive. The dedicated 1PPS signal is active by default.

Figure 42: Boreas Web UI GPIO Configuration Page

9.1.3.6 Odometer

The Odometer page allows the user to configure the odometer pulse length and offset. See **7.10 Odometer** and **8.8 Odometer Pulse Length** for more information on the use of odometers. The odometer offset is also applied when using a DVL input.

Figure 43: Boreas Web UI Odometer Configuration Page

9.1.3.7 Reset

The Reset button causes the system to perform a power cycle. No configuration settings or state data are lost.

The Cold Start button clears all filters, and connections are reset and must re-established. No configuration settings are lost.

The Factory Reset button resets all Boreas settings back to their factory defaults, including state data and all configuration settings. It also erases the hot start data so that the system is forced to perform a cold start.

Note: A Factory Reset will re-enable the DHCP Client and lose any static IP address settings.

Figure 44: Boreas Web UI Reset Page

9.1.3.8 Reference Point Offsets

The Reference Point Offsets page allows the user to set measurement points away from its default position at the physical centre of the Boreas unit. The primary reference point offset applies to data from all ANPP packets as well as all peripheral output such as NMEA messages and Heave Point 1.

The Centre of Gravity (COG) Lever Arm Offset should be used to define where the centre of gravity is for the vehicle. It is useful in applications, such as a surface vessels, to improve the ability of the **8.4 Heading Sources** to complete coarse alignment.

The Heave Points 3 and 4 allow the user to offset reference points for the heave values 3 and 4 in the **11.4.36 Heave Packet**.

Figure 45: Boreas Web UI Reference Point Offsets Dialogue

9.1.3.9 Manual Initialisation

This page can be used to manually initialise Boreas when a GNSS fix is not available. Setting the position will initialise the navigation filter. Setting the heading will also initialise the heading filter.

Figure 46: Boreas Web UI Manual Initialisation Page

9.1.3.10 Dual Antenna

The Dual Antenna configuration page is only used if the primary and secondary GNSS antennas are not installed in their recommended and default positions of primary front and secondary rear, at the same height.

If it is not practical to mount the antennas in the recommended alignment, the alternate alignments must be entered into this page. It is recommended to try and use one of the automatic offsets where possible, where the antennas must be installed in one of four different automatic offset orientations aligned on an axis.

If it is not possible to use one of the automatic offsets, the antennas can be installed in any configuration and a manual offset should be entered. The manual offset is measured from the central base of the secondary antenna to the central base of the primary antenna in the body co-ordinate frame (X+ forward, Z+ down). If using a manual offset, be careful to measure the offset accurately, as even small offset errors can result in relatively large heading errors e.g. 2 cm error = 1.15 degrees heading error with a 1 metre separation.

When using an automatic offset, the manual offset values are ignored.

When using a manual offset, the automatic offset selection is ignored.

When using automatic offset, the manual offset values will show the distance that Boreas has automatically measured.

Figure 47: Boreas Web UI Dual Antenna Page

9.1.3.11 Ethernet Settings

The Ethernet Settings page allows you to enable or disable the DHCP Client. When the DHCP Client is disabled you need to enter the TCP/IP settings if you wish to access the web UI.

If you are only connecting to Boreas via the primary port these settings can be ignored.

The default is for the Ethernet mode to be set to DHCP.

Figure 48: Boreas Web UI Ethernet Settings page

9.1.3.12 NTRIP Client

The NTRIP client built into Boreas can be used to connect to a network DGPS (Differential GPS, a older standard for GNSS corrections of lower performance than RTK) or RTK service to stream correction data to Boreas for DGPS or RTK. The NTRIP client requires that Boreas has an available internet connection to the NTRIP Caster to function.

The source of the corrections data can be either your own base station, configured as an NTRIP Caster, or a third-party service. Either way, you will need the login details for connecting to and authenticating with the NTRIP Caster, and identifying the nearest mountpoint.

These steps are required:

1. Select Enabled.

2. For Host/Server, enter the NTRIP Caster address.

3. For Port, enter the NTRIP Caster port numbe. This is usually 2101.

4. Click Save.

5. Click Get Mountpoints.

6. Select your mountpoint from the Mountpoint drop down list, being mindful that the distance should not exceed 50km.

7. Enter your username in the Username box.

8. Enter your password in the Password box.

9. Click Save.

To disconnect from the NTRIP Caster unselect Enabled and click Save.
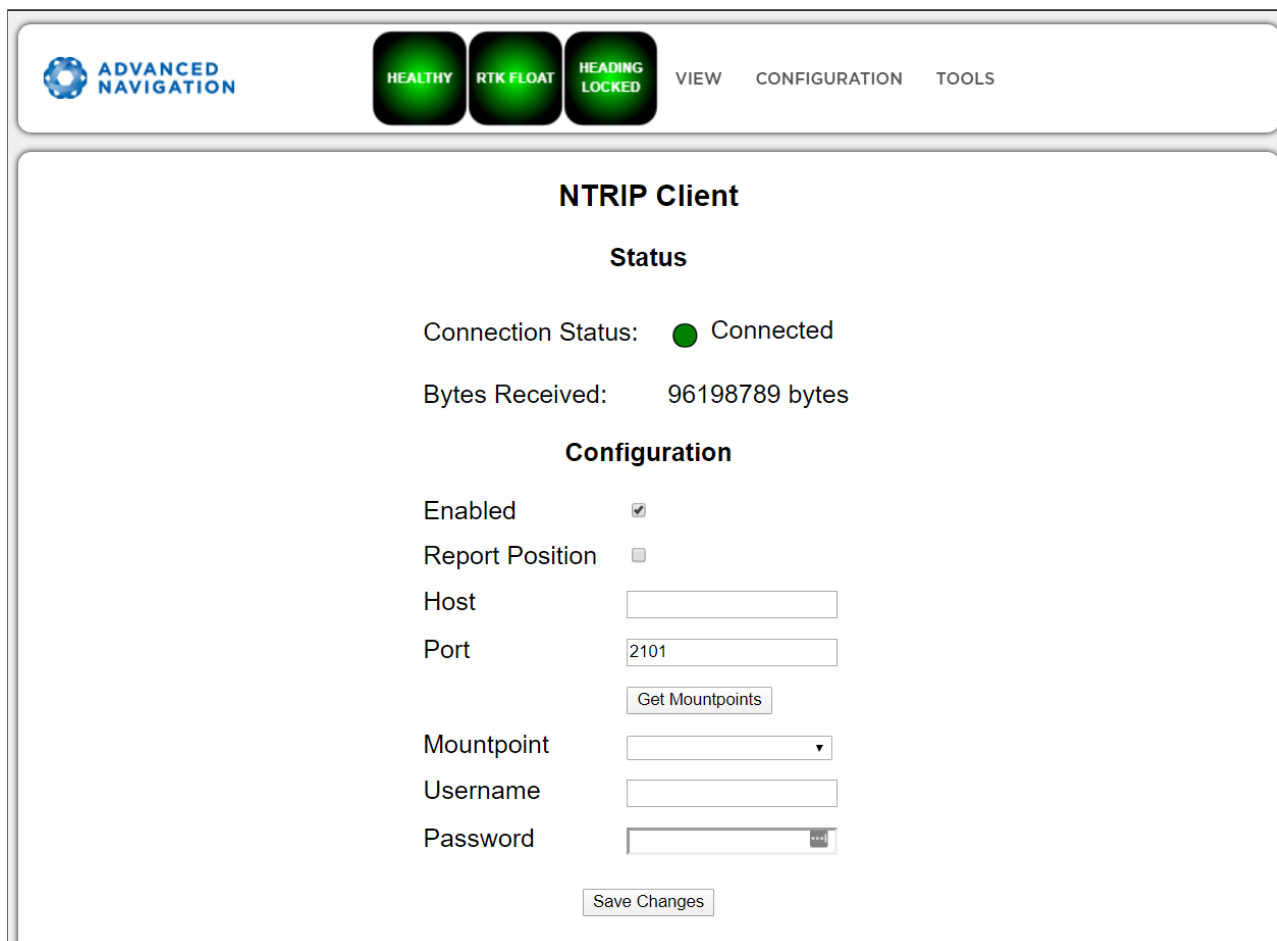
Troubleshooting NTRIP Caster Connections

Some mountpoints require that Boreas send its position. To do this, click the Report Position check box, and then click Save Changes. The current Boreas position will then be sent to the NTRIP Caster every 10 seconds.

If you cannot get the list of mountpoints, ensure the Host Address and Port number are correct for your NTRIP Caster.

If the Connection Status is not green, and says UNAUTHORISED this indicates an incorrect username or password.

Contact **support@advancednavigation.com** for further assistance with network DGPS or RTK.

Figure 49: Boreas Web UI NTRIP Client Page

9.1.3.13 CAN Settings

The CAN Settings page allows you to enable or disable the CAN functionality. If you are only connecting to Boreas via the primary port then these settings can be ignored.

The default for CAN is Enabled at 1,000,000 baud rate. A CANOpen EDS file is available. Contact Support for a copy of this file.
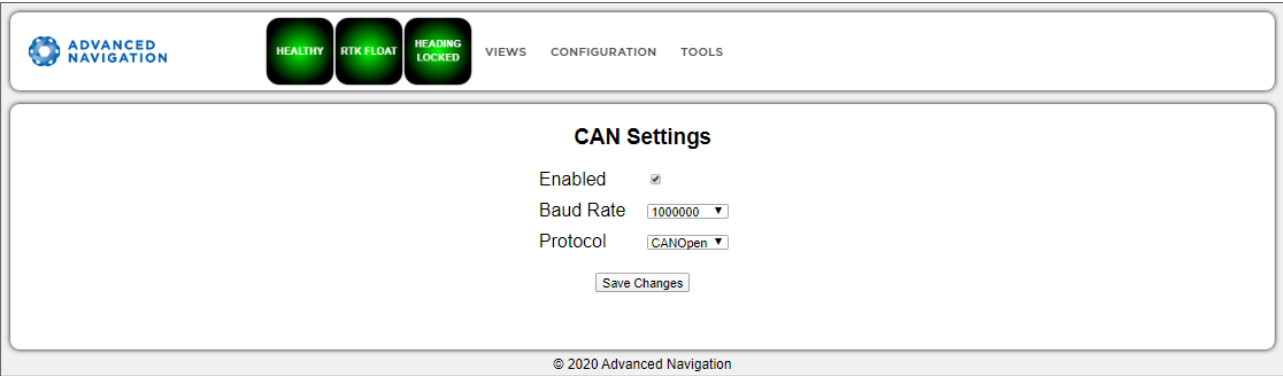
Figure 50: Boreas Web UI CAN Settings Page

9.1.3.14 Advanced

The Advanced page allows you to set the voltage level of the GPIO and 1PPS signals lines along with the packet rates.

The options are 5 V, 3.3 V, or Disabled. The default is 5 V.

Note: The dedicated 1PPS signal is active whenever the voltage is set to 5 V or 3.3 V, and is therefore active by default.

The CANopen output packet rates can be configured as the period between packets in milliseconds within the range of 10 ms to 10,000 ms. The default is 50 ms.
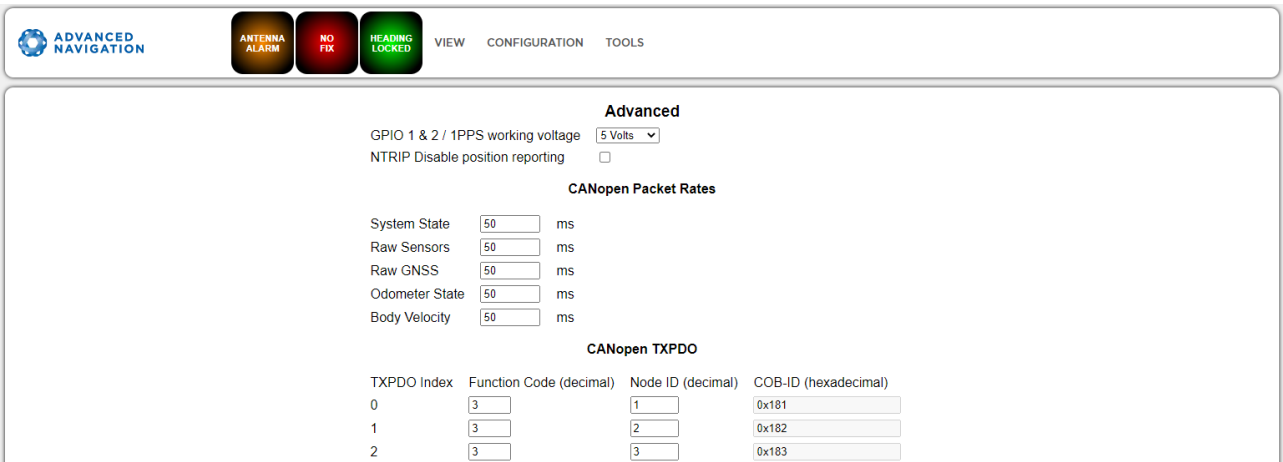
Figure 51: Boreas Web UI Advanced Page

9.1.3.15 GNSS Configuration

The GNSS Configuration page allows you to select constellation configurations based on the type of GNSS receiver installed.

If an invalid configuration is entered, the system will revert to the previous configuration when you try to save the changes. To confirm that changes have been successfully saved, close and re-open the GNSS Configuration dialogue.

Aries GNSS Receiver

When using an Aries GNSS receiver, the following configuration rules are applicable:

- By default, GPS, Galileo and GLONASS are enabled, along with SBAS and QZSS correction services.
- When selecting a GNSS constellation, all frequencies for that constellation must be selected.
- SBAS and QZSS correction services can also be enabled for all constellation configurations , except when using GPS, Galileo and BeiDou together.

Figure 52: Boreas Web UI Aries GNSS Configuration Page

The table below lists the supported constellations and the corresponding GNSS sample period depending upon the number of constellations selected. When setting the **9.1.3.2 Data Ports**, the packet rate of the **11.4.10 Raw GNSS Packet** and **11.4.37 Raw Satellite Data Packet** are automatically adjusted to the next lower integer multiple of the sample period.

# of Constellations Configured	Sample Period	Example Effective Packet 60 Rate	Supported Constellation Configurations
1	50 ms	1 ms - 99 ms = 50 ms (20 Hz) 100 ms - 149 ms = 100 ms (10 Hz) 150 ms - 199 ms = 150 ms (6.67 Hz)	GPS Galileo GLONASS BeiDou
2	80 ms	1 ms - 159 ms = 80 ms = 12.5 Hz 160 ms - 239 ms = 160 ms (6.25 Hz)	GPS & Galileo GPS & GLONASS GPS & BeiDou
3	100 ms	1 ms - 199 ms = 100 ms (10 Hz) 200 ms - 299 ms = 200 ms (5 Hz)	GPS, GLONASS & Galileo GPS, GLONASS & BeiDou (no correction services)

# of Constellations Configured	Sample Period	Example Effective Packet 60 Rate	Supported Constellation Configurations
4	125 ms	1 ms - 249 ms = 125 ms (8 Hz) 250 ms - 374 ms = 250 ms (4 Hz)	GPS, Galileo, GLONASS & BeiDou

Table 27: Aries Supported GNSS Constellation Configurations

Trimble BD992 GNSS Receiver

When using a Trimble BD992 GNSS receiver, the following configuration rules are applicable:

- For any given constellation, the first (1) frequency must be enabled in order to receive additional frequencies
- Galileo and BeiDou are licensed separately, see **5.3 GNSS Receiver Licence Upgrades** for details.
- L Band corrections are available on this receiver, however require an additional subscription to Omnistar or RTX. Advanced Navigation does not supply these, contact Trimble for further details.

Figure 53: Boreas Web UI BD992 GNSS Configuration Page

9.1.4 Tools Menu

The Tools menu contains tools for performing certain procedures with Boreas.

9.1.4.1 Firmware Update

This page is used to update the Boreas device firmware,

Boreas contains firmware which is regularly updated to improve performance and add features. Advanced Navigation recommends that you upgrade to the latest version whenever available. The firmware update function is robust, such that power loss, file corruption or other issues cannot cause problems with units. Check the **Boreas** product page of the Advanced Navigation website periodically for updates.

Note: Advanced Navigation device firmware files have the extension .anfw.
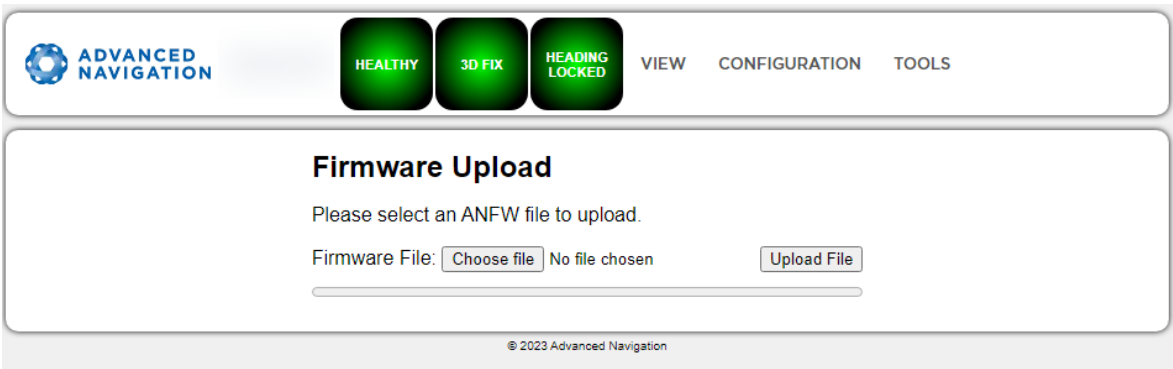
Figure 54: Web UI Firmware Update Page

Click "Choose File" and select the appropriate ANFW file for upload.
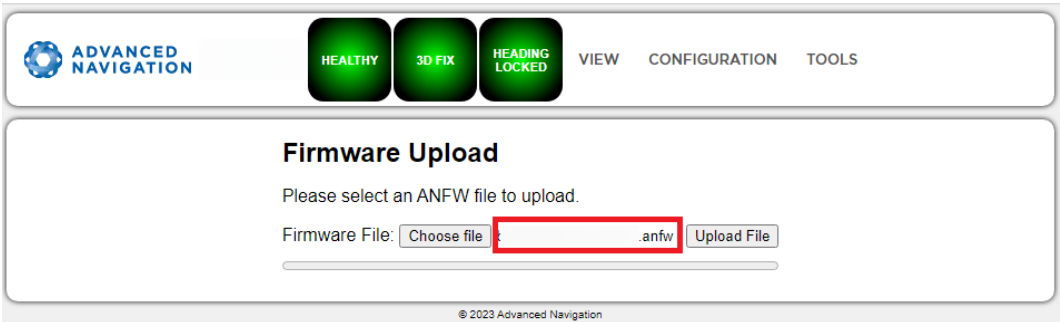
Figure 55: Firmware Update Choose File

Wait while the system uploads the firmware.
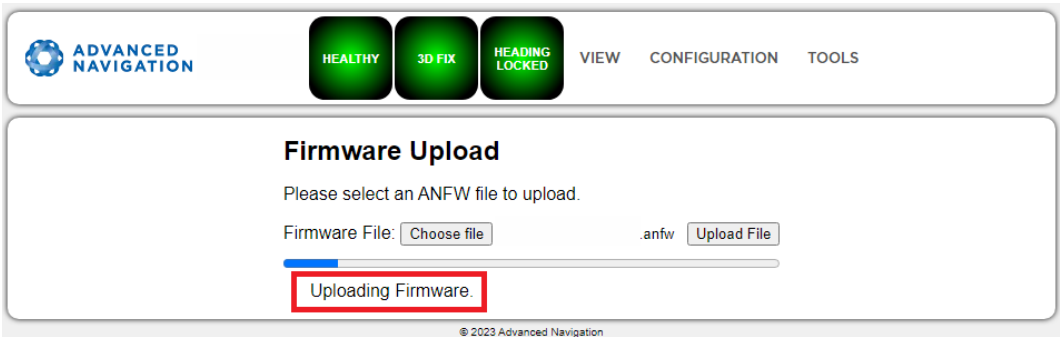
Figure 56: Firmware Update Uploading Firmware

Once uploaded, the system will automatically verify the firmware prior to reboot.

Figure 57: Firmware Update Verifying

Upon successful verification, a dialog box will appear indicating the device is rebooting to apply the update.
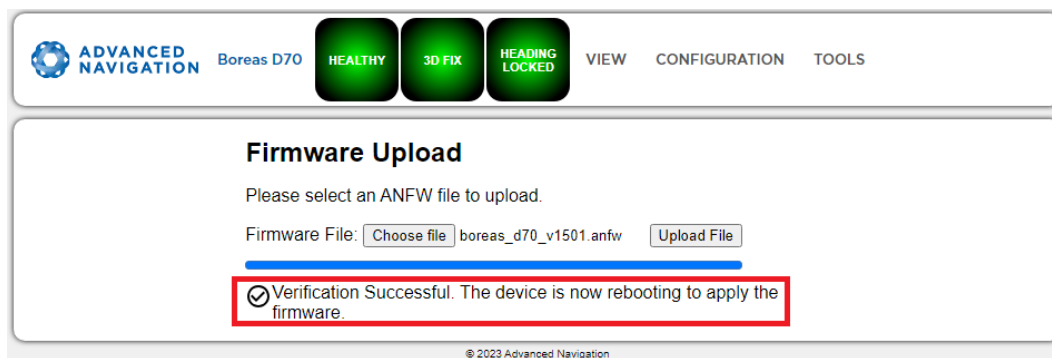
Figure 58: Firmware Update Complete

9.1.4.2 Logs

Boreas features an onboard high capacity data logging system. Logging is enabled by default, but by default no specific data is configured to be logged. To enable logging of specific data packets or messages, see the Logging section on the **9.1.3.2 Data Ports** page (in the **9.1.3 Configuration Menu**).

If any log files exist on the Boreas they will appear on this page in a list, with the most recent at the top. The log file name includes the date and time the log file recording commenced, using UTC time, in the format BoreasLog_yy-mm-dd_hh-mm-ss.xxx. The log file extension identifies the file type.

If the time and date in the log file name is incorrect, this usually indicates that Boreas does not have a GNSS fix and has therefore not yet determined the correct time.

Note that the logging configuration and recorded log files can only be accessed by the web UI. You cannot use the serial port interfaces.

Note: If there is a requirement not to store potentially sensitive information, it is possible to order Boreas without internal storage. If this is the case, no internal logging will be possible.

Enabling and Disabling Logging

To enable or disable the logging functionality, select or deselect the Enable Logging check box and click Save Changes.

The log file currently being recorded is highlighted in green.

If recording an ANPP-format log file, the log file will include the current Boreas device configuration.

Limiting the Maximum Log File Size

If you wish to limit the maximum file size for individual log files, select the Enable Splitting check box, enter a Max Log Size (in MiB), and then click the Save Changes button. This will not affect pre-existing log files but will affect the currently recording log file. Note this will round down to an integer if you enter a number with decimal places.

Downloading Log Files

You can download individual log files by simply clicking on them. Note, only one log file can be downloaded at a time using this method.

To download multiple log files, first select the files required, and then click the Download Selected button. This will download all the files to your computer and compress them into one ZIP file. Note, it may appear that nothing is happening during this process, and it can take some time to complete.

You can select all log files using the Select All button, or individually select log files using the check box on the left of the log file name.

Deleting Log Files

You can delete log files by selecting the specific log file(s) using the check box to the left of the log file name, or using the Select All button, and then click the Delete Selected button.

For bulk erasing ALL log files you can use the Format button. This will erase all log files irrecoverably. Note, it can take some time.

Starting New Log Files

The Start New Log button will stop writing the current log file and commence writing a new file. This new file will also include the current Boreas device configuration. If logging is currently not enabled, this button will not do anything.

9.1.4.3 Viewing Logged Data

The ANPP log files are binary data and are therefore not in a human-readable format. To convert the ANPP log files you can use the Log Converter function of Boreas Manager, see section **9.2.8.4 Log Converter**. This will create CSV and KML files for your analysis.

All the ANPP packets are described in detail in **11 Advanced Navigation Packet Protocol**.

NMEA0183 log files are ASCII text and can be opened in any text editor.

9.2 Using Boreas Manager

Boreas Manager is a software tool provided by Advanced Navigation for logging, testing, display and configuration of Boreas. It is designed to be simple and easy to use. It should run on most Windows, MacOS and Linux computers.

> **Note**: Java 11 is required to run Boreas Manager. Adoptium JRE 11 is the recommended Java installer to be used on all platforms. Install the latest version of Java 11 from **Adoptium**, selecting the correct operating system and architecture for your computer.

Boreas Manager contains almost identical functionality to the web UI. This section will only include the areas that are different or absent from the web UI. Refer to the documentation for **9.1 Using the Web User Interface** as required.
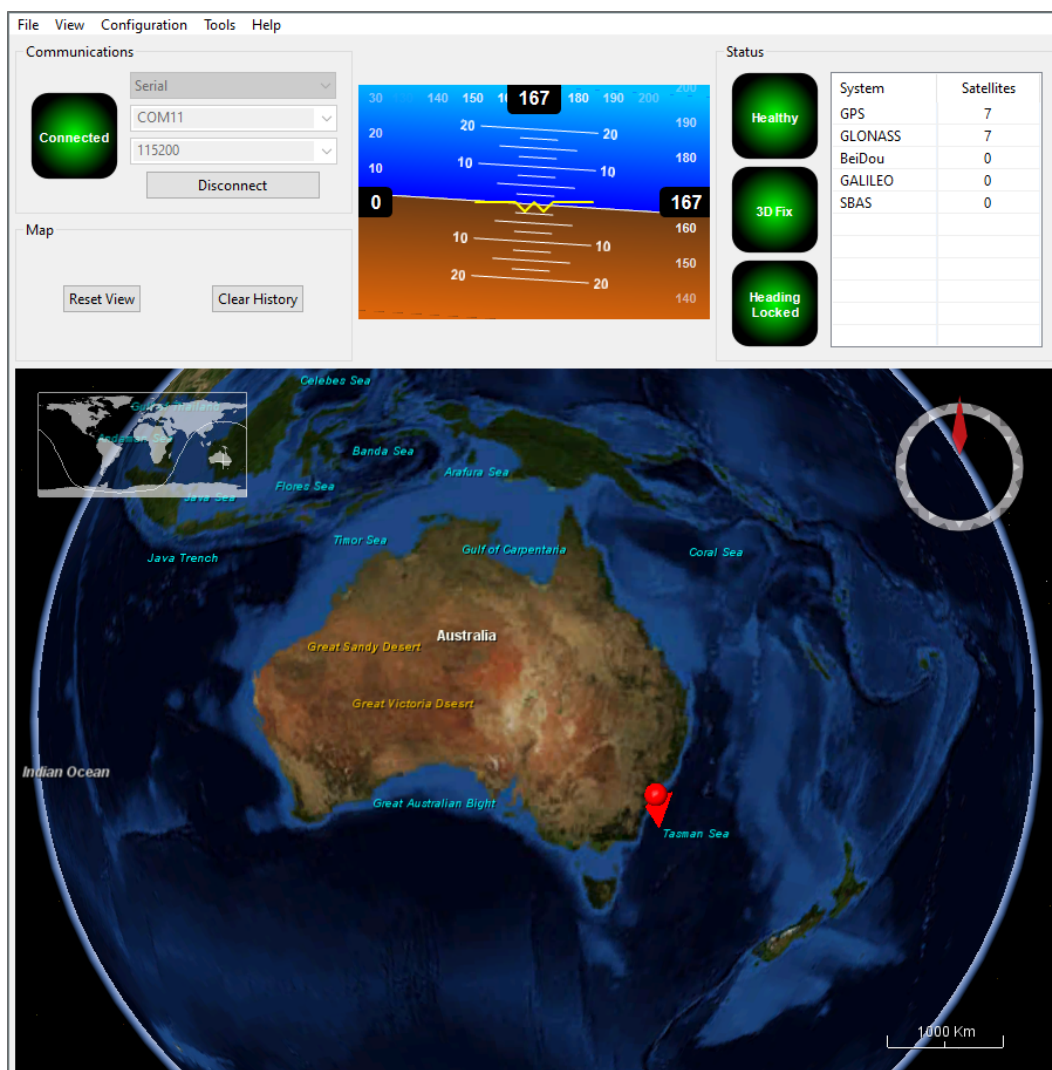
Figure 59: Screenshot of Boreas Manager

9.2.1 Boreas Manager Software Changelog

Version	Date	Changes
7.2	10 Nov 2023	Clear map history on reconnection Fix incorrect timezone text displayed in terminal.csv Updated leap-seconds list URL Add automatically log configuration at the start of a new log Added support for NavIC satellite system Fixed indicators behaviour on disconnect Updated support for Mac silicon with latest macOS Added support for extra NMEA 0183 messages Removed GNSS status indicator Fixed issue with opening windows containing charts Increased NTRIP client timeout Update support for Trimble BD9xx RTX frequencies as of 30 Sep 2022 Show COCOM status of Trimble BD9xx receivers in the licence field In satellites window, only populate azimuth and elevation fields in the table view when the values have been determined Added elevation to the gimbal state packet Add support for Boreas subtypes Add ability to set Packet Timer period
7.0	13 February 2023	Updated from JDK8 to JDK11. **JRE11/JDK11 required to run this release** Refresh Port Mode information on reconnection Refresh Packet Rates information on reconnection Fixed Ethernet Settings Static IP setting Improved reliability of firmware update Changed Low Voltage label to Internal Data Logging Error to support newer firmware Fixed issue with NTRIP client streaming from some servers When the NTRIP sourcetable says authentication type is any of '', 'B', 'N', then use Basic Authentication. This is to workaround NTRIP servers that incorrectly populate the authentication field Overwrite/clear existing packet rates on import of configuration Added Disable Dual Antenna Heading option Updated Seastar frequencies for Trimble receivers Updated RTX frequencies for Trimble receivers Added support for ARM (aarch64) processors with 64-bit OS Added support for Apple M1 processors and improved MacOS support Various UI improvements
6.2	10 October 2022	Fixed Heading indicator reporting as invalid after a successful Coarse Heading Alignment Added Moving Base output to GPIO configuration Fixed Packet Rates not being refreshed after a save Removed unavailable GPIO options Fixed status indicator message in case of a logging error Fixed configuration import via network Added allow firmware update over ANPP using Auxiliary, GPIO and Ethernet ports Added GNSS Firmware Update for BD992 variants Added CAN settings configuration

Version	Date	Changes
		Added ANPP14 Subcomponent information to Log Converter
		Added support for NTRIP Casters that request Username & Password to retrieve source table
		Added copying version numbers etc from Device Information and GNSS Receiver Information dialog boxes
		Renamed Log Conversion menu item
		Added Settings menu item
		Various bug fixes
6.1	18 Febru-ary 2022	Initial release of Boreas Manager

Table 28: Boreas Manager Software Changelog

9.2.2 System Requirements

Boreas Manager is only available for systems with x64 and ARM architectures.

Boreas Manager includes a 3D mapping display which requires an internet connection. If your machine does not meet the graphics requirements the mapping view will only show space without a globe.

Note, when Boreas is running at very high output rates e.g. 1000 Hz, Boreas Manager can consume significant system resources handling such large quantity of data.

9.2.3 Installation and Starting

The latest version of Boreas Manager can be downloaded from the **Boreas** product page of the Advanced Navigation website. Installation notes are as follows:

- **Java 11 is required** to run Boreas Manager.
  Adoptium JRE 11 is the recommended Java installer to be used on all platforms. Install the latest version of Java 11 from **Adoptium**, selecting the correct operating system and architecture for your computer.

- No installation process required for the Boreas Manager application on a Windows system — it can be run from any directory by simply double clicking on it. To open the program on some systems it may be necessary to right click and select open with → Java Runtime Environment.

- On MacOS systems it may be necessary to run the application from a terminal window:
  `java –jar -XstartOnFirstThread BoreasManager.jar`

- On Linux systems it may be necessary to run the application from a terminal window:
  java –jar BoreasManager.jar

The Boreas Evaluation Kit includes an FTDI USB to RS232 / RS422 adaptor cable. The drivers are normally installed automatically, but if not they are available for download from **www.ftdichip.com/Drivers/VCP.htm**.

9.2.4 Troubleshooting

If the application will not start, the most common reason is that you have 32-bit Java installed on a 64-bit operating system. Uninstall Java and reinstall the 64-bit version.

If the globe does not appear in the 3D map area, this indicates that either your graphics card is not powerful enough, your graphics card driver is out of date, or you have no internet connection.

- Ensure the RS232 / RS422 switch is in the correct mode. The Boreas factory default mode is RS422.

- Ensure you select the correct COM port. This can be easily identified by unplugging and re-plugging in the USB connector.

- Ensure you have the correct baud rate selected in Boreas Manager. The factory default value for the baud rate is 115200 bps for the Primary, GPIO and Auxiliary ports.

Contact technical support **support@advancednavigation.com** if you have any questions or require further assistance.

9.2.4.1 Windows

There is a well known problem with USB serial devices under Windows known as "crazy mouse". The problem occurs when the system mistakenly installs the USB serial device as a mouse. If you experience this problem, often a restart will resolve it. Otherwise there is a tool that can fix this issue available at **http://www.stentec.com/anonftp/pub/wingps/pnpblockersetup.exe**.

If the serial port does not show up when you plug in the FTDI USB to RS232/RS422 adaptor cable, you may need to install the drivers from **www.ftdichip.com/Drivers/VCP.htm**.

When operating Boreas on Windows at a high data rate, data can be lost due to the latency of the FTDI driver. To resolve this problem the latency of the driver should be reduced to 1 ms:

1. Start the Windows Device Manager (1) and find the Ports section (2).

2. Identify the specific COM port being used (3) by dis-connecting and re-connecting the USB to RS232 / RS422 adaptor cable.

3. Right click on the identified COM port and select Properties. Select the Port Settings tab (4) and select Advanced (5).

4. Change the Latency Timer value (6) to 1 msec then press OK (7), and OK again for the previous window.
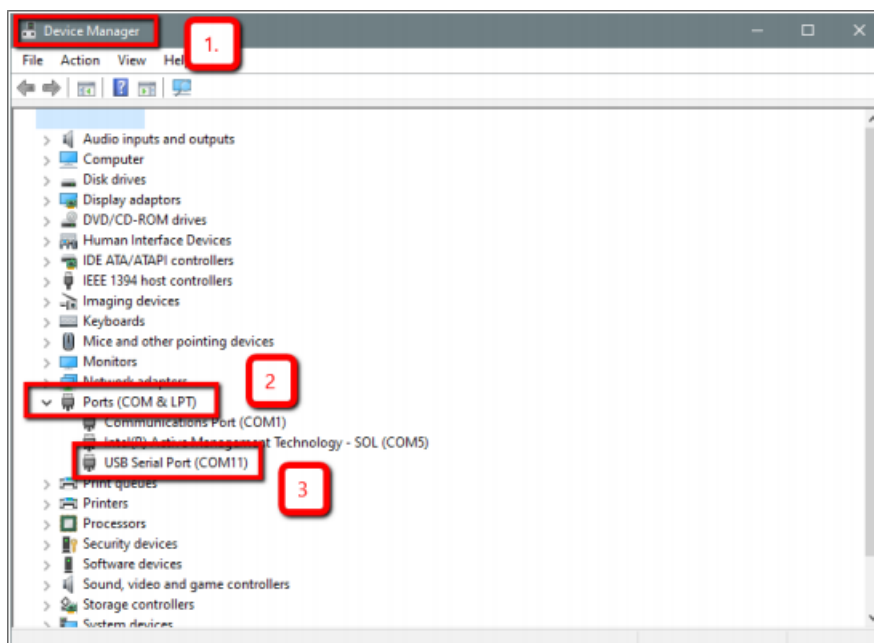
Figure 60: Setting the Windows Port Latency Value - 1
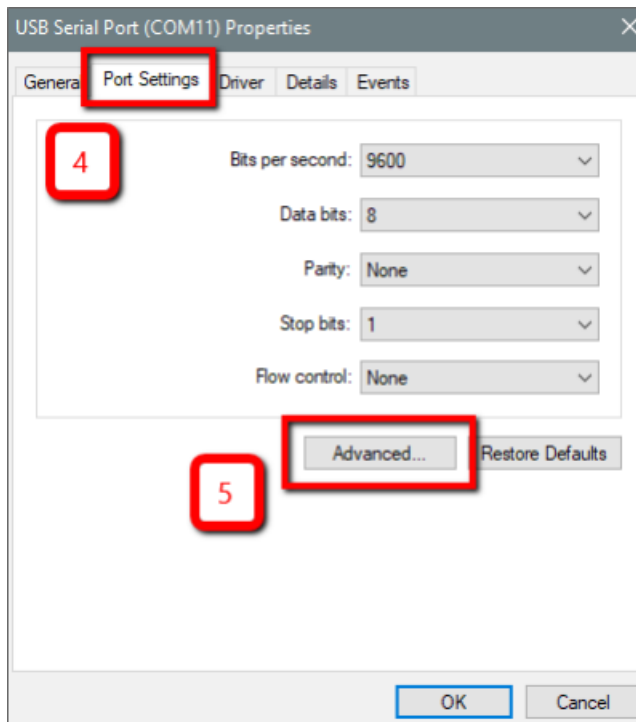
Figure 61: Setting the Windows Port Latency Value - 2
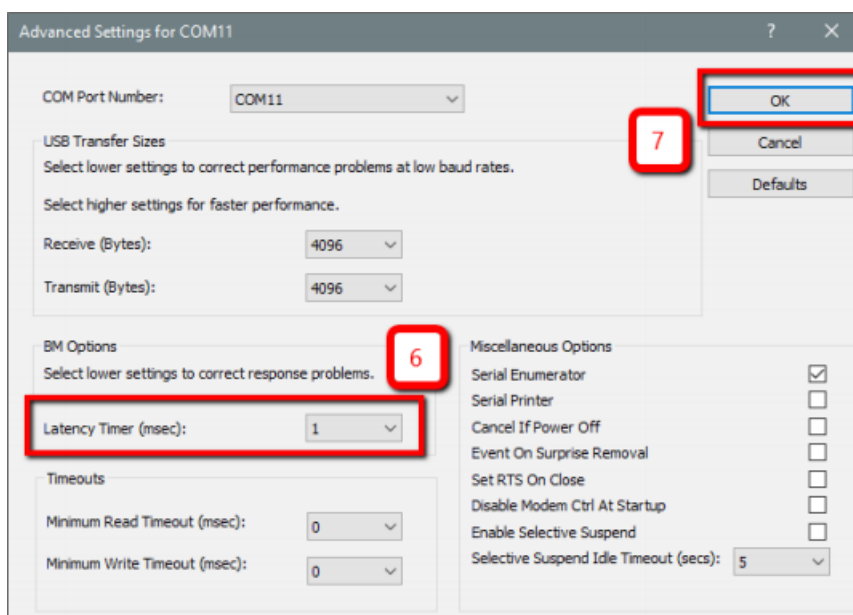
Figure 62: Setting the Windows Port Latency Value - 3

9.2.4.2 Linux

If serial ports do not show up, the typical reason is a lack of permissions. The user should add themselves to the dialout group with the command:

```
sudo adduser username dialout
```

Compiz causes issues with the 3D mapping. If you are experiencing problems it is recommended to turn off Compiz.

Modemmanager can also sometimes cause problems on Linux installations. If you are not using a modem, it is recommended to remove modemmanager with the command:

```
sudo apt-get remove modemmanager
```

9.2.5 Main View
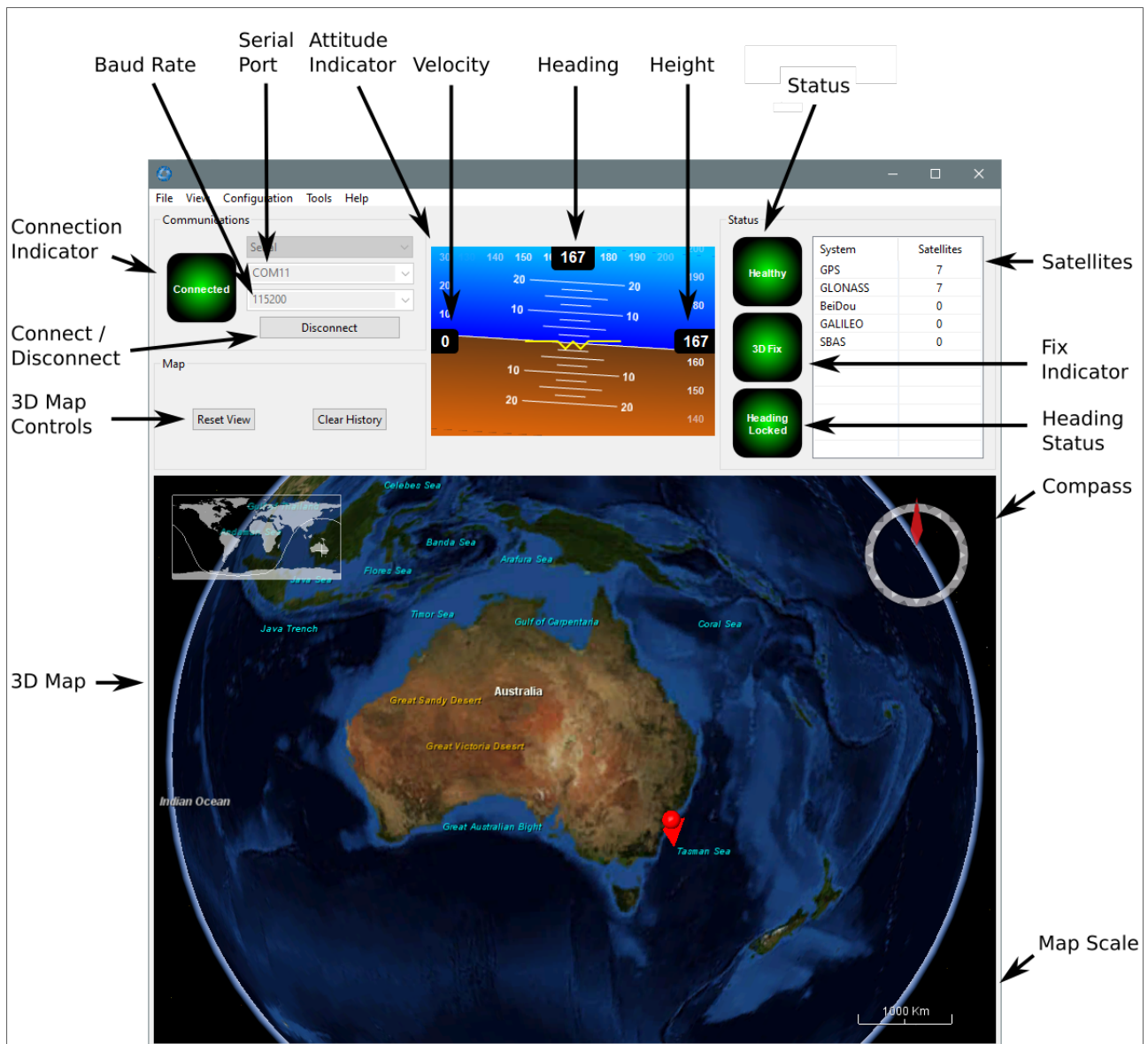
Figure 63: Manager Main View

9.2.5.1 Serial Port

The Serial Port dialogue is used to connect to Boreas. Select the serial port and baud rate and click **Connect**. The default baud rate of Boreas is 115200. The Connection Indicator displays whether there is communication with a Boreas unit.

9.2.5.2 Attitude Indicator

The aircraft style Attitude Indicator shows roll and pitch through a virtual horizon. Around the sides heading, speed and height are shown. All units are SI (metric) and degrees.

9.2.5.3 Satellites Table

The Satellites table shows the number of satellites visible by the primary antenna. More detailed information can be found in the **9.2.6.4 Satellites** sub section under the **9.2.6 View Menu**.

9.2.5.4 Status Indicator

The Status indicator section contains a Boreas status indicator, a fix indicator and a satellites table.

- Boreas Status Indicator - This indicator shows any problems with Boreas. Before a GNSS position fix is achieved it will show the status "Filter not initialised". Once the filter has initialised it should show "Healthy". Clicking on the indicator will show the detailed status flags.

- Fix Indicator - This shows the status of the GNSS position fix. Under normal operating conditions it should show either "3D Fix" or "SBAS Fix". When satellite visibility is poor it may show either "2D Fix" or "No Fix".

- Satellites Table - The Satellites table shows the number of active satellites being used in the current GNSS solution. More detailed information can be found in the satellites view.

9.2.5.5 3D Map

The 3D map shows the Boreas position on the Earth as well as a red trail of position history. When the filter initialises the map will automatically reset the view to the Boreas position. To move the camera click and drag on the map. To zoom in and out use the mouse scroll wheel. To change the camera view right click and drag or shift click and drag.

9.2.5.6 3D Map Controls

- Reset View : This resets the map view to current position.

- Clear History: This clears the current position history, this is the red trail shown on the map.

9.2.5.7 Baud Rate

This displays the current and available baud rates options for the serial connection.

9.2.5.8 Connect / Disconnect

This button enables the serial connection to be either connected or disconnected.

9.2.6 View Menu

9.2.6.1 View

The View menu contains a number of different options for viewing data from Boreas.
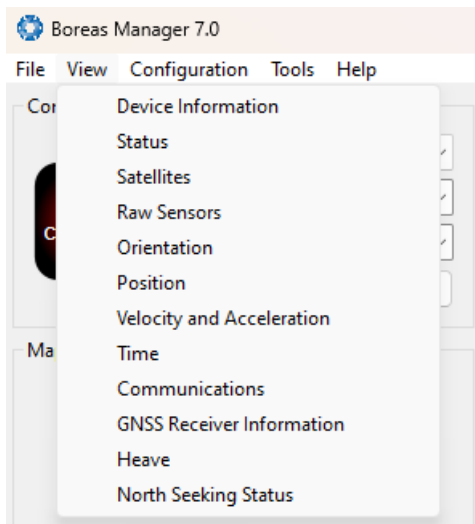
Figure 64: Manager View Menu

9.2.6.2 Device Information

Device information is useful during technical support and for tracking your serial number, firmware and hardware version.
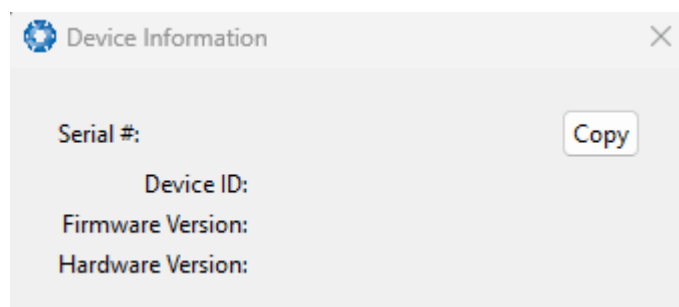
Figure 65: Manager Device Information

9.2.6.3 Status

The Status shows the current status of Boreas as reported by sections **11.4.1 System State Packet** (ID#20) and **11.4.10 Raw GNSS Packet**. (ID#29).

Note: The following Status flags do not update for Boreas units with a Trimble BD992 GNSS Receiver. These flags are only applicable to Aries GNSS Receivers: GNSS 2, Antenna 1 disconnected, Antenna 2 disconnected, Antenna 1 short, Antenna 2 short
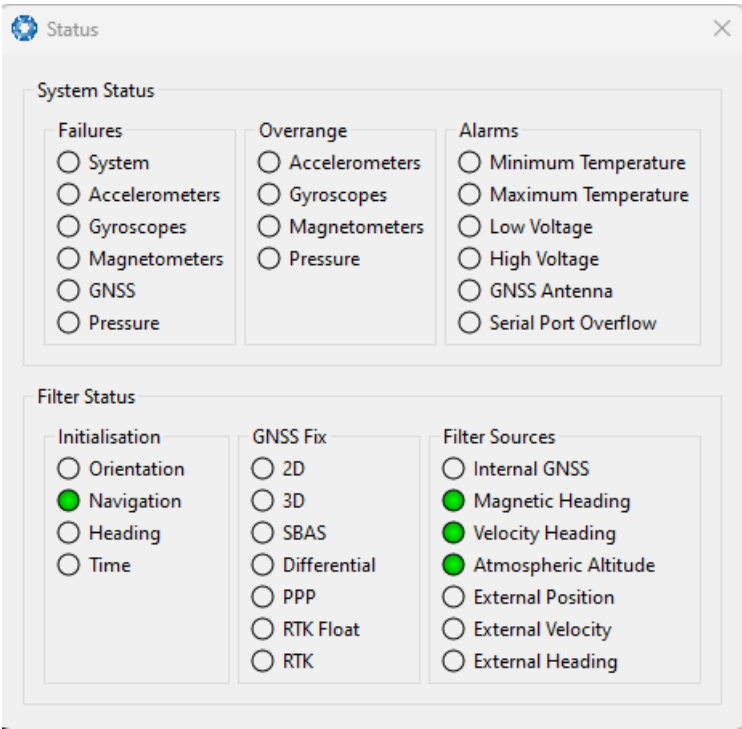
Figure 66: Manager Status Dialogue

9.2.6.4 Satellites

The Satellites dialogue shows detailed information on the satellites that are visible to the Boreas GNSS receiver.

The information is displayed as a satellite skyplot, a table and an SNR (Signal-to-Noise Ratio) graph. A maximum of 28 satellites will be displayed, even if more are accessible. This plot shows the SNR of each satellite at the primary and secondary antenna. As a guideline, these should be within 5-10 dB of each other in the absence of cable or antenna faults. Elevation and azimuth are in units of degrees.

Figure 67: Manager Satellites Table

9.2.6.5 Raw Sensors

Raw sensors shows the temperature calibrated raw sensor values.

Temperature readings are available for a range of sensors: T(Ax), T(Ay), and T(Az) correspond to the accelerometer's x, y, and z axes; T(Gx), T(Gy), and T(Gz) relate to the gyroscope's X, Y, and Z axes; T(M) is for the magnetometer; and T(P) indicates pressure.
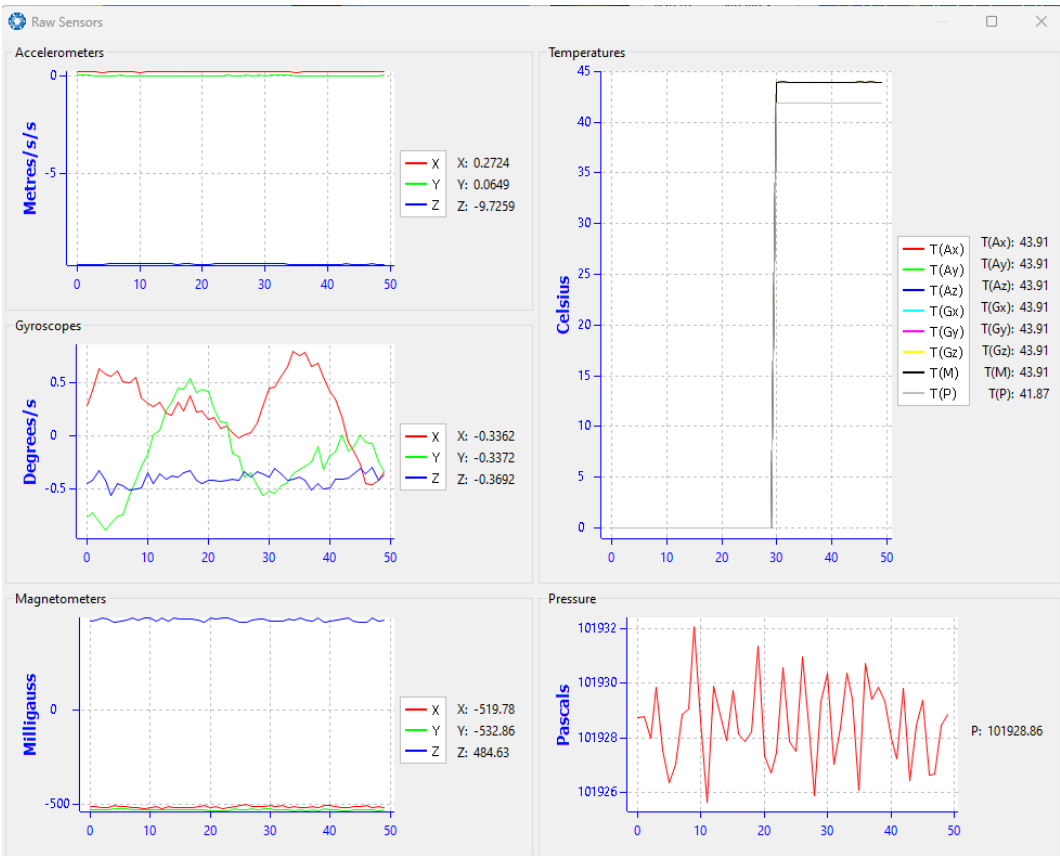
Figure 68: Manager Raw Sensor Outputs

9.2.6.6 Orientation

Orientation shows the Boreas orientation, angular velocity and orientation error. To enhance the user's understanding of some of the less intuitive metrics, **Course** is defined as the path determined by measuring sequential positions, and **Slip** is the difference between the heading and the course.
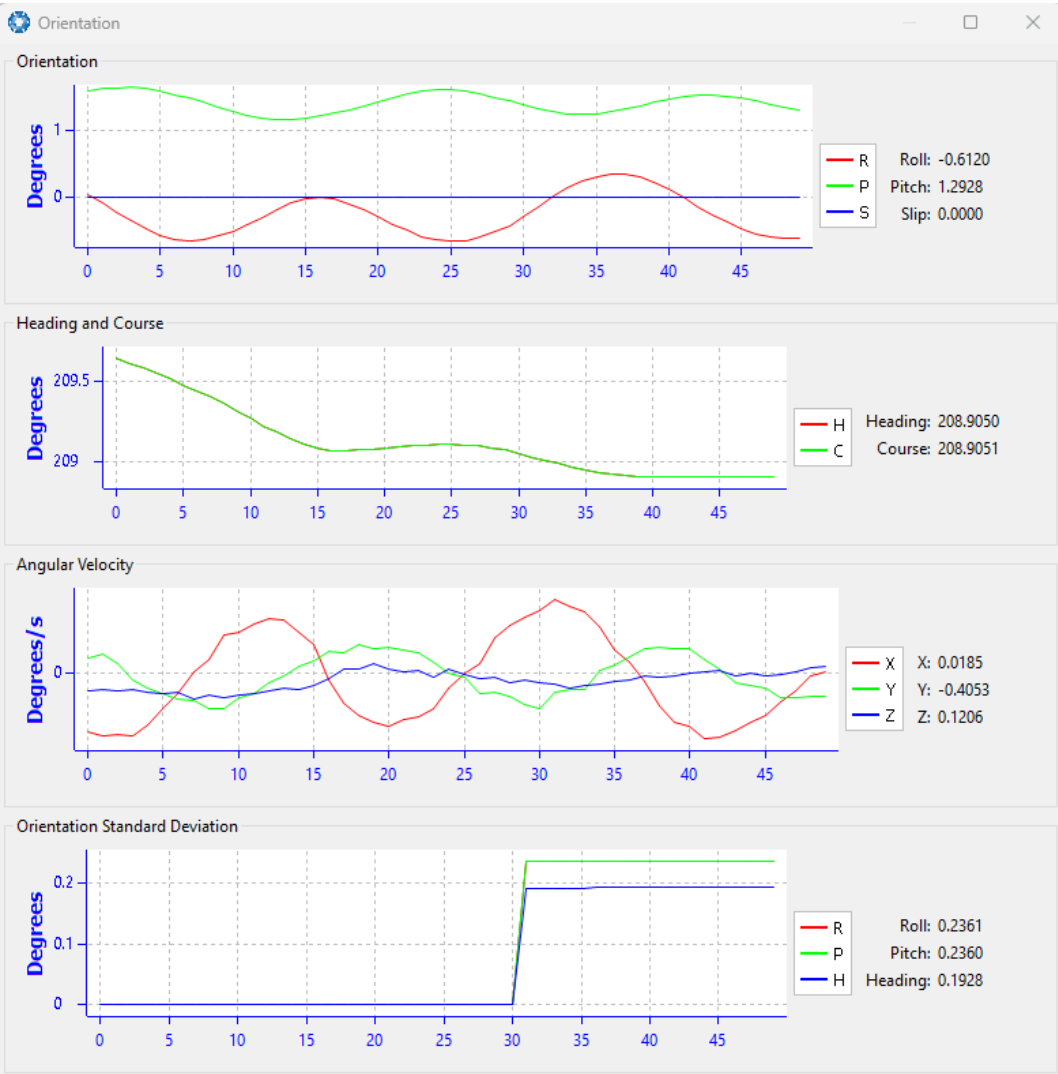
Figure 69: Manager Orientation Outputs

9.2.6.7 Position

Position shows the Boreas position and position error. Latitude and longitude are converted to North and East metres from a reference point that can be reset.
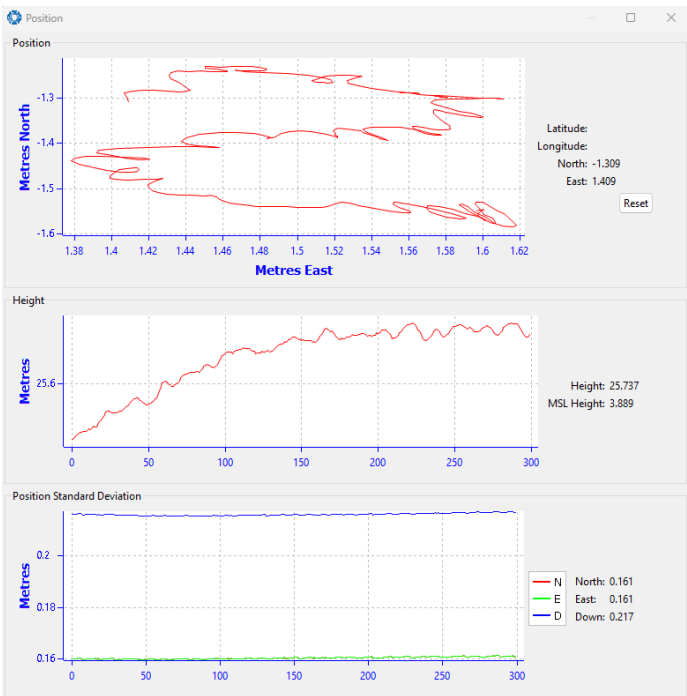
Figure 70: Manager Position Outputs

9.2.6.8 Velocity and Acceleration

Velocity and Acceleration shows the Boreas velocity, acceleration and g-force.
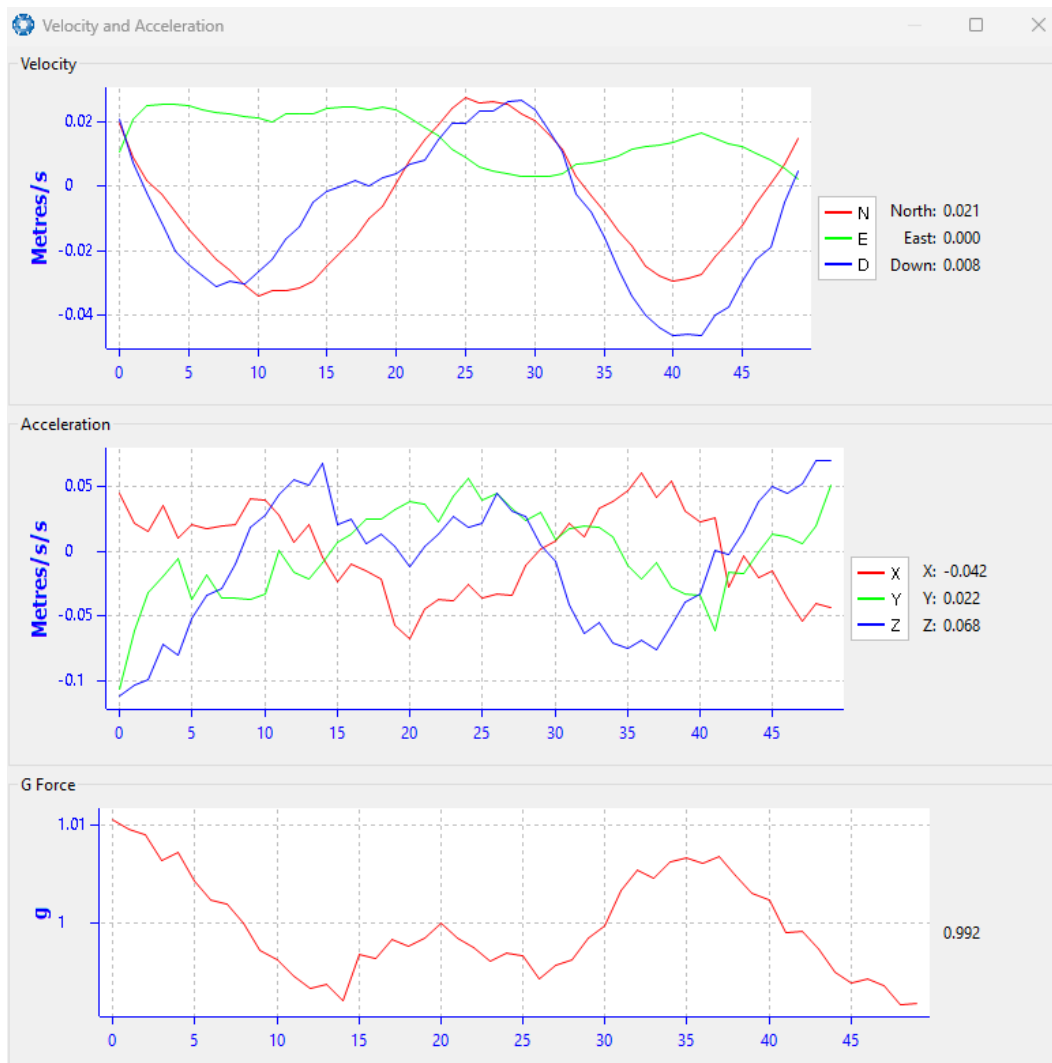
Figure 71: Manager Velocity and Acceleration Outputs

9.2.6.9 Time

This dialogue box allows the to view the time for the connected device. Views are in Unix, UTC, or Local time formats to best suit user requirements to ensure accurate timekeeping and synchronisation across systems.
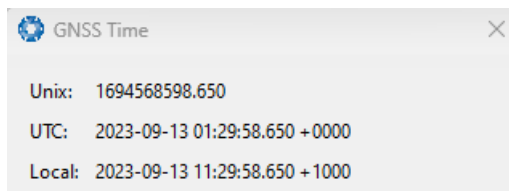
Figure 72: Time Dialogue

9.2.6.10 Communications

This dialogue shows statistics on the data packets received from Boreas and can be useful in diagnosing signal integrity problems.
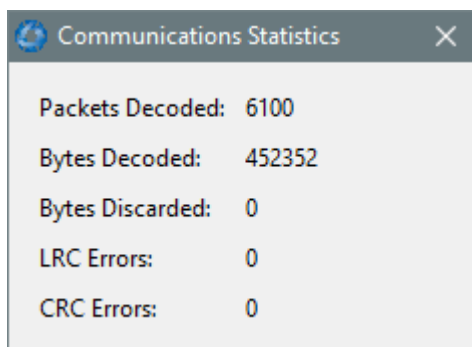
Figure 73: Manager Communications Dialogue

9.2.6.11 GNSS Receiver Information

This dialogue shows information about the GNSS receiver fitted to the Boreas.
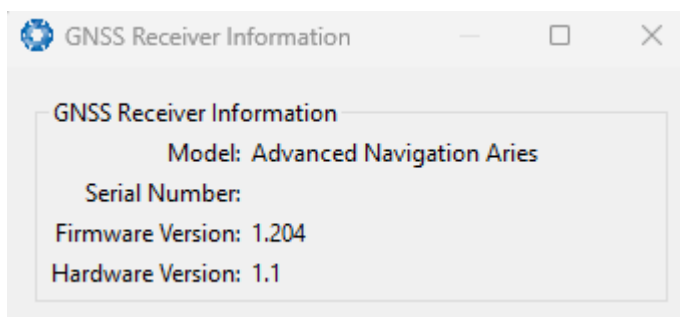
Figure 74: Manager GNSS Receiver Information Dialogue

9.2.6.12 Heave

For the Heave dialogue to function the heave packet (ID 58) must be set to output periodically using the Packet Rates dialogue.
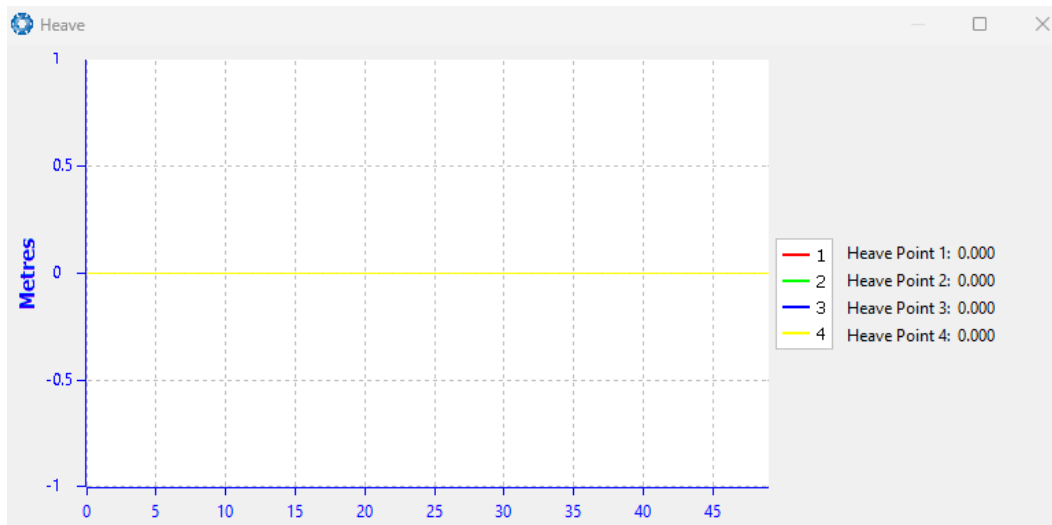
Figure 75: Manager Heave Outputs

9.2.6.13 North Seeking Status

Coarse Alignment is used to derive the heading based on a gyrocompass' estimation of true North. For more information, see **8.4 Heading Sources**. Coarse alignment is necessary to establish an approximate heading when a dual antenna GNSS heading or alternate source is unavailable, such as in a GNSS denied environment. Once coarse alignment is complete, a heading is established, after which the gyrocompass will be used for fine alignment.

The Coarse Heading Alignment page displays the current status of the initialisation process. Given below is a list statuses and warnings that may be displayed during this process:

Status Messages	Description
Awaiting position via GNSS or manual initialisation	An approximate position is required to complete coarse alignment. Initialisation will commence as soon as the position is available. If GNSS positioning is not available, provide the position details manually on the **9.1.3.9 Manual Initialisation** page.
Initialising, please wait	With the position known, the process of determining the coarse heading alignment has commenced. This process will take 2 minutes, unless it is restarted due to excessive motion or a significant change in latitude.
Alignment initialised via alternate source	Coarse alignment is not required as heading has been initialised via an alternate source, such as **dual antenna** , **velocity** or **external input**. If heading is available from one of these sources, coarse alignment is not required.
Heading coarse alignment complete	The system has successfully determined an approximate heading.

Table 29: Coarse Heading Alignment - Status Messages

Warning Messages	Description
Initialisation restarted - excessive motion detected	Initialisation has been automatically restarted due to excessive motion.
Initialisation restarted - change in latitude detected	Initialisation has been automatically restarted due to a significant change in latitude.
Initialisation restarted - Change in COG lever arm detected	Initialisation has been automatically restarted due to a change in the Centre of Gravity (COG) lever arm **configuration**.
Warning - Check latitude, value out of range	A discrepancy between the current latitude and the coarse alignment algorithm has been detected. Check the current latitude is correct.

Table 30: Coarse Heading Alignment - Warning Messages

9.2.7 Configuration Menu

The Configuration menu contains a number of dialogues for the configuration of Boreas.
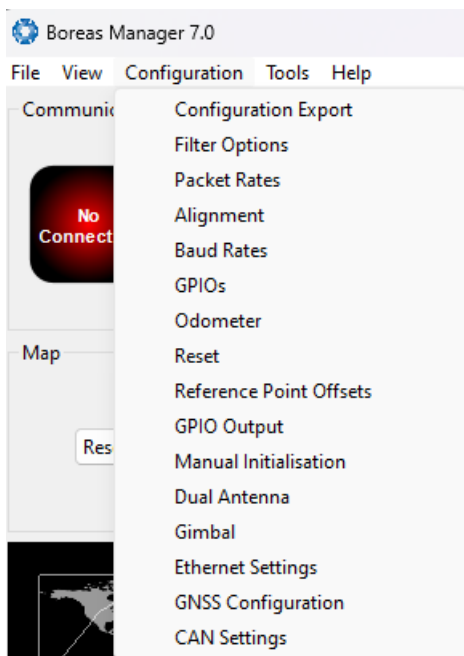
Figure 76: Manager Configuration Menu

9.2.7.1 Configuration Export

The Configuration Export dialogue can be used to export all the Boreas settings to a file. This file can be imported at a later date or on other units. This is useful to restore a unit to a pre set configuration at a later date or for batch configuration of multiple units.
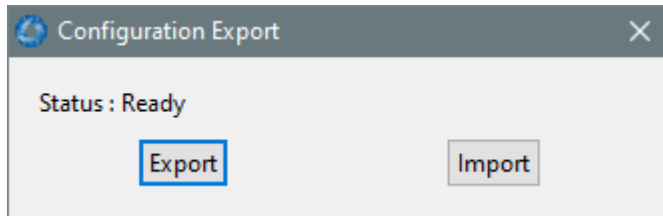
Figure 77: Manager Configuration Export Dialogue

9.2.7.2 Filter Options

For most applications the default filter options should be used and only the vehicle profile set. If in doubt please contact **support@advancednavigation.com**.
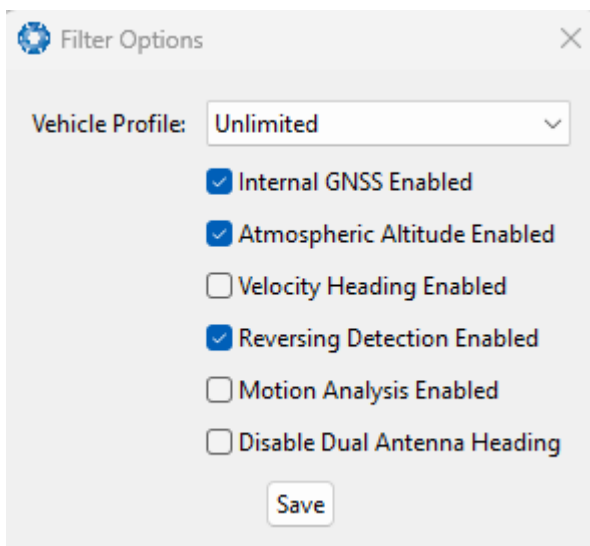
Figure 78: Manager Filter Options

9.2.7.3 Packet Rates

The Packet Rates dialogue allows the user to specify which packets output on a periodic basis and at what rate. The default packets enabled are the System State Packet (ID 20) and the Raw Sensors Packet (ID 28) at 20Hz and these typically provide all the data that a user will require. These two packets need to be enabled for the data graphs to update in Boreas Manager. Other state packets can be enabled as required.

> **Note**: Packet rate configuration applies only to the data port which the Manager is connected to. To configure other ports, the Manager must be connected to that port.

Figure 79: Manager Packet rates

9.2.7.4 Alignment

The Alignment dialogue is used to set the alignment offsets of the system installation. It is important to set the values in this dialogue correctly for accurate results. For most applications only the GNSS antenna offset values need to be entered and the rest of the values can be left at their factory defaults of zero.
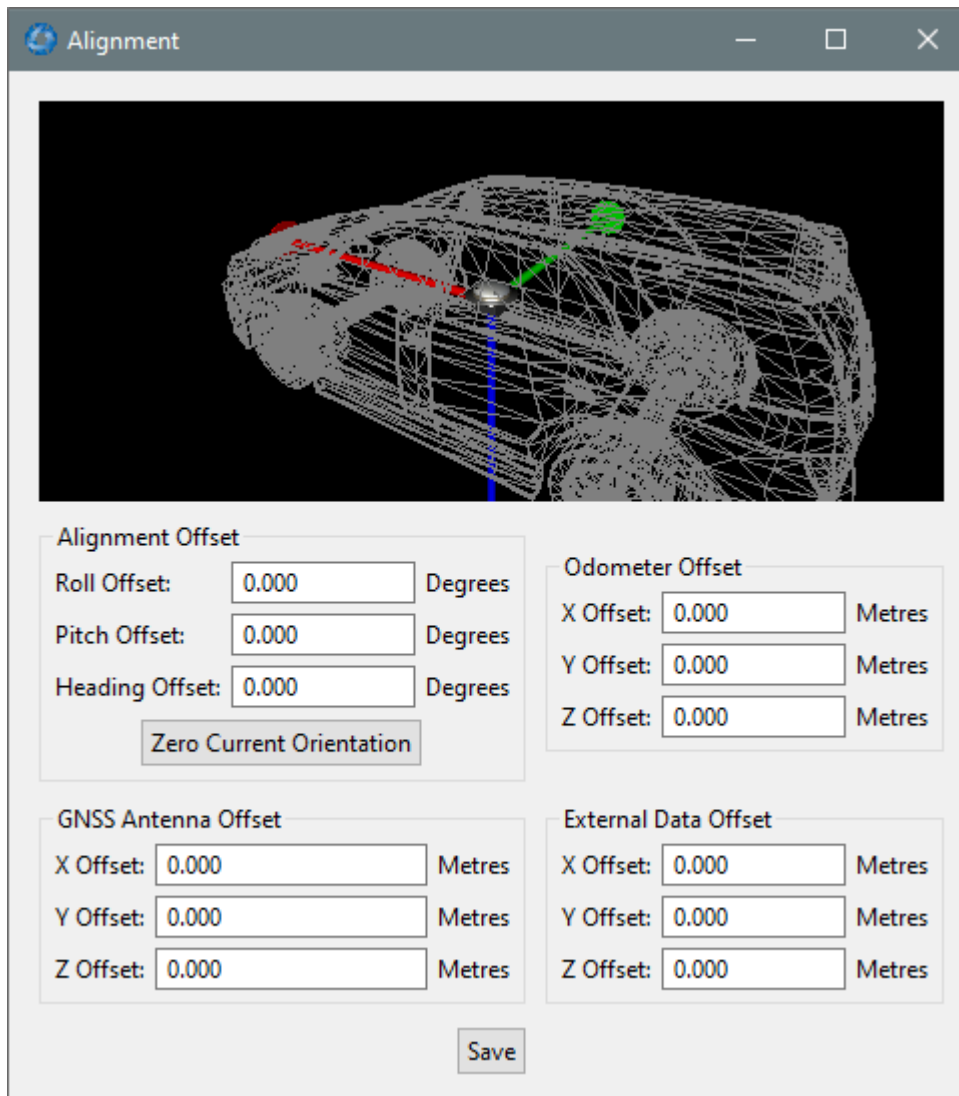
Figure 80: Manager Alignment Dialogue

Alignment Offset

If Boreas is installed into the vehicle with the positive X-axis pointing forwards and the positive Z-axis pointing down, then no alignment offset is required and the roll, pitch and heading offset values can remain at the factory defaults of zero.

If the unit is installed in a different orientation then the roll, pitch and heading offset must be entered. For example if the unit is installed on its side with the X-axis pointing up and the Z-axis pointing forwards and no change to the Y-axis, then this would result in a pitch offset of +90 degrees with roll and heading remaining zero.

If there is a small misalignment due to mechanical mounting error this can be compensated for by setting the vehicle stationary on a level surface and pressing the **Zero Current Orientation** button.

Note: Zero Current Orientation will only correct for roll and pitch offsets, the Heading offset must be entered manually and saved before using this function.

All the other offsets will be measured in the realigned body co-ordinate frame (X positive forward, Z positive down) after being corrected for any alignment offset entered.

GNSS Antenna Offset

The GNSS antenna offset is measured from the centre of the Boreas unit to the phase centre of the primary antenna in the orientation of the **12.3 The Body Co-ordinate Frame** (X positive forward, Z positive down).

Odometer Offset

The odometer offset is measured from the centre of the Boreas unit to the point at which the vehicle's tyre being measured makes contact with the road in the body co-ordinate frame (X positive forward, Z positive down).

If your odometer is not measuring a specific wheel, the offset should be to the point on the ground beneath the measurement point. If, for example, your car is a front wheel drive and you are using the velocity from the car OBDII port, the measurement point would be midway between the two front wheels.

External Data Offset

These values are only required for speciality applications operating with an external source of velocity data. The offsets are used when providing NMEA Input, External GNSS, or with an Air Data Unit. When using a DVL, use the odometer offset. Contact **support@advancednavigation.com** for assistance with these values.

9.2.7.5 Port Mode and Baud Rates

Some machines running Microsoft Windows do not support higher baud rates. When changing baud rates, it is recommended to test the baud rate configuration first, without ticking the Permanent box. This way, if it is not possible to communicate at the higher baud rate, a power cycle can be used to revert to the previous baud rate setting.

The factory default baud rate value for these ports is 115200 bps.

The primary and auxiliary ports can be set to RS232 or RS422. The factory default is RS232 for both ports.
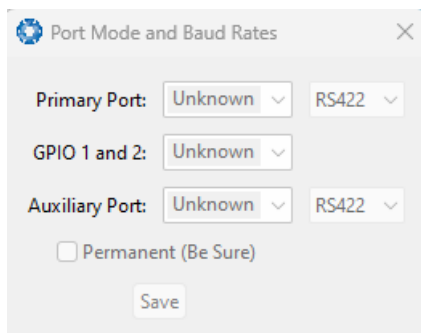
Figure 81: Manager Baud Rates Dialogue

9.2.7.6 GPIO

This page allows the user to configure the input and output functions of the GPIO and Auxiliary ports. These functions are described in detail in **10.6.1 Dynamic Pin Functions**. These functions change dynamically and are effective immediately upon clicking **Save Changes**.

> **Note**: The GPIO port functions at RS232 levels for data functions and 0 to 5 volt (or 0 to 3.3 V) levels for all other functions. The auxiliary port functions at RS232 or RS422 levels for data functions and 0 to 5 volt (or 0 to 3.3 V) levels for all other functions. The internal hardware automatically reconfigures based upon the selected function.

The default values for these settings are Inactive. The dedicated 1PPS signal is active by default.

Figure 82: Manager GPIO configuration Dialogue

9.2.7.7 Odometer

The Odometer dialogue allows the user to configure the odometer pulse length and view the real time odometer data to verify correct operation. See **7.10 Odometer** and **8.8 Odometer Pulse Length** for more information on the use of odometers. The odometer offset is also applied when using a DVL input.
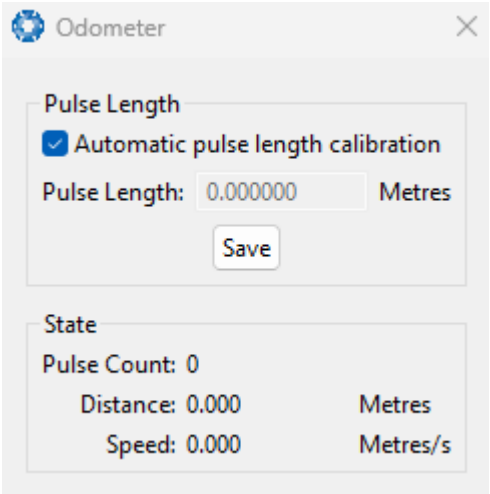
Figure 83: Manager Odometer Dialogue

9.2.7.8 Reset

The Reset button causes the system to perform a power cycle. No configuration settings or state data are lost. The Cold Start button clears all filters, and connections are reset and must re-established. No configuration settings are lost. The Factory Restore button resets all Boreas settings back to their factory defaults, including state data and all configuration settings. It also erases the hot start data so that the system is forced to perform a cold start.

Note: A Factory Restore will re-enable the DHCP Client and lose any static IP address settings.
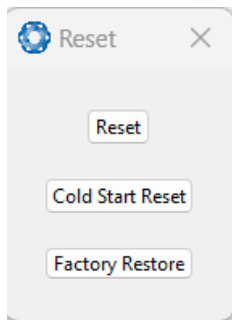
Figure 84: Manager Reset Dialogue

9.2.7.9 Reference Position Offsets
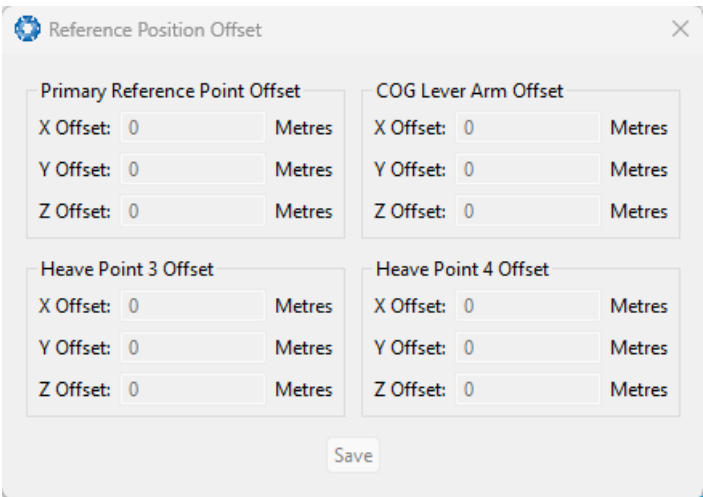
The Reference Point Offsets dialogue allows the user to set measurement points away from its default position at the physical centre of the Boreas unit. The primary reference point offset applies to data from all ANPP packets as well as all peripheral output such as NMEA messages and Heave Point 1.

When the values are zero the measurement point is the centre of the Boreas unit. This can be offset to a different position on the profile by entering the offset value from the centre of the Boreas unit to the desired position in the body co-ordinate frame (X positive forwards, Z positive down).

The Centre of Gravity (COG) Lever Arm Offset should be used to define where the centre of gravity is for the vehicle. It is useful in applications, such as a surface vessels, to improve the ability of the **8.4 Heading Sources** to complete coarse alignment.

The Heave Points 3 and 4 allow the user to offset reference points for the heave values 3 and 4 in the **11.4.36 Heave Packet**.

Note: These values only apply to the Heave Packet. NMEA, TSS and Simrad heave is not affected by the values in this dialogue which are always measured at the centre of the Boreas unit.

Figure 85: Manager Reference Position Offset

9.2.7.10 GPIO Output

The GPIO output configuration dialogue allows the user to configure the NMEA0183, TSS1 and SIMRAD output rates for the GPIO and Auxiliary port. These output rates will be observed with respect to the actual output selected in the **9.2.7.6 GPIO** port configuration.

Figure 86: Manager GPIO Output Dialogue

9.2.7.11 Manual Initialisation

The Manual Initialisation dialogue can be used to manually initialise Boreas when a GNSS fix is not available. Setting the position will initialise the navigation filter. Setting the heading will also initialise the heading filter.

Figure 87: Manual Initialisation Dialogue

9.2.7.12 Dual Antenna

The Dual Antenna configuration page is only used if the primary and secondary GNSS antennas are not installed in their recommended and default positions of primary front and secondary rear, at the same height. If it is not practical to mount the antennas in the recommended alignment, the alternate alignments must be entered into this page. It is recommended to try and use one of the automatic offsets where possible, where the antennas must be installed in one of four different automatic offset orientations aligned on an axis. If it is not possible to use one of the automatic offsets, the antennas can be installed in any configuration and a manual offset should be entered. The manual offset is measured from the central base of the secondary antenna to the central base of the primary antenna in the body co-ordinate frame (X+ forward, Z+ down). If using a manual offset, be careful to measure the offset accurately, as even small offset errors can result in relatively large heading errors e.g. 2 cm error = 1.15 degrees heading error with a 1 metre separation.

- When using an automatic offset, the manual offset values are ignored.
- When using a manual offset, the automatic offset selection is ignored.
- When using automatic offset, the manual offset values will show the distance that Boreas has automatically measured.

Figure 88: Manager Dual Antenna Dialogue

9.2.7.13 Gimbal

The Gimbal configuration dialogue is only used in speciality gimbal applications. Contact **support@advancednavigation.com** for more information on using Boreas inside a gimbal.
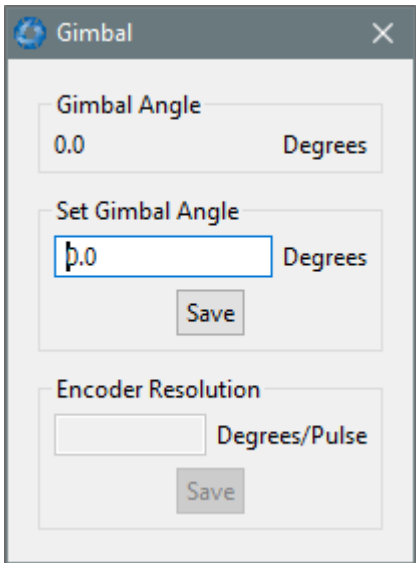
Figure 89: Manager Gimbal Dialogue

9.2.7.14 Ethernet Settings

The Ethernet Settings dialogue allows the user to enable or disable the DHCP Client. When the DHCP Client is disabled you need to enter the TCP/IP settings if the user wishes to access the web UI. If the user is connecting to Boreasvia the primary port these settings can be ignored. The default is for the Ethernet mode to be set to DHCP.
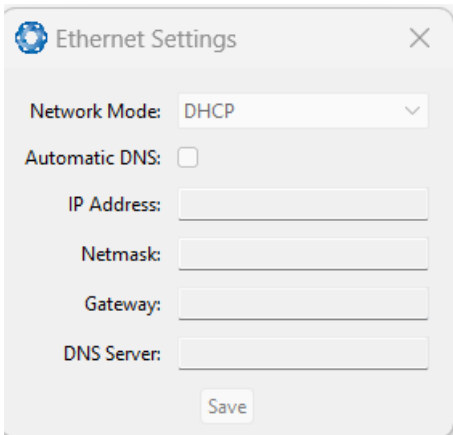
Figure 90: Manager Ethernet Settings Dialogue

9.2.7.15 GNSS Configuration

The GNSS Configuration dialogue allows the user to select constellation configurations based on the type of GNSS receiver installed. If an invalid configuration is entered, the system will revert to the previous configuration when attempting to save changes. To confirm that changes have been successfully saved, close and re-open the GNSS Configuration dialogue.
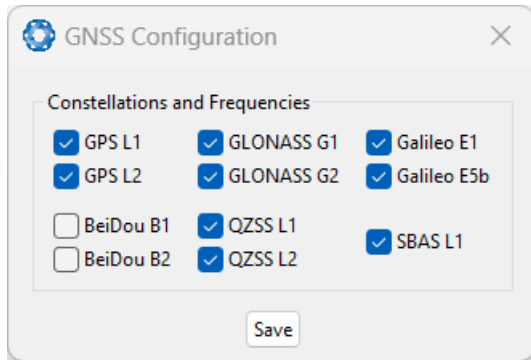
Figure 91: Manager GNSS Configuration Dialogue

Aries GNSS Receiver

When using an Aries GNSS receiver, the following configuration rules are applicable:

- By default, GPS, Galileo and GLONASS are enabled, along with SBAS and QZSS correction services.
- When selecting a GNSS constellation, all frequencies for that constellation must be selected.
- SBAS and QZSS correction services can also be enabled for all constellation configurations, except when using GPS, Galileo and BeiDou together.

The table below lists the supported constellations and the corresponding GNSS sample period depending upon the number of constellations selected. When setting the data ports, the packet rate of the **11.4.10 Raw GNSS Packet** and **11.4.37 Raw Satellite Data Packet** are automatically adjusted to the next lower integer multiple of the sample period.

# of Constellations Configured	Sample Period	Example Effective Packet 60 Rate	Supported Constellation Configurations
1	50 ms	1 ms - 99 ms = 50 ms (20 Hz) 100 ms - 149 ms = 100 ms (10 Hz) 150 ms - 199 ms = 150 ms (6.67 Hz)	GPS Galileo GLONASS BeiDou
2	80 ms	1 ms - 159 ms = 80 ms = 12.5 Hz 160 ms - 239 ms = 160 ms (6.25 Hz)	GPS & Galileo GPS & GLONASS GPS & BeiDou
3	100 ms	1 ms - 199 ms =	GPS, GLONASS &

# of Constellations Configured	Sample Period	Example Effective Packet 60 Rate	Supported Constellation Configurations
		100 ms (10 Hz) 200 ms - 299 ms = 200 ms (5 Hz)	Galileo GPS, GLONASS & BeiDou (no correction services)
4	125 ms	1 ms - 249 ms = 125 ms (8 Hz) 250 ms - 374 ms = 250 ms (4 Hz)	GPS, Galileo, GLONASS & BeiDou

Trimble BD992 GNSS Receiver

When using a Trimble BD992 GNSS receiver, the following configuration rules are applicable:

- For any given constellation, the first (1) frequency must be enabled in order to receive additional frequencies.
- Galileo and BeiDou are licensed separately, see **5.3 GNSS Receiver Licence Upgrades** for details.
- L Band corrections are available on this receiver, however require an additional subscription to Omnistar or RTX. Advanced Navigation does not supply these, contact Trimble for further details.

9.2.7.16 CAN Settings

The CAN Settings page allows you to enable or disable the CAN functionality. If the user is connecting to Boreas via the primary port then these settings can be ignored. The default for CAN is Enabled at 1,000,000 baud rate. A CANOpen EDS file is available. Contact **support@advancednavigation.com** to obtain a copy of this file.
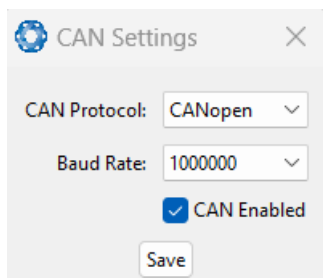
Figure 92: Manager CAN Settings Dialogue

9.2.8 Tools Menu

The **Tools** menu contains tools for performing certain procedures with Boreas.

Figure 93:
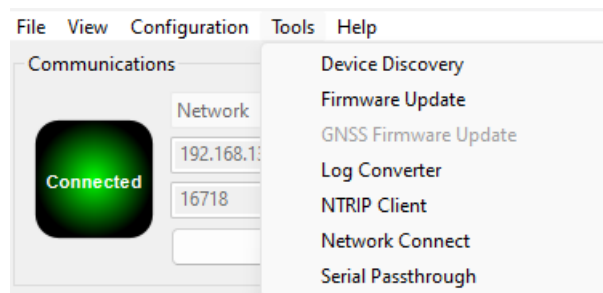
Figure 94: Manager Tools Menu

9.2.8.1 Device Discovery

Device discovery allows network discovery and reconfiguration of devices on the local network regardless of network settings.
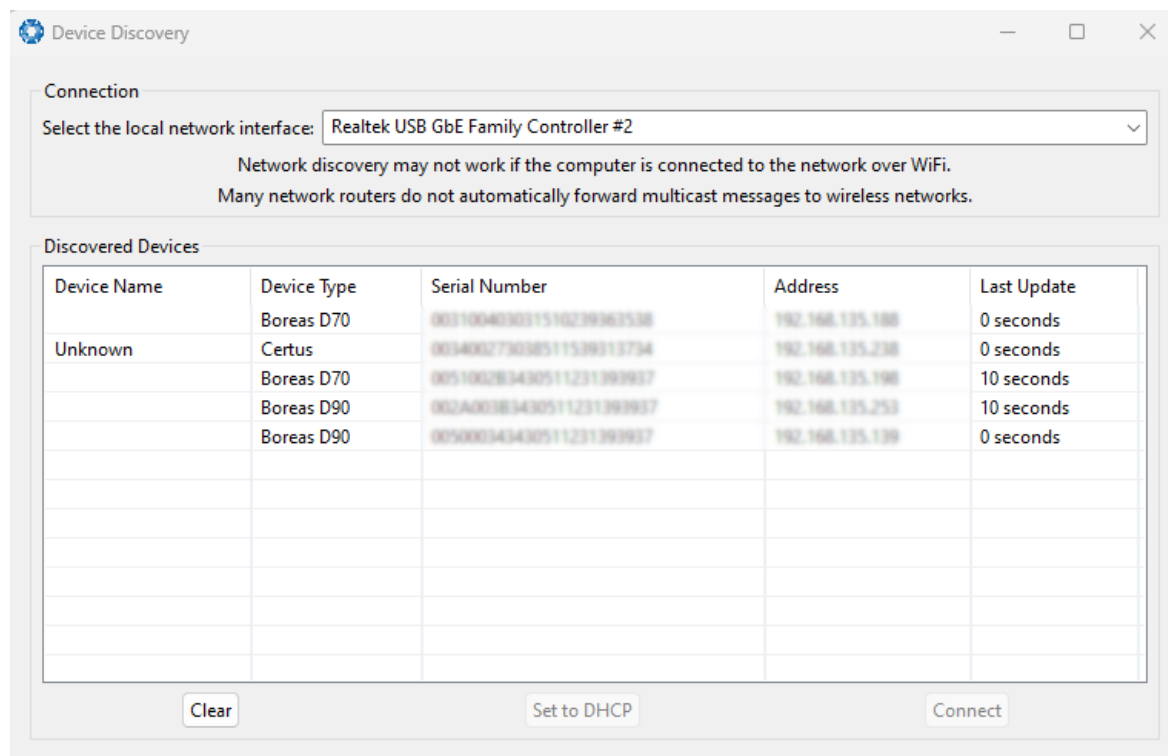
Figure 95: Device Discovery Dialogue

Set to DHCP

Once discovered devices on uncontactable network addresses can be reset to DHCP by pressing the "Set to DHCP" button for that device.

9.2.8.2 Firmware Update

This dialogue is used to update the Boreas device firmware.

Boreas contains firmware which is regularly updated to improve performance and add features. Advanced Navigation recommends that you upgrade to the latest version whenever available. The firmware update function is robust, such that power loss, file corruption or other issues cannot cause problems with units. Check the **Boreas** product page of the Advanced Navigation website periodically for updates.

Note: Advanced Navigation device firmware files have the extension .anfw.

After the appropriate file is uploaded, the Firmware Update dialogue will display "**Firmware Update Ready**" in the status line.
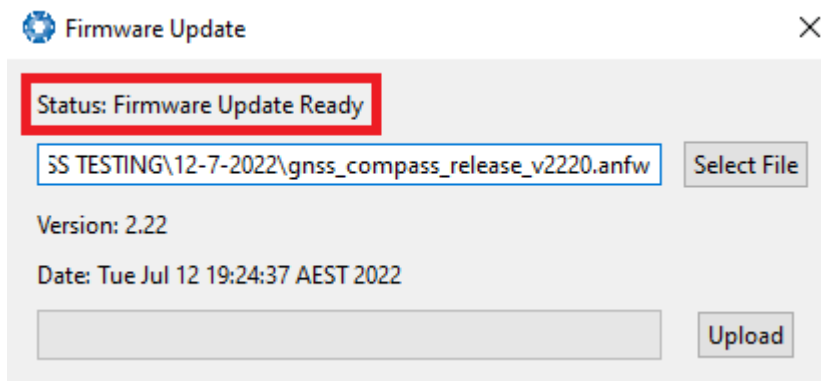
Figure 96: Firmware Update Ready Dialogue

Once the user clicks "upload", the dialogue status line will update to "**In Progress**"
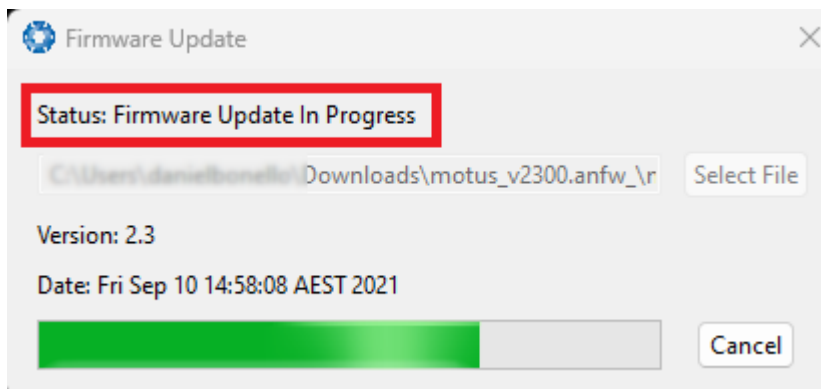
Figure 97: Firmware Update In Progress Dialogue

During this process, the user will notice the connection indicator change from "**Connected**" to "**Bootloader**." This change confirms that the upload is functioning properly.
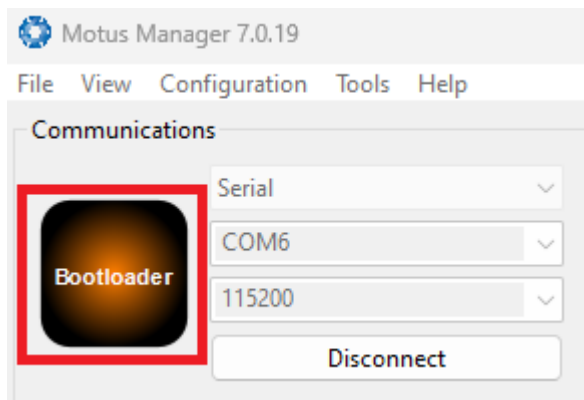
Figure 98: Firmware Update Bootloader Indicator

After the upload finishes, the system will restart. The device indicator will then display "**Connected**," and the firmware update status line will show "**Complete**."

Figure 99: Firmware Update Complete Dialogue

After the update, the user can close the firmware update dialogue and verify the update by looking at the version in the Device Information dialogue, found under the view menu of the manager.
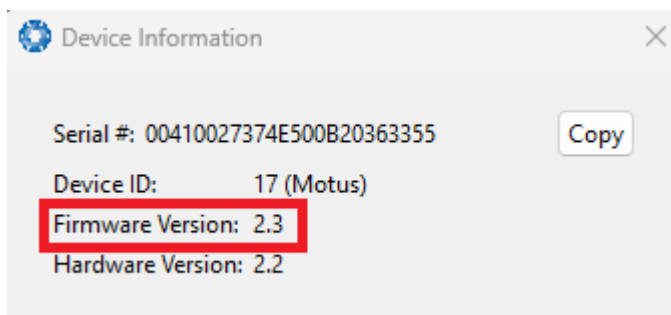
Figure 100: Device Information Dialogue

9.2.8.3 GNSS Firmware Update

Note: Refer to Firmware changelog to confirm which version of Trimble BD992 GNSS receiver firmware is compatible with the firmware being used in Boreas

Follow these steps to upgrade the GNSS Receiver Firmware:

1. Navigate to the GNSS Receiver product support page to download the firmware version that is compatible with the product being used. **Trimble BD992 Firmware Download**

Note: On the Trimble BD992 support page, if the available firmware version is not supported by your product, please refer to the archived firmware section for older, compatible BD992 firmware versions.

2. Navigate to the GNSS Firmware Update page form the Tools menu (shown above)

3. Select **Select File** and select the downloaded file from the product support page.

Note: Ensure the format of the firmware file is of the .timg format

4. Select **Update**

5. When the process is complete, power cycle the device. To confirm the upgrade was successful, navigate to **View → GNSS Receiver Information**. The firmware version must match the version number in the firmware files.

Note: The process is anticipated to take several minutes, during which a progress bar and a percentage indicator should show the update's progress. Should the progress either halt or display an error, a power cycle of the device is recommended. After reconnecting, selecting 'Update' will restart the update process.

Figure 101: GNSS Receiver Firmware Upgrade Dialogue

9.2.8.4 Log Converter

This tool allows the user to convert Boreas log files into various standard formats that are interchange and readable by many programs. The Position Offset settings are used to project the exported position of origin to a point other than the actual centre of the Boreas unit. For most users, these values should be left at zero.
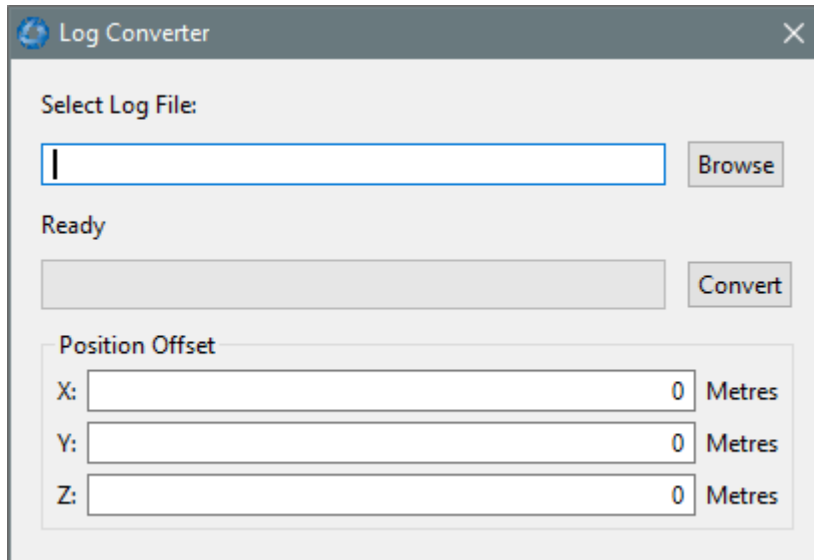
Figure 102: Manager Log Converter Dialogue

To configure the Log path, navigate to *Settings*, under the File menu.
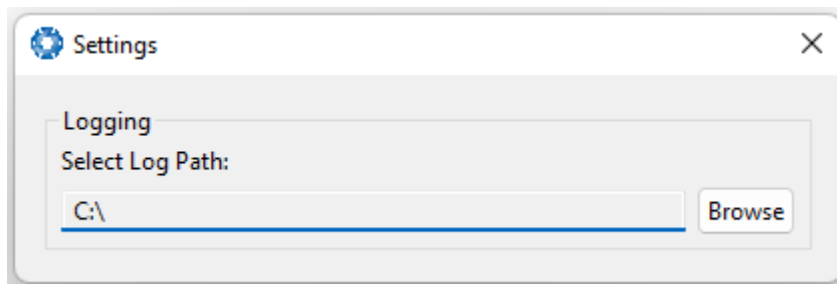
Figure 103: Settings menu for configuring Log Path

9.2.8.5 NTRIP Client

The NTRIP client can be used to connect to a network DGPS or RTK service to stream correction data to Boreas for DGPS or RTK. The NTRIP client requires an internet connection to function. Contact **Support** for guidance on getting set up with network DGPS or RTK.
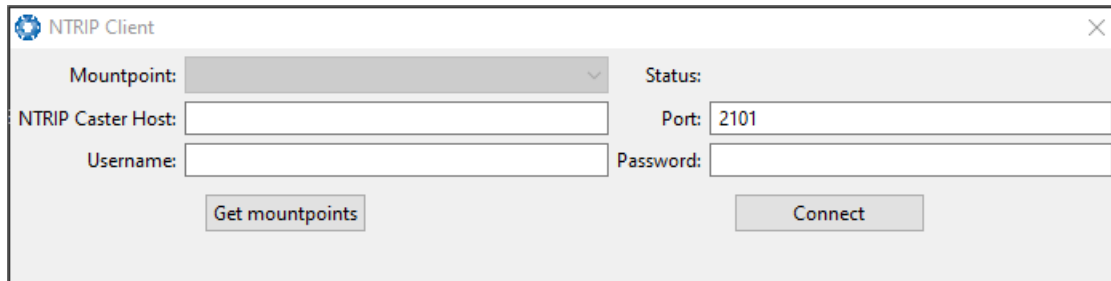
Figure 104: Manager NTRIP Client Dialogue

Note: These settings refer to the NTRIP Client built into the Boreas . The Boreas also contains a built in NTRIP client, to configure, this needs to be configured within the Boreas webUI, see **9.1.3.12 NTRIP Client**

9.2.8.6 Network Connect

The network connect dialogue allows Boreas Manager to make a connection to Boreas over a TCP/IP network rather than the primary serial port connection.
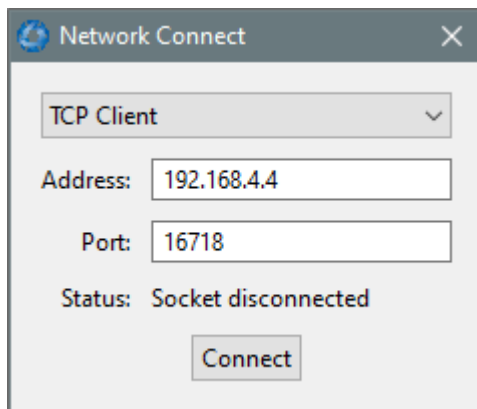
Figure 105: Manager Network Connect Dialogue

9.2.8.7 Serial Passthrough

This function allows pass-through communication through either GPIO 1 and 2 or the Auxiliary port.
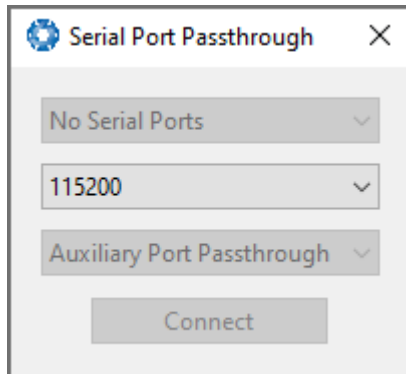
Figure 106: Manager Serial Port Passthrough Dialogue

9.2.9 Logging

Boreas Manager features a fully automatic logging system. Every time the serial port **Connect** button is clicked Boreas Manager starts a new log file in the current directory. The log file is given the file name BoreasLog_ date_time.anpp and contains all of the raw data received from Boreas in the AN packet protocol. The log files are closed when the serial port is disconnected.

To convert these log files into easily accessible formats, the **9.2.8.4 Log Converter** dialogue in the **Tools** menu can be used. The Log Converter creates a folder if no Log Path is set and generates files in the CSV (comma separated values) format that can be easily opened with Microsoft Excel, Matlab, LibreOffice and most other data analysis programs. It also creates a GPX file and a KML file that are designed to be opened with **Google Earth Pro**.

Figure 107: Files Generated by the Log Converter

Note: This data logging is performed by the Boreas Manager application and is separate from the Boreas inbuilt logging functionality accessible via the web UI.

9.3 Using the Android App

The Spatial Manager Android app provides logging and visualisation functions for Android phones and tablets. It is particularly useful for field testing purposes. You can use this app to connect to your Boreas via Bluetooth and:

- Monitor position and orientation in real time
- Log real-time data for later analysis and review
- Configure NTRIP stream corrections
- Configure device alignment offsets and manual initialisation

You will require a Serial to Bluetooth adaptor with Bluetooth v2.0 support connected to the primary serial port.

The app can be found by searching the Google Play store for "Advanced Navigation Spatial Manager". Refer to the in-app Quick Start guide for more information. Contact **support@advancednavigation.com** if you have any questions about the Android app.

9.4 Using ANPP

Boreas can be configured and monitored using the Advanced Navigation Packet Protocol (ANPP), which is detailed fully in **11 Advanced Navigation Packet Protocol**.

A software development kit (SDK) is available at no extra charge to assist you when developing your own applications. It contains example code in a number of programming languages, ready to compile and test. This is available from the Boreas **product page**.

10 Interfacing

Communication with Boreas is possible on the following ports:

- **10.1 Ethernet**
- **10.2 Serial Interface**
- **10.4 CAN Interface**
- **10.3 1PPS Signal**
- **10.6 GPIO Pins and the Auxiliary Port**

Each port has different input and output capabilities.

10.1 Ethernet

The Ethernet interface offers a 100 MBit port for connection to a network, router or laptop/computer. The interface offers a **Web UI**, as well as 4 (four) configurable data ports. Each Data Port

- can be configured as a TCP Server, TCP Client or a UDP Client as detailed in **10.1.1 Ethernet Modes**
- can be configured with an Input and/or Output for a number of protocols as detailed in **10.1 Ethernet**.
- should only be used to establish a connection with a single remote computer/device at any one time.

10.1.1 Ethernet Modes

Ethernet Mode	Description	Required Configuration
TCP Server	Boreas will establish a TCP Server listening on the defined port. A connected client is able to receive Output data and send Input data based on the defined Input and Output functions.	Port
TCP Client	Boreas will continuously attempt to establish a TCP connection to the defined Destination IP and Port. Once established, a connected client is able to receive Output data and send Input data based on the defined Input and Output functions.	Client Destination IP address Port
UDP Client	Boreas will send UDP Output data to the defined Destination IP and Port. A client can also send UDP Input data to Boreas this same Port.	Client Destination IP address Port

Table 31: Ethernet Data Port Modes

10.1.2 Ethernet Functions

Function Type	Name
Ethernet Input	**10.1.2.1 NMEA Input**
	10.1.2.19 GNSS Receiver Passthrough
	10.1.2.2 Novatel GNSS Input
	10.1.2.3 Topcon GNSS Input
	10.1.2.4 ANPP Input
	10.1.2.5 RTCM Differential GNSS Corrections Input
	10.1.2.6 Trimble GNSS Input
	10.1.2.7 u-blox GNSS Input
	10.1.2.8 Hemisphere GNSS Input
	10.1.2.9 Teledyne DVL Input
	10.1.2.10 Tritech USBL Input
	10.1.2.11 Linkquest DVL Input
	10.1.2.12 Nortek DVL Input
Ethernet Output	**10.1.2.13 NMEA Output**
	10.1.2.14 ANPP Output
	10.1.2.15 TSS1 Output
	10.1.2.16 Simrad 1000 Output
	10.1.2.17 Simrad 3000 Output
	10.1.2.18 Serial Port Passthrough
	10.1.2.19 GNSS Receiver Passthrough

Table 32: Ethernet Data Port Functions

10.1.2.1 NMEA Input

Description: This function accepts external data in the NMEA 0183 format. Advanced Navigation recommends against using NMEA 0183 input wherever possible due to the inefficiency, low accuracy and precision and weak error checking of the format. All NMEA messages received must have a valid checksum. Supported messages are listed below. The recommended combination of messages are GPGGA, GPVTG and GPZDA with optional messages GPGSV and GPGSA.

Message ID	Description
GPGGA	3D position
GPGLL	2D position
GPRMC	2D position, 2D velocity and coarse time
GPVTG	2D velocity
GPHDT GNHDT HEHDT	Heading
GPGSV	Satellites
GPGSA	Dilution of Precision
GPZDA	Time
xxPIPS	Depth below surface
xxVBW	Water speed, ground speed
xxHDM	Magnetic heading
PSIMSSB	SSBL position
xxVHW	Water speed and heading
xxDBS	Depth below surface

Table 33: Supported NMEA messages

10.1.2.2 Novatel GNSS Input

Description: This function is designed for interfacing Boreas with a Novatel GNSS receiver. It accepts data in the Novatel binary format and requires messages BESTPOS and BESTVEL at rates higher than 1 Hz (20Hz recommended). The message BESTSATS is optional to display detailed satellite information. The message HEADING is also supported for ALIGN capable receivers.

10.1.2.3 Topcon GNSS Input

Description: This function is designed for interfacing Boreas with a Topcon GNSS receiver. It accepts data in the GRIL TPS binary format and expects messages PG and VG at rates higher than 1 Hz.

10.1.2.4 ANPP Input

Description:	This function accepts data in the ANPP format as specified in **11 Advanced Navigation Packet Protocol**.

10.1.2.5 RTCM Differential GNSS Corrections Input

Description:	This function accepts RTCM v3 GNSS corrections messages. This allows for Differential GNSS or RTK with the Boreas internal GNSS receiver.

10.1.2.6 Trimble GNSS Input

Description:	This function is designed for interfacing Boreas with an external Trimble GNSS receiver. It accepts data in the Trimble binary format GSOF and expects packet 0x40 with records 1, 2, 8, and 12 at rates higher than 1Hz (20Hz recommended) and optional records 9 and 34 at 1 to 2Hz.

10.1.2.7 u-blox GNSS Input

Description:	This function is designed for interfacing Boreas with an external u-blox GNSS receiver. It accepts data in the u-blox binary format and expects message NAV-PVT at rates higher than 1Hz.

10.1.2.8 Hemisphere GNSS Input

Description:	This function is designed for interfacing Boreas with an external Hemisphere GNSS receiver. It accepts data in the Hemisphere binary format and expects message Bin1 at rates higher than 1Hz. For Hemisphere receivers that provide heading using two antennas, NMEA should be used instead as the binary format does not allow for transmission of heading information.

10.1.2.9 Teledyne DVL Input

Description:	This function accepts DVL data from a Teledyne DVL. For assistance with configuration, contact **Support**.

10.1.2.10 Tritech USBL Input

Description:	This function accepts USBL data from a Tritech USBL. For assistance with configuration, contact **Support**.

10.1.2.11 Linkquest DVL Input

Description:	This function accepts DVL data from a Linkquest DVL. The DVL should be configured to output in NQ1 format. For assistance with configuration, contact **Support**.

10.1.2.12 Nortek DVL Input

Description:	This function accepts DVL data in the Nortek DVL binary format. It accepts the packets 0x1B (DVL Bottom Track) and 0x1D (DVL Water Track). The recommended update rate is 8Hz.

10.1.2.13 NMEA Output

Description: This function outputs a configurable combination of the NMEA messages GPZDA, GPGGA, GPVTG, GPRMC, GPHDT, PASHR, GPROT, GPHEV, GPGSV, PFECGPAtt, and PFECGPHve at up to 50 Hz. The messages output and the output rate can be configured using the web UI or Boreas Manager. An example output is shown below.

```
$GPZDA,031644.460,07,05,2013,00,00*52

$GPGGA,031644.460,3352.3501851,S,15112.2355488,E,6,00,1.4,150.
0,M,0.0,M,,,*7E

$GPVTG,089.19,T,089.19,M,000.00,N,000.00,K,E*27

$GPRMC,031644.460,A,3352.3501851,S,15112.2355488,E,0.0,89.2,07
0513,12.5,W,E*02

$GPHDT,89.2,T*06

$PASHR,031644.460,089.19,T,-00.01,-00.47,-00.00,,,,0,0*2E
```

10.1.2.14 ANPP Output

Description: This function outputs data in the ANPP format as specified in **11 Advanced Navigation Packet Protocol**. This function is for ANPP peripheral devices only.

10.1.2.15 TSS1 Output

Description: This function outputs the TSS1 format at a user configurable rate of up to 50 Hz. The output rate can be configured using the page in the web UI.

10.1.2.16 Simrad 1000 Output

Description: This function outputs the Simrad 1000 format at a user configurable rate of up to 50 Hz. The output rate can be configured using the **9.1.3.2 Data Ports** page in the **9.1 Using the Web User Interface**.

10.1.2.17 Simrad 3000 Output

Description: This function outputs the Simrad 3000 format at a user configurable rate up to 50 Hz. The output rate can be configured using the **9.1.3.2 Data Ports** page in the **9.1 Using the Web User Interface**.

10.1.2.18 Serial Port Passthrough

Description: This function allows passthrough communication through either GPIO 1 and 2 or the Auxiliary port. To transmit data use the **11.3.7 Serial Port Passthrough Packet**. When data is received it will be sent back using the same **11.3.7 Serial Port Passthrough Packet**.

10.1.2.19 GNSS Receiver Passthrough

Description: This function allows for pass through connection to the internal GNSS receiver. This is

useful for firmware updates of the internal GNSS receiver.

10.2 Serial Interface

There are two serial ports available for use. The GPIO port can also be used as a serial port, with less functionality.

Model	Primary Port	Auxiliary Port	GPIO Port
Boreas	ANPP only over RS232 or RS422. **No** dynamic pin functions	ANPP over RS232 or RS422, **10.6.1 Dynamic Pin Functions**	ANPP over RS232, **10.6.1 Dynamic Pin Functions**

Table 34: I/O Ports Available

10.2.1 Baud Rate

The default baud rate of Boreas is 115,200. The primary and auxiliary port baud rate can be set anywhere from 4,800 to 4,000,000 baud and can be modified using the Baud Rates page in the web UI or Boreas Manager. The GPIO port baud rate can be set anywhere from 4,800 to 250,000 baud. It is important to select a baud rate that is capable of carrying the amount of data that Boreas has been configured to output. See **11.1.4 Packet Rates** for more details on the data output calculation. The data rate in bytes per second can be calculated by dividing the baud rate by 10. For example if the baud rate is 115,200, the data rate is 11,520 bytes per second. If the selected data rate is insufficient, data may be lost without warning.

The support team can provide a baud rate calculator if it is required. For more information or assistance, contact technical support via email at **support@advancednavigation.com**.

10.2.2 Format

The format is fixed at 1 start bit, 8 data bits, 1 stop bit and no parity. See **11 Advanced Navigation Packet Protocol** for details on the ANPP protocol.

10.3 1PPS Signal

There is a dedicated 1PPS signal available on the **6.6 IO Connection**. See the **9.1.3.14 Advanced** section of the Configuration Menu for information on changing 1PPS and GPIO settings, and see **10.6.1 Dynamic Pin Functions** for information on 1PPS and GPIO output voltage.

The 1PPS signal reference ground is the GPIO ground domain. See **7.7 Electrical Domains** for more information.

The signal is normally low and pulses high for 100 milliseconds to signal the precise second, which starts on the rising edge of the signal.

This dedicated 1PPS signal is the recommended 1PPS signal to use as it is more accurate. The validity of this 1PPS signal can be monitored using the time initialised status flag.

10.4 CAN Interface

The CAN interface is available on the Connector Pin-out, and is used for low-level device integration with other vehicle systems.

A CANopen EDS file is available. Contact the Advanced Navigation support team at **support@advancednavigation.com** for a copy of this.

10.5 External Data

External sources of position, velocity and/or heading can be integrated into the Boreas filter solution. The data can be sent to Boreas in the ANPP format over the primary (RS232 or RS422), auxiliary (RS232 or RS422) or GPIO ports (RS232 only) or in a number of different formats. If using the ANPP format, use the table below to find the relevant section.

Packet
11.4.24 External Position and Velocity Packet
11.4.25 External Position Packet
11.4.26 External Velocity Packet
11.4.27 External Body Velocity Packet
11.4.28 External Heading Packet
11.4.31 External Time Packet
11.4.32 External Depth Packet
11.4.39 External Odometer Packet
11.4.40 External Air Data Packet

Table 35: ANPP External Data Packets

10.6 GPIO Pins and the Auxiliary Port

In addition to the primary port and CAN port, Boreas contains two general purpose input/output (GPIO) pins and an auxiliary port on the IO Breakout Connector. These pins are multi function and can be used to extend Boreas with additional peripherals, sensors and data formats. Both GPIO pins have digital input, digital output, frequency input and frequency output functionality.

GPIO1 can also function as an RS232 (only) serial transmit line and GPIO2 can function as an RS232 (only) serial receive line. The GPIO serial baud rate can be configured anywhere from 4800 to 250 K baud. The auxiliary serial baud rate can be configured anywhere from 4800 to 4 M baud. See **11.5.3.1 Supported Baud Rate**. Changes to these baud rates can be made by using the Baud Rates page in the **web UI** or **Boreas Manager**.

The available GPIO and auxiliary functions are listed in the section **10.6.1 Dynamic Pin Functions**. The function of a GPIO pin or the auxiliary port can be changed at any time using the GPIO Configuration page in the Boreas **web UI** or **Manager**. GPIO 1 and GPIO 2 operate at standard voltage levels for digital input, digital output, frequency input and frequency output, but when a serial data function is selected, this GPIO pin automatically switches to RS232 voltage level.

10.6.1 Dynamic Pin Functions

Function Type	Name
Tristate	**10.6.1.1 Inactive**
Digital Output	**10.6.1.2 1PPS Output**
	10.6.1.3 GNSS Fix Output
Digital Input	**10.6.1.4 Zero Velocity Input**
	10.6.1.5 Disable GNSS
	10.6.1.6 Disable Pressure
	10.6.1.7 Set Zero Orientation Alignment
	10.6.1.8 System State Packet Trigger
	10.6.1.9 Raw Sensors Packet Trigger
	10.6.1.10 1PPS Input
	10.6.1.11 Event 1 Input
	10.6.1.12 Event 2 Input
	10.6.1.13 Odometer Direction, Forward Low
	10.6.1.14 Odometer Direction, Forward High
	10.6.1.15 Reverse Alignment, Forward Low
	10.6.1.16 Reverse Alignment, Forward High
	10.6.1.17 Zero Angular Velocity Input
Frequency Input	**10.6.1.18 Odometer Input**
	10.6.1.19 Pitot Tube Input
	10.6.1.20 Pressure Depth Transducer (deprecated)
	10.6.1.21 Left Wheel Speed Sensor
	10.6.1.22 Right Wheel Speed Sensor
	10.6.1.23 Wheel Speed Sensor
	10.6.1.24 Wheel Encoder Phase A
	10.6.1.25 Wheel Encoder Phase B
	10.6.1.26 Gimbal Encoder Phase A
	10.6.1.27 Gimbal Encoder Phase B

Function Type	Name
Serial Receive	**10.6.1.28 NMEA Input**
	10.6.1.29 Novatel GNSS Input
	10.6.1.30 Topcon GNSS Input
	10.6.1.31 ANPP Input
	10.6.1.32 RTCM Differential GNSS Corrections Input
	10.6.1.33 Trimble GNSS Input
	10.6.1.34 u-blox GNSS Input
	10.6.1.35 Hemisphere GNSS Input
	10.6.1.36 Teledyne DVL Input
	10.6.1.37 Tritech USBL Input
	10.6.1.38 Linkquest DVL Input
	10.6.1.39 Linkquest USBL Input
	10.6.1.40 Nortek DVL Input
Serial Transmit	**10.6.1.41 NMEA Output**
	10.6.1.42 ANPP Output
	10.6.1.43 TSS1 Output
	10.6.1.44 Simrad 1000 Output
	10.6.1.45 Simrad 3000 Output
Serial	**10.6.1.46 Serial Port Passthrough**
	10.6.1.47 GNSS Receiver Passthrough

Table 36: Dynamic Pin Functions

10.6.1.1 Inactive

Type:	Tristate
GPIO Port:	1, 2
Auxiliary:	All

10.6.1.2 1PPS Output

Type:	Digital Output
GPIO Port:	1, 2
Auxiliary:	Transmit
Description:	There is a difference between the output of the GPIO and auxiliary ports when set to 1PPS output mode.

1PPS Source	Voltage Level	Trigger
Auxiliary	-5 V to 5 V	Falling Edge
GPIO	0 to 5 V, 0 to 3.3 V	Rising Edge

Figure 108: 1PPS Specifications

The pin is normally low and pulses high for 50 milliseconds to signal the precise second. The 1PPS line starts pulsing approximately 100 milliseconds after power up and always fires irrespective of whether Boreas has accurate time or not. It is important to note that when Boreas acquires time corrections from it's GNSS receiver, the 1PPS signal may fire at an interval of less than 1 second. This typically only occurs the first time the GNSS receiver obtains a fix after startup. The time initialised status flag can be used to determine whether the time and 1PPS line is accurate or not.

The dedicated **10.3 1PPS Signal** on the Connector Pin-out is the recommended 1PPS signal to use as it comes direct from the internal GNSS receiver rather than the internal microprocessor. The validity of the dedicated 1PPS signal can be monitored using the "time initialised" flag in the **11.4.1 System State Packet**.

10.6.1.3 GNSS Fix Output

Type:	Digital Output
GPIO Port:	1, 2
Auxiliary:	Transmit
Description:	In this function, the pin is low when there is no GNSS fix or a 2D fix and high when there is a 3D, SBAS, Differential or RTK GNSS fix.

10.6.1.4 Zero Velocity Input

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	When using this function, a high state indicates to Boreas that it is stationary. The low state indicates that the vehicle is not stationary. Use of this function can prevent drift during periods when a GNSS signal is not available.

10.6.1.5 Disable GNSS

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function accepts a digital input with a low state enabling the GNSS and a high state disabling the GNSS.

10.6.1.6 Disable Pressure

Type:	Digital Input

GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function accepts a digital input with a low state enabling the atmospheric pressure sensor and a high state disabling the atmospheric pressure sensor.

10.6.1.7 Set Zero Orientation Alignment

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function accepts a digital input. The input is normally low and a transition from low to high causes Boreas to set its alignment so that the current orientation is zero. Due to the risk of exhausting the flash cycles, the change is not permanent and will disappear on reset. To make it permanent the **11.5.4 Installation Alignment Packet** must be read and then sent back to Boreas with the permanent flag set. This function requires de-bouncing if attached to a switch.

10.6.1.8 System State Packet Trigger

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function accepts a digital input. The input is normally low and a transition from low to high causes Boreas to send the System State Packet. This function requires de-bouncing if attached to a switch.

10.6.1.9 Raw Sensors Packet Trigger

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function accepts a digital input. The input is normally low and a transition from low to high causes Boreas to send the **11.4.9 Raw Sensors Packet**. This function requires de-bouncing if attached to a switch.

10.6.1.10 1PPS Input

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed to allow external GNSS receivers to synchronise time with Boreas. It triggers on a transition from low to high.

10.6.1.11 Event 1 Input

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed to allow external events to be recorded by Boreas. The event is recorded in the Filter Status (see **11 Advanced Navigation Packet Protocol**), and resets after the next packet is output. The event triggers on a transition from low to high.

10.6.1.12 Event 2 Input

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed to allow external events to be recorded by Boreas. The event is recorded in the Filter Status (see **11 Advanced Navigation Packet Protocol**), and resets after the next packet is output. The event triggers on a transition from low to high.

10.6.1.13 Odometer Direction, Forward Low

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed to take a reversing indication input for direction with an odometer or wheel encoder. It should be used in combination with Odometer Input or Wheel Speed Sensor.

10.6.1.14 Odometer Direction, Forward High

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed to take a reversing indication input for direction with an odometer or wheel encoder. It should be used in combination with Odometer Input or Wheel Speed Sensor.

10.6.1.15 Reverse Alignment, Forward Low

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed to reverse the alignment settings for vehicles that can have two vehicle forward directions, such as locomotives.

10.6.1.16 Reverse Alignment, Forward High

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed to reverse the alignment settings for vehicles that can have two vehicle forward directions, such as locomotives.

10.6.1.17 Zero Angular Velocity Input

Type:	Digital Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	In this function, a high state indicates to Boreas that the vehicle is not rotating. The low state indicates that the vehicle could be rotating. Use of this function can significantly improve heading drift performance when a GNSS signal is not available.

10.6.1.18 Odometer Input

Type:	Frequency Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed for low-resolution vehicle speed sensors and odometers. It expects a normally low input with a high state for the trigger. If the pulse length is more than 0.1 metres then this odometer input function should be used. If it is less than 0.1 metres, the wheel speed sensor function should be used. Contact technical support at **support@advancednavigation.com** for help integrating with your speed sensor.

Parameter	Value
Trigger	Low → High
Maximum Frequency	600 Khz
Maximum Pulse Rate	4294967 pulses/metre

Table 37: Odometer Specifications

10.6.1.19 Pitot Tube Input

Type:	Frequency Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function allows fixed wing aircraft to measure airspeed to improve navigation performance. It requires a differential pressure sensor that has a frequency output such as the Kavlico P992 (frequency output option) or the Paroscientific series 5300. Contact technical support at **support@advancednavigation.com** for help integrating with a pitot tube.

10.6.1.20 Pressure Depth Transducer (deprecated)

Type:	Frequency Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed for interfacing with a legacy pressure depth transducer. These are no longer available and the function is now deprecated.

10.6.1.21 Left Wheel Speed Sensor

Type:	Frequency Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed for the left wheel of a vehicle with dual wheel speed sensors.

10.6.1.22 Right Wheel Speed Sensor

Type:	Frequency Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed for the right wheel of a vehicle with dual wheel speed sensors.

10.6.1.23 Wheel Speed Sensor

Type:	Frequency Input
GPIO Port:	1, 2
Auxiliary:	Receive
Description:	This function is designed for high resolution vehicle speed sensors and wheel speed sensors. It expects a normally low input with a high state for the trigger. If the pulse length is more than 0.1 metres the odometer input function should be used, if it is less than 0.1 metres the wheel speed sensor function should be used. Contact technical support via email at **support@advancednavigation.com** for with help integrating with your speed sensor.

Parameter	Value
Trigger	Low → High
Maximum Frequency	40 MHz
Maximum Pulse Rate	4,294,967,295 pulses/metre

Table 38: Wheel Speed Sensor Specifications

10.6.1.24 Wheel Encoder Phase A

Type:	Frequency Input

GPIO Port:	1, 2
Auxiliary:	N/A
Description:	This function is designed for rotary incremental quadrature encoders. It should be used in combination with Wheel Encoder Phase B.

10.6.1.25 Wheel Encoder Phase B

Type:	Frequency Input
GPIO Port:	1, 2
Auxiliary:	N/A
Description:	This function is designed for rotary incremental quadrature encoders. It should be used in combination with Wheel Encoder Phase A.

10.6.1.26 Gimbal Encoder Phase A

Type:	Frequency Input
GPIO Port:	1, 2
Auxiliary:	N/A
Description:	This function is designed for interfacing with a rotary incremental quadrature encoder to measure the azimuth angle of a gimbal in which Boreas is installed. It should be used in combination with Gimbal Encoder Phase B.

10.6.1.27 Gimbal Encoder Phase B

Type:	Frequency Input
GPIO Port:	1, 2
Auxiliary:	N/A
Description:	This function is designed for interfacing with a rotary incremental quadrature encoder to measure the azimuth angle of a gimbal in which Boreas is installed. It should be used in combination with **Gimbal Encoder Phase A**.

10.6.1.28 NMEA Input

Type:	Serial Receive
GPIO Port:	2
Auxiliary:	Receive
Description:	This function accepts external data in the NMEA 0183 format. Advanced Navigation recommends against using NMEA 0183 input wherever possible due to the inefficiency, low accuracy and precision and weak error checking of the format. All NMEA messages received must have a valid checksum. Supported messages are listed below. The recommended combination of messages are GPGGA and GPVT with optional messages GPGSV and GPGSA.

Message ID	Description
GPGGA GNGGA	3D position
GPGLL GNGLL	2D position
GPRMC GNRMC	2D position, 2D velocity and coarse time
GPVTG GNVTG	2D velocity
GPHDT GNHDT HEHDT	Heading
GPGSV GNGSV	Satellites
GPGSA GNGSA	Dilution of Precision
xxPIPS	Depth below surface
xxVBW	Water speed, ground speed
xxHDM	Magnetic heading
PSIMSSB	SSBL position
xxVHW	Water speed and heading
xxDBS	Depth below surface

Table 39: Supported NMEA messages

10.6.1.29 Novatel GNSS Input

Type:	Serial Receive
GPIO Port:	2
Auxiliary:	Receive
Description:	This function is designed for interfacing Boreas with a Novatel GNSS receiver. It accepts data in the Novatel binary format and requires messages BESTPOSB and BESTVELB at rates higher than 1 Hz (20 Hz recommended). The message BESTSATSB is optional to display detailed satellite information. The message HEADING is also supported for ALIGN capable receivers.

10.6.1.30 Topcon GNSS Input

Type:	Serial Receive
GPIO Port:	2
Auxiliary:	Receive
Description:	This function is designed for interfacing Boreas with a Topcon GNSS receiver. It accepts data in the GRIL TPS binary format and expects messages PG and VG at rates higher than 1 Hz.

10.6.1.31 ANPP Input

Type:	Serial Receive
GPIO Port:	2
Auxiliary:	Receive

Description: This function accepts data in the ANPP format as specified in **11 Advanced Navigation Packet Protocol**.

When this function is enabled, the GPIO and auxiliary ports function the same as the primary port, with one exception:

- When setting the ANPP packet and message output rates, the changes only apply to the port you are connected to. For example, you cannot change the primary port or GPIO port packet and message rates when connected to the auxiliary port.

10.6.1.32 RTCM Differential GNSS Corrections Input

Type: Serial Receive

GPIO Port: 2

Auxiliary: Receive

Description: This function accepts RTCM v3 GNSS corrections messages. This allows for Differential GNSS or RTK with the Boreas internal GNSS receiver.

10.6.1.33 Trimble GNSS Input

Type: Serial Receive

GPIO Port: 2

Auxiliary: Receive

Description: This function is designed for interfacing Boreas with an external Trimble GNSS receiver. It accepts data in the Trimble binary format GSOF and expects packet 0x40 with records 1, 2, 8, and 12 at rates higher than 1Hz (20 Hz recommended) and optional records 9 and 34 at 1 to 2 Hz.

10.6.1.34 u-blox GNSS Input

Type: Serial Receive

GPIO Port: 2

Auxiliary: Receive

Description: This function is designed for interfacing Boreas with an external u-blox GNSS receiver. It accepts data in the u-blox binary format and expects message NAV-PVT at rates higher than 1 Hz.

10.6.1.35 Hemisphere GNSS Input

Type: Serial Receive

GPIO Port: 2

Auxiliary: Receive

Description: This function is designed for interfacing Boreas with an external Hemisphere GNSS receiver. It accepts data in the Hemisphere binary format and expects message Bin1 at rates higher than 1 Hz. For Hemisphere receivers that provide heading using two antennas, NMEA should be used instead as the binary format does not allow for transmission of heading information.

10.6.1.36 Teledyne DVL Input

Type:	Serial Receive
GPIO Port:	2
Auxiliary:	Receive
Description:	This function accepts DVL data from a Teledyne DVL. For assistance with configuration, contact **support@advancednavigation.com**.

10.6.1.37 Tritech USBL Input

Type:	Serial Receive
GPIO Port:	2
Auxiliary:	Receive
Description:	This function accepts USBL data from a Tritech USBL. For assistance with configuration, contact **support@advancednavigation.com**.

10.6.1.38 Linkquest DVL Input

Type:	Serial Receive
GPIO Port:	2
Auxiliary:	Receive
Description:	This function accepts DVL data from a Linkquest DVL. For assistance with configuration, contact **support@advancednavigation.com**.

10.6.1.39 Linkquest USBL Input

Type:	Serial Receive
GPIO Port:	2
Auxiliary:	Receive
Description:	This function accepts USBL data from a Linkquest USBL. For assistance with configuration, contact **support@advancednavigation.com**.

10.6.1.40 Nortek DVL Input

Type:	Serial Receive
GPIO Port:	2
Auxiliary:	Receive
Description:	This function accepts DVL data in the Nortek DVL binary format. It accepts the packets 0x1B (DVL Bottom Track) and 0x1D (DVL Water Track). The recommended update rate is 8 Hz.

10.6.1.41 NMEA Output

Type:	Serial Transmit

GPIO Port:	1
Auxiliary:	Transmit
Descrip-tion:	This function outputs a configurable combination of the NMEA messages GPZDA, GPGGA, GPVTG, GPRMC, GPHDT, PASHR, GPROT, GPHEV, GPGSV, PFECGPAtt, and PFECGPHve at up to 50 Hz. The messages output and the output rate can be configured using the web UI or Boreas Manager. An example output is shown below.

```
$GPZDA,031644.460,07,05,2013,00,00*52

$GPGGA,031644.460,3352.3501851,S,15112.2355488,E,6,00,1.4,150
.0,M,0.0,M,,*7E

$GPVTG,089.19,T,089.19,M,000.00,N,000.00,K,E*27

$GPRMC,031644.460,A,3352.3501851,S,15112.2355488,E,0.0,89.2,0
70513,12.5,W,E*02

$GPHDT,89.2,T*06

$PASHR,031644.460,089.19,T,-00.01,-00.47,-00.00,,,,0,0*2E
```

10.6.1.42 ANPP Output

Type:	Serial Transmit
GPIO Port:	1
Auxiliary:	Transmit
Description:	This function outputs data in the ANPP format as specified in **11 Advanced Navigation Packet Protocol**. This function is for ANPP peripheral devices only.
	When this function is enabled, the GPIO and auxiliary ports function the same as the primary port, with one exception:

- When setting the ANPP packet and message output rates, the changes only apply to the port you are connected to. For example, you cannot change the primary port or GPIO port packet and message rates when connected to the auxiliary port.

10.6.1.43 TSS1 Output

Type:	Serial Transmit
GPIO Port:	1
Auxiliary:	Transmit
Description:	This function outputs the TSS1 format at a user configurable rate of up to 50 Hz. The output rate can be configured using the page in the web UI.

10.6.1.44 Simrad 1000 Output

Type:	Serial Transmit
GPIO Port:	1
Auxiliary:	Transmit

Description:	This function outputs the Simrad 1000 format at a user configurable rate of up to 50 Hz. The output rate can be configured using the **9.1.3.5 GPIO** page in the web UI or the **9.2.7.10 GPIO Output** dialogue in the Boreas Manager.

10.6.1.45 Simrad 3000 Output

Type:	Serial Transmit
GPIO Port:	1
Auxiliary:	Transmit
Description:	This function outputs the Simrad 3000 format at a user configurable rate up to 50 Hz.The output rate can be configured using the **9.1.3.5 GPIO** page in the web UI or the **9.2.7.10 GPIO Output** dialogue in the Boreas Manager.

10.6.1.46 Serial Port Passthrough

Type:	Serial
GPIO Port:	1, 2
Auxiliary:	All
Description:	This function allows passthrough communication through either GPIO 1 and 2 or the Auxiliary port. To transmit data use the **11.3.7 Serial Port Passthrough Packet**. When data is received it will be sent back using the same **11.3.7 Serial Port Passthrough Packet**.

10.6.1.47 GNSS Receiver Passthrough

Type:	Serial
GPIO Port:	1, 2
Auxiliary:	All
Description:	This function allows for pass through connection to the internal GNSS receiver. This is useful for firmware updates of the internal GNSS receiver.

11 Advanced Navigation Packet Protocol

The Advanced Navigation Packet Protocol (ANPP) is a binary protocol designed with high error checking, high efficiency and safe design practices. It has a well defined specification and is very flexible. ANPP is proprietary and is used across all Advanced Navigation products. A packet type can be identified by its unique Packet ID. For more information about packets, see **11.1 About Packets**.

The following packet types are available:

- **11.3 System Packets** - These packets have ID values of less than 20.
- **11.4 State Packets** - These packets have ID values between 20 and 179.
- **11.5 Configuration Packets** - These packets have IDs greater than 179.

The following table lists Advanced Navigation packets by type.

Packet ID	Name	Length	R/W
System Packets			
0	**11.3.1 Acknowledge Packet**	4	R
1	**11.3.2 Request Packet**	Varies	W
2	**11.3.3 Boot Mode Packet**	1	R/W
3	**11.3.4 Device Information Packet**	24	R
4	**11.3.5 Restore Factory Settings Packet**	4	W
5	**11.3.6 Reset Packet**	4	W
10	**11.3.7 Serial Port Passthrough Packet**	Varies	R/W
11	**11.3.8 IP Configuration Packet**	30	R/W
14	**11.3.9 Subcomponent Information Packet**	24	R

Packet ID	Name	Length	R/W
State Packets			
20	**11.4.1 System State Packet**	100	R
21	**11.4.2 Unix Time Packet**	8	R
22	**11.4.3 Formatted Time Packet**	14	R
23	**11.4.4 Status Packet**	4	R
24	**11.4.5 Position Standard Deviation Packet**	12	R
25	**11.4.6 Velocity Standard Deviation Packet**	12	R
26	**11.4.7 Euler Orientation Standard Deviation Packet**	12	R
27	**11.4.8 Quaternion Orientation Standard Deviation Packet**	16	R
28	**11.4.9 Raw Sensors Packet**	48	R
29	**11.4.10 Raw GNSS Packet**	74	R/W
30	**11.4.11 Satellites Packet**	13	R
32	**11.4.12 Geodetic Position Packet**	24	R

Packet ID	Name	Length	R/W
33	**11.4.13 ECEF Position Packet**	24	R
34	**11.4.14 UTM Position Packet**	26	R
35	**11.4.15 NED Velocity Packet**	12	R
36	**11.4.16 Body Velocity Packet**	12	R
37	**11.4.17 Acceleration Packet**	12	R
38	**11.4.18 Body Acceleration Packet**	16	R
39	**11.4.19 Euler Orientation Packet**	12	R
40	**11.4.20 Quaternion Orientation Packet**	16	R
41	**11.4.21 DCM Orientation Packet**	36	R
42	**11.4.22 Angular Velocity Packet**	12	R
43	**11.4.23 Angular Acceleration Packet**	12	R
44	**11.4.24 External Position and Velocity Packet**	60	R/W
45	**11.4.25 External Position Packet**	36	R/W
46	**11.4.26 External Velocity Packet**	24	R/W
47	**11.4.27 External Body Velocity Packet**	16 or 24	R/W
48	**11.4.28 External Heading Packet**	8	R/W
49	**11.4.29 Running Time Packet**	8	R
51	**11.4.30 Odometer State Packet**	20	R
52	**11.4.31 External Time Packet**	8	W
53	**11.4.32 External Depth Packet**	8	R/W
54	**11.4.33 Geoid Height Packet**	4	R
55	**11.4.34 RTCM Corrections Packet**	Varies	W
57	**11.4.35 Wind Packet**	12	R/W
58	**11.4.36 Heave Packet**	16	R
60	**11.4.37 Raw Satellite Data Packet**	Varies	R
61	**11.4.38 Raw Satellite Ephemeris Packet**	Varies	R
67	**11.4.39 External Odometer Packet**	13	W
68	**11.4.40 External Air Data Packet**	25	R/W
69	**11.4.41 GNSS Receiver Information Packet**	Varies	R
70	**11.4.42 Raw DVL Data Packet**	60	R/W
71	**11.4.43 North Seeking Initialisation Status Packet**	28	R
72	**11.4.44 Gimbal State Packet**	8	R/W
73	**11.4.45 Automotive Packet**	24	R
80	**11.4.46 Basestation Packet**	45	R

Packet ID	Name	Length	R/W
83	**11.4.47 Zero Angular Velocity Packet**	8	W
84	**11.4.48 Extended Satellites Packet**	Varies	R
85	**11.4.49 Sensor Temperature Packet**	32	R
86	**11.4.50 System Temperature Packet**	64	R

Packet ID	Name	Length	R/W
Configuration Packets			
180	**11.5.1 Packet Timer Period Packet**	4	R/W
181	**11.5.2 Packets Period Packet**	Varies	R/W
182	**11.5.3 Baud Rates Packet**	17	R/W
185	**11.5.4 Installation Alignment Packet**	73	R/W
186	**11.5.5 Filter Options Packet**	17	R/W
188	**11.5.6 GPIO Configuration Packet**	13	R/W
192	**11.5.7 Odometer Configuration Packet**	8	R/W
193	**11.5.8 Set Zero Orientation Alignment Packet**	5	W
194	**11.5.9 Reference Point Offsets Packet**	49	R/W
195	**11.5.10 GPIO Output Configuration Packet**	183	R/W
196	**11.5.11 Dual Antenna Configuration Packet**	17	R/W
197	**11.5.12 GNSS Configuration Packet**	85	R/W
198	**11.5.13 User Data Packet**	64	R/W
199	**11.5.14 GPIO Input Configuration Packet**	65	R/W
202	**11.5.15 IP Dataports Configuration Packet**	30	R/W
203	**11.5.16 CAN Configuration Packet**	30	R/W

Table 40: Advanced Navigation Packets

11.1 About Packets

11.1.1 Packet Structure

The ANPP packet structure and the header format are shown in the tables below. Example source code is provided in multiple languages via the SDK, available from the **Boreas** product page of the Advanced Navigation website.

Header				
Header LRC	Packet ID	Packet Length	CRC16	Packet Data

Table 41: ANPP Packet Structure

Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	**Header LRC**

Field #	Bytes Offset	Data Type	Size	Description
2	1	u8	1	**Packet ID**
3	2	u8	1	**Packet Length**
4	3	u16	2	**CRC**

Table 42: ANPP Header Format

11.1.1.1 Header LRC

The header LRC (Longitudinal Redundancy Check) provides error checking on the packet header. It also allows the decoder to find the start of a packet by scanning for a valid LRC. Only the lower 8 bits of the calculation below are provided in the LRC field of the packet header. The LRC can be found using the following:

$$LRC = (PacketID + PacketLength + crc_0 + crc_1) \oplus 0\mathrm{xFF} + 1$$

11.1.1.2 Packet ID

The packet ID is used to distinguish the contents of the packet. Packet IDs range from 0 to 255. See **11 Advanced Navigation Packet Protocol**.

System packets have packet IDs in the range 0 to 19. These packets are implemented the same by every device using ANPP.

State packets are packets that contain data that changes with time, i.e. temperature. State packets can be set to output at a certain rate. State packets are packet IDs in the range 20 to 179.

Configuration packets are used for reading and writing device configuration. Configuration packets are packet IDs in the range 180 to 255.

11.1.1.3 Packet Length

The packet length denotes the length of the packet data, i.e. from byte index 5 onwards inclusive. Packet length has a range of $0 - 255$.

11.1.1.4 CRC

The CRC is a CRC16-CCITT. The starting value is 0xFFFF. The CRC covers only the packet data.

11.1.2 Packet Requests

Any of the state and configuration packets can be requested at any time using the **11.3.2 Request Packet**.

11.1.3 Packet Acknowledgement

When configuration packets are sent to Boreas, it will reply with an acknowledgement packet that indicates whether the configuration change was successful or not. See **11.3.1 Acknowledge Packet**.

External data packets will also generate negative acknowledgement packets if there is a problem with the packet. Positive acknowledgements will not be sent. See **10.5 External Data** for a list of External Data Packets.

11.1.4 Packet Rates

The packet rates can be configured either using the web UI, or Boreas Manager or through the **11.5.2 Packets Period Packet**. By default Boreas is configured to output the **11.4.1 System State Packet** at 20 Hz and the **11.4.9 Raw Sensors Packet** at 20 Hz. When configuring packet rates it is essential to ensure the baud rate is capable of handling the data throughput. This can be calculated using the rate and packet size. The packet size

is calculated by adding the packet overhead to the packet length; the packet overhead is a fixed value of 5. For example to output the system state packet at 50Hz the calculation would be:

Data throughput = (100 (packet length) + 5 (fixed packet overhead)) * 50 (rate)

Data throughput = 5250 bytes per second

Minimum baud rate = data throughput x 11 = 57750 Baud

Closest standard baud rate = 115200 Baud

When multiple packets are set to output at the same rate, the order the packets output is from lowest ID to highest ID.

11.1.5 Packet Timing

Packets are output in order of packet ID from lowest ID to highest ID and all packets that are output in one sequence have their data matched to the same time of validity. The time of validity can be found in either the **11.4.1 System State Packet**, the **11.4.2 Unix Time Packet** or the **11.4.3 Formatted Time Packet**. For example if the **11.4.2 Unix Time Packet**, **11.4.4 Status Packet** and **11.4.15 NED Velocity Packet** packet were all set to output at 10 Hz, at each 0.1 second period the three packets would output consecutively by order of packet ID with all data synchronised between them and the **11.4.2 Unix Time Packet** providing the time of validity for the other two packets.

11.2 Data Types

The following data types are used in the packet protocol. All data types in the protocol are little endian byte ordering.

Abbreviation	Bytes	Also known as
u8	1	unsigned char, unsigned byte, uint8_t
s8	1	char, byte, int8_t
u16	2	unsigned short, uint16_t
s16	2	short, int16_t
u32	4	unsigned int, unsigned long, uint32_t
s32	4	int, long, int32_t
u64	8	unsigned long long, uint64_t
s64	8	long long, int64_t
fp32	4	float
fp64	8	double

Table 43: Data Type Abbreviations used in the ANPP

11.3 System Packets

11.3.1 Acknowledge Packet

Acknowledgement Packet				
Packet ID			0	
Length			4	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Packet ID being acknowledged
2	1	u16	2	CRC of packet being acknowledged
3	3	u8	1	**11.3.1.1 Acknowledge Result**

Table 44: Acknowledge Packet

11.3.1.1 Acknowledge Result

Value	Description
0	Acknowledge success
1	Acknowledge failure, CRC error
2	Acknowledge failure, packet size incorrect
3	Acknowledge failure, values outside of valid ranges
4	Acknowledge failure, system flash memory failure
5	Acknowledge failure, system not ready
6	Acknowledge failure, unknown packet

Table 45: Acknowledge Result

11.3.2 Request Packet

Request Packet				
Packet ID			1	
Length			1 x number of packets requested	
Read / Write			Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Packet ID requested
+				Field 1 repeats for additional packet requests

Table 46: Request Packet

11.3.3 Boot Mode Packet

Boot Mode Packet				
Packet ID			2	
Length			1	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	**11.3.3.1 Boot Mode Types**

Table 47: Boot Mode Packet

11.3.3.1 Boot Mode Types

Value	Description
0	Bootloader
1	Main Program

Table 48: Boot Mode Types

11.3.4 Device Information Packet

Device Information Packet				
Packet ID			3	
Length			24	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	Software version
2	4	u32	4	**11.3.4.1 Device ID**
3	8	u32	4	Hardware revision
4	12	u32	4	Boreas Serial number part 1
5	16	u32	4	Boreas Serial number part 2
6	20	u32	4	Boreas Serial number part 3

Table 49: Device Information Packet

11.3.4.1 Device ID

Value	Description
1	Spatial
4	Spatial FOG
5	Spatial Dual
11	Orientus (>v3)
13	Air Data Unit
14	Subsonus
16	Spatial FOG Dual
17	Motus
19	GNSS Compass
21	Subsonus Tag
22	Poseidon
26	Certus
27	Aries
28	Boreas D90
41	Boreas D70

Table 50: Device IDs

11.3.5 Restore Factory Settings Packet

Note: A Factory Reset will re-enable the DHCP Client and lose any static IP address settings.

Restore Factory Settings Packet				
Packet ID			4	
Length			4	
Read / Write			Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	Verification sequence (set to 0x85429E1C)

Table 51: Restore Factory Settings Packet

11.3.6 Reset Packet

Reset Packet				
Packet ID			5	
Length			4	
Read / Write			Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	**11.3.6.1 Verification Sequence Values**

Table 52: Reset Packet

11.3.6.1 Verification Sequence Values

Value	**Description**
0x21057A7E	Standard hot start reset
0x9A5D38B7	Cold start reset

Table 53: Verification Sequence Values

11.3.7 Serial Port Passthrough Packet

Serial Port Passthrough Packet				
Packet ID			10	
Length			Variable, up to 255 bytes	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	**Passthrough Route**
2	1			Passthrough Data

Table 54: Serial Port Passthrough Packet

11.3.7.1 Passthrough Route

Value	**Description**
1	GPIO 1 and 2
2	Auxiliary

Table 55: Passthrough Route

11.3.8 IP Configuration Packet

IP Configuration Packet				
Packet ID			11	
Length			30	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u8	1	**11.3.8.1 DHCP Mode**
3	2	u32	4	IP Address
4	6	u32	4	IP Netmask
5	10	u32	4	IP Gateway
6	14	u32	4	DNS Server
7	18	u32	4	Boreas Serial number part 1
8	22	u32	4	Boreas Serial number part 2
9	26	u32	4	Boreas Serial number part 3

Table 56: IP Configuration Packet

11.3.8.1 DHCP Mode

Bit	Description
0	DHCP Enabled
1	Automatic DNS
2-4	Link Mode. See **11.3.8.2 Link Mode Index**
5-7	Reserved (set to zero)

Table 57: DHCP Mode

11.3.8.2 Link Mode Index

Value	Bit 4	Bit 3	Bit 2	Description
0	0	0	0	Auto

Table 58: Link Mode Index

11.3.8.3 Discovery Network Setting Overwrite

Settings 7,8 and 9 are optional over standard network interfaces but required to overwrite settings over multi-cast discovery. To overwrite network settings for a device over multi-cast send this packet to address 239.48.81.7 port 48817, the serial number must be set to the serial number of the device you want to overwrite settings for.

11.3.9 Subcomponent Information Packet

Only Advanced Navigation sub-components will be shown here, for GNSS Receiver see **11.4.41 GNSS Receiver Information Packet**

Subcomponent Information Packet				
Packet ID			14	
Length			24 x number of subcomponents	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	Subcomponent Software version
2	4	u32	4	**11.3.9.1 Subcomponent Device ID**
3	8	u32	4	Subcomponent Hardware Revision
4	12	u32[3]	12	Subcomponent Serial Number
Fields 1-4 repeat for additional subcomponents				

Table 59: Subcomponent Information Packet

11.3.9.1 Subcomponent Device ID

Value	Description
5	Spatial MEMS IMU
17	Evo MEMS IMU
27	Aries

Table 60: Subcomponent Device IDs

11.4 State Packets

Boreas supports a ANPP number of packets providing extensive functionality. However for the majority of users the easiest approach is to configure Boreas using the web UI or Boreas Manager software and then support only the single system state packet shown in **11.4.1 System State Packet**. Advanced functionality can be added as required through the other packets.

This section covers the following topics:

Packet ID	Name	Length	R/W
State Packets			
20	**11.4.1 System State Packet**	100	R
21	**11.4.2 Unix Time Packet**	8	R
22	**11.4.3 Formatted Time Packet**	14	R
23	**11.4.4 Status Packet**	4	R
24	**11.4.5 Position Standard Deviation Packet**	12	R
25	**11.4.6 Velocity Standard Deviation Packet**	12	R
26	**11.4.7 Euler Orientation Standard Deviation Packet**	12	R
27	**11.4.8 Quaternion Orientation Standard Deviation Packet**	16	R
28	**11.4.9 Raw Sensors Packet**	48	R
29	**11.4.10 Raw GNSS Packet**	74	R/W
30	**11.4.11 Satellites Packet**	13	R
32	**11.4.12 Geodetic Position Packet**	24	R
33	**11.4.13 ECEF Position Packet**	24	R
34	**11.4.14 UTM Position Packet**	26	R
35	**11.4.15 NED Velocity Packet**	12	R
36	**11.4.16 Body Velocity Packet**	12	R
37	**11.4.17 Acceleration Packet**	12	R
38	**11.4.18 Body Acceleration Packet**	16	R
39	**11.4.19 Euler Orientation Packet**	12	R
40	**11.4.20 Quaternion Orientation Packet**	16	R
41	**11.4.21 DCM Orientation Packet**	36	R
42	**11.4.22 Angular Velocity Packet**	12	R
43	**11.4.23 Angular Acceleration Packet**	12	R
44	**11.4.24 External Position and Velocity Packet**	60	R/W
45	**11.4.25 External Position Packet**	36	R/W
46	**11.4.26 External Velocity Packet**	24	R/W

Packet ID	Name	Length	R/W
47	**11.4.27 External Body Velocity Packet**	16 or 24	R/W
48	**11.4.28 External Heading Packet**	8	R/W
49	**11.4.29 Running Time Packet**	8	R
51	**11.4.30 Odometer State Packet**	20	R
52	**11.4.31 External Time Packet**	8	W
53	**11.4.32 External Depth Packet**	8	R/W
54	**11.4.33 Geoid Height Packet**	4	R
55	**11.4.34 RTCM Corrections Packet**	Varies	W
57	**11.4.35 Wind Packet**	12	R/W
58	**11.4.36 Heave Packet**	16	R
60	**11.4.37 Raw Satellite Data Packet**	Varies	R
61	**11.4.38 Raw Satellite Ephemeris Packet**	Varies	R
67	**11.4.39 External Odometer Packet**	13	W
68	**11.4.40 External Air Data Packet**	25	R/W
69	**11.4.41 GNSS Receiver Information Packet**	Varies	R
70	**11.4.42 Raw DVL Data Packet**	60	R/W
71	**11.4.43 North Seeking Initialisation Status Packet**	28	R
72	**11.4.44 Gimbal State Packet**	8	R/W
73	**11.4.45 Automotive Packet**	24	R
80	**11.4.46 Basestation Packet**	45	R
83	**11.4.47 Zero Angular Velocity Packet**	8	W
84	**11.4.48 Extended Satellites Packet**	Varies	R
85	**11.4.49 Sensor Temperature Packet**	32	R
86	**11.4.50 System Temperature Packet**	64	R

Table 61: State Packets

11.4.1 System State Packet

System State Packet				
Packet ID			20	
Length			100	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u16	2	**11.4.1.1 System Status**
2	2	u16	2	**11.4.1.2 Filter Status**
3	4	u32	4	**11.4.1.4 Unix Time Seconds**
4	8	u32	4	**11.4.1.5 Microseconds**
5	12	fp64	8	Latitude (rad)
6	20	fp64	8	Longitude (rad)
7	28	fp64	8	Height (m)
8	36	fp32	4	Velocity north (m/s)
9	40	fp32	4	Velocity east (m/s)
10	44	fp32	4	Velocity down (m/s)
11	48	fp32	4	Body acceleration X (m/s/s)
12	52	fp32	4	Body acceleration Y (m/s/s)
13	56	fp32	4	Body acceleration Z (m/s/s)
14	60	fp32	4	G force (g)
15	64	fp32	4	Roll (radians)
16	68	fp32	4	Pitch (radians)
17	72	fp32	4	Heading (radians)
18	76	fp32	4	Angular velocity X (rad/s)
19	80	fp32	4	Angular velocity Y (rad/s)
20	84	fp32	4	Angular velocity Z (rad/s)
21	88	fp32	4	Latitude standard deviation (m)
22	92	fp32	4	Longitude standard deviation (m)
23	96	fp32	4	Height standard deviation (m)

Table 62: System State Packet

11.4.1.1 System Status

This field contains 16 bits that indicate problems with the system. These are boolean fields with a zero indicating false and one indicating true.

Use the Raw GNSS packet #29 to identify which of the GNSS receivers or antennas has a problem.

Bit	Description
0	System Failure
1	Accelerometer Sensor Failure
2	Gyroscope Sensor Failure
3	Reserved
4	Pressure Sensor Failure
5	GNSS Failure
6	Accelerometer Over Range
7	Gyroscope Over Range
8	Reserved
9	Pressure Over Range
10	Minimum Temperature Alarm
11	Maximum Temperature Alarm
12	Internal Data Logging Error
13	High Voltage Alarm
14	GNSS Antenna Connection (open or short circuit, primary or secondary antenna). NOTE: This bit is not applicable to units with a Trimble BD992 GNSS Receiver
15	Data Output Overflow Alarm

Table 63: System Status

11.4.1.2 Filter Status

This field contains 16 bits that indicate the status of the filters. These are boolean fields with a zero indicating false and one indicating true.

Bit	Description
0	Orientation Filter Initialised
1	Navigation Filter Initialised
2	Heading Initialised
3	UTC Time Initialised
4	**11.4.1.3 GNSS Fix Status**
5	
6	
7	Event 1 Occurred
8	Event 2 Occurred
9	Internal GNSS Enabled
10	Dual Antenna Heading Active
11	Velocity Heading Enabled
12	Atmospheric Altitude Enabled
13	External Position Active
14	External Velocity Active
15	External Heading Active

Table 64: Filter Status

11.4.1.3 GNSS Fix Status

Value	Bit 6	Bit 5	Bit 4	Description
0	0	0	0	No GNSS fix
1	0	0	1	2D GNSS fix
2	0	1	0	3D GNSS fix
3	0	1	1	SBAS GNSS fix
4	1	0	0	Differential GNSS fix
5	1	0	1	PPP GNSS fix
6	1	1	0	RTK Float GNSS fix
7	1	1	1	RTK Fixed GNSS fix

Table 65: GNSS Fix Status

11.4.1.4 Unix Time Seconds

This field provides the Unix time in seconds, using the standard epoch of January 1, 1970.

11.4.1.5 Microseconds

This field provides the sub-second component of time. It is represented as microseconds since the last second. Minimum value is 0 and maximum value is 999999.

11.4.2 Unix Time Packet

Unix Time Packet				
Packet ID				21
Length				8
Read / Write				Read
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	Unix time stamp (seconds). See **11.4.1.4 Unix Time Seconds**
2	4	u32	4	**Microseconds**

Table 66: Unix Time Packet

11.4.3 Formatted Time Packet

Formatted Time Packet				
Packet ID				22
Length				14
Read / Write				Read
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	Microseconds
2	4	u16	2	Year
3	6	u16	2	Year day, 0 - 365
4	8	u8	1	Month, 0 - 11
5	9	u8	1	Month Day, 1 - 31
6	10	u8	1	Week Day, 0 – 6 (0 = Sunday)
7	11	u8	1	Hour, 0 - 23
8	12	u8	1	Minute, 0 - 59
9	13	u8	1	Second, 0 - 59

Table 67: Formatted Time Packet

11.4.4 Status Packet

Status Packet				
Packet ID			23	
Length			4	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u16	2	**System Status**
2	2	u16	2	**Filter Status**

Table 68: Status Packet

11.4.5 Position Standard Deviation Packet

Position Standard Deviation Packet				
Packet ID			24	
Length			12	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Latitude standard deviation (m)
2	4	fp32	4	Longitude standard deviation (m)
3	8	fp32	4	Height standard deviation (m)

Table 69: Position Standard Deviation Packet

11.4.6 Velocity Standard Deviation Packet

Velocity Standard Deviation Packet				
Packet ID			25	
Length			12	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Velocity north standard deviation (m/s)
2	4	fp32	4	Velocity east standard deviation (m/s)
3	8	fp32	4	Velocity down standard deviation (m/s)

Table 70: Velocity Standard Deviation Packet

11.4.7 Euler Orientation Standard Deviation Packet

Euler Orientation Standard Deviation Packet				
Packet ID			26	
Length			12	
Read / Write			Read	
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Roll standard deviation (rad)
2	4	fp32	4	Pitch standard deviation(rad)
3	8	fp32	4	Heading standard deviation(rad)

Table 71: Euler Orientation Standard Deviation Packet

11.4.8 Quaternion Orientation Standard Deviation Packet

Quaternion Orientation Standard Deviation Packet				
Packet ID			27	
Length			16	
Read / Write			Read	
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Q0 standard deviation
2	4	fp32	4	Q1 standard deviation
3	8	fp32	4	Q2 standard deviation
4	12	fp32	4	Q3 standard deviation

Table 72: Quaternion Orientation Standard Deviation Packet

11.4.9 Raw Sensors Packet

Raw Sensors Packet				
Packet ID			28	
Length			48	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Accelerometer X (m/s/s)
2	4	fp32	4	Accelerometer Y (m/s/s)
3	8	fp32	4	Accelerometer Z (m/s/s)
4	12	fp32	4	Gyroscope X (rad/s)
5	16	fp32	4	Gyroscope Y (rad/s)
6	20	fp32	4	Gyroscope Z (rad/s)
7	24	fp32	4	Reserved
8	28	fp32	4	Reserved
9	32	fp32	4	Reserved
10	36	fp32	4	IMU Temperature (deg C)
11	40	fp32	4	Pressure (Pascals)
12	44	fp32	4	Pressure Temperature (deg C)

Table 73: Raw Sensors Packet

11.4.10 Raw GNSS Packet

This packet represents the raw data as it is received from the GNSS receiver. The position is not corrected for antenna position offset and the velocity is not compensated for the antenna lever arm offset. The INS position and velocity that are in the other packets are corrected for antenna position offset and lever arm.

Raw GNSS Packet				
Packet ID			29	
Length			74	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	Unix time stamp (seconds)
2	4	u32	4	Microseconds
3	8	fp64	8	Latitude (rad)
4	16	fp64	8	Longitude (rad)
5	24	fp64	8	Height (m)
6	32	fp32	4	Velocity north (m/s)
7	36	fp32	4	Velocity east (m/s)
8	40	fp32	4	Velocity down (m/s)
9	44	fp32	4	Latitude standard deviation (m)
10	48	fp32	4	Longitude standard deviation (m)
11	52	fp32	4	Height standard deviation (m)
12	56	fp32	4	Tilt (rad)
13	60	fp32	4	Heading (rad)
14	64	fp32	4	Tilt standard deviation (rad)
15	68	fp32	4	Heading standard deviation (rad)
16	72	u16	2	Status. See **11.4.10.1 Raw GNSS Status**

Table 74: Raw GNSS Packet

11.4.10.1 Raw GNSS Status

Bit	Description
0	**GNSS Fix Status**
1	
2	
3	Doppler velocity valid
4	Time valid
5	External GNSS
6	Tilt valid

Bit	Description
7	Heading valid
8	Floating ambiguity heading
9	Reserved (set to zero)
10	Antenna 1 disconnected (not applicable to units with Trimble BD992 GNSS receiver)
11	Antenna 2 disconnected (not applicable to units with Trimble BD992 GNSS receiver)
12	Antenna 1 short (not applicable to units with Trimble BD992 GNSS receiver)
13	Antenna 2 short (not applicable to units with Trimble BD992 GNSS receiver)
14	GNSS1 failure
15	GNSS2 failure (not applicable to units with Trimble BD992 GNSS receiver)

Table 75: Raw GNSS Status

11.4.11 Satellites Packet

Satellites Packet				
Packet ID			30	
Length			13	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	HDOP
2	4	fp32	4	VDOP
3	8	u8	1	GPS satellites
4	9	u8	1	GLONASS satellites
5	10	u8	1	BeiDou satellites
6	11	u8	1	GALILEO satellites
7	12	u8	1	SBAS satellites

Table 76: Satellites Packet

11.4.12 Geodetic Position Packet

Geodetic Position Packet				
Packet ID			32	
Length			24	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp64	8	Latitude (rad)
2	8	fp64	8	Longitude (rad)
3	16	fp64	8	Height (m)

Table 77: Geodetic Position Packet

11.4.13 ECEF Position Packet

ECEF Position Packet				
Packet ID			33	
Length			24	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp64	8	ECEF X (m)
2	8	fp64	8	ECEF Y (m)
3	16	fp64	8	ECEF Z (m)

Table 78: ECEF Position Packet

11.4.14 UTM Position Packet

UTM Position Packet				
Packet ID			34	
Length			26	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp64	8	Northing (m)
2	8	fp64	8	Easting (m)
3	16	fp64	8	Height (m)
4	24	u8	1	Zone number
5	25	s8	1	Zone character

Table 79: UTM Position Packet

11.4.15 NED Velocity Packet

NED Velocity Packet				
Packet ID			35	
Length			12	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Velocity north (m/s)
2	4	fp32	4	Velocity east (m/s)
3	8	fp32	4	Velocity down (m/s)

Table 80: NED Velocity Packet

11.4.16 Body Velocity Packet

Body Velocity Packet				
Packet ID			36	
Length			12	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Velocity X (m/s)
2	4	fp32	4	Velocity Y (m/s)
3	8	fp32	4	Velocity Z (m/s)

Table 81: Body Velocity Packet

11.4.17 Acceleration Packet

This packet includes the acceleration due to gravity.

Acceleration Packet				
Packet ID			37	
Length			12	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Acceleration X (m/s/s)
2	4	fp32	4	Acceleration Y (m/s/s)
3	8	fp32	4	Acceleration Z (m/s/s)

Table 82: Acceleration Packet

11.4.18 Body Acceleration Packet

This packet does not include the acceleration due to gravity.

Body Acceleration Packet				
Packet ID			38	
Length			16	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Body acceleration X (m/s/s)
2	4	fp32	4	Body acceleration Y (m/s/s)
3	8	fp32	4	Body acceleration Z (m/s/s)
4	12	fp32	4	G force (g)

Table 83: Body Acceleration Packet

11.4.19 Euler Orientation Packet

Euler Orientation Packet				
Packet ID			39	
Length			12	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Roll (rad)
2	4	fp32	4	Pitch (rad)
3	8	fp32	4	Heading (rad)

Table 84: Euler Orientation Packet

11.4.20 Quaternion Orientation Packet

Quaternion Orientation Packet				
Packet ID			40	
Length			16	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	QS
2	4	fp32	4	QX
3	8	fp32	4	QY
4	12	fp32	4	QZ

Table 85: Quaternion Orientation Packet

11.4.21 DCM Orientation Packet

DCM Orientation Packet				
Packet ID			41	
Length			36	
Read / Write			Read	
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	DCM[0][0]
2	4	fp32	4	DCM[0][1]
3	8	fp32	4	DCM[0][2]
4	12	fp32	4	DCM[1][0]
5	16	fp32	4	DCM[1][1]
6	20	fp32	4	DCM[1][2]
7	24	fp32	4	DCM[2][0]
8	28	fp32	4	DCM[2][1]
9	32	fp32	4	DCM[2][2]

Table 86: DCM Orientation Packet

11.4.22 Angular Velocity Packet

Angular Velocity Packet				
Packet ID			42	
Length			12	
Read / Write			Read	
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Angular velocity X (rad/s)
2	4	fp32	4	Angular velocity Y (rad/s)
3	8	fp32	4	Angular velocity Z (rad/s)

Table 87: Angular Velocity Packet

11.4.23 Angular Acceleration Packet

Angular Acceleration Packet				
Packet ID			43	
Length			12	
Read / Write			Read	
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Angular acceleration X (rad/s/s)
2	4	fp32	4	Angular acceleration Y (rad/s/s)
3	8	fp32	4	Angular acceleration Z (rad/s/s)

Table 88: Angular Acceleration Packet

11.4.24 External Position and Velocity Packet

External Position and Velocity Packet				
Packet ID			44	
Length			60	
Read / Write			Read / Write	
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp64	8	Latitude (rad)
2	8	fp64	8	Longitude (rad)
3	16	fp64	8	Height (m)
4	24	fp32	4	Velocity north (m/s)
5	28	fp32	4	Velocity east (m/s)
6	32	fp32	4	Velocity down (m/s)
7	36	fp32	4	Latitude standard deviation (m)
8	40	fp32	4	Longitude standard deviation (m)
9	44	fp32	4	Height standard deviation (m)
10	48	fp32	4	Velocity north standard deviation (m/s)
11	52	fp32	4	Velocity east standard deviation (m/s)
12	56	fp32	4	Velocity down standard deviation (m/s)

Table 89: External Position and Velocity Packet

11.4.25 External Position Packet

External Position Packet				
Packet ID			45	
Length			36	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp64	8	Latitude (rad)
2	8	fp64	8	Longitude (rad)
3	16	fp64	8	Height (m)
4	24	fp32	4	Latitude standard deviation (m) Must be non-zero positive value
5	28	fp32	4	Longitude standard deviation (m) Must be non-zero positive value
6	32	fp32	4	Height standard deviation (m) Must be non-zero positive value

Table 90: External Position Packet

11.4.26 External Velocity Packet

External Velocity Packet				
Packet ID			46	
Length			24	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Velocity north (m/s)
2	4	fp32	4	Velocity east (m/s)
3	8	fp32	4	Velocity down (m/s)
4	12	fp32	4	Velocity north standard deviation (m/s)
5	16	fp32	4	Velocity east standard deviation (m/s)
6	20	fp32	4	Velocity down standard deviation (m/s)

Table 91: External Velocity Packet

11.4.27 External Body Velocity Packet

This packet has been defined to support a single velocity standard deviation for all three axes, or, different values for all three axes. Modify the packet length in the packet header accordingly, depending on which format you are using.

External Body Velocity Packet				
Packet ID			47	
Length			16 or 24	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Velocity X (m/s)
2	4	fp32	4	Velocity Y (m/s)
3	8	fp32	4	Velocity Z (m/s)
4	12	fp32	4	Velocity X standard deviation (m/s)
5	16	fp32	4	OPTIONAL: Velocity standard deviation Y (m/s)
6	20	fp32	4	OPTIONAL: Velocity standard deviation Z (m/s)

Table 92: External Body Velocity Packet

11.4.28 External Heading Packet

External Heading Packet				
Packet ID			48	
Length			8	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Heading (rad)
2	4	fp32	4	Heading standard deviation (rad)

Table 93: External Heading Packet

11.4.29 Running Time Packet

This packet provides the running time in seconds since the most recent power on.

Running Time Packet				
Packet ID			49	
Length			8	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	Running time (seconds)
2	4	u32	4	**11.4.1.5 Microseconds**

Table 94: Running Time Packet

11.4.30 Odometer State Packet

Odometer State Packet				
Packet ID			51	
Length			20	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	s32	4	Odometer pulse count
2	4	fp32	4	Odometer distance (m)
3	8	fp32	4	Odometer speed (m/s)
4	12	fp32	4	Odometer slip (m)
5	16	u8	1	Odometer active
6	17		3	Reserved

Table 95: Odometer State Packet

11.4.31 External Time Packet

External Time Packet				
Packet ID			52	
Length			8	
Read / Write			Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	**11.4.1.4 Unix Time Seconds**
2	4	u32	4	**11.4.1.5 Microseconds**

Table 96: External Time Packet

11.4.32 External Depth Packet

External Depth is the measured distance below Mean Sea Level

External Depth Packet				
Packet ID			53	
Length			8	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Depth (m)
2	4	fp32	4	Depth standard deviation (m)

Table 97: External Depth Packet

11.4.33 Geoid Height Packet

This packet provides the offset at the current location between the WGS84 ellipsoid and the EGM96 geoid model. This can be used to determine the current height above mean sea level and also depth through the following equations:

Height Above Mean Sea Level = WGS84 Height – Geoid Height

Depth = Geoid Height – WGS84 Height

WGS84 Height is the height at the current location in the System State packet, see **11.4.1 System State Packet**

Geoid Height Packet				
Packet ID			54	
Length			4	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Geoid height (m)

Table 98: Geoid Height Packet

11.4.34 RTCM Corrections Packet

This packet is used to encapsulate RTCM v3 correction data to be sent to the Boreas internal GNSS receiver for DGPS or RTK GNSS functionality.

RTCM Corrections Packet				
Packet ID			55	
Length			Variable, up to 255 bytes	
Read / Write			Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0			RTCM corrections data

Table 99: RTCM Corrections Packet

11.4.35 Wind Packet

This packet provides the Boreas current 2D wind velocity. These values are only valid when external air data is provided to Boreas. This can be either through the **11.4.40 External Air Data Packet** or when a pitot tube is interfaced to one of the GPIO pins. When this packet is written to the device, it disables the wind estimation filter and the wind values provided are used statically.

Wind Packet				
Packet ID			57	
Length			12	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Wind velocity north (m/s)
2	4	fp32	4	Wind velocity east (m/s)
3	8	fp32	4	Wind velocity standard deviation (m/s)

Table 100: Wind Packet

11.4.36 Heave Packet

Heave Packet				
Packet ID			58	
Length			16	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Heave point 1 (m)
2	4	fp32	4	Heave point 2 (m)
3	8	fp32	4	Heave point 3 (m)
4	12	fp32	4	Heave point 4 (m)

Table 101: Heave Packet

11.4.37 Raw Satellite Data Packet

The Boreas Manager Log Converter will automatically convert this packet to RINEX 3.02 format.

Note: Once this packet is enabled, Packet 61 (**11.4.38 Raw Satellite Ephemeris Packet**) will also be enabled automatically.

Raw Satellite Data Packet				
Packet ID			60	
Length			16 + Satellites * (6 + Frequencies * 26)	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**

Raw Satellite Data Packet					
1	0	u32	4	**Unix time (seconds)**
2	4	u32	4	Nanoseconds
3	8	s32	4	Receiver clock offset (nanoseconds)
4	12	u8	1	Receiver number
5	13	u8	1	Packet number (range 1 to Total)
6	14	u8	1	Total packets
7	15	u8	1	Number of satellites
For each satellite				
8	16	u8	1	**Satellite Systems**
9	17	u8	1	PRN or satellite number
10	18	u8	1	Elevation (degrees)
11	19	u16	2	Azimuth (degrees)
12	21	u8	1	Number of frequencies
For each frequency of each satellite				
13	22	u8	1	**Satellite Frequencies**
14	23	u8	1	**Tracking Status**
15	24	fp64	8	Carrier phase (cycles)
16	32	fp64	8	Pseudo range (m)
17	40	fp32	4	Doppler frequency (Hz)
18	44	fp32	4	Signal to noise ratio (dB-Hz)

Table 102: Raw Satellite Data Packet

11.4.37.1 Satellite Systems

Value	System
0	Unknown
1	GPS
2	GLONASS
3	BeiDou
4	Galileo
5	SBAS
6	QZSS
7	Reserved
8	Reserved
9	Reserved

Table 103: Satellite Systems

11.4.37.2 Satellite Frequencies

Value	GPS	GLONASS	Galileo	BeiDou	SBAS	QZSS
0	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
1	L1 C/A	G1 C/A	E1 OS	B1	L1 C/A	L1 C/A
2	L1 C		E1 PRS			L1 C
3	L1 P	G1 P				L1 SAIF
4	L1 M					
5	L2 C	G2 C/A	E6 CS	B2		L2 C
6	L2 P	G2 P	E6 PRS			LEX
7	L2 M					
8	L5	G3	E5 a	B3	L5	L5
9			E5 b			
10			E5 a+b			

Table 104: Satellite Frequencies

11.4.37.3 Tracking Status

Bit	Description
0	Carrier phase valid
1	Carrier phase cycle slip detected
2	Carrier phase half-cycle ambiguity
3	Pseudo range valid
4	Doppler valid
5	SNR valid
6-7	Reserved (set to zero)

Table 105: Tracking Status

11.4.38 Raw Satellite Ephemeris Packet

Boreas Manager will automatically convert this packet to RINEX 3.02 format.

Note: This packet is enabled automatically when packet 60 (**11.4.37 Raw Satellite Data Packet**) is enabled. This packet cannot be enabled independently of Packet 60.

Raw Satellite Ephemeris Packet	
Packet ID	61
Length	Varies

Raw Satellite Ephemeris Packet					
Read / Write				Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**	
1	0	u32	4	Unix timestamp (seconds)	
2	4	u8	1	Satellite System	
3	5	u8	1	Satellite number (PRN)	
For GPS Satellites (132 bytes)					
5	6	u32	4	Time of ephemeris (Toe) (s)	
6	10	u16	2	Issue of Data Clock [IODC] (s)	
7	12	u16	2	Issue of Data Ephemeris [IODE] (s)	
8	14	fp32	4	Satellite Clock Bias [af0] (s)	
9	18	fp32	4	Satellite Clock Drift [af1] (s/s)	
10	22	fp32	4	Satellite Clock Drift Rate [af2] (s/s/s)	
11	26	fp32	4	Crs (m)	
12	30	fp32	4	Delta N (rad/s)	
13	34	fp64	8	M0 (rad)	
14	42	fp32	4	Cuc (rad)	
15	46	fp64	8	Eccentricity [e]	
16	54	fp32	4	Cus (rad)	
17	58	fp64	8	$\sqrt{A}$ ($\sqrt{m}$)	
18	66	fp32	4	Cic (rad)	
19	70	fp64	8	OMEGA0 (rad)	
20	78	fp32	4	Cis (rad)	
21	82	fp64	8	i0 (rad)	
22	90	fp32	4	Crc (m)	
23	94	fp64	8	Omega (rad)	
24	102	fp64	8	Omega dot (rad/s)	
25	110	fp64	8	IDOT (rad/s)	
26	118	fp32	4	TGD (s)	
27	122	u16	2	Ephemeris week number	
28	124	u32	4	Transmission time (s)	
29	128	u16	2	User range accuracy (m)	
30	130	u16	2	**11.4.38.1 GPS Flags**	
For GLONASS satellites (94 Bytes)					
5	6	fp32	4	Satellite clock bias (s)	

Raw Satellite Ephemeris Packet				
6	10	fp32	4	Satellite frequency bias [gamma]
7	14	fp64	8	Satellite position X (m)
8	22	fp64	8	Satellite position Y (m)
9	30	fp64	8	Satellite position Z (m)
10	38	fp64	8	Satellite velocity X (m/s)
11	46	fp64	8	Satellite velocity Y (m/s)
12	54	fp64	8	Satellite velocity Z (m/s)
13	62	fp64	8	Satellite acceleration X (m/s/s)
14	70	fp64	8	Satellite acceleration Y (m/s/s)
15	78	fp64	8	Satellite acceleration Z (m/s/s)
16	86	u32	4	Message frame start time (s)
17	90	u8	1	Age of operational information [E] (days)
18	91	s8	1	Frequency slot number
19	92	u8	1	Satellite Health
20	93	u8	1	Reserved

Table 106: Raw Satellite Ephemeris Packet

11.4.38.1 GPS Flags

Bit	Description
0	Data flag for L2 P-code
1-2	Codes on L2 channel
3	Anti-spoof flag
4-9	Satellite health
10	Fit interval flag
11	URA bad
12-14	Satellite block type

Table 107: GPS Flags

11.4.39 External Odometer Packet

External Odometer Packet				
Packet ID			67	
Length			13	
Read / Write			Write	
Field #	Bytes Offset	Data Type	Size	Description

External Odometer Packet					
1	0	fp32	4	Estimated delay (s)	
2	4	fp32	4	Speed (m/s)	
3	8	fp32	4	Reserved (set to zero)	
4	12	u8	1	Odometer flags	

Table 108: External Odometer Packet

11.4.39.1 Odometer Flags

Bit	Description
0	Reversing detection supported
1-7	Reserved (set to zero)

Table 109: Odometer Flags

11.4.40 External Air Data Packet

External Air Data Packet				
Packet ID			68	
Length			25	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Barometric altitude delay (s)
2	4	fp32	4	Airspeed delay (s)
2	8	fp32	4	Barometric altitude (m)
3	12	fp32	4	Airspeed (m/s)
4	16	fp32	4	Barometric altitude standard deviation (m)
5	20	fp32	4	Airspeed standard deviation (m/s)
6	24	u8	1	**Flags**

Table 110: External Air Data Packet

11.4.40.1 External Air Data Flags

Bit	Description
0	Barometric altitude set and valid
1	Airspeed set and valid
2	Barometric altitude reference reset

Table 111: External Air Data Flags

Barometric altitude does not need to be referenced to any co-ordinate frame or QNH. If the barometric altitude reference is changed during operation, the barometric altitude reference reset flag should be set for the next packet.

11.4.41 GNSS Receiver Information Packet

11.4.41.1 Aries GNSS Receiver

Aries GNSS Receiver Information Packet				
Packet ID			69	
Length			68	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	**GNSS manufacturer ID**
2	1	u8	1	**GNSS receiver model**
3	2	s8 [24]	24	GNSS serial number in ASCII character string
4	26	u32	4	Firmware version
5	30	u32	4	Hardware version
6	34		34	Reserved (set to zero)

Table 112: Aries GNSS Receiver Information Packet

11.4.41.2 Trimble BD992 GNSS Receiver

Trimble BD992 GNSS Receiver Information Packet				
Packet ID			69	
Length			48	
read/Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	**GNSS manufacturer ID**
2	1	u8	1	**GNSS receiver model**
3	2	s8[10]	10	GNSS serial number in ASCII character string
4	12	u32	4	Firmware version
5	16	u32[3]	12	Software license code
6	28	u32	4	Omnistar serial number
7	32	u32	4	Omnistar subscription start unix time
8	36	u32	4	Omnistar subscription expiry unix time
9	40	u8	1	**Omnistar engine mode**
10	41	u8	1	**RTK Software license accuracy**
11	42		6	Reserved (set to zero)

Table 113: Trimble BD992 GNSS Receiver Information Packet

11.4.41.3 GNSS Manufacturer IDs and Receiver Models

Manufacturer		Receiver	
ID	**Description**	**Value**	**Description**
0	GNSS Manufacturer Unknown	0	GNSS Receiver Model Unknown
1	Trimble	0	GNSS Receiver Model Unknown
		1	Trimble BD920
		2	Trimble BD930
		3	Trimble BD982
		4	Trimble MB-One
		5	Trimble MB-Two
		6	Trimble BD940
		7	Trimble BD992
3	Advanced Navigation	0	GNSS Receiver Model Unknown
		1	Aries
		2	Aries GC2

Table 114: GNSS Manufacturer IDs and Receiver Models

11.4.41.4 Omnistar Engine Modes

Value	Description
0	Omnistar engine not active
1	HP
2	XP
3	G2
4	HP+G2
5	HP+XP

Table 115: Omnistar Engine Modes

11.4.41.5 RTK Software License Accuracy

Value	Description
0	RTK accuracy unknown
1	0.3m horizontal, 0.3m vertical
2	0.1m horizontal, 0.1m vertical
3	0.1m horizontal, 0.02m vertical
4	0.008m horizontal, 0.1m vertical
5	0.008m horizontal, 0.02m vertical

Table 116: RTK Software License Accuracies

11.4.42 Raw DVL Data Packet

> **Note**: The Raw DVL Data packet will be output each time it is received, unless a certain output rate has been set in "Configuration"→"Packet Rates" of Boreas Manager.

Raw DVL Data Packet				
Packet ID		70		
Length		60		
Read / Write		Read / Write		
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	Unix timestamp (seconds)
2	4	u32	4	Microseconds
3	8	u32	4	Flags, see **11.4.42.1 Raw DVL Data Flags**
4	12	fp32	4	Bottom velocity X (m/s)
5	16	fp32	4	Bottom velocity Y (m/s)
6	20	fp32	4	Bottom velocity Z (m/s)
7	24	fp32	4	Bottom velocity standard deviation (m/s)
8	28	fp32	4	Water velocity X (m/s)
9	32	fp32	4	Water velocity Y (m/s)
10	36	fp32	4	Water velocity Z (m/s)
11	40	fp32	4	Water velocity standard deviation (m/s)
12	44	fp32	4	Water velocity layer depth (m)
13	48	fp32	4	Depth (m)
14	52	fp32	4	Altitude (m)
15	56	fp32	4	Temperature (deg C)

Table 117: Raw DVL Data Packet

11.4.42.1 Raw DVL Data Flags

Bit	**Description**
0	Bottom velocity valid
1	Water velocity valid
2	Temperature valid
3	Depth valid
4	Altitude valid

Table 118: Raw DVL Data Flags

11.4.43 North Seeking Initialisation Status Packet

North Seeking Initialisation Status Packet				
Packet ID			71	
Length			28	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u16	2	Flags, See **11.4.43.1 North Seeking Initialisation Status Flags**
2	2	u16	2	Version
3	4	u8	1	Progress (%)
4	5	u8	1	Alignment Attempts
5	6		2	Reserved (set to zero)
6	8	fp32	4	Coarse alignment heading (rad)
7	12	fp32	4	Predicted accuracy (rad)
8	16		12	Reserved (set to zero)

Table 119: North Seeking Initialisation Status Packet

11.4.43.1 North Seeking Initialisation Status Flags

Value	Description
0	North seeking initialisation complete
1	North seeking initialisation cannot start because the position is unknown
2	Solution out of range
3	Solution non-orthogonal
4	Restarted due to excessive movement
5	Restarted due to change in latitude
6	Restarted due to user change in lever arm offset
7	Latitude check failed
8-15	Reserved (set to zero)

Table 120: North Seeking Initialisation Status Flags

11.4.44 Gimbal State Packet

Boreas will accept (write) Current angle values between -2pi and 2pi exclusive.

Boreas will output (read) values between -pi and pi for current angle.

Gimbal State Packet	
Packet ID	72
Length	8

Gimbal State Packet				
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Current angle (rad)
2	4		4	Reserved (set to zero)

Table 121: Gimbal State Packet

11.4.45 Automotive Packet

The value of the slip angle will be zero unless velocity is greater than 3.45 m/s and heading is valid.

Automotive Packet				
Packet ID			73	
Length			24	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Virtual odometer distance (m)
2	4	fp32	4	Slip Angle (rad) Value reported is zero, unless heading is valid and the velocity is greater than 3.45 m/s
3	8	fp32	4	Velocity X (m/s)
4	12	fp32	4	Velocity Y (m/s)
5	16	fp32	4	Distance standard deviation (m)
6	20		4	Reserved (set to zero)

Table 122: Automotive Packet

11.4.46 Basestation Packet

Basestation Packet				
Packet ID			80	
Length			45	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u32	4	**11.4.1.4 Unix Time Seconds**
2	4	u32	4	**11.4.1.5 Microseconds**
3	8	fp64	8	Basestation position, latitude (rad)
4	16	fp64	8	Basestation position, longitude (rad)
5	24	fp64	8	Basestation position, altitude (rad)
6	32	fp32	4	Basestation relative position, north (m)
7	36	fp32	4	Basestation relative position, east (m)
8	40	fp32	4	Basestation relative position, down (m)
9	44	u8	1	**11.4.46.1 GNSS Fix Status**

Table 123: Basestation packet

11.4.46.1 GNSS Fix Status

Value	Description
0	No GNSS fix
1	2D GNSS fix
2	3D GNSS fix
3	SBAS GNSS fix
4	Differential GNSS fix
5	Omnistar/Starfire GNSS fix
6	RTK Float GNSS fix
7	RTK Fixed GNSS fix

Table 124: GNSS Fix Status

11.4.47 Zero Angular Velocity Packet

Zero Angular Velocity Packet				
Packet ID			83	
Length			8	
Read / Write			Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	Duration. See **11.4.47.1 Zero Angular Velocity Dur-**

Zero Angular Velocity Packet

				ation
2	4		4	Reserved (set to zero)

Table 125: Zero Angular Velocity Packet

11.4.47.1 Zero Angular Velocity Duration

Duration is the duration that the unit has been stationary for about the heading axis. The minimum value is 0.1 seconds and the maximum value is 2 seconds.

11.4.48 Extended Satellites Packet

Extended Satellites Packet

Packet ID				84
Length				2 + 9 x number of satellites
Read / Write				Read

Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Total number of extended satellites packets
2	1	u8	1	Packet number (range 1 to Total)
3	2	u8	1	**Satellite System**
4	3	u8	1	Satellite number (PRN)
5	4	s8	1	**11.4.48.2 Satellite Frequencies**
6	5	u8	1	Elevation (deg)
7	6	u16	2	Azimuth (deg)
8	8	u8	1	SNR receiver 1
9	9	u8	1	SNR receiver 2
10	10	u8	1	Flags. See **Extended Satellites Flags**
+				Fields 3-10 repeat for additional satellites

Table 126: Extended Satellites Packet

The maximum number of satellites per packet is 28. If there are more than 28 satellites to report, multiple packets will be sent per epoch. In this case the total number of packets in field #1 will be greater than 1, and the Packet Index in field #2 will increment accordingly.

11.4.48.1 Satellite Systems

Value	System
0	Unknown
1	GPS
2	GLONASS
3	BeiDou
4	Galileo
5	SBAS

Value	System
6	QZSS
7	Reserved
8	Reserved
9	Reserved

Table 127: Satellite Systems

11.4.48.2 Satellite Frequencies

Value	GPS	GLONASS	Galileo	BeiDou	SBAS	QZSS
0	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
1	L1 C/A	G1 C/A	E1 OS	B1	L1 C/A	L1 C/A
2	L1 C		E1 PRS			L1 C
3	L1 P	G1 P				L1 SAIF
4	L1 M					
5	L2 C	G2 C/A	E6 CS	B2		L2 C
6	L2 P	G2 P	E6 PRS			LEX
7	L2 M					
8	L5	G3	E5 a	B3	L5	L5
9			E5 b			
10			E5 a+b			

Table 128: Satellite Frequencies

11.4.48.3 Extended Satellites Flags

Bit	Description
0	Visible by receiver 1
1	Visible by receiver 2
2	Used in primary position solution
3	Used in moving baseline solution
4-7	Reserved (set to zero)

Table 129: Extended Satellites Flags

11.4.49 Sensor Temperature Packet

Sensor Temperatures Packet				
Packet ID			85	
Length			32	
Read / Write			Read	
Field #	Bytes Offset	Data Type	Size	Description

Sensor Temperatures Packet				
1	0	fp32[3]	12	Accelerometer temperature
2	12	fp32[3]	12	Gyroscope temperature
3	24	fp32	4	Reserved (set to 0)
4	28	fp32	4	Pressure sensor temperature

Table 130: Sensor temperature packet

11.4.50 System Temperature Packet

Sensor Temperatures Packet				
Packet ID			86	
Length			64	
Read / Write			Read	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	fp32	4	System Temperature
2	4	u8[60]	60	Reserved

Table 131: System temperature packet

11.5 Configuration Packets

Configuration packets can be both read from and written to the Boreas. On many of the configuration packets the first byte is a permanent flag. A zero in this field indicates that the settings will be lost on reset, a one indicates that they will be permanent (i.e. stored in flash).

This section covers the following topics:

Packet ID	Name	Length	R/W
Configuration Packets			
180	**11.5.1 Packet Timer Period Packet**	4	R/W
181	**11.5.2 Packets Period Packet**	Varies	R/W
182	**11.5.3 Baud Rates Packet**	17	R/W
185	**11.5.4 Installation Alignment Packet**	73	R/W
186	**11.5.5 Filter Options Packet**	17	R/W
188	**11.5.6 GPIO Configuration Packet**	13	R/W
192	**11.5.7 Odometer Configuration Packet**	8	R/W
193	**11.5.8 Set Zero Orientation Alignment Packet**	5	W
194	**11.5.9 Reference Point Offsets Packet**	49	R/W
195	**11.5.10 GPIO Output Configuration Packet**	183	R/W
196	**11.5.11 Dual Antenna Configuration Packet**	17	R/W
197	**11.5.12 GNSS Configuration Packet**	85	R/W
198	**11.5.13 User Data Packet**	64	R/W
199	**11.5.14 GPIO Input Configuration Packet**	65	R/W
202	**11.5.15 IP Dataports Configuration Packet**	30	R/W
203	**11.5.16 CAN Configuration Packet**	30	R/W

11.5.1 Packet Timer Period Packet

Packet Timer Period Packet				
Packet ID			180	
Length			4	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u8	1	**11.5.1.1 UTC Synchronisation**
3	2	u16	2	**11.5.1.2 Packet Timer Period**

Table 132: Packet Timer Period Packet

11.5.1.1 UTC Synchronisation

This is a boolean value that determines whether or not the packet timer is synchronised with UTC time, with zero for disabled and one for enabled. For UTC Synchronisation to be enabled the packet timer period must multiply into 1000000 evenly. For example if the packet timer period is 10000 (10 ms), 1000000/10000 = 100 which is valid for UTC synchronisation. If the packet timer period is 15000 (15 ms), 1000000/15000 = 66.6666 which is not valid for UTC synchronisation. To get the rate, use the following formula:

Packet Timer Rate = 1000000/(Packet Timer Period) Hz

11.5.1.2 Packet Timer Period

This is a value in microseconds that sets the master packet timer period. The minimum value is 1000 (1 ms) or 1000 Hz and the maximum value is 65000 (65 ms) or 15.38 Hz. The packet timer period must be in increments of 1000.

11.5.2 Packets Period Packet

This packet allows the user to configure, add, remove, modify and clear state packets (packets 20 through 180).

Note: This packet will only affect the port from which the packet is sent, leaving the other ports unaffected. e.g. If you are connected to the Primary serial port, sending this packet will only change the ANPP output for the Primary serial port.

Packets Period Packet				
Packet ID			181	
Length			2 + (5 x number of packet periods)	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u8	1	**Clear Existing Packet Periods**
3	2	u8	1	Packet ID
4	3	u32	4	**Packet Period**
+				Fields 3-4 repeat for additional packet periods

Table 133: Packets Period Packet

11.5.2.1 Clear Existing Packets

This is a boolean field, when set to one it deletes any existing packet rates. When set to zero existing packet rates remain. Only one packet rate can exist per packet ID, so new packet rates will overwrite existing packet rates for the same packet ID.

11.5.2.2 Packet Period

This indicates the period in units of the packet timer period. The packet rate can be calculated as follows.

Packet Rate = 1000000/(Packet Period x Packet Timer Period) Hz

For example if the packet timer period is set to 1000 (1 ms). Setting packet ID 20 with a packet period of 50 will give the following.

Packet 20 Rate = 1000000/(50 x 1000)

Packet 20 Rate = 20 Hz

11.5.3 Baud Rates Packet

Baud Rates Packet				
Packet ID			182	
Length			17	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u32	4	Primary RS232 and RS422 see **11.5.3.1 Supported Baud Rate** bit #31: 0 = RS232, 1 = RS422
3	5	u32	4	GPIO 1 & 2 **Maximum Baud Rate 250000** see **11.5.3.1 Supported Baud Rate**
4	9	u32	4	Auxiliary RS232 see **11.5.3.1 Supported Baud Rate** bit #31: 0 = RS232, 1 = RS422
5	13		4	Reserved (set to zero)

Table 134: Baud Rates Packet

11.5.3.1 Supported Baud Rate

Note: Not all Advanced Navigation products support minimum and maximum baud rates.

Supported Baud Rates - Bits 0-30
2400
4800
9600
19200
38400
57600
115200
230400
250000
460800
500000
800000
921600
1000000
1250000

Supported Baud Rates - Bits 0-30
2000000
4000000

Table 135: Supported Baud Rates

11.5.4 Installation Alignment Packet

Installation Alignment Packet				
Packet ID			185	
Length			73	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	fp32	4	Alignment DCM[0][0]
3	5	fp32	4	Alignment DCM[0][1]
4	9	fp32	4	Alignment DCM[0][2]
5	13	fp32	4	Alignment DCM[1][0]
6	17	fp32	4	Alignment DCM[1][1]
7	21	fp32	4	Alignment DCM[1][2]
8	25	fp32	4	Alignment DCM[2][0]
9	29	fp32	4	Alignment DCM[2][1]
10	33	fp32	4	Alignment DCM[2][2]
11	37	fp32	4	GNSS antenna offset X (m)
12	41	fp32	4	GNSS antenna offset Y (m)
13	45	fp32	4	GNSS antenna offset Z (m)
14	49	fp32	4	Odometer offset X (m)[1]
15	53	fp32	4	Odometer offset Y (m)[1]
16	57	fp32	4	Odometer offset Z (m)[1]
17	61	fp32	4	External data offset X (m)[2]
18	65	fp32	4	External data offset Y (m)[2]
19	69	fp32	4	External data offset Z (m)[2]
[1]Odometer offset is used for Odometer and DVL input				
[2]External data offset is used for NMEA input, External GNSS and Air Data Unit				

Table 136: Installation Alignment Packet

11.5.4.1 Alignment DCM

The alignment DCM (Direction Cosine Matrix) is used to represent an alignment offset of Boreas from its standard alignment. A DCM is used rather than Euler angles for accuracy reasons. To convert Euler angles to DCM, use the formula below with angles in radians.

DCM[0][0] = cos(heading) * cos(pitch)

DCM[0][1] = sin(heading) * cos(pitch)

DCM[0][2] = -sin(pitch)

DCM[1][0] = -sin(heading) * cos(roll) + cos(heading) * sin(pitch) * sin(roll)

DCM[1][1] = cos(heading) * cos(roll) + sin(heading) * sin(pitch) * sin(roll)

DCM[1][2] = cos(pitch) * sin(roll)

DCM[2][0] = sin(heading) * sin(roll) + cos(heading) * sin(pitch) * cos(roll)

DCM[2][1] = -cos(heading) * sin(roll) + sin(heading) * sin(pitch) * cos(roll)

DCM[2][2] = cos(pitch) * cos(roll)

11.5.5 Filter Options Packet

Filter Options Packet				
Packet ID			186	
Length			17	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u8	1	**11.5.5.1 Vehicle Types**
3	2	u8	1	Internal GNSS enabled (boolean)
4	3	u8	1	Reserved (set to zero)
5	4	u8	1	Atmospheric altitude enabled (boolean)
6	5	u8	1	Velocity heading enabled (boolean)
7	6	u8	1	Reversing detection enabled (boolean)
8	7	u8	1	Motion analysis enabled (boolean)
9	8	u8	1	Reserved (set to zero)
10	9	u8	1	Dual antenna disabled
11	10		7	Reserved (set to zero)

Table 137: Filter Options Packet

11.5.5.1 Vehicle Types

Value	Description
0	Unlimited
1	Bicycle or Motorcycle
2	Car

Value	Description
3	Hovercraft
4	Submarine
5	3D Underwater Vehicle
6	Fixed Wing Plane
7	3D Aircraft
8	Human
9	Boat
10	Large Ship
11	Stationary
12	Stunt Plane
13	Race Car

Table 138: Vehicle Types

11.5.6 GPIO Configuration Packet

GPIO Configuration Packet				
Packet ID			188	
Length			13	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u8	1	GPIO1 function. See **11.5.6.1 GPIO Functions**
3	2	u8	1	GPIO2 function. See **11.5.6.1 GPIO Functions**
4	3	u8	1	Auxiliary RS232 transmit function. See **11.5.6.2 Auxiliary Functions**
5	4	u8	1	Auxiliary RS232 receive function. See **11.5.6.2 Auxiliary Functions**
6	5	u8	1	**11.5.6.3 GPIO Voltage Selection**
7	6		7	Reserved (set to zero)

Table 139: GPIO Configuration Packet

11.5.6.1 GPIO Functions

Value	Description	GPIO Function Type
0	Inactive	GPIO1, GPIO2
1	**1PPS Output**	
2	**GNSS Fix Output**	
3	**Odometer Input**	
4	**Zero Velocity Input**	
5	**Pitot Tube Input**	
6	**NMEA Input**	GPIO2
7	**NMEA Output**	GPIO1
8	**Novatel GNSS Input**	GPIO2
9	**Topcon GNSS Input**	
11	**ANPP Input**	
12	**ANPP Output**	GPIO1
14	**Disable GNSS**	GPIO1, GPIO2
15	**Disable Pressure**	GPIO1, GPIO2
16	**Set Zero Orientation Alignment**	
17	**System State Packet Trigger**	
18	**Raw Sensors Packet Trigger**	
19	**RTCM Differential GNSS Corrections Input**	GPIO2
20	**Trimble GNSS Input**	
21	**u-blox GNSS Input**	
22	**Hemisphere GNSS Input**	
23	**Teledyne DVL Input**	
24	**Tritech USBL Input**	
25	**Linkquest DVL Input**	

Value	Description	GPIO Function Type
26	**Pressure Depth Transducer**	GPIO1, GPIO2
27	**Left Wheel Speed Sensor**	
28	**Right Wheel Speed Sensor**	
29	**1PPS Input**	
30	**Wheel Speed Sensor**	
31	**Wheel Encoder Phase A**	
32	**Wheel Encoder Phase B**	
33	**Event 1 Input**	
34	**Event 2 Input**	
35	**Linkquest USBL Input**	GPIO2
38	**GNSS Receiver Passthrough**	GPIO1, GPIO2
39	**TSS1 Output**	GPIO1
40	**Simrad 1000 Output**	
41	**Simrad 3000 Output**	
42	**Serial Port Passthrough**	GPIO1, GPIO2
43	**Gimbal Encoder Phase A**	
44	**Gimbal Encoder Phase B**	
45	**Odometer Direction, Forward Low**	
46	**Odometer Direction, Forward High**	
51	**Nortek DVL Input**	GPIO2
53	**Reverse Alignment, Forward Low**	GPIO1, GPIO2
54	**Reverse Alignment, Forward High**	
55	**Zero Angular Velocity Input**	

Table 140: GPIO functions

11.5.6.2 Auxiliary Functions

Value	Description	Auxiliary Function Type
0	Inactive	Transmit, Receive
1	**1PPS Output**	Transmit
2	**GNSS Fix Output**	
3	**Odometer Input**	Receive
4	**Zero Velocity Input**	
5	**Pitot Tube Input**	
6	**NMEA Input**	

Value	Description	Auxiliary Function Type
7	**NMEA Output**	Transmit
8	**Novatel GNSS Input**	Receive
9	**Topcon GNSS Input**	
11	**ANPP Input**	
12	**ANPP Output**	Transmit
14	**Disable GNSS**	Receive
15	**Disable Pressure**	
16	**Set Zero Orientation Alignment**	
17	**System State Packet Trigger**	
18	**Raw Sensors Packet Trigger**	
19	**RTCM Differential GNSS Corrections Input**	
20	**Trimble GNSS Input**	
21	**u-blox GNSS Input**	
22	**Hemisphere GNSS Input**	
23	**Teledyne DVL Input**	
24	**Tritech USBL Input**	
25	**Linkquest DVL Input**	
26	**Pressure Depth Transducer**	
27	**Left Wheel Speed Sensor**	
28	**Right Wheel Speed Sensor**	
29	**1PPS Input**	
30	**Wheel Speed Sensor**	
33	**Event 1 Input**	
34	**Event 2 Input**	
35	**Linkquest USBL Input**	
38	**GNSS Receiver Passthrough**	Transmit, Receive
39	**TSS1 Output**	Transmit
40	**Simrad 1000 Output**	
41	**Simrad 3000 Output**	
42	**Serial Port Passthrough**	Transmit, receive

Value	Description	Auxiliary Function Type
45	**Odometer Direction, Forward Low**	Receive
46	**Odometer Direction, Forward High**	
51	**Nortek DVL Input**	
53	**Reverse Alignment, Forward Low**	
54	**Reverse Alignment, Forward High**	
55	**Zero Angular Velocity Input**	

Table 141: Auxiliary Functions

11.5.6.3 GPIO Voltage Selection

Value	Description
0	5V
1	3.3V
2	Power Disabled

Table 142: GPIO Voltage Selection

11.5.7 Odometer Configuration Packet

Odometer Configuration Packet				
Packet ID			192	
Length			8	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u8	1	Automatic pulse measurement active
3	2		2	Reserved (set to zero)
4	4	fp32	4	Pulse length (m)

Table 143: Odometer Configuration Packet

11.5.8 Set Zero Orientation Alignment Packet

Set Zero Orientation Alignment Packet				
Packet ID			193	
Length			5	
Read / Write			Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u32	4	Verification sequence (set to 0x9A4E8055)

Table 144: Set Zero Orientation Alignment Packet

11.5.9 Reference Point Offsets Packet

The reference point offsets packet can be used to adjust the measurement point that all data is referenced to. By default all the values of this packet are zero and the measurement point that all data is referenced to is the centre of the Boreas unit. The primary reference point offset can be used to adjust the measurement point to a different location on the vehicle, in the body co-ordinate frame. The primary reference point offset applies to all data output including NMEA etc as well as heave point 1.

Heave point 2 is reserved for use for the Centre of Gravity (COG) Lever Arm offset to improve coarse heading alignment.

The other heave point offsets do not apply to heave point 1 in the **11.4.36 Heave Packet**.

Reference Point Offsets Packet				
Packet ID			194	
Length			49	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	fp32	4	Heave point 1 offset X (m) / Primary reference point offset X (m)
3	5	fp32	4	Heave point 1 offset Y (m) / Primary reference point offset Y (m)
4	9	fp32	4	Heave point 1 offset Z (m) / Primary reference point offset Z (m)
5	13	fp32	4	Heave point 2 offset X (m) N.B. Used for COG Lever Arm Offset
6	17	fp32	4	Heave point 2 offset Y (m) N.B. Used for COG Lever Arm Offset
7	21	fp32	4	Heave point 2 offset Z (m) N.B. Used for COG Lever Arm Offset
8	25	fp32	4	Heave point 3 offset X (m)
9	29	fp32	4	Heave point 3 offset Y (m)
10	33	fp32	4	Heave point 3 offset Z (m)
11	37	fp32	4	Heave point 4 offset X (m)
12	41	fp32	4	Heave point 4 offset Y (m)
13	45	fp32	4	Heave point 4 offset Z (m)

Table 145: Reference Point Offsets Packet

11.5.10 GPIO Output Configuration Packet

GPIO Output Configuration Packet				
Packet ID			195	
Length			183	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u8	1	Auxiliary port Input Mode. See **11.5.10.1 Port Input Modes**
3	2	u8	1	Auxiliary port Output Mode. See **11.5.10.2 Port Output Modes**
4	3	u8	1	Auxiliary port NMEA fix behaviour. See **11.5.10.3 NMEA Fix Behaviour**
5	4	u8	1	Auxiliary port GPZDA Rates. See **11.5.10.4 Port Output Rates**
6	5	u8	1	Auxiliary port GPGGA Rates. See **11.5.10.4 Port Output Rates**
7	6	u8	1	Auxiliary port GPVTG Rates. See **11.5.10.4 Port Output Rates**
8	7	u8	1	Auxiliary port GPRMC Rates. See **11.5.10.4 Port Output Rates**
9	8	u8	1	Auxiliary port GPHDT Rates. See **11.5.10.4 Port Output Rates**
10	9	u8	1	Auxiliary port GPGLL Rates. See **11.5.10.4 Port Output Rates**
11	10	u8	1	Auxiliary port PASHR Rates. See **11.5.10.4 Port Output Rates**
12	11	u8	1	Auxiliary port TSS1 Rates. See **11.5.10.4 Port Output Rates**
13	12	u8	1	Auxiliary port Simrad Rates. See **11.5.10.4 Port Output Rates**
14	13	u8	1	Auxiliary port GPROT Rates. See **11.5.10.4 Port Output Rates**
15	14	u8	1	Auxiliary port GPHEV Rates. See **11.5.10.4 Port Output Rates**
16	15	u8	1	Auxiliary port GPGSV Rates. See **11.5.10.4 Port Output Rates**
17	16	u8	1	Auxiliary port PFECAtt Rates. See **11.5.10.4 Port Output Rates**
18	17	u8	1	Auxiliary port PFECHve Rates. See **11.5.10.4 Port Out-**

GPIO Output Configuration Packet				
				put Rates
19	18	u8	1	Auxiliary port GPGST Rates. See **11.5.10.4 Port Output Rates**
20	19	u8[8]	8	Reserved (set to zero)
+				Fields 2-20 Repeat 6 more times (a total of 7 copies) for: GPIO port Logging port Data Port #1 Data Port #2 Data Port #3 Data Port #4

Table 146: GPIO Output Configuration Packet

11.5.10.1 Port Input Modes

Value	Description
0	Inactive
6	NMEA0183
11	ANPP
38	GNSS Receiver Passthrough

Table 147: Port Input Modes

11.5.10.2 Port Output Modes

Value	Description
0	Inactive
7	NMEA0183
12	ANPP
38	GNSS Receiver Passthrough
39	TSS1
40	Simrad 1000
41	Simrad 3000

Table 148: Port Output Modes

Note: The Port Input and Output Modes are read only for the auxiliary and GPIO ports. For compatibility with legacy devices, the modes for these two ports are set using the GPIO Configuration Packet.

11.5.10.3 NMEA Fix Behaviour

Value	Description
0	Normal
1	Always indicate 3D fix when the navigation filter is ini-

Value	Description
	tialised

Table 149: NMEA Fix Behaviour

11.5.10.4 Port Output Rates

Value	Bit 3	Bit 2	Bit 1	Bit 0	Description
0	0	0	0	0	Disabled
1	0	0	0	1	0.1 Hz
2	0	0	1	0	0.2 Hz
3	0	0	1	1	0.5 Hz
4	0	1	0	0	1 Hz
5	0	1	0	1	2 Hz
6	0	1	1	0	5 Hz
7	0	1	1	1	10 Hz
8	1	0	0	0	25 Hz
9	1	0	0	1	50 Hz
10	1	0	1	0	8 Hz

Table 150: Port Output Rates

11.5.11 Dual Antenna Configuration Packet

By default the system uses automatic offset with primary front and secondary rear.

When using an automatic offset:

- There are four available configurations, listed in the Automatic Offset Orientations table below.
- Manual offset values will be ignored and should be set to zero.
- The manual offset values will be populated with the automatically calculated offset values.

If your antenna configuration does not match one of the four available automatic offset configurations you must use a manual offset. These values are measured from the secondary antenna to the primary antenna in the body co-ordinate frame.

Dual Antenna Configuration Packet				
Packet ID			196	
Length			17	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u16	2	**Offset type**
3	3	u8	1	**Automatic offset orientation**
4	4	u8	1	Reserved (set to zero)

Dual Antenna Configuration Packet				
5	5	fp32	4	Manual offset X (m)
6	9	fp32	4	Manual offset Y (m)
7	13	fp32	4	Manual offset Z (m)

Table 151: Dual Antenna Configuration Packet

11.5.11.1 Offset Types

Value	Description
0	Manual offset
1	Automatic offset

Table 152: Offset Types

11.5.11.2 Automatic Offset Orientations

Value	Description
0	Primary front and secondary rear
1	Primary rear and secondary front
2	Primary right and secondary left
3	Primary left and secondary right

Table 153: Automatic Offset Orientations

11.5.12 GNSS Configuration Packet

11.5.12.1 Aries GNSS Receiver

Aries GNSS Receiver Configuration Packet				
Packet ID			197	
Length			85	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u64	8	GNSS frequencies. This is a bitfield where each bit describes whether a particular frequency is enabled. For a list of the fields that are currently available, see **11.5.12.3 GNSS Frequency Bitfields**.
3	9		76	Reserved (set to 0)

Table 154: Aries GNSS Receiver Configuration Packet

11.5.12.2 Trimble BD992 GNSS Receiver

Trimble BD992 GNSS Receiver Configuration Packet	
Packet ID	197

Trimble BD992 GNSS Receiver Configuration Packet				
Length			85	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u64	8	GNSS frequencies. This is a bitfield where each bit describes whether a particular frequency is enabled. For a list of the fields that are currently available, see **11.5.12.3 GNSS Frequency Bitfields**.
3	9	fp32	4	PDOP threshold - the Position Dilution of Precision to achieve a fix
4	13	fp32	4	TDOP threshold - The Time dilution of Precision to achieve a fix
5	17	u8	1	Elevation mask (degrees) - Minimum elevation of the satellite that will be used when calculating fix
6	18	u8	1	SNR Mask (dB) - Signal-to-noise (SNR) ratio of a satellite signal to allow it to be used when calculating a fix
7	19	u8	1	SBAS corrections enabled
8	20	u8	1	**11.5.12.4 L Band Modes**
9	21	u32	4	L band frequency (Hz)
10	25	u32	4	L band baud rate
11	29	u32	4	Primary antenna type
12	33	u32	4	Secondary antenna type
13	37	u8	1	**11.5.12.5 L Band Satellite IDs** - this refers to the satellite name
14	38		47	Reserved

Table 155: Trimble BD992 GNSS Receiver Configuration Packet

11.5.12.3 GNSS Frequency Bitfields

Each GNSS frequency is a field that contains 8 bits that indicate whether a particular frequency is enabled for a constellation. These are boolean fields with a zero indicating false and a one indicating true. The table below provides a description of each bit, which is a combination of a constellation name and its frequency.

Bit	Description
0	GPS L1CA
1	GPS L1C
2	GPS L1P
3	GPS L2C
4	GPS L2P

Bit	Description
5	GPS L2M
6	GPS L5
7	GLONASS G1CA
8	GLONASS G1P
9	GLONASS L1OC
10	GLONASS L1SC
11	GLONASS G2CA
12	GLONASS G2P
13	GLONASS L2OC
14	GLONASS L2SC
15	GLONASS L3OC
16	GLONASS L3SC
17	BEIDOU B1
18	BEIDOU B2
19	BEIDOU B3
20	GALILEO E1
20	GALILEO E5A
22	GALILEO E5B
23	GALILEO E5AB
24	GALILEO E6
25	QZSS L1CA
25	QZSS L1SAIF
26	QZSS L1C
27	QZSS L2C
28	QZSS L5
29	QZSS LEX
30	SBAS L1CA

11.5.12.4 L Band Modes

L Band Mode	L Band Mode Name
0	Disabled
2	Omnistar Auto
3	Omnistar HP
4	Omnistar XP

L Band Mode	L Band Mode Name
5	Omnistar VBS
8	Omnistar G2
9	Omnistar HP+G2
10	Omnistar HP+XP
11	Trimble RTX
13	Omnistar L1 Only
14	Omnistar G4 Only
15	Omnistar G2+ Only
16	Omnistar G4+ Only

Table 156: L Band Modes

11.5.12.5 L Band Satellite IDs

L Band Satellite ID	Satellite Name
110	Auto
100	Custom
2	IOSAT
8	AORET
15	RTXMX
16	AMSAT
17	WASAT
18	OCSAT
19	RTXAL
20	RTXIO
22	CONNA
23	RTXNA
27	RTXPA
29	RTXEA
30	EMSAT

Table 157: L Band Satellite IDs

11.5.13 User Data Packet

This packet is for storage of users data. The data itself is not used by Boreas.

User Data Packet	
Packet ID	198
Length	64

User Data Packet

Read / Write				Read / Write
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0		64	User Data

Table 158: User Data Packet

11.5.14 GPIO Input Configuration Packet

GPIO Input Configuration Packet

Packet ID				199
Length				65
Read / Write				Read / Write
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	fp32	4	Gimbal radians per encoder tick
3	5		60	Reserved (set to zero)

Table 159: GPIO Input Configuration Packet

11.5.15 IP Dataports Configuration Packet

IP Dataports Configuration Packet

Packet ID				202
Length				30
Read / Write				Read / Write
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u16	2	Reserved
2	2	u32	4	TCP/UDP IP Address
3	6	u16	2	TCP/UDP Port
4	8	u8	1	**11.5.15.1 IP Dataport Mode**
+				Fields 2-4 Repeat 3 times (a total of 4 copies) for each of the 4 data ports

Table 160: IP Dataports Configuration Packet

11.5.15.1 IP Dataport Mode

Value	Description
0	MODE_NONE
1	Reserved
2	MODE_TCP_SERVER

Value	Description
3	MODE_TCP_CLIENT
4	MODE_UDP

Table 161: IP Dataport Mode

11.5.16 CAN Configuration Packet

CAN Configuration Packet				
Packet ID			203	
Length			11	
Read / Write			Read / Write	
Field #	**Bytes Offset**	**Data Type**	**Size**	**Description**
1	0	u8	1	Permanent
2	1	u8	1	Enabled
3	2	u32	4	Baud Rate
4	6	u8	1	**CAN Protocol**
5	7	u8	4	Reserved (set to zero)

Table 162: CAN Configuration Packet

11.5.16.1 CAN Protocol

Value	Description
0	CANopen

Table 163: CAN Protocol

12 Reference Information

This chapter is a learning reference that briefly covers knowledge essential to understanding Boreas and INS generally. It explains the following concepts in simple terms so that people unfamiliar with the technology may understand it:

- **12.1 Technology Overview**, including Global Navigation Satellite System (GNSS) , Inertial Navigation System (INS) and Attitude and Heading Reference System (AHRS)
- **12.2 The Sensor Co-ordinate Frame**
- **12.3 The Body Co-ordinate Frame**
- **12.4 Roll, Pitch and Heading**
- **12.5 Geodetic Co-ordinate System**
- **12.6 NED Co-ordinate Frame**
- **12.7 ECEF Co-ordinate Frame**

12.1 Technology Overview

12.1.1 GNSS

GNSS stands for Global Navigation Satellite System. A GNSS consists of a set of satellites in medium Earth orbit that broadcast navigation signals with a common operator. These navigation signals can be picked up by a GNSS receiver on the earth to estimate that receiver's position and velocity. For a long time the only operational GNSS was the United States GPS. However, the Russian GLONASS, the Chinese BeiDou GNSS, and the European Union's Galileo GNSS are fully operational.

GNSS provides a fairly accurate absolute position (down to 1.2 metres without assistance and as low as 8 mm with) and velocity (as low as 0.007 metres/second). The main drawback of GNSS is that the receiver must have a clear signal from at least 4 satellites to function. GNSS signals are very weak and struggle to penetrate through buildings, trees and other objects obstructing an uninterrupted view of the sky. GNSS can also occasionally drop out due to disturbances in the upper atmosphere, or the presence of jammers.

12.1.2 AHRS

AHRS stands for Attitude and Heading Reference System. An AHRS uses accelerometers and gyroscopes combined in a mathematical algorithm to provide orientation. Orientation consists of the three body angles roll, pitch and heading.

12.1.3 INS

INS stands for Inertial Navigation System. An inertial navigation system can provide position and velocity similar to GNSS but with some major differences. The principle of inertial navigation is the measurement of acceleration, which is then integrated into velocity. The velocity is then further integrated to estimate position. Due to noise in the measurement and the compounding of that noise through the integration steps, inertial navigation has an error that increases exponentially over time. Inertial navigation systems have a very low relative error over short time periods but over long time periods the error can increase enormously.

12.1.4 GNSS/INS

By combining GNSS and INS together in a mathematical algorithm, it is possible to take advantage of the benefits of the long-term precision of GNSS and the short-term accuracy of inertial sensors. This provides an

enhanced position and velocity solution that can withstand GNSS drop outs.

12.2 The Sensor Co-ordinate Frame

Inertial sensors have 3 different axes: X, Y and Z and these determine the references around which angles and accelerations are measured. It is very important to align these axes correctly in installation, otherwise the system won't work correctly.

These axes are marked on the top of the device as shown in **Figure 109: Boreas Axes** below, with the X axis pointing in the direction of the connectors, the Z axis pointing down through the base of the unit and the Y axis pointing off to the right.
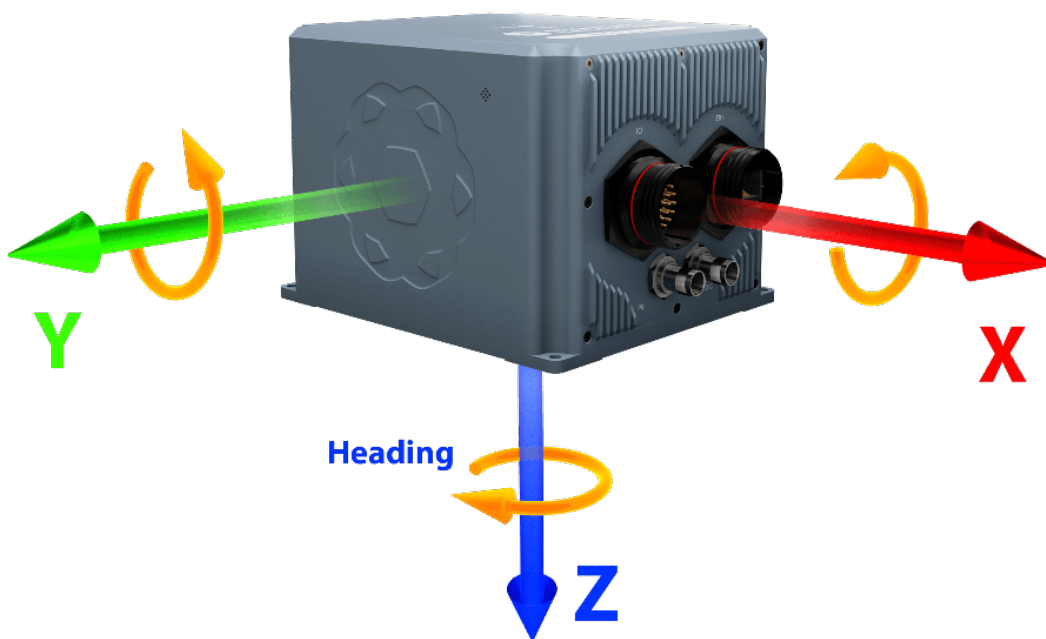
Figure 109: Boreas Axes

12.2.1 Right Hand Rule

When installed in an application the X axis should be aligned such that it points forwards and the Z axis aligned so that it points down when the system is level. A good way to remember the sensor axes is the right hand rule, which is visualised in **Figure 110: First Right-hand Rule**.
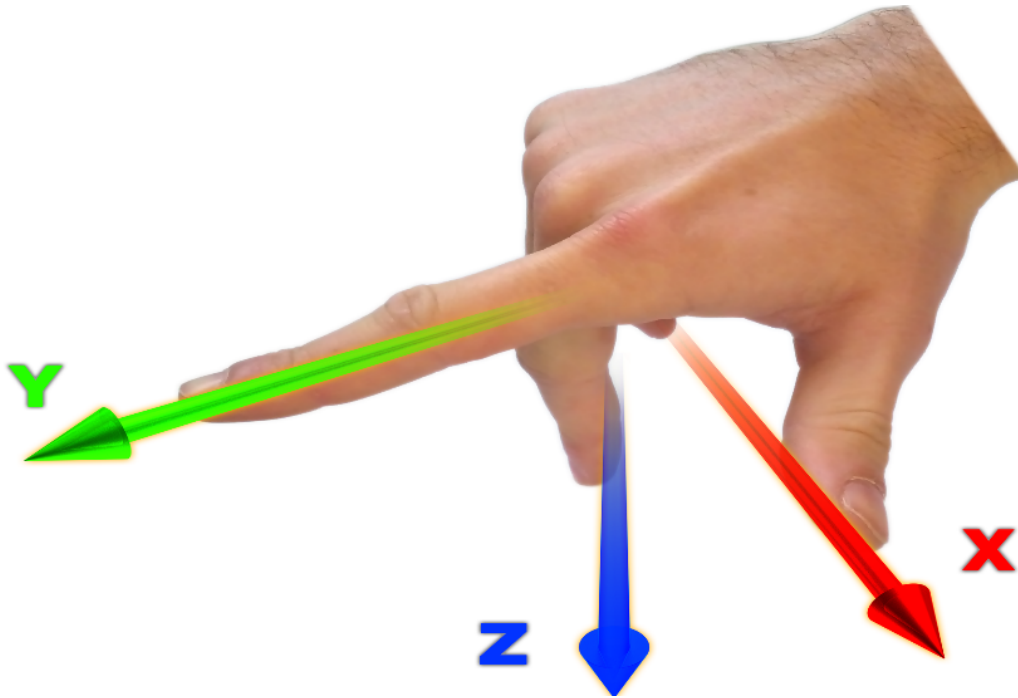
Figure 110: First Right-hand Rule

You take your right hand and extend your thumb, index and middle. Your thumb then denotes the positive X axis, your index denotes the positive Y axis and your middle denotes the positive Z axis.

12.3 The Body Co-ordinate Frame

Also known as the vehicle co-ordinate (reference) frame, this can be described most easily using a car (the body or vehicle) as an example. The forward direction of travel for a car is the positive X axis, out to the right of the car is the positive Y axis, and down is the positive Z axis. The distinction between the sensor co-ordinate frame and the body co-ordinate frame becomes important when the INS device is not mounted with its axes aligned to the vehicle axes, for example when the INS is mounted with a 90 degree heading rotation. Offset measurements, which are described later in this document, will always be in the body co-ordinate frame to remove any INS alignment variations. Generally any data output by the INS using the X, Y and Z axes will be using the body co-ordinate frame.

12.4 Roll, Pitch and Heading

Orientation can be described by the three angles roll, pitch and heading: these are known as the Euler angles. The rotation axes of roll, pitch and heading are shown visually in **Figure 109: Boreas Axes**. The arrow indicates the positive rotation direction.

Roll is the angle around the X axis and is zero when the unit is level. Pitch is the angle around the Y axis and is zero when the unit is level. Heading is the angle around the Z axis and is zero when the positive X axis is pointing to true north.

12.4.1 Second Right Hand Rule

The two right hand rules are often the best way to memorise the sensor axes and directions of positive rotation. The first right hand rule gives the positive axis directions and is described in **12.2 The Sensor Co-ordinate Frame**. The second right hand rule shown in the figure below provides the direction of positive rotation. To use

it, point your thumb in the positive direction of that axis, then the direction that your fingers curl over shows the positive rotation on that axis.
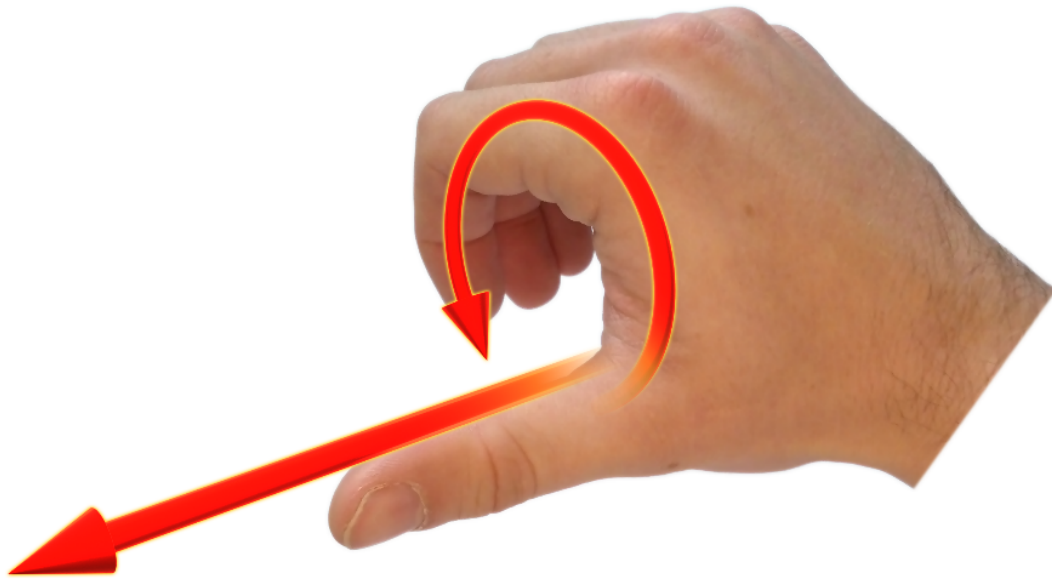

Figure 111: Second right Hand Rule

12.4.2 Rotation Order

When multiple axes are rotated, to imagine the final orientation the three rotations must be performed in the order heading first, then pitch and then roll. To deduce the final orientation the unit should first be considered level with the X axis pointing north and the Z axis pointing down. Heading is applied first, then pitch is applied and finally roll is applied to give the final orientation. This can be hard for some people to grasp at first and is often best learned experimentally by rotating Boreas with your hand whilst watching the orientation plot in real time on the computer.

12.5 Geodetic Co-ordinate System

The geodetic co-ordinate system is the most popular way of describing an absolute position on the Earth. It is made up of two angles, latitude and longitude, combined with a height relative to an ellipsoid.

12.5.1 Latitude and Longitude

Latitude is the angle that specifies the north to south position of a point on the Earth's surface, reported as ± 90°. Longitude is the angle that specifies the east to west position of a point on the Earth's surface, reported as ± 180°. The line of zero latitude is the equator, and the line of zero longitude is the prime meridian. See **Figure 112: Latitude and longitude represented visually to describe a position on an ellipsoid**.
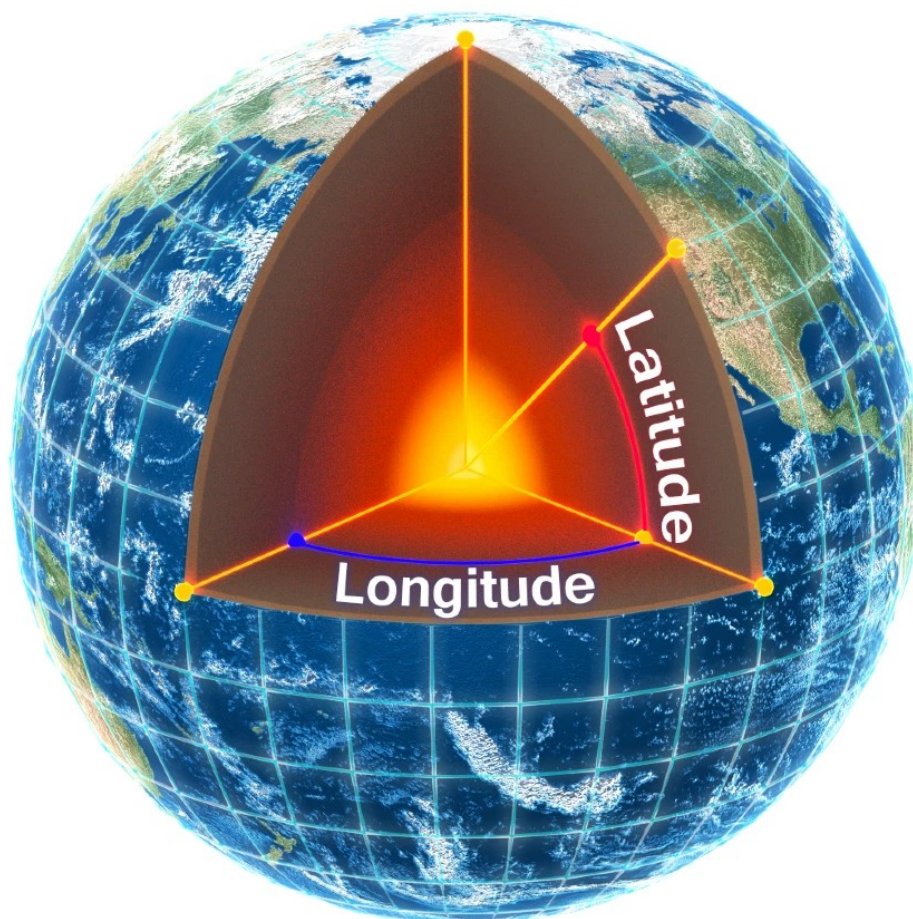

Figure 112: Latitude and longitude represented visually to describe a position on an ellipsoid

The figure below shows latitude and longitude on a map of the world, represented with a standard Mercator projection.
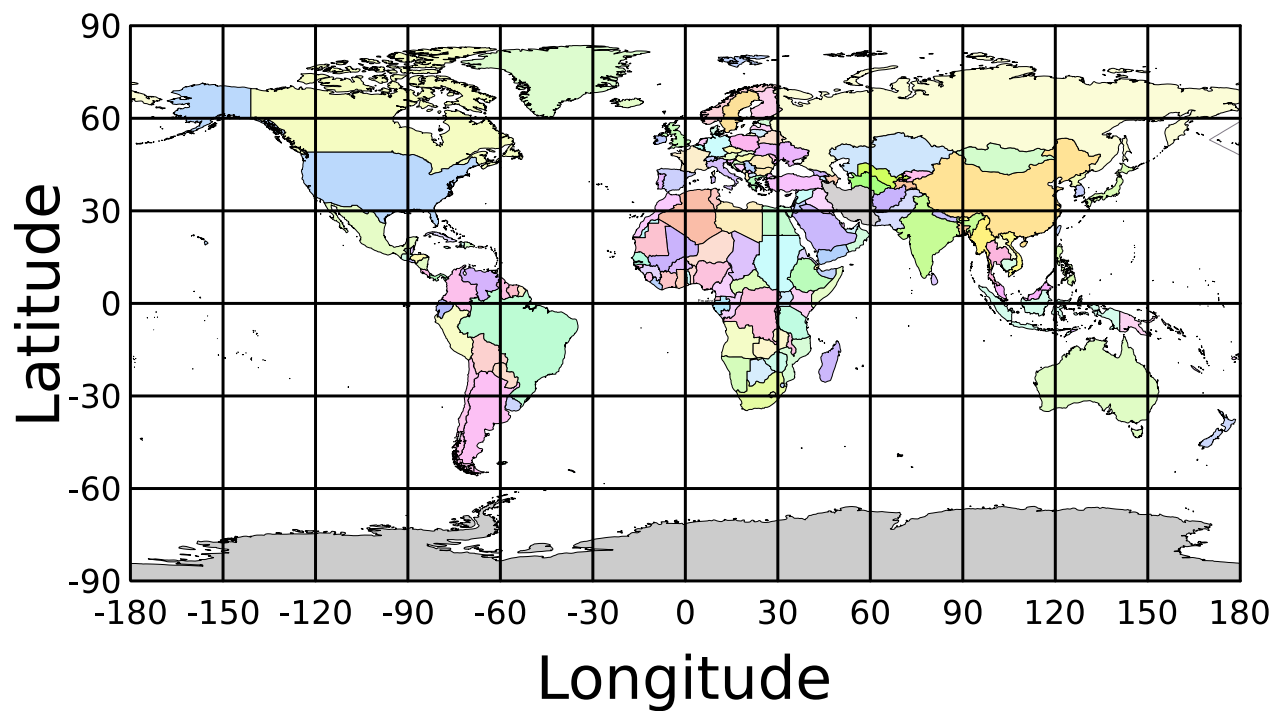

Figure 113: World map showing latitudes and longitudes

Latitude and longitude give the 2D point on the surface of the Earth. These are combined with height to give the 3D position on the Earth.

12.5.2 Height

Any height data output by Advanced Navigation devices is the height referenced the WGS84 reference ellipsoid. The WGS84 reference ellipsoid is a smooth mathematical model that approximates the form of the surface of the earth. The ellipsoid height (as used by GNSS) is not referenced to mean sea level; the height from the EGM96 geoid (orthometric height) approximates the height above mean sea level (MSL).

See **Figure 114: Orthometric, ellipsoid and geoid height diagram** below for a visual representation of geoid height, ellipsoid height and orthometric height (height above mean sea level).

> **Note**:
> Ellipsoid height refers to the height of a point of interest referenced to the WGS84 reference ellipsoid.
> Geoid height refers to the height of the EGM96 geoid referenced to the WGS84 reference ellipsoid at a point of interest.
> Orthometric height is the height at a point of interest referenced to the EGM96 geoid.
>
> All heights can be either positive or negative dependant upon direction from the reference surface.
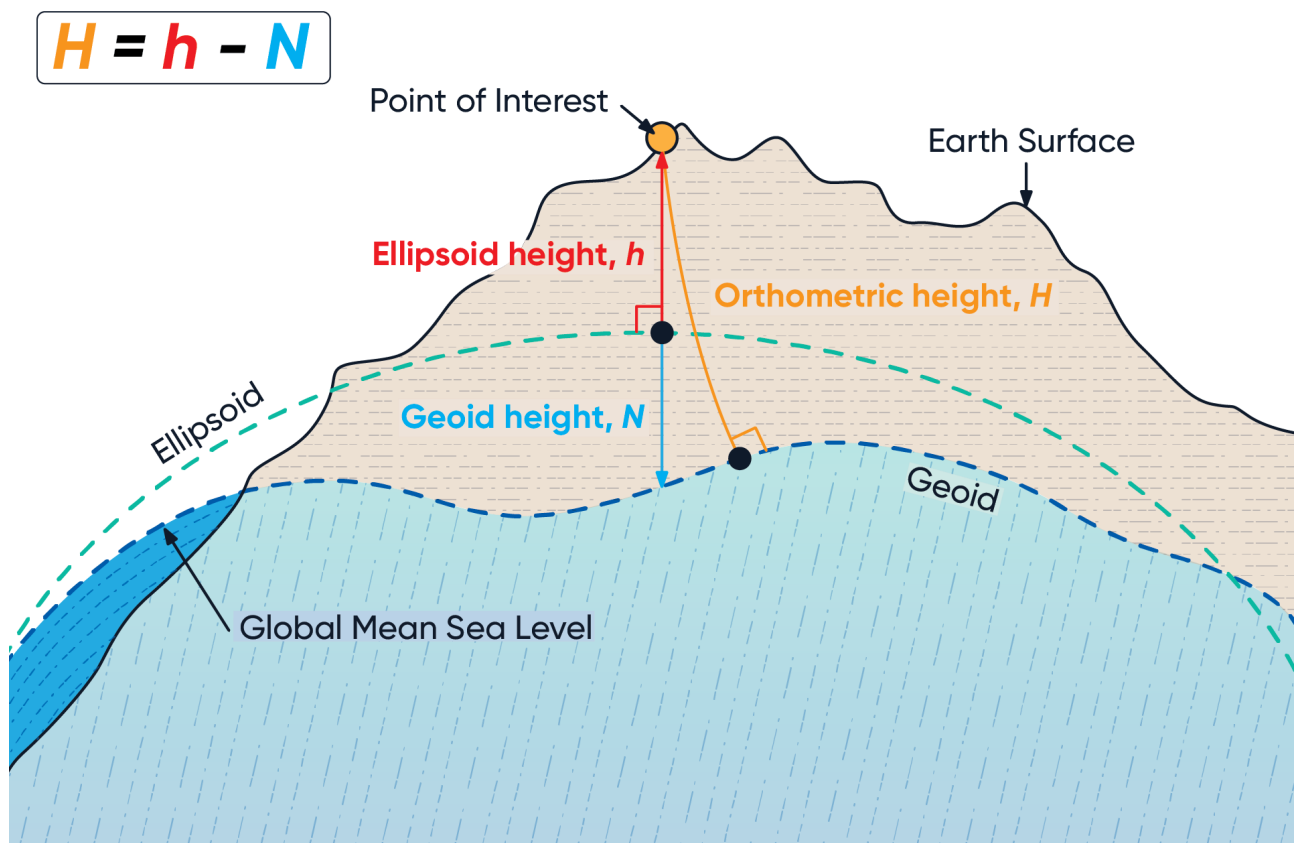

Figure 114: Orthometric, ellipsoid and geoid height diagram

The value required to convert the WGS84 ellipsoid height to orthometric height can be found in the geoid height packet, see **11.4.33 Geoid Height Packet**.

12.6 NED Co-ordinate Frame

The NED (North East Down) co-ordinate frame is used to express velocities and relative positions. The origin of the co-ordinate frame is the current position. From that origin, the north axis points true north and parallel to the line of latitude at that point. The east axis points perpendicular to the north axis and parallel to the line of longitude at that point. The down axis points directly down towards the centre of the Earth. See the figure below for a graphical representation of the NED co-ordinate frame at a position on the Earth.
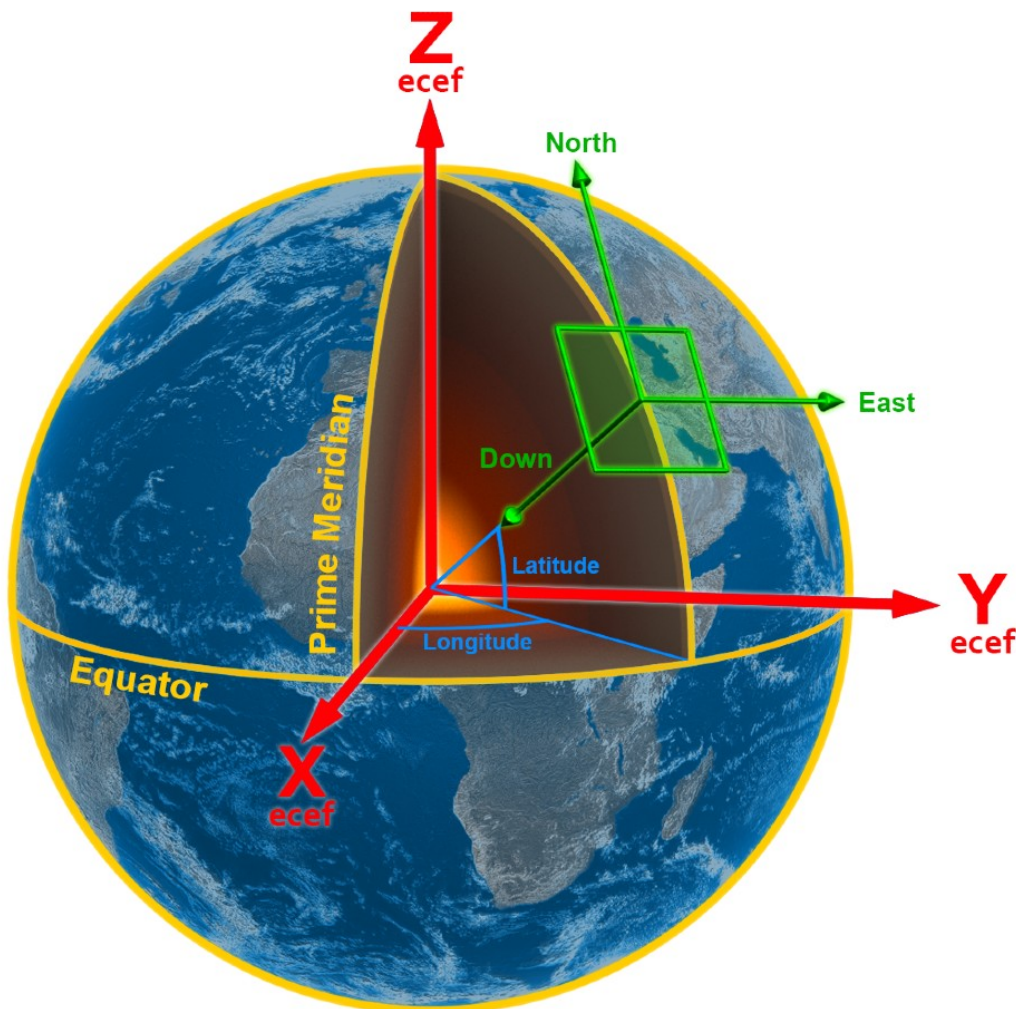

Figure 115: Graphic Showing Geodetic, NED and ECEF Co-ordinates

12.7 ECEF Co-ordinate Frame

The ECEF (Earth-centred earth-fixed) co-ordinate frame is a Cartesian co-ordinate frame used to represent absolute positions on the Earth. Its origin is at the centre of the Earth. ECEF is an alternative to the geodetic co-ordinate frame. It is represented by the three axes X, Y and Z which are presented graphically in **Figure 115: Graphic Showing Geodetic, NED and ECEF Co-ordinates**. ECEF positions can be retrieved from Advanced Navigation products, however the geodetic system is used as the default.