Spatial FOG Reference Manual

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1 Revision History

Version	Date	Changes
2.9	14/11/2023	Updated firmware changelog, section 2 Updated software changelog, section 11.1 Updated part numbers, section 7 Updated Disclaimer
2.8	17/02/2023	Updated firmware changelog, section 2 Updated hardware changelog, section 3 Updated software changelog, section 11.1 Updated software installation information to include Java 11 requirement, section 11.3 Added instructions to run Manager on MacOS, section 11.3 Updated GPIO Output Configuration Packet, section 13.10.10
2.7	04/11/2022	Updated software changelog, section 11.1 Corrected incorrect shock limit specification, section 8.6 Added Raw DVL Data packet, section 13.9.46 Updated External Time Packet to show it is Read only, section 13.7 Added note that Spatial FOG Manager only works on systems with x64 architecture, sections 6.2 and 9.1
2.6	08/03/2022	Added Device ID table, section 13.8.4.1 Updated Log Converter Tool image and description, section 11.9.2 Added logging command line information, section 11.6 Clarified geoid, ellipsoid and orthometric heights, section 5.8
2.5	18/02/2022	Updated accessories section 7.4 Updated part number notes section 7 Added additional receiver models section 13.9.45 Updated firmware changelog, section 2 Updated Spatial FOG Manager changelog, section 11.1 Removed references to dual antenna heading

Version	Date	Changes
2.4	04/06/2019	Updated firmware changelog, section 2 Updated external body velocity packet size and definition 13.9.28 Added wheel speed sensor specifications, section 12.4.30 Added note about external data packet acknowledgement, section 13.4 Clarified geoid height packet description, section 13.9.35 Updated description of quaternions, section 13.9.21 and 13.9.8 Corrected units for velocity in Packet 29, section 13.9.10 Added 1PPS voltage levels, section 12.4.1 Clarified height referenced to mean sea level, section 13.9.35 Added the size of the DC power socket to Illustration 15 Updated advice on heat dissipation, section 9.2 Updated dynamic pin functions table, section 12.4 Updated GPIO configuration packet, section 13.10.6 Added pressure depth transducer deprecated input function 12.4.17 Added Teledyne DVL input function 12.4.22 Added Tritech USBL input function 12.4.23 Added Linkquest DVL input function 12.4.24 Added Linkquest USBL input functionality 12.4.25 Removed external pitot pressure packet, section 13.9.37 Added reverse alignment input functions 12.4.44 Added zero angular velocity input function 12.4.46 Added moving base corrections output function 12.4.47 Clarified port baud rates in sections 8.5 , 12.1 , 12.3 and 13.10.3 Updated packet summary 13.7
2.3	03/05/2018	Updated firmware changelog, section 2 Updated hardware changelog, section 3 Updated navigation specifications, section 8.2 Updated RTK operation, section 10.11 Added raw satellite data, section 10.12 Added post processing, section 10.13 Updated Spatial FOG Manager tools, section 11.9 Added Nortek binary format, section 12.4.26 Updated GPIO 2 receive functions, section 13.10.6.2 Updated auxiliary RS232 receive functions, section 13.10.6.4 Updated GPIO output configuration, section 13.10.10
2.2	27/04/2016	Updated firmware changelog, section 2 Updated hardware changelog, section 3 Updated images in foundation knowledge, section 5 Updated sensor specifications with more detail, section 8.3 Added antenna offset diagrams, section 9.5 Updated Spatial FOG Manager changelog, section 11.1
2.1	02/04/2015	Updated firmware changelog, section 2 Added part numbers and ordering options, section 7 Updated serial number, section 8.11 Updated Spatial FOG Manager changelog, section 11.1

Version	Date	Changes
		Added gimbal encoder phase a function, section 12.4.40 Added gimbal encoder phase b function, section 12.4.41 Added odometer direction forward low, section 12.4.42 Added odometer direction forward high, section 12.4.43 Updated reset packet with cold start option, section 13.8.6 Added gimbal state packet, section 13.9.48 Added automotive packet, section 13.9.49 Heave offsets packet changed name to reference point offsets packet, format remains the same, section 13.10.9 Added user data packet, section 13.10.11 Added GPIO input configuration packet, section 13.10.12
2.0	10/10/2014	Updated firmware changelog, section 2 Added hardware changelog, section 3 Updated all images through foundation knowledge, section 5 Updated mechanical drawings, section 8.1 Updated GNSS specifications, section 8.4 Updated hardware specifications, section 8.6 Updated connector pin-out, section 8.9 Updated Spatial FOG evaluation cable, section 8.10 Added serial number information, section 8.11 Added installation checklist, section 9.1 Updated power supply, section 9.4 Updated GNSS antennas, section 9.5 Added GNSS antenna cables, section 9.6 Updated OBDII Odometer photo, section 9.8.2 Updated initialisation, section 10.1 Updated north seeking gyrocompassing, section 10.4.1 Updated dual antenna heading Updated Spatial FOG Manager changelog, section 11.1 Updated linux troubleshooting, section 11.4.3 Added communications dialogue, section 11.7.8 Added GNSS receiver dialogue, section 11.7.9 Added heave dialogue, section 11.7.10 Added north seeking status dialogue, section 11.7.11 Updated all configuration screenshots, section 11.8 NMEA Output is now GPIO Output, section 11.8.10 Added serial port pass through function, section 12.4.38 Added serial port pass through packet, section 13.8.7 Changed Raw GNSS packet, section 13.9.10.1 Name of wind estimation packet changed to wind packet and it is also now read/write, section 13.9.38 Added external odometer packet, section 13.9.43 Added external air data packet, section 13.9.44 Added GNSS receiver information packet, section 13.9.45 Added north seeking initialisation status packet, section 13.9.47 Added new stunt plane vehicle profile, section 13.10.5.1 NMEA configuration packet has changed to GPIO output configuration packet, section 13.10.10

Version	Date	Changes
		Corrected error with dual antenna packet
1.4	10/12/2013	Added firmware changelog, section 2 Corrected error in connector pin-out, section 8.9
1.3	15/10/2013	Integrated Spatial FOG Manager manual, section 11 Added TSS1 output, section 12.4.35 Added Simrad 1000 output, section 12.4.36 Added Simrad 3000 output, section 12.4.37 Updated vehicle types, section 13.10.5.1 Updated NMEA configuration packet
1.2	30/07/2013	Corrected error in mechanical drawings, section 8.1
1.1	29/07/2013	Added evaluation kit information, section 6 Updated evaluation cable harness, section 8.10 Updated odometer installation, section 9.8 Updated heading source, section 10.4 Updated north seeking heading, section 10.4.1 Updated magnetics, section 10.5 Updated GPIO pins voltage levels, section 12.3.1 Added event 1 input, section 12.4.33 Added event 2 input, section 12.4.34
1.0	14/05/2013	Updated photo Updated mechanical drawings, section 8.1 Updated electrical specifications, section 8.7 Updated connector pinout, section 8.9 Updated electrical connection example Updated evaluation cable harness, section 8.10 Updated mounting plate drawing, section 9.3 Added reversing detection, section 10.9 Added motion analysis, section 10.10 Added heave information, section 10.15 Updated odometer input, section 12.4.3 Updated NMEA input, section 12.4.6 Updated NMEA output, section 12.4.7 Added 1PPS input, section 12.4.29 Added wheel speed sensor, section 12.4.30 Added wheel encoder phase a, section 12.4.31 Added wheel encoder phase b, section 12.4.32 Updated detailed satellites packet, section 13.9.12 Added RTCM corrections packet, section 13.9.36 Added external pitot pressure packet, section 13.9.37 Added wind estimation packet, section 13.9.38 Added heave packet, section 13.9.39 Added post processing packet, section 13.9.40 Added raw satellite data packet, section 13.9.41 Added raw satellite ephemeris packet, section 13.9.42 Updated filter options packet, section 13.10.5 Updated GPIO configuration packet, section 13.10.6

Version	Date	Changes
		Added COM2 and COM3 transmit functions Added COM2 and COM3 receive functions Added heave offset packet, section 13.10.9 Added NMEA output configuration packet
0.6	14/01/2013	Added RTK GNSS foundation knowledge, section 5.5 Completed north seeking gyrocompass, section 10.4.1 Added RTK GNSS operation Added GPIO pins voltage level, section 12.3.1 Added auxiliary RS232 COM2 multiplexer, section 12.3.2
0.5	09/01/2013	Draft release. Please email support@advancednavigation.com.au if you notice any mistakes or anything that is unclear.

Table 1: Revision history

2 Firmware Changelog

Version	Date	Changes
2.81	19/06/2023	Fix temperature reporting issue with HW v2.5 IMU
2.8	14/12/2022	Added support for hardware v2.5. **Minimum FW version required for v2.5 hardware** Fixed Time Filter initialised when receiving 1PPS and Raw GNSS packet in the GPIO or Aux port Updated DVL input to use Odometer Offset
2.7	23/12/2019	Fix to the GNSS receiver firmware update through Spatial FOG Manager
2.6	31/05/2019	Fixed regression with integrity monitoring introduced in version 2.5.
2.5	07/05/2019	Improvements to INS performance in urban canyons Improvements to odometer aided navigation Added support for u-blox Z9P protocol changes World magnetic model updated to WMM2015v2 Added zero angular velocity GPIO input Improvements to water height estimation algorithm Online odometer scaling now adjusts for up to 5% scaling error
2.4	18/04/2018	Addition of extra BeiDou and Galileo frequencies to raw satellite data output. Hemisphere binary input now supports Bin1 and GPHDT messages. Hot start performance improvements Fix for SBAS and QZSS satellite numbering Added Nortek DVL support Added support for new NMEA messages PFEC,Gpatt, PFEC,Gphve, PSIMSSB and GPVHW. Significantly improved integrity monitoring algorithms allow the system to more effectively filter out bad data from GNSS receivers, odometers and external sources. NMEA PASHR message updated to include standard deviation. Improved motion analysis (ZUPT). IMU1750 temperature reporting changed to 2 decimal places.
2.31	01/07/2016	Bug fix for time taking too long to initialise when using the system with an external Trimble receiver
2.2	05/04/2016	Performance improvements Added support for NMEA messages GPROT and GPHEV Added support for raw GNSS packet input Bug fix for NMEA mode character indicating incorrectly Bug fix for raw satellite data packet update rate not saving correctly
2.1	02/04/2015	Enhanced odometer hot start dead reckoning performance Bug fix with serial port passthrough incorrect port ID

Version	Date	Changes
		New tightly coupled heave filter operating at 1000Hz Improved hot start performance and functionality New algorithm for use inside gimbals (requires encoder) More robust time acceptance from external sources NMEA time is now perfectly aligned to the millisecond Support for offsetting reference position of output data Improved handling of leap second change during operation Virtual odometer distance filter added Slip filter added Bug fix for differential corrections being sent to GNSS receiver before initialised causing issues Bug fix for temporary accelerometer/gyroscope failure being indicated by system after flash writes Updated world magnetic model to 2015 version Improved reversing detection filter Added gimbal state and configuration packets Added automotive packet
2.0	10/10/2014	Support added for new hardware version 2.1 North seeking algorithm overhauled, now much more robust against disturbances and interference and will not allow an initialisation with a poor north seeking result Significant filter performance improvements under high dynamics Improved filter performance under dead reckoning Improved performance in urban canyon conditions where a GNSS fix is rarely available Improvements to car and fixed wing plane vehicle profiles Improvements to delay compensation filter Fixed bug that could cause temporary GNSS failure after long periods Raw GNSS packet updated to new format GPIO output configuration packet updated Support for external odometer packet added Support for external air data packet added Support for north seeking initialisation status packet Wind estimation filter improvements Added stunt plane vehicle profile Added support for serial port passthrough Support for GNSS receiver information packet added GPIO data output now up to 50Hz
1.1	15/12/2013	Post-processing improvements
1.0	09/01/2013	Initial release

Table 2: Firmware changelog

3 Hardware Changelog

Version	Date	Changes
2.5	07/03/2022	Updated IMU to Prism Updated magnetometer
2.4	01/06/2016	Slightly reduced power consumption and heat generation Minor internal improvements
2.2	03/08/2015	Internal solid state hot start battery changed resulting in longer hot start capability Other minor internal improvements
2.1	09/05/2014	Hardware has changed from two enclosures to a single integrated enclosure Dimensions and weight changed Connector changed GNSS receiver changed from Trimble BD920 to Trimble BD930 Support for GPS L5 signal and BeiDou B1/B2 Reduced power consumption Reduced heat generation Same electrical connections and mounting footprint as previous hardware generations
1.5	17/10/2013	Minor internal improvements No noticeable changes for customers
1.0	10/08/2013	Initial release

Table 3: Hardware changelog

4 Introduction

Spatial FOG is a ruggedised GPS aided inertial navigation system and AHRS that provides accurate position, velocity, acceleration and orientation under the most demanding conditions. It combines ultra high accuracy fibre optic gyroscopes, accelerometers, magnetometers and a pressure sensor with an RTK GNSS receiver. These are coupled in a sophisticated fusion algorithm to deliver accurate and reliable navigation and orientation.

Spatial FOG can provide amazing results but it does need to be set up properly and operated with an awareness of its limitations. Please read through this manual carefully to ensure success within your application.

The Spatial FOG Manager software is downloadable from the software section. It allows Spatial FOG to be easily configured and tested. It is referenced throughout this manual.

Note: Spatial FOG Manager is only available for systems with x64 and ARM architectures.

If you have any questions please contact support@advancednavigation.com.au.

5 Foundation Knowledge

This chapter is a learning reference that briefly covers knowledge essential to understanding Spatial FOG and the following chapters. It explains the concepts in simple terms so that people unfamiliar with the technology may understand it.

5.1 GNSS

GNSS stands for global navigation satellite system. A GNSS consists of a number of satellites in space that broadcast navigation signals. These navigation signals can be picked up by a GNSS receiver on the earth to determine that receiver's position and velocity. For a long time the only operational GNSS was the United States GPS. However the Russian GLONASS is now fully operational with similar performance to GPS. The Chinese BeiDou is in the process of becoming operational and the European Union's GALILEO should be operational within ten years.

GNSS is excellent for navigational purposes and provides fairly accurate position (2.5 metres) and velocity (0.03 metres/second). The main drawback of GNSS is that the receiver must have a clear signal from at least 4 satellites to function. GNSS satellite signals are very weak and struggle to penetrate through buildings and other objects obstructing view of the sky. GNSS can also occasionally drop out due to disturbances in the upper atmosphere.

5.2 INS

INS stands for inertial navigation system. An inertial navigation system can provide position and velocity similar to GNSS but with some big differences. The principle of inertial navigation is the measurement of acceleration. This acceleration is then integrated into velocity. The velocity is then integrated into position. Due to noise in the measurement and the compounding of that noise through the integration, 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 dramatically.

5.3 GNSS/INS

By combining GNSS and INS together in a mathematical algorithm, it is possible to take advantage of the benefits of GNSS long-term accuracy and INS short-term accuracy. This provides an overall enhanced position and velocity solution that can withstand short GNSS drop outs.

5.4 AHRS

AHRS stands for attitude and heading reference system. An AHRS uses accelerometers, gyroscopes and magnetometers combined in a mathematical algorithm to provide orientation. Orientation consists of the three body angles roll, pitch and heading.

5.5 RTK GNSS

RTK stands for real time kinematic. RTK is a technology used to significantly enhance the accuracy of GNSS. With standard GNSS the accuracy achievable is approximately 2.5 metres, with RTK GNSS the accuracy achievable is 0.01 metres. RTK works by estimating the phase of the carrier wave of the GNSS signal. By using the phase of the carrier wave, rather than the data content, RTK is able to measure the signal 1000 times more precisely.

RTK GNSS requires continuous correction data from a base station to function. These corrections are typically received either over a radio modem or through a cellular network.

5.6 The Sensor Co-ordinate Frame

Inertial sensors have 3 different axes: X, Y and Z and these determine the directions around which angles and accelerations are measured. It is very important to align the axes correctly in installation otherwise the system won't work correctly. These axes are marked on the top of the device as shown in Illustration 1 below with the X axis pointing in the direction of the connector, the Z axis pointing down through the base of the unit and the Y axis pointing out of the starboard side.

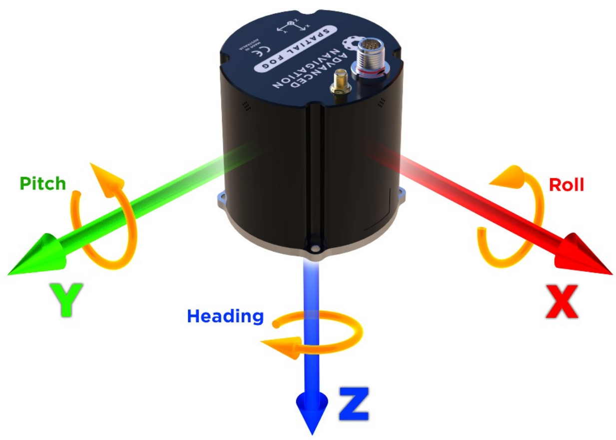


Illustration 1: Spatial FOG axes

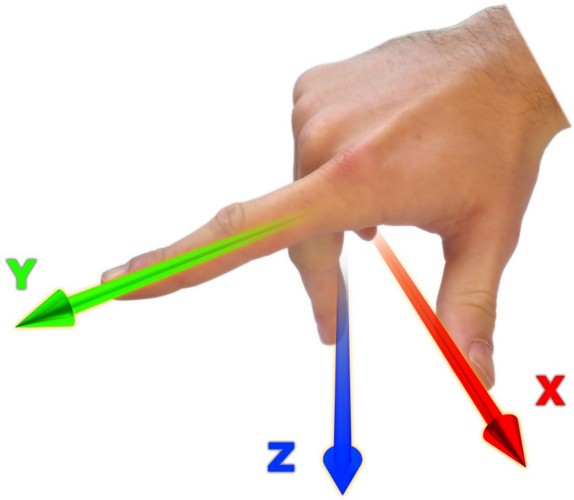


Illustration 2: First right hand rule

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 level. A good way to remember the sensor axes is the right hand rule, which is visualised in Illustration 2. You take your right hand and extend your thumb, index and middle. Your thumb then denotes the X axis, your index denotes the Y axis and your middle denotes the Z axis.

5.7 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 Illustration 1. 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.

5.7.1 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 section 5.6. The second right hand rule shown in Illustration 3 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 is the positive rotation on that axis.

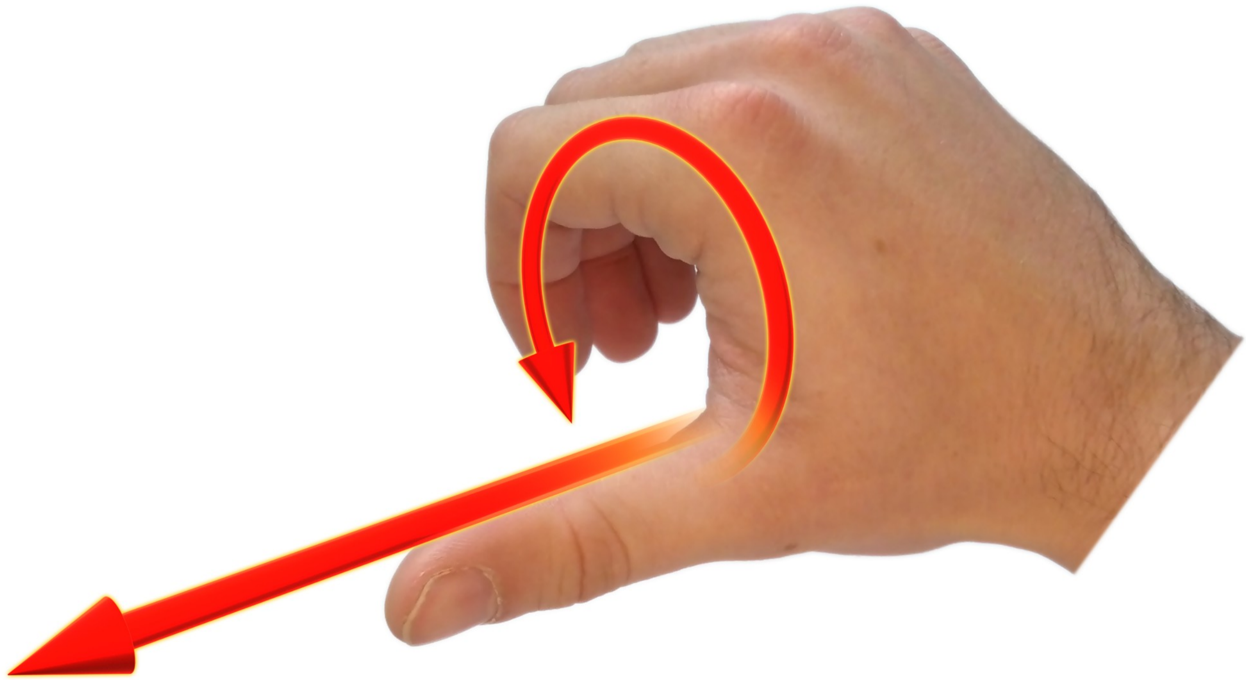


Illustration 3: Second right hand rule

5.7.2 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 Spatial FOG with your hand whilst watching the orientation plot in real time on the computer.

5.8 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 the angles latitude and longitude combined with a height relative to the ellipsoid.

5.8.1 Longitude and Latitude

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. Illustration 4 shows how latitude and longitude angles are used to describe a position on the surface of the Earth.

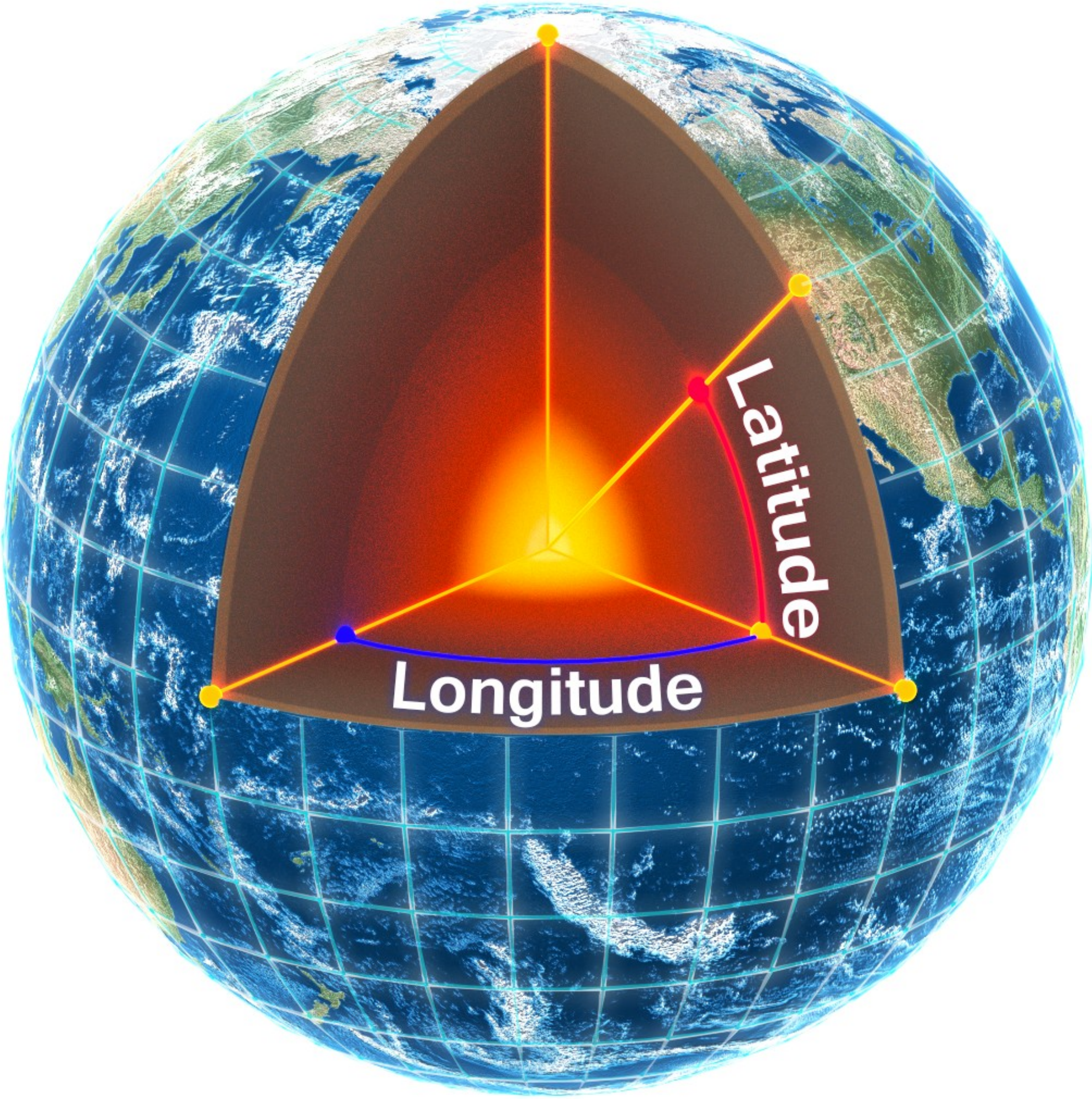


Illustration 4: Latitude and longitude represented visually to describe a position

Illustration 5 shows latitude and longitude on a map of the world, represented with a standard Mercator projection.

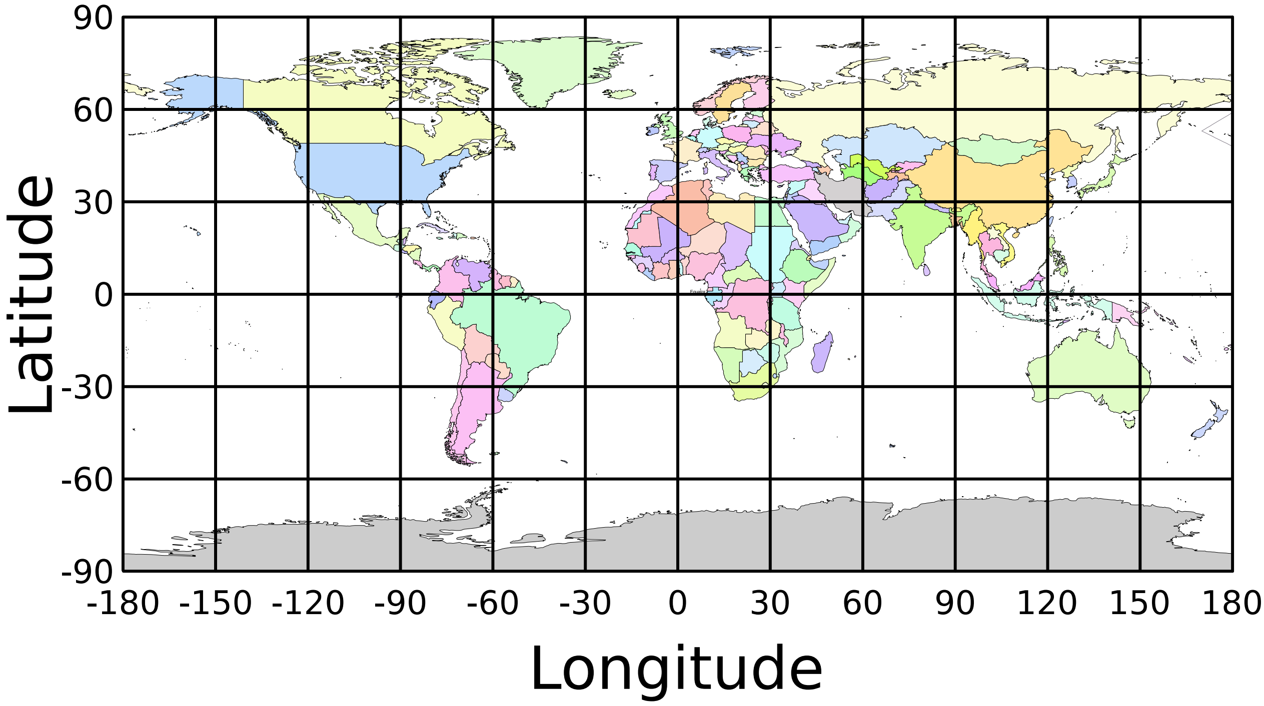


Illustration 5: World map showing latitudes and longitudes

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.

5.8.2 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 Illustration 7 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.

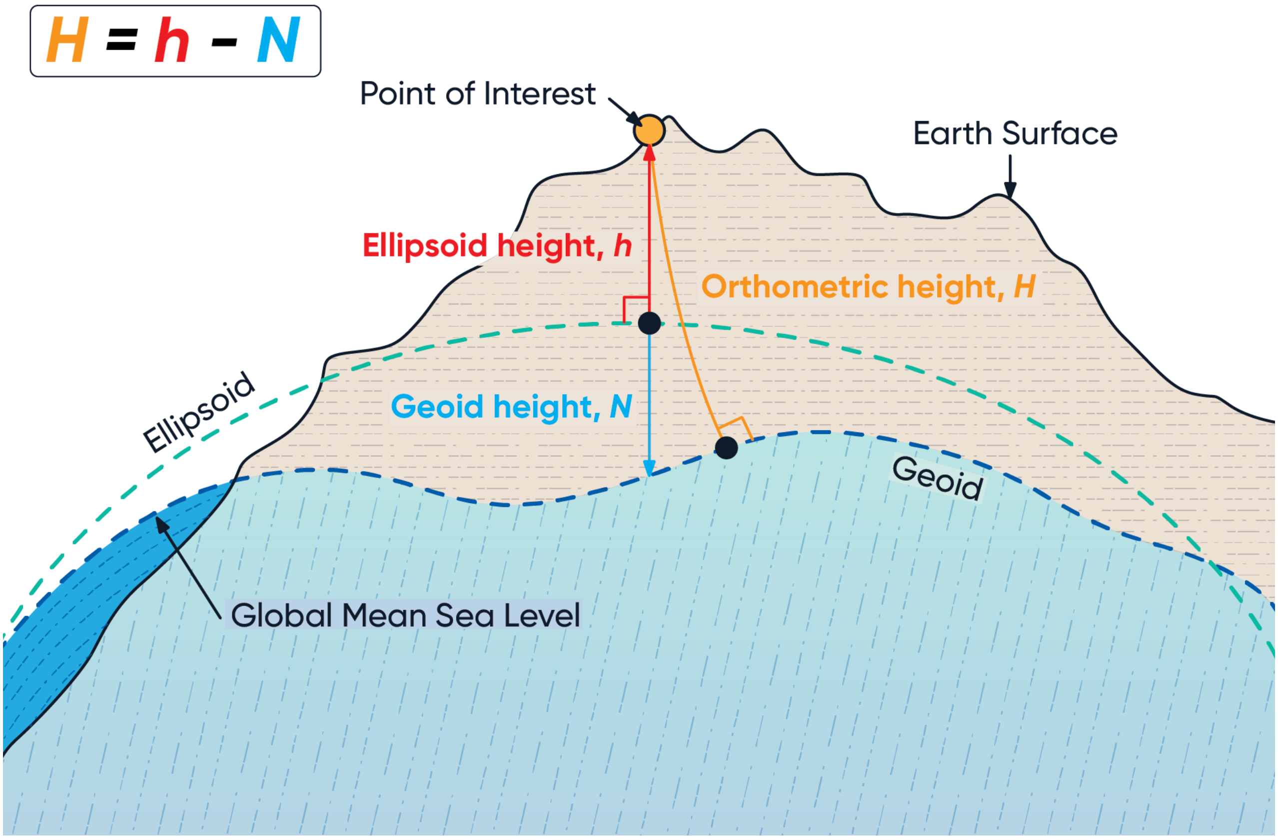


Illustration 6: Orthometric, ellipsoid and geoid height diagram

The value required to convert the WGS84 ellipsoid height to orthometric height can be found in the geoid height packet, see section 13.9.35 .

5.9 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 can be considered the current position. From that origin, the north axis points true north and parallel to the line of longitude at that point. The east axis points perpendicular to the north axis and parallel to the line of latitude at that point. The down axis points directly down towards the centre of the Earth. See for a graphical representation of the NED co-ordinate frame at a position on the Earth.

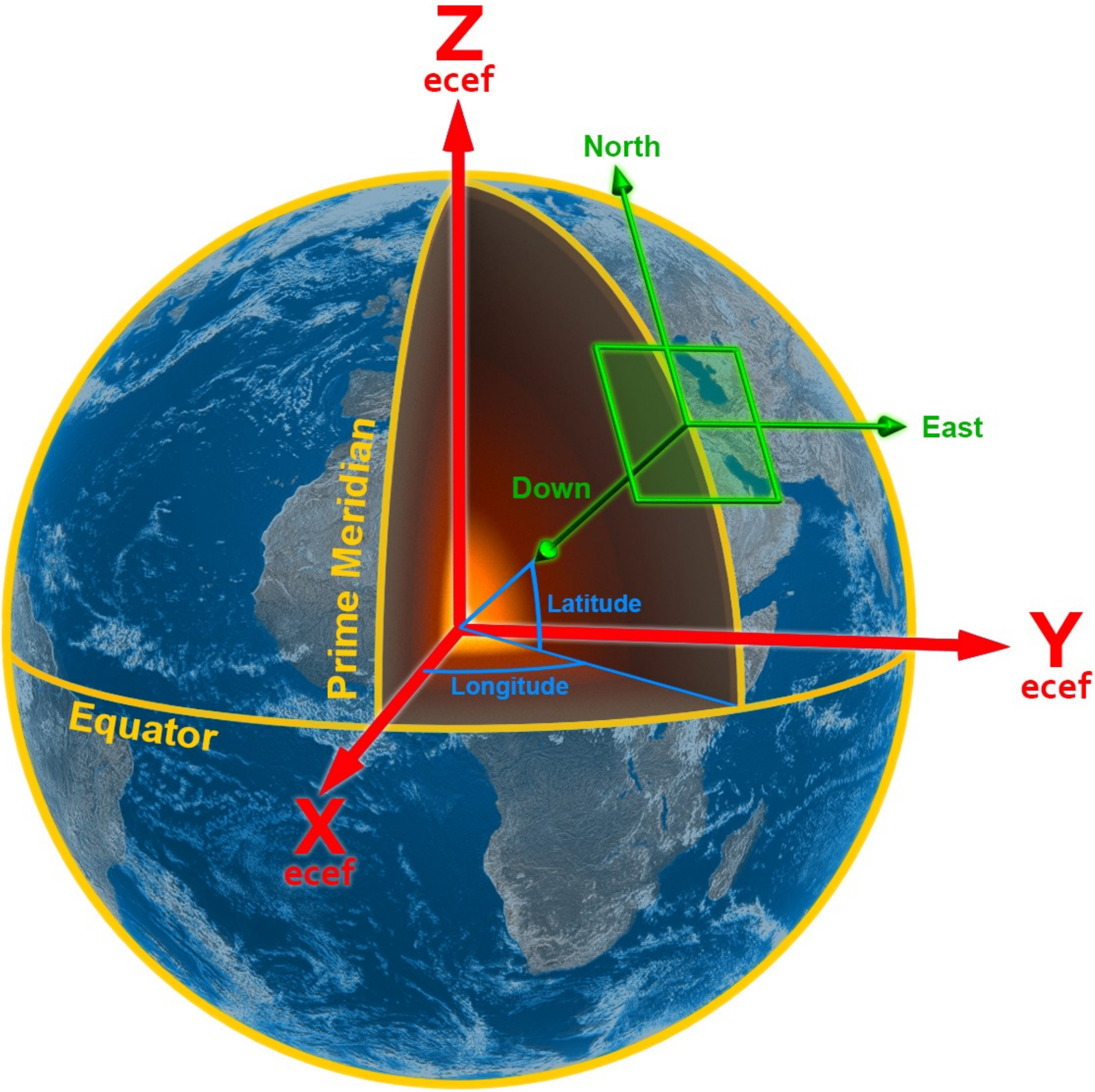


Illustration 7: Graphic showing geodetic, NED and ECEF co-ordinates

5.10 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. It's 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 Illustration 7. ECEF positions can be retrieved from Advanced Navigation products however the geodetic system is used as the default.

6 Evaluation Kit

Spatial FOG is supplied in an evaluation kit that contains everything required to get started operating the system right away. The evaluation kit is supplied in a rugged transport case to protect the equipment during shipping.

Illustration 8: Spatial FOG Evaluation Kit rugged transport case

Illustration 9: Spatial FOG Evaluation Kit contents

6.1 Kit Contents

1. Spatial FOG GNSS/INS
2. Interface cable harness, see section 8.10
3. Antcom G5Ant-53A4T1 L1/L2/L5 GPS/GLONASS/GALILEO/BeiDou GNSS antenna
4. 4 metre RG58A/U antenna cable
5. 2 metre USB to RS422 cable
6. 120/240 V AC to 24 V DC power supply

6.2 Quick Start

1. Attach the interface cable harness to the Spatial FOG unit and screw up finger tight.
2. Plug the power supply into the cable harness and then into the wall socket
3. Plug the USB to RS422 cable into the cable harness primary RS422 socket and your computer
4. Position the GNSS antenna level with a clear view of the sky and connect the coaxial cable between it and Spatial FOG.
5. Download the Spatial FOG Manager software from the Advanced Navigation website. Java is required to run the software. Java is available from http://www.java.com if not already installed.

   Note: Spatial FOG Manager is only available for systems with x64 and ARM architectures.

6. Click the connect button in Spatial FOG Manager.
7. The various windows in Spatial FOG Manager can be used to view the real time data.
8. If north seeking is being used for heading the unit must first obtain a GNSS fix, it should then be left stationary for 5 minutes, then rotated approximately 90 degrees around the Z axis and left stationary for a further 5 minutes. The rotations and dwell times should be repeated two more times. At this point the heading will lock and the status view in Spatial FOG Manager will show that heading has initialised. The North Seeking Status dialogue in Spatial FOG Manager can be used to view the progress of the north seeking.
9. To view the data logs, click disconnect in Spatial FOG Manager. In the tools menu, select log converter and press convert. The *.anpp binary log file will be converted to CSV files that can be opened with popular data processing programs such as Matlab or Microsoft Excel. The log files can be found in the same folder as the Spatial FOG Manager software.

6.3 Antenna Survey Mount Assembly

The Antcom G5Ant-53A4T1 antenna included in the evaluation kit can either be mounted to a panel or mounted to a standard 5/8”-11 survey mount thread with the optional survey mount kit included in the evaluation kit. Please see Illustration 10 below for assembly of antenna with the survey mount kit.

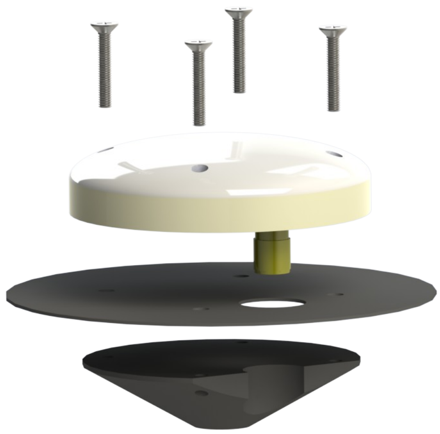


Illustration 10: Antenna survey mount exploded view

7 Part Numbers and Ordering Options

7.1 Evaluation Kit

Part Number	Description	Notes
SPATIAL-FOG2-EK	Spatial FOG Evaluation Kit	Spatial FOG evaluation kit Includes items listed in section 6.1 L1 GPS, GLONASS, BeiDou, GALILEO, SBAS supported License required for RTK, L2, L5

Table 4: Evaluation kit part numbers

7.2 Standalone Unit

Part Number	Description	Notes
SPATIAL-FOG2	Spatial FOG Unit	Spatial FOG unit L1 GPS, GLONASS, BeiDou, GALILEO, SBAS supported License required for RTK, L2, L5 No cables included

Table 5: Standalone unit part numbers

7.3 Internal GNSS Receiver License Upgrades

These license upgrades can either be ordered with the unit or purchased later and installed in the field using Spatial FOG Manager.

Part Number	Description	Notes
SF-LIC-8MM	RTK, L2, L5 License Upgrade	GNSS receiver software license upgrade that enables RTK, L2, L5

Table 6: Internal GNSS receiver license upgrade part numbers

7.4 Accessories

Part Number	Description	Notes
8071-4336-78	Unterminated Interface Cable	Spatial FOG connector with 2 metres of unterminated cable See section 8.9
SF-CABLE-KIT	Spatial FOG Evaluation Cable Harness	Spatial FOG connector with 2 metres of cable to industry standard connectors See section 8.10
CABLE-FTDI	USB to RS232 / RS422 cable 1 m	FTDI USB to RS232 / RS422 (selectable) 1 metre cable
SUPPLY-24V	24V DC Power Supply	100-240V AC Mains to 24V 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
BF046WS130621-06	Right Angle SMA to TNC 4m Cable	Right Angle SMA to TNC connector 4 metre antenna cable
G5ANT-53A4T1	Antcom GNSS Antenna	Antcom G5 L1/L2/L5 GNSS antenna with survey mount
VSP6337L	VeroStar GNSS Antenna	VeroStar GNSS Antenna - L1/L2/L5 plus L-band, pole mount, TNC Female Connector
OBDII-ODOMETER	OBDII Odometer	OBDII Odometer Interface See section 9.8.2
Various Air Data Units	Air Data Unit	Air data unit provides pitot and static air data aiding for Spatial FOG Dual 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

Table 7: Accessories part numbers

8 Specifications

8.1 Mechanical Drawings

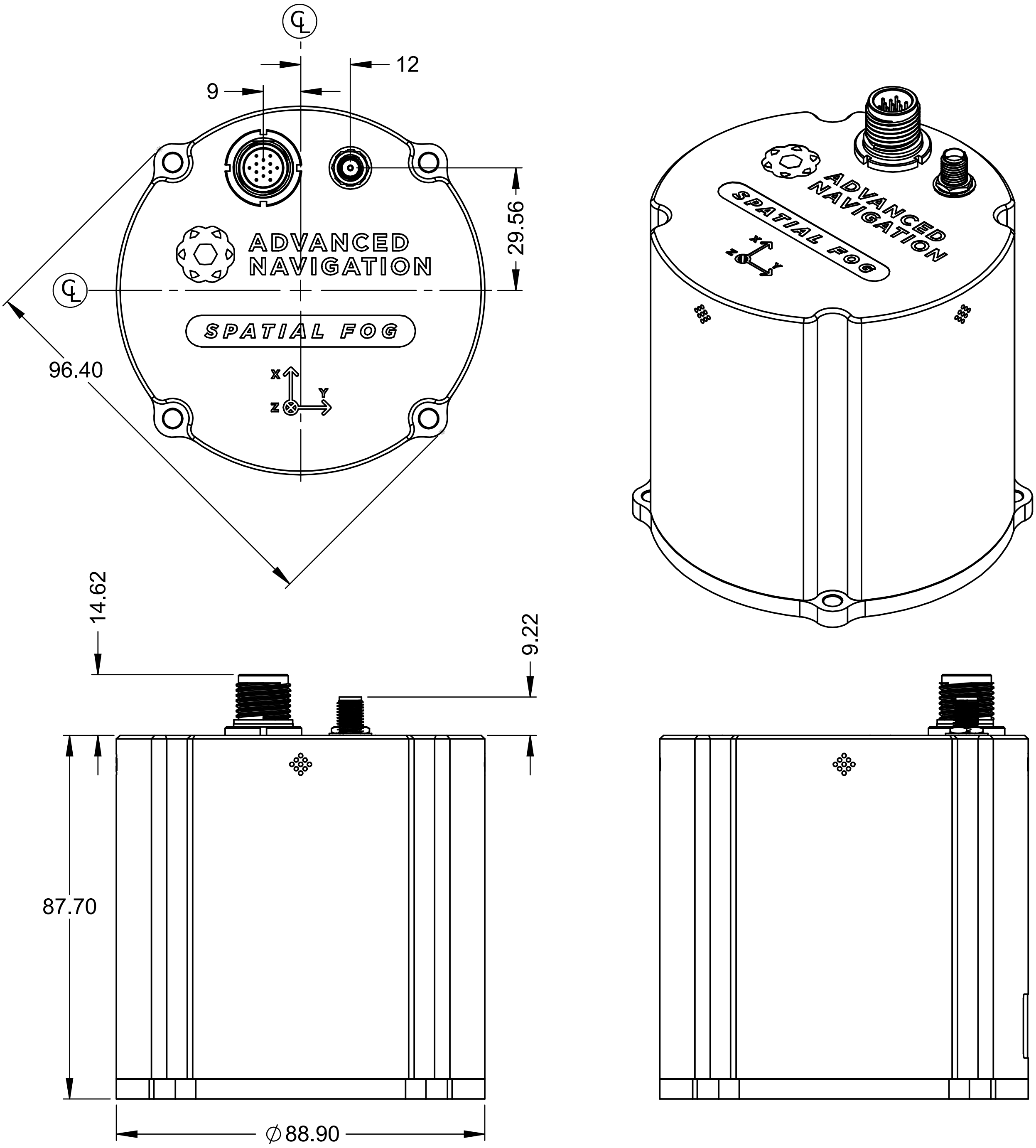


Illustration 11: Mechanical drawings of Spatial FOG

8.2 Navigation Specifications

Parameter	Value
Horizontal Position Accuracy	0.8 m
Vertical Position Accuracy	1.5 m
Horizontal Position Accuracy (RTK or Kinematica Post Processing)	0.008 m
Vertical Position Accuracy (RTK)	0.015 m
Velocity Accuracy	0.007 m/s
Roll & Pitch Accuracy	0.01 °
Heading Accuracy (GNSS aided)	0.05 °
Heading Accuracy (north seeking only)	0.25 ° secant latitude
Roll & Pitch Accuracy (Kinematica Post Processing)	0.01 °
Heading Accuracy (Kinematica Post Processing)	0.01 °
Hot Start Time	2 s
Internal Filter Rate	1000 Hz
Output Data Rate	Up to 1000 Hz

Table 8: Navigation specifications

8.3 Sensor Specifications

Parameter	Accelerometers	Gyroscopes	Magnetometers	Pressure
Range	±10 g	±490 °/s	±8 G	10 to 120 KPa
Bias Instability	15 ug	0.05 °/hr	-	10 Pa
Initial Bias	< 1 mg	< 1 °/hr	-	< 100 Pa
Initial Scaling Error	< 0.03 %	< 0.01 %	< 0.07 %	-
Scale Factor Stability	< 0.06 %	< 0.02 %	< 0.05 %	-
Non-linearity	< 0.03 %	< 0.005 %	< 0.08 %	-
Cross-axis Alignment Error	< 0.05 °	< 0.02 °	< 0.05 °	-
Noise Density (Random Walk)	120 ug/√Hz (0.07 m/s/√hr)	0.7 °/hr/√Hz (0.012 °/√hr)	210 uG/√Hz	0.56 Pa/√Hz
Bandwidth	200 Hz	440 Hz	110 Hz	50 Hz

Table 9: Sensor specifications

8.4 GNSS Specifications

Parameter	Value
Supported Navigation Systems	GPS L1, L2, L5 GLONASS L1, L2 GALILEO E1, E5 BeiDou B1, B2
Supported SBAS Systems	WAAS EGNOS MSAS GAGAN QZSS
Update Rate	20 Hz
Hot Start First Fix	3 s
Cold Start First Fix	30 s
Horizontal Position Accuracy	1.2 m
Horizontal Position Accuracy (with SBAS)	0.5 m
Horizontal Position Accuracy (with RTK)	0.008 m
Velocity Accuracy	0.007 m/s
Timing Accuracy	20 ns

Table 10: GNSS Specifications

8.5 Communication Specifications

Parameter	Value
Interface	RS422 (RS232 optional)
Primary Port Speed	2400 to 10 M baud
Auxiliary Port Speed	2400 to 2 M baud
GPIO Port Speed	2400 to 250 K baud
Protocol	AN Packet Protocol
Peripheral Interface	2x GPIO 1x Auxiliary RS232 1x GNSS corrections RS232
GPIO Level	5 V or RS232

Table 11: Communication specifications

8.6 Hardware Specifications

Parameter	Value
Operating Voltage	9 to 36 V
Input Protection	-40 to 100 V
Power Consumption	550 mA @ 12 V (typical)
Backup Battery Capacity	> 24 hrs
Backup Battery Charge Time	30 mins
Backup Battery Endurance	> 10 years
Operating Temperature	-40 °C to 75 °C
Environmental Sealing	IP68 MIL-STD-810G
Shock Limit	25 g
Dimensions	90 x 90 x 96 mm
Weight	860 grams

Table 12: Hardware specifications

8.7 Electrical Specifications

Parameter	Minimum	Typical	Maximum
Power Supply			
Input Supply Voltage	9 V		36 V
Input Protection Range	-40 V		100 V
RS232			
Tx Voltage Low		-5.4 V	-5 V
Tx Voltage High	5 V	5.4 V	
Tx Short Circuit Current			±60 mA
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			
Output Voltage Low	0 V		0.3 V
Output Voltage High	4.8 V		5 V
Output Current			5 mA
Input Voltage	-20 V		20 V
Input Threshold Low			1.5 V
Input Threshold High	3.5 V		
GNSS Antenna			
Active Antenna Supply Voltage	4.8 V		5 V
Antenna Supply Current			150 mA

Table 13: Electrical specifications

8.8 Power Consumption

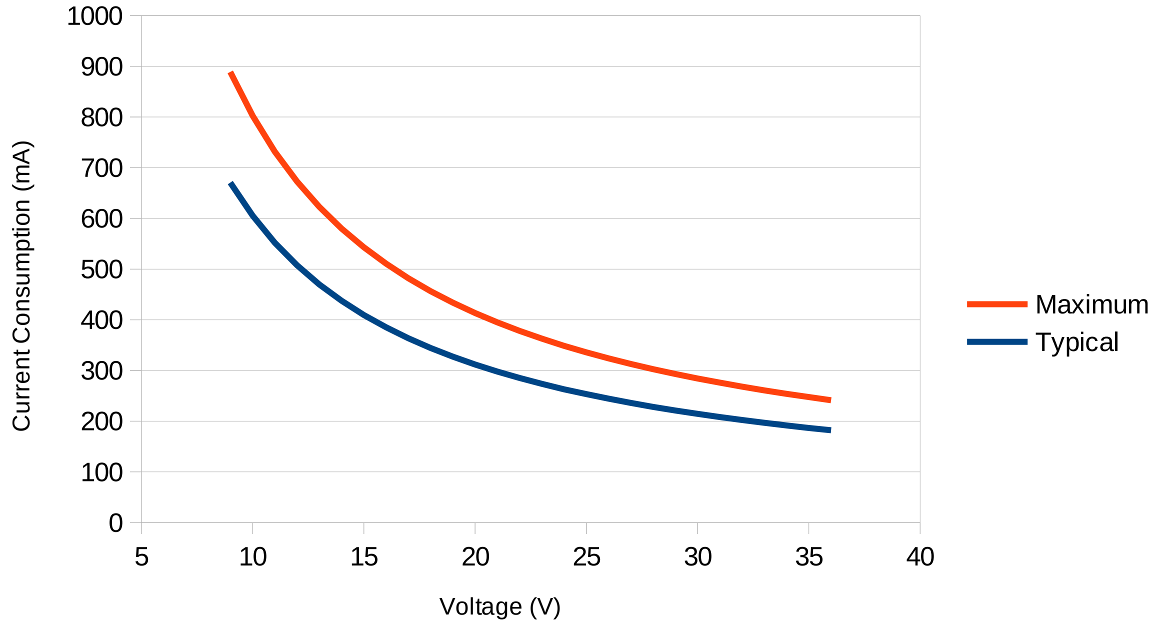


Illustration 12: Maximum and typical current consumption across operating voltage

8.9 Connector Pin-out

Power supply and signal connections are made through a 13 pin Glenair mighty mouse series 801 connector. The Glenair part number is 801-007-16M8-13SA. The connector provides a reliable and rugged connection to Spatial FOG under demanding conditions and is rated to IP68 in the mated condition. Connection to Spatial FOG may be made with the Spatial FOG evaluation cable harness, which provides a pre-terminated 2 metre cable assembly with all signals broken out to industry standard connectors, see section 8.10. Advanced Navigation also supplies connectors with 2 metres of unterminated cable, see Illustration 13. Custom lengths are available on request.

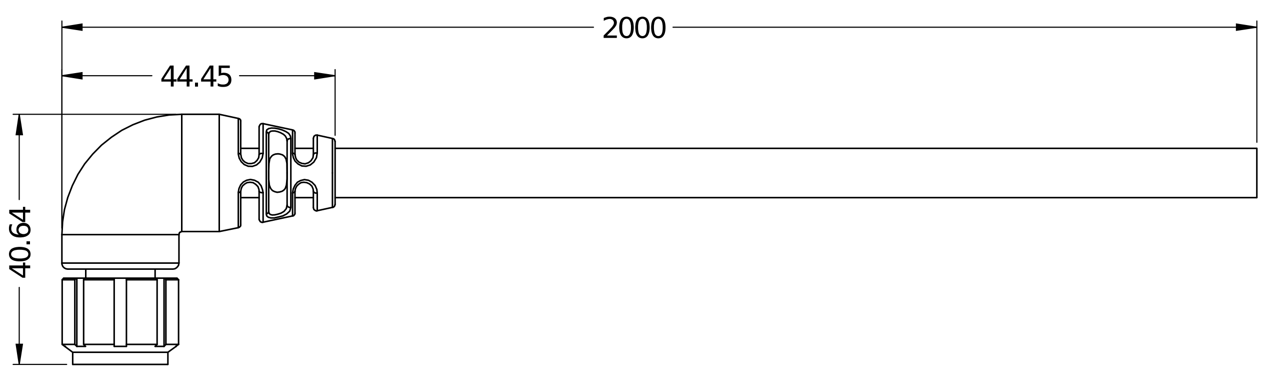


Illustration 13: Spatial FOG connector with 2 metres of unterminated cable

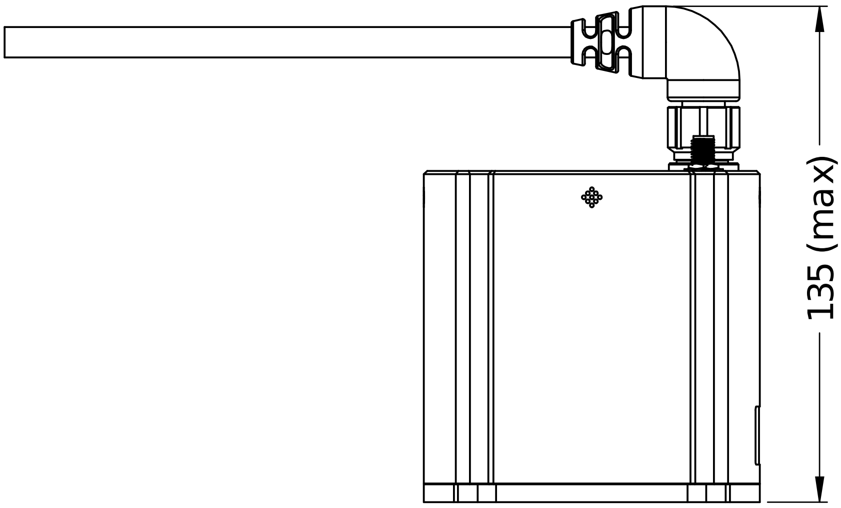


Illustration 14: Spatial FOG mated connector clearance

Pin	Colour	Function
1	Black	GPIO 1
2	Brown	GPIO 2
3	Red	Signal Ground
4	Orange	Power Ground
5	Yellow	Power Supply
6	Green	Primary RS422 Rx(+) / RS232 Rx
7	Blue	Primary RS422 Rx(-)
8	Violet	Primary RS422 Tx(+) / RS232 Tx
9	Grey	Primary RS422 Tx(-)
10	White	Auxiliary RS232 Tx
11	White/Black	Auxiliary RS232 Rx
12	White/Brown	GNSS RS232 Rx
13	White/Red	GNSS RS232 Tx

Table 14: Pin allocation table for Spatial FOG connector

8.10 Spatial FOG Evaluation Cable Harness

Advanced Navigation offers a pre-terminated evaluation cable harness for quick connection to Spatial FOG. All external signal and power connections are provided with 2 metres of cable. For quick testing in applications, the interface cable is provided with industry standard 9 pin DSUB connectors on the communication channels with industry standard pinouts. The evaluation cable harness is supplied as part of the Spatial FOG Evaluation Kit, see section 6.

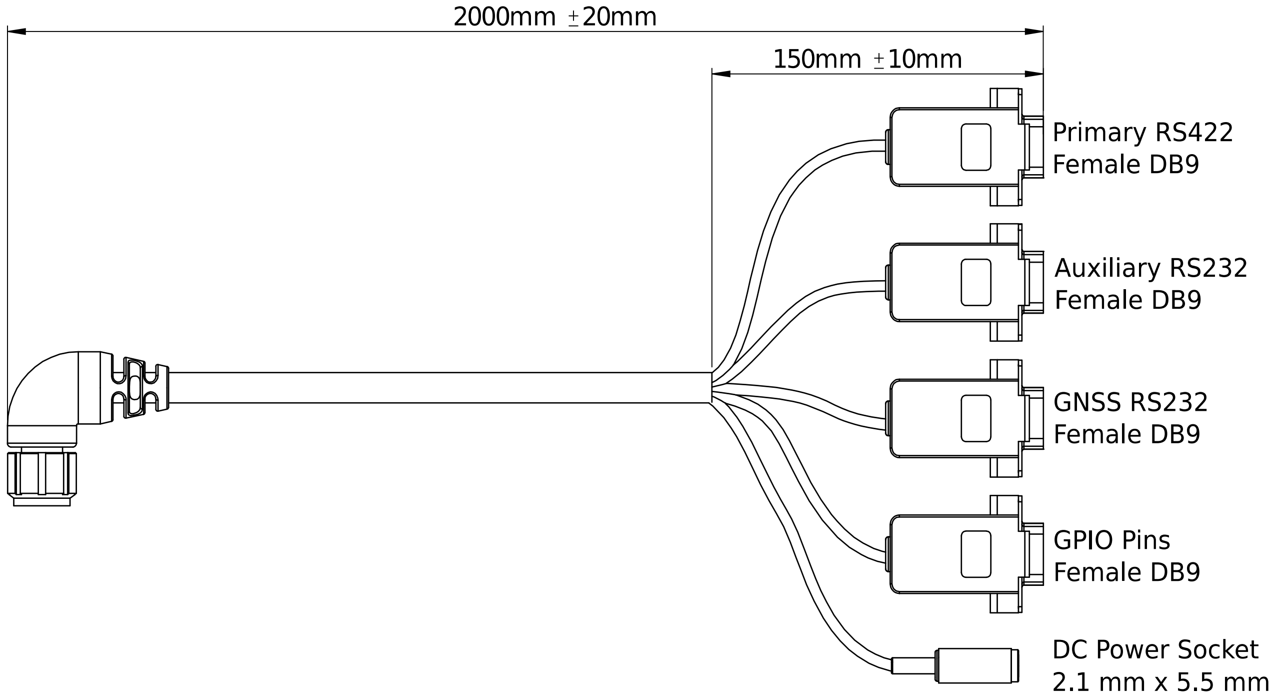


Illustration 15: Spatial FOG evaluation cable harness diagram

Function	Primary	Auxiliary	GNSS	GPIO	Power
GPIO 1				2	
GPIO 2				3	
Signal Ground	5	5	5	5	
Power Ground					Ring
Power Supply					Tip
Primary RS422 Rx(+)	3				
Primary RS422 Rx(-)	7				
Primary RS422 Tx(+)	2				
Primary RS422 Tx(-)	8				
Auxiliary RS232 Tx		2			
Auxiliary RS232 Rx		3			
GNSS RS232 Rx			3		
GNSS RS232 Tx			2		

Table 15: Spatial FOG evaluation cable harness connector pin-out

8.11 Serial Number

The serial number can be inspected by using the device information dialogue in the Spatial FOG Manager software, see section 11.7.1. The primary serial number label is located inside the enclosure and is accessible only by Advanced Navigation technicians. The secondary 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 external label also contains the hardware version and build date. Applications are available for most smart-phones that can scan the 2D data matrix bar code to display the serial number.

Illustration 16: Spatial FOG external serial number label

9 Installation

9.1 Installation Checklist

1. Securely mount the unit to the vehicle following the guidelines in section 9.2.
2. Mount the GNSS antenna following the guidelines in section 9.5 and then connect the antenna cable between the antenna and the Spatial FOG unit.
3. Connect the connector cable to Spatial FOG and then connect a suitable power supply as specified in section 9.4.
4. Connect the USB converter cable to the primary port and a computer, open the Spatial FOG Manager software and click connect.

   Note: Spatial FOG Manager is only available for systems with x64 and ARM architectures.
5. If the unit is mounted in an alignment other than the standard alignment of X pointing forward and Z pointing down, this alignment offset will need to be entered into the Alignment Configuration dialogue in Spatial FOG Manager. Please see section 9.2.1 for more details.
6. Accurately measure the GNSS antenna offset from the centre of the Spatial FOG unit to the central base of the antenna in the body co-ordinate frame (X positive forward and Z positive down) and enter these values into the Alignment Configuration dialogue in Spatial FOG Manager. Please see section 9.5 for more details. Please note that the body axes are always X positive forward and Z positive down irrespective of any alignment offset entered in the previous step.
7. Enter the vehicle type in the Filter Options dialogue in Spatial FOG Manager.
8. The system is now ready for use.

9.2 Position and Alignment

When installing Spatial FOG into a vehicle, correct positioning and alignment are essential to achieve good performance. There are a number of goals in selecting a mounting site in your application, these are:

1. Spatial FOG should be mounted in an area that is not going to exceed it's temperature range and mounted in a manner that will properly dissipate heat; please contact support@advancednavigation.com for advice specific to your application.
2. Spatial FOG should be mounted away from vibration where possible.
3. Spatial FOG should be mounted within several metres of the GNSS antenna where possible.
4. If atmospheric altitude is going to be used, the two vents on the sides of Spatial FOG should not be obstructed.
5. Spatial FOG should be mounted close to the centre of gravity of the vehicle where possible.
6. As FOG technology is subject to minor bias variations under strong magnetic fields, Spatial FOG should be mounted at least 0.25 metres away from sources of dynamic magnetic interference such as high current wiring, large motors and rotating or reciprocating

machinery.

9.2.1 Alignment

The easiest way to align Spatial FOG is by installing it with the sensor axes aligned with the vehicle axes. This means that the X axis points forward towards the front of the vehicle and the Z axis points down towards the ground.

If aligning Spatial FOG with the vehicle axes is not possible or not optimal, it may be mounted in a different alignment and the alignment offset should be configured using the alignment configuration dialogue in Spatial FOG Manager, see section 11.8.4. For easy alignment, the set zero orientation button in the Spatial FOG Manager alignment dialogue can be used to set the current orientation as the zero orientation alignment, see section 11.8.4. Please note that this will only correct for roll and pitch offsets. Any heading offset will need to be entered manually and saved before using this function.

9.3 Mounting Plate

Spatial FOG's mounting plate and hole guide is shown below in Illustration 17. The holes are designed for M4 bolts. The alignment holes can be used to ensure precise alignment of Spatial FOG through the use of alignment pins.

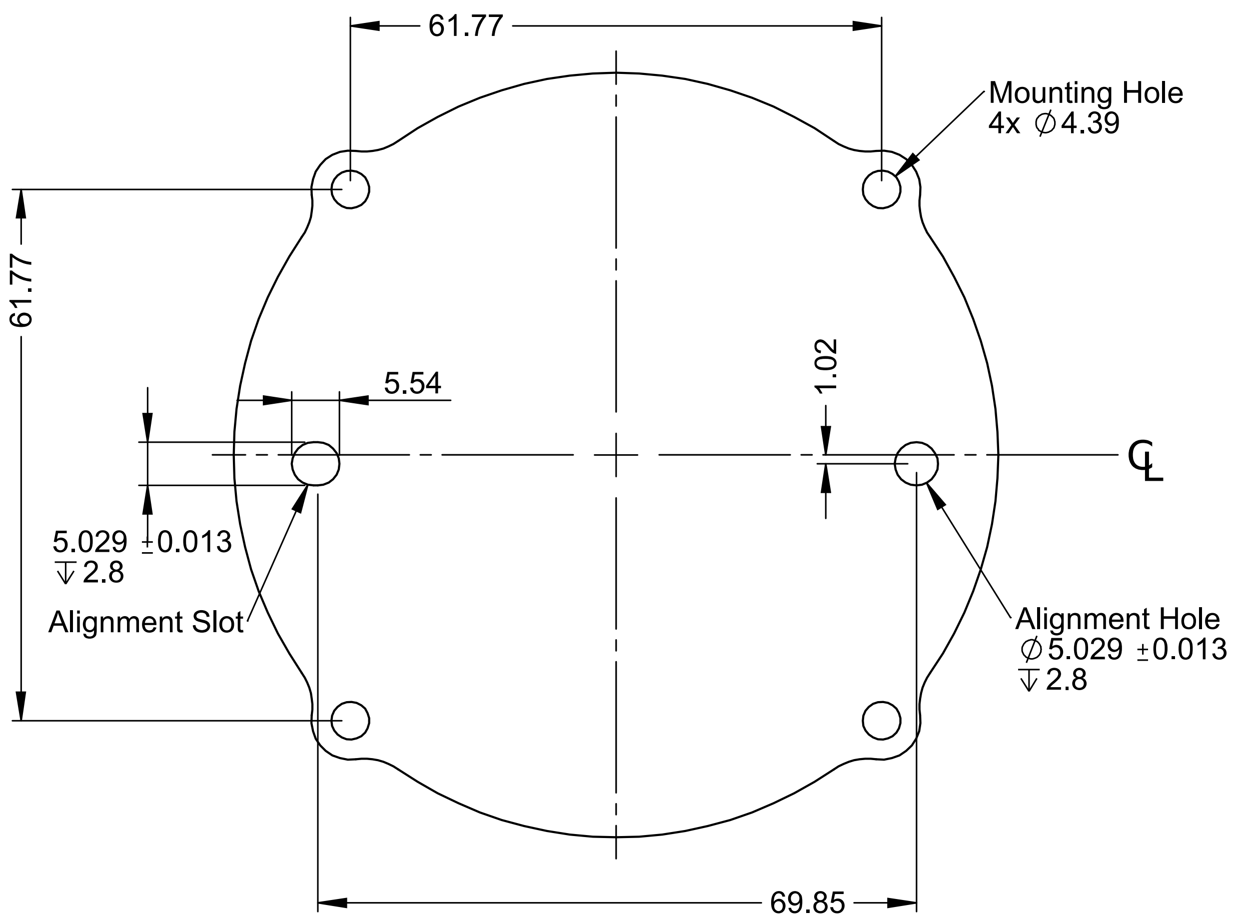


Illustration 17: Spatial FOG mounting plate

9.4 Power Supply

A high level of power supply filtering has been built into Spatial FOG to allow for reliable operation in demanding environments. Spatial FOG contains a fully isolated power supply and has separate grounds for power and signal to ensure that power supply noise does not corrupt communications or cause ground loops with other equipment. When wiring the system, the signal ground should be routed with the primary RS232, auxiliary RS232, GNSS RS232 and GPIO pins. The power ground should be routed with the power supply to the power source.

A power supply should be selected that can provide at least the maximum current calculated from the graph in Illustration 12.

Spatial FOG contains an active protection circuit on the power supply input that protects the unit from under-voltage, over-voltage and reverse polarity events. The protection circuit shuts off power and automatically recovers the unit to full operation once the fault is removed. Take care when running the unit close to its under-voltage lockout of 9 V because small voltage drops can engage the under-voltage shutdown and potentially oscillate between the on and off state. It is recommended that the unit is always run at 10 V or more to avoid issues associated with this.

9.5 GNSS Antenna

The GNSS antenna should be installed level with a clear unobstructed view of the sky and close to the Spatial FOG unit where possible. The antenna should be mounted away from any RF emitters. 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.

The GNSS antenna position offset should be configured in the Spatial FOG unit by using the alignment configuration dialogue in Spatial FOG Manager, see section 11.8.4. The antenna offset is measured from the centre of the Spatial FOG unit to the central base (ARP) of the antenna in the body frame. It is very important to set the antenna offset accurately as Spatial FOG corrects for lever arm velocities. Incorrect GNSS antenna offset will lead to performance degradation under turning and angular rotations. The antenna offset is measured from the centre of the Spatial unit to the centre of the antenna in the body frame (X forward, Z down). Please note that as Z is positive down, mounting the antenna above the Spatial unit will result in a negative Z offset.

An example installation with axes marked is shown below in Illustration 18 and Illustration 19. In this installation there would be a positive X antenna offset value, a positive Y antenna offset value and a negative Z offset value.

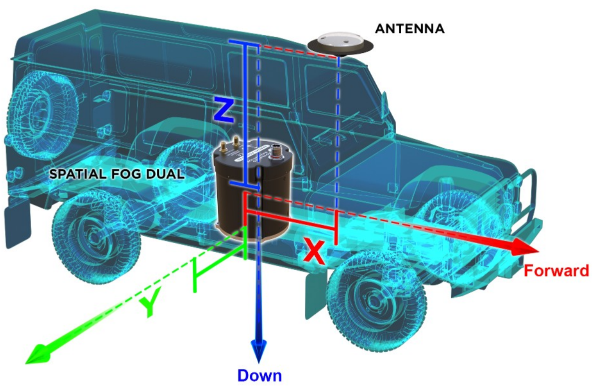


Illustration 18: Spatial FOG antenna offset isometric view

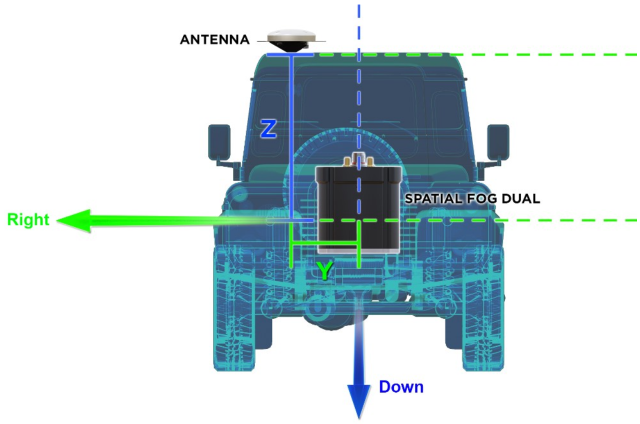


Illustration 19: Spatial FOG antenan offset front view

The standard antenna supplied in the Spatial FOG evaluation kit is the Antcom G5Ant-53A4T1. It is an L1/L2/L5 RTK antenna that supports GPS, GLONASS, BeiDou, Galileo, Omnistar and SBAS. It is environmentally sealed to the IP68 standard.

If you are supplying your own antenna it is important to ensure that the antenna is able to receive all constellations and not just GPS, otherwise you will not achieve full performance. It is also important to select an IP67 antenna with an IP67 SMA connector, otherwise the system will not be environmentally sealed.

It is recommended to use an antenna with the following characteristics:

- The antenna should be capable of receiving GPS, GLONASS and BeiDou.
- If the unit is being used for RTK, the antenna needs to be capable of receiving both L1 and L2. It should also have an accurate phase centre.
- The antenna should have a minimum LNA gain of 29dB and a maximum gain of 50dB.
- The antenna should be environmentally sealed, including connectors.

If you are sourcing your own antenna cables it is important to ensure that the antenna has enough gain to support the loss over the cable. Spatial FOG requires a minimum of 29dB of gain at the connector. With the standard 4 metre LMR240 antenna cables supplied by Advanced Navigation, the minimum antenna gain is 30dB.

9.6 GNSS 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 beyond it's maximum bend radius. It is recommended to use wide cable ties and be careful not to do them up too tight. Advanced Navigation recommends 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

Cable Type	Minimum Bend Radius	Signal Loss
LMR240	20 mm	~0.33 dB/m
LMR300	22.2 mm	~0.26 dB/m
LMR400	25.4 mm	~0.17 dB/m

Table 16: GNSS antenna co-axial cable properties

9.7 Static Port

Spatial FOG uses atmospheric pressure to stabilise its vertical velocity. The static port vents can be found on the sides of the Spatial FOG enclosure at the top. These are special vents that do not allow water to enter the enclosure.

9.8 Odometer

On ground vehicles, the use of an odometer input can greatly improve Spatial FOG's navigation and orientation solution during GNSS dropouts. With a high resolution wheel encoder Spatial FOG can be used to navigate indoors with GNSS disabled altogether.

There are several different options for odometer installation which are listed below.

9.8.1 Factory VSS Signal

Most road cars since 1980 contain a VSS (vehicle speed sensor) signal that can be wired directly into one of Spatial FOG's GPIO pins. The vehicle should be taken to an automotive electrician to perform the work.

To setup the odometer, the appropriate GPIO pin should be set to the odometer input function using Spatial FOG Manager, see section 11.8.6. The odometer pulse length must then be set either manually or automatically, please see section 10.8 for more information.

For more information on the GPIO signals and their requirements please see section 12.4.3.

9.8.2 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 OBDII odometer interface that plugs into this OBDII port and feeds Spatial FOG with odometer data over the Auxiliary RS232 port, please see Illustration 20. These units are priced at approximately AUD 500. Please contact Advanced Navigation sales for more information.

Illustration 20: Advanced Navigation OBDII Odometer

9.8.3 Aftermarket Wheel Speed Sensor

Applications requiring very high performance are recommended to use a high precision aftermarket wheel speed sensor. Advanced Navigation recommends aftermarket wheel speed sensors from Pegasem or GMH Engineering.

Illustration 21: Aftermarket wheel speed sensor

9.8.4 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.

Illustration 22: Radar speed sensor

9.9 Vibration

Spatial FOG is able to tolerate a high level of vibration compared to other inertial systems. There is however a limit to the amount of vibration that Spatial FOG can tolerate and large levels of vibration will cause Spatial FOG's accuracy to degrade.

When mounting Spatial FOG to a platform with vibration there are several options. It is recommended to first try mounting Spatial FOG and see whether it can tolerate the vibrations. The raw sensor view in the Spatial FOG Manager software can give you a good idea of how bad the vibrations are. If the vibrations are causing the sensors to go over range you will need to take preventative steps against the vibration.

If Spatial FOG is unable to tolerate the vibrations there are several options:

1. Try to find a mounting point with less vibration.
2. Spatial FOG can be mounted on top of a small flat piece of rubber. Please note that this may cause small changing orientation errors due to flexing of the rubber.
3. Spatial FOG can be mounted to a plate which is then mounted to the platform through vibration isolation mounts.

10 Operation

10.1 Initialisation

There are four different levels of initialisation on Spatial FOG. These are orientation, navigation, heading and time. The initialisation can be monitored by inspecting the status view in Spatial FOG Manager, see section 11.7.2.

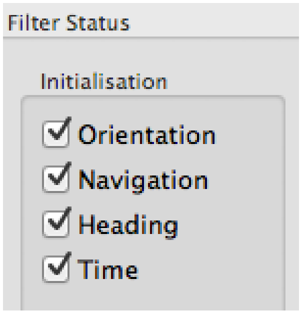


Illustration 23: The four initialisation levels

After all four levels of initialisation, Spatial FOG's filter takes several minutes to achieve it's full accuracy. It is recommended to wait two minutes after initialisation for applications requiring high accuracy.

10.1.1 Orientation Initialisation

Orientation initialisation occurs automatically upon power on and typically completes within several seconds. Once orientation initialisation is complete, the roll, pitch and angular velocity values will be valid.

When Spatial FOG starts up, it assumes that it can be in any orientation. To determine it's orientation it uses the accelerometers to detect the gravity vector. Whilst this is occurring, if there are random accelerations present, these can cause an incorrect orientation to be detected. To prevent this, Spatial FOG 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. In this scenario Spatial FOG will progressively correct the orientation error over a period of several seconds.

10.1.2 Navigation Initialisation

Navigation initialisation completes once the system has determined a starting position. The most common method of navigation initialisation is for the system to get a 3D GNSS fix. If the system is hot starting it will remember it's position from when it was switched off and use this as the starting position. The other possibility for navigation initialisation is an external position source, see section 12.2 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 position dialogue in Spatial FOG Manager, see section 11.8.11.

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

10.1.3 Heading Initialisation

Heading initialisation completes once the system has determined a heading. The conditions required to determine a heading depend upon the heading source being used, see section 10.4. If north seeking gyrocompass heading is being used as the sole heading source the heading initialisation will only complete once the north seeking alignment procedure has been completed, see section 10.4.1. If velocity heading is enabled, the heading will also initialise once the system travels at a speed of over 1.15 metres/second for over 5 seconds with a 3D GNSS fix. If the system is hot starting it will remember it's heading from when it was switched off and use this as the starting heading until another source becomes available.

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 be able to reach full accuracy.

10.1.4 Time Initialisation

Time initialisation completes once the system has determined time accurately. This occurs as soon as the GNSS receiver obtains it's first fix. It is also possible to provide an external source of time, see section 12.2 for more information on external time sources.

Until the time has initialised the values of unix time and formatted time that Spatial FOG outputs will not be valid and may change.

10.2 Hot Start

Spatial FOG is the first GNSS/INS on the market with hot start functionality. This allows Spatial FOG to start inertial navigation within 2 seconds and obtain a GNSS fix in as little as 3 seconds. Spatial FOG's hot start is always on and fully automatic.

A next generation backup battery system within Spatial FOG provides the hot start ability for more than 24 hours without power. When Spatial FOG 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 fix far more quickly than it otherwise would. When the GNSS achieves it's first fix, if this position deviates from the hot start position, Spatial FOG will jump to the new position without causing any side effects to the filter.

Whilst Spatial FOG is without power it keeps track of the time accurately to within 1 second so that the time is immediately valid on a hot start.

Spatial FOG's hot start 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 startup time.

10.3 Time

Spatial FOG was designed to provide a highly accurate time reference. When a GNSS fix is available Spatial FOG's time is accurate to within 50 nanoseconds. When a GNSS fix is lost, Spatial FOG's time accuracy typically remains within 10 microseconds over extended time periods. When Spatial FOG hot starts the time accuracy is typically within 1 second immediately on startup and corrected to within 50 nanoseconds as soon as a GNSS fix is achieved. To synchronise with Spatial FOG's high accuracy time, both the packet protocol and a 1PPS line must be used.

10.4 Heading Source

There are four different heading sources available for Spatial FOG. By default Spatial FOG uses north seeking gyrocompass heading. This can be complemented with velocity heading for forward driving vehicles such as cars. It is possible to use multiple heading sources and this will often provide performance benefits.

10.4.1 North Seeking Gyrocompass Heading

Spatial FOG's high accuracy gyroscopes allow it to detect the rotation of the earth and seek north with a high degree of accuracy. When used as the sole heading source, initialisation of the north seeking takes 15 minutes and requires that the unit remain stationary in between three rotations. With the assistance of another heading source, the gyrocompass heading can take as little as 60 seconds to initialise and will not require any rotations or stationary time. For example on a ship that is moving at a speed of over 1.15 metres/second with velocity heading enabled, the north seeking algorithm will automatically initialise during the first 60 seconds of operation.

When used as the sole heading source, the north seeking initialisation procedure is:

1. Turn on Spatial FOG and leave stationary for 5 minutes.
2. Rotate Spatial FOG approximately +90 degrees about the Z axis and leave stationary for 3 minutes.
3. Rotate Spatial FOG approximately +90 degrees about the Z axis and leave stationary for 3 minutes.
4. Rotate Spatial FOG approximately +90 degrees about the Z axis and leave stationary for 3 minutes.

To assist users in getting accustomed to the north seeking procedure there is a north seeking status dialogue in Spatial FOG Manager that provides feedback and guides the user through the initialisation process, see section 11.7.11.

Spatial FOG's gyrocompass heading is fully automatic and always on. For all applications, the gyrocompass heading requires approximate position. For moving applications, the gyrocompass heading function requires continuous velocity updates to provide accurate heading. This data is typically provided by the internal GNSS receiver, however it can also be provided by an odometer or other type of speed sensor.

Applications where north seeking should not be used as the sole heading source include

- Environments with high vibration.
- Environments with rapid temperature fluctuations.
- Environments with strong changing magnetic fields close to the FOG unit (the fibre optic gyroscopes bias is affected by strong magnetic fields).
- Applications where it is impractical to perform the initialisation procedure.
- Applications where the system is moving at speeds of over 1 metre/second and no velocity aiding information is available.

In these scenarios an alternative heading source should be considered. Please see the alternative options of Velocity Heading and External Heading below. If in doubt, please contact Advanced Navigation support for assistance in selecting the correct heading source for your application.

10.4.2 Velocity Heading

Velocity heading works by deriving heading from the direction of velocity and acceleration. Velocity heading works well with cars, boats, fixed wing aircraft and other vehicles that don't move sideways. Velocity heading does not work with helicopters and other 3D vehicles. The downside of velocity heading is that heading can not be measured until the vehicle moves at a horizontal speed of over 1.15 metres/second with a GNSS fix. Velocity heading is very useful for getting accurate heading quickly on moving vehicles without requiring any specific initialisation procedure. It is also able to initialise the north seeking gyrocompass heading without requiring the initialisation procedure described in section 10.4.1.

10.4.3 External Heading

External heading can be used if there is some other way to derive heading that is external to Spatial FOG. Examples include dual antenna GNSS systems, reference markers and SLAM systems. The heading must be fed into Spatial FOG using the External Heading Packet or through NMEA into a GPIO pin.

10.5 Magnetics

Spatial FOG uses magnetometers to detect changes in heading which allows the north seeking algorithm to initialise faster. If strong dynamic magnetic disturbances are present this will not effect the accuracy of the heading but may cause the north seeking initialisation to take longer.

10.6 Data Anti Aliasing

Internally Spatial FOG's filters update at 1000 Hz. When Spatial FOG outputs data, most applications require the data at a much lower rate (typically < 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, Spatial FOG 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.

10.7 Vehicle Profiles

Spatial FOG supports a number of different vehicle profiles. These vehicle profiles impose constraints upon the filter that can increase performance. If your application matches one of the available vehicle profiles, it is recommended to select it for use in the filter options dialogue in Spatial FOG Manager, see section 11.8.2. For a list of the different vehicle profiles please see section 13.10.5.1. Please note that if the wrong vehicle profile is selected it can cause a significant decrease in performance.

10.8 Odometer Pulse Length

For Spatial FOG 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. The odometer pulse length can either be entered manually or automatically calibrated by Spatial FOG. To enter the pulse length manually, please use the odometer configuration dialogue in Spatial FOG Manager, see section 11.8.7. To automatically calibrate the odometer pulse length please use the procedure listed below in section 10.8.1. By default the odometer will automatically calibrate itself.

10.8.1 Odometer Automatic Pulse Length Calibration Procedure

1. Ensure that the signal is connected correctly and that the GPIO pin is configured as an odometer input using the GPIO configuration dialogue in Spatial FOG Manager, see section 11.8.6.
2. Open Spatial FOG Manager, connect to Spatial FOG and open the odometer configuration dialogue. In the odometer configuration dialogue tick the automatic pulse length calibration check box and press the write button, see section 11.8.7.
3. Wait until Spatial FOG has a continuous GNSS fix and then drive 1000 metres over flat terrain with as little turning as possible.
4. If Spatial FOG 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 1000 metres.
5. Once 1000 metres has been driven, press the read button and check that the automatic pulse length check box becomes un-ticked and the pulse length value is read.

10.9 Reversing Detection

Reversing detection is an algorithm that can detect when the vehicle is travelling in reverse. Knowledge of reverse motion is important when using velocity heading or odometer input to provide correct results. If Spatial FOG is fitted to a vehicle that does not reverse or doesn't use velocity heading or odometer, this function should be disabled. Reversing detection is enabled by default and it can be disabled using the filter configuration dialogue in Spatial FOG Manager, see section 11.8.2.

10.10 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 it's primary benefit is in ground vehicles. When active it can be recognised by 2Hz steps in velocity data. Motion analysis is disabled by default and can be enabled using the filter configuration window in Spatial FOG Manager, see section 11.8.2.

10.11 RTK

Spatial FOG's internal GNSS receiver supports RTK GNSS which uses correction data from a base station to provide significantly higher positional accuracy than standard GNSS. RTK requires additional infrastructure equipment to receive corrections and is not practical for all applications. There are two different options for receiving RTK corrections. For applications where Spatial FOG can be connected to a computer that has access to the internet, network RTK corrections are recommended, see section 10.11.1. For applications that are unable to access the internet we recommend base station radio modem RTK corrections, see section 10.11.2.

10.11.1 Network RTK Corrections

Spatial FOG Manager has a built in NTRIP client that can connect to a network RTK service to provide RTK corrections to Spatial FOG. Please see section 11.9.3. This requires that the computer running Spatial FOG Manager is connected to the internet. It also requires a valid subscription with a local network RTK service. Typically these services will offer a free trial period. Please contact support@advancednavigation.com.au for assistance in getting set up for network RTK corrections.

10.11.2 Base station radio modem RTK corrections

Illustration 24: Trimble R8s base station

Illustration 25: Trimble TDL 450L radio modem

Base station radio modem RTK corrections require two additional pieces of hardware, these are the base station and the radio modem receiver. The base station is setup at a fixed location and transmits corrections to the radio modem receiver that is connected to the mobile Spatial FOG unit. The radio modem receiver and Spatial FOG unit must remain within range of the base station to receive these corrections, typically this range is approximately 50km. Advanced Navigation recommends contacting a local surveying company for assistance setting up a base station.

10.12 Raw Satellite Data

Spatial FOG supports outputting raw satellite data. This raw satellite data can be used by post-processing programs to achieve high accuracy kinematic positioning.

The maximum output rate for raw satellite data is 20Hz and it can be enabled by turning on the Raw Satellite Data Packet (ID 60) in the packet rates dialogue in Spatial FOG Manager, see Illustration 26. This packet will be automatically converted to RINEX v3.02 by Spatial FOG Manager’s log converter utility.

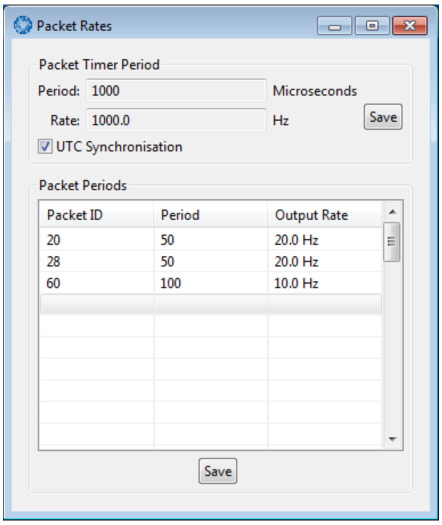


Illustration 26: Enabling packet 60

10.13 Post Processing

Spatial FOG can be used with Advanced Navigation's post processing platform Kinematica to achieve high accuracy kinematic positioning of 8mm and significantly improved dead reckoning performance.

To configure Spatial FOG for use with Kinematica please follow the steps below.

1. Connect to your device using Spatial FOG Manager.
2. Ensure your GNSS offset and any alignment offset has been entered as per the installation checklist in section 9.1.
3. Open the Baud Rates dialogue under the Configuration menu and set the primary port baud rate to 1,000,000. See Illustration 27. If you are using Windows ensure you have adjusted the latency settings for the serial port as detailed in section 11.4.2.
4. Open the Packet Rates dialogue under the Configuration menu and set up the packets as shown in Illustration 27.

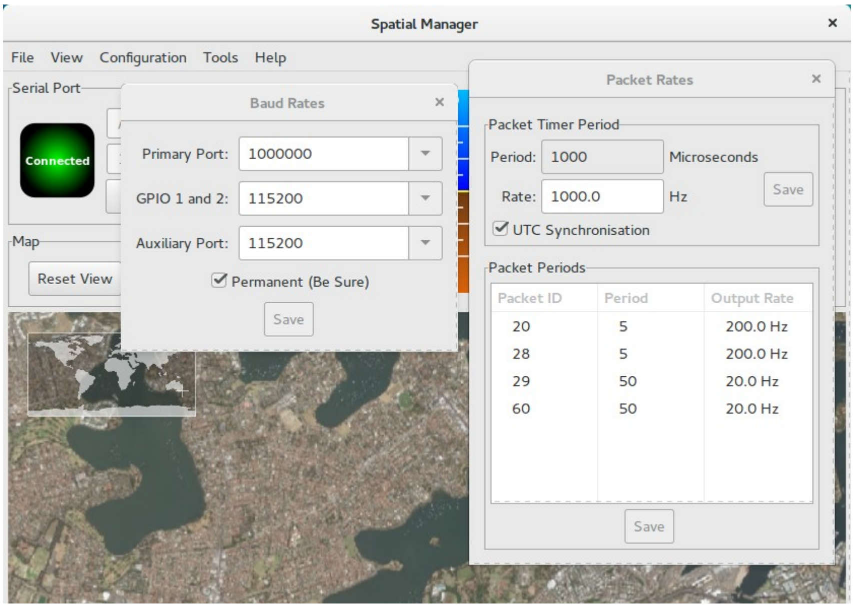


Illustration 27: Spatial Dual post processing configuration

For more information on using Kinematica, please see the Kinematica Reference Manual available for download from the Advanced Navigation website.

10.14 RAIM

RAIM stands for receiver autonomous integrity monitoring. It allows a GNSS receiver to detect and exclude both faulty and fraudulent satellite signals. Spatial FOG's internal GNSS is equipped with RAIM and it is enabled by default.

10.15 Heave

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

By default Spatial FOG provides heave from the point at which the Spatial FOG unit is mounted, however it can provide heave at four different offset points on the ship. To set the heave offsets, either use the heave configuration dialogue in Spatial FOG Manager, see section 11.8.9.

10.16 Environmental Exposure

Whilst Spatial FOG is environmentally protected, there are clearly defined limits to this protection that must be adhered to for reliable operation.

Spatial FOG is only protected when it's connector is mated and an IP67 SMA GNSS antenna is attached. When any of these connections are not made the unit offers no environmental protection.

Spanners or tools should never be used to tighten the connectors. They should only ever be finger tight.

10.16.1 Temperature

Spatial FOG should not be subjected to temperature's outside of it's operating range. Subjecting Spatial FOG to temperature's outside of the storage range can cause failure of the system.

10.16.2 Water

Spatial FOG is water-proof to the IP68 standard which means that it can be submersed in water to a depth of up to 2 metres only. Submersion to depths beyond 2 metres can cause water entry and destruction of the internal electronics.

10.16.3 Salt

Spatial FOG is made from marine grade aluminium which gives it reasonably good salt water corrosion resistance. However Spatial FOG cannot tolerate extended periods of time in salt water environments. After any contact with salt water environments, Spatial FOG should be thoroughly rinsed with fresh water.

10.16.4 Dirt and Dust

Spatial FOG is completely sealed against dirt and dust entry. It is important to note that this is only the case when the connectors are mated. When un-mating the connectors if the Spatial FOG unit is dirty or dusty, the dirt should be rinsed off with fresh water first and then dried off. This is to prevent dirt or dust entering the connectors which can cause them to fail.

10.16.5 PH Level

Environments with a high or low PH level can cause the Spatial FOG enclosure to corrode. If Spatial FOG comes into contact with these environments it should be rinsed in fresh water as soon as possible. It is not recommended to operate Spatial FOG in non neutral PH environments.

10.16.6 Shocks

Spatial FOG can tolerate shocks to 25g, however continuous shocks of this severity are likely to cause premature failure. Shocks above 25g can effect the factory sensor calibration and degrade performance. Normally shocks to Spatial FOG when mounted in a vehicle are fine. Even a high speed car crash is likely to reach a peak of only 50g. Shocks directly to Spatial FOG's enclosure can more easily go over the limit however so care should be taken when handling the unit prior to mounting.

11 Spatial FOG Manager

Spatial FOG Manager is a software tool provided by Advanced Navigation for logging, testing, display and configuration of Spatial FOG. It is designed to be simple and easy to use.

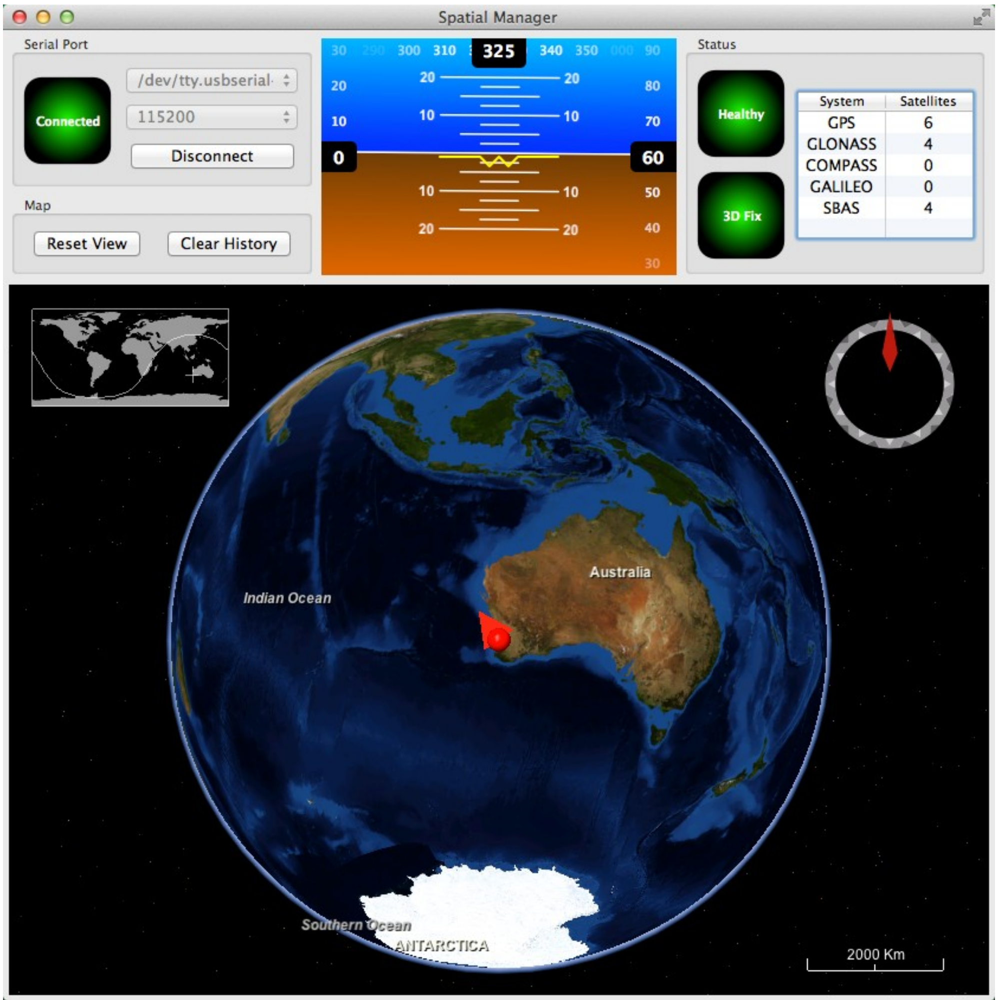


Illustration 28: Screenshot of Spatial FOG Manager

11.1 Software Changelog

Version	Date	Changes
7.2	10/11/2023	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 elevation to the gimbal state packet Fixed indicators behaviour on disconnect In satellites window, only populate azimuth and elevation fields in the table view when the values have been determined. Increased NTRIP client timeout Updated support for Mac silicon with latest macOS Removed 3D model display for better cross platform compatibility.
7.0	13/02/2023	Updated from JDK8 to JDK11. **JRE11/JDK11 required to run this release** Refresh Port Mode information on reconnection Refresh Packet Rates information on reconnection Improved reliability of firmware update 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 support for ARM (aarch64) processors with 64-bit OS Updated Seastar frequencies for Trimble receivers Updated RTX frequencies for Trimble receivers Added support for Apple M1 processors and improved MacOS support Various UI improvements
6.2	10/10/2022	Removed of SBAS corrections option when SBAS is not supported on the device Renamed position error to position standard deviation in position page of view menu Allowed copying version numbers etc from Device Information and GNSS Receiver Information dialog boxes. Clicking on the field will copy it to the clipboard. Supported NTRIP Casters that request Username & Password to retrieve Source Table. Renamed Log Conversion menu item Added Settings menu item

6.1	18/02/2022	Device information updated automatically after a firmware update GNSS receiver information is updated after applying a receiver option Improve display of Trimble receiver options Add ability to control log file location Included software version number in title Improved NTRIP mountpoint selection. Added handling of non-standard NTRIP server responses Improved NTRIP server reconnection Improved Log files saved by default in the directory from where the application is launched Improve export configuration reliability Updated source of map tiles Force the device to exit bootloader mode if a firmware update is not in progress
4.4	12/04/2016	Extended NTRIP support for older versions Log converter now outputs a KML file for Google Earth with detailed information as well as the GPX file Added serial port passthrough tool Secondary antenna raw satellite data is now converted to RINEX as well as the primary antenna
4.3	17/08/2015	Spatial Manager now requests all configuration upon connection Spatial Manager converts any configuration packets found in ANPP log files into text Bug fix for NTRIP invalid connection
4.2	02/04/2015	Added network connection capability Added NTRIP client Two new satellite views in satellites dialogue Added gimbal configuration dialogue Heave offsets changed to reference point offsets
4.0	10/10/2014	Improvements to the 3D map Support for more graphics cards Status display now shows when heading not initialised Communications dialogue added, section 11.7.8 GNSS receiver dialogue added, section 11.7.9 Heave dialogue added, section 11.7.10 North seeking status dialogue added, section 11.7.11 GPIO output configuration dialogue added, section 11.8.10 Dual antenna configuration dialogue added Configuration dialogues now auto update
3.1	15/10/2013	Added 3D model dialogue, section Error: Reference source not found Added configuration export dialogue, section 11.8.1
3.0	13/09/2013	Initial Release

11.2 System Requirements

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

The software includes a 3D mapping display which requires a modern 3D graphics card and up to date drivers to run. If your machine does not meet the graphics requirements the mapping view will only show space without a globe.

When Spatial FOG is running at very high output rates e.g. 1000 Hz, Spatial FOG Manager can consume significant system resources handling the large quantity of data.

11.3 Installation

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

- Java 11 is required to run Spatial FOG 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.
- Spatial FOG Manager does not need to be installed and 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 SpatialFOGManager-7.x.jar
- On Linux systems it may be necessary to run the application from a terminal window:

  java –jar SpatialFOGManager-7.x.jar

The Spatial FOG evaluation kit makes use of an FTDI USB to RS422 device. The drivers are normally installed automatically, if not they are available from http://www.ftdichip.com/Drivers/VCP.htm.

11.4 Troubleshooting

Please contact support@advancednavigation.com.au if you are having issues.

11.4.1 All Platforms

If the globe does not appear in the 3D map area, this indicates that either your graphics card is not powerful enough or your graphics card driver is out of date.

11.4.2 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. Unfortunately Microsoft has not fixed this problem in over 15 years, so it probably won't be fixed. If you experience this problem, often a restart will resolve it. Otherwise there is a tool available at http://www.stentec.com/anonftp/pub/wingps/pnpblockersetup.exe that can fix the issue.

If the serial port does not show up when you plug in your Spatial FOG USB device, you may need to install the drivers from http://www.ftdichip.com/Drivers/VCP.htm.

If you experience a blue screen of death whilst using Spatial FOG Manager, this is typically a problem associated with older FTDI drivers. To resolve the problem, install the latest drivers from http://www.ftdichip.com/Drivers/VCP.htm.

When operating Spatial FOG at a very 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 by going to control panel → system → device manager → ports and right click on the USB serial port, then click properties. In the properties window click the port settings tab and then the advanced button. You then need to change the latency timer setting to 1ms. Please see the screenshot in Illustration 29.

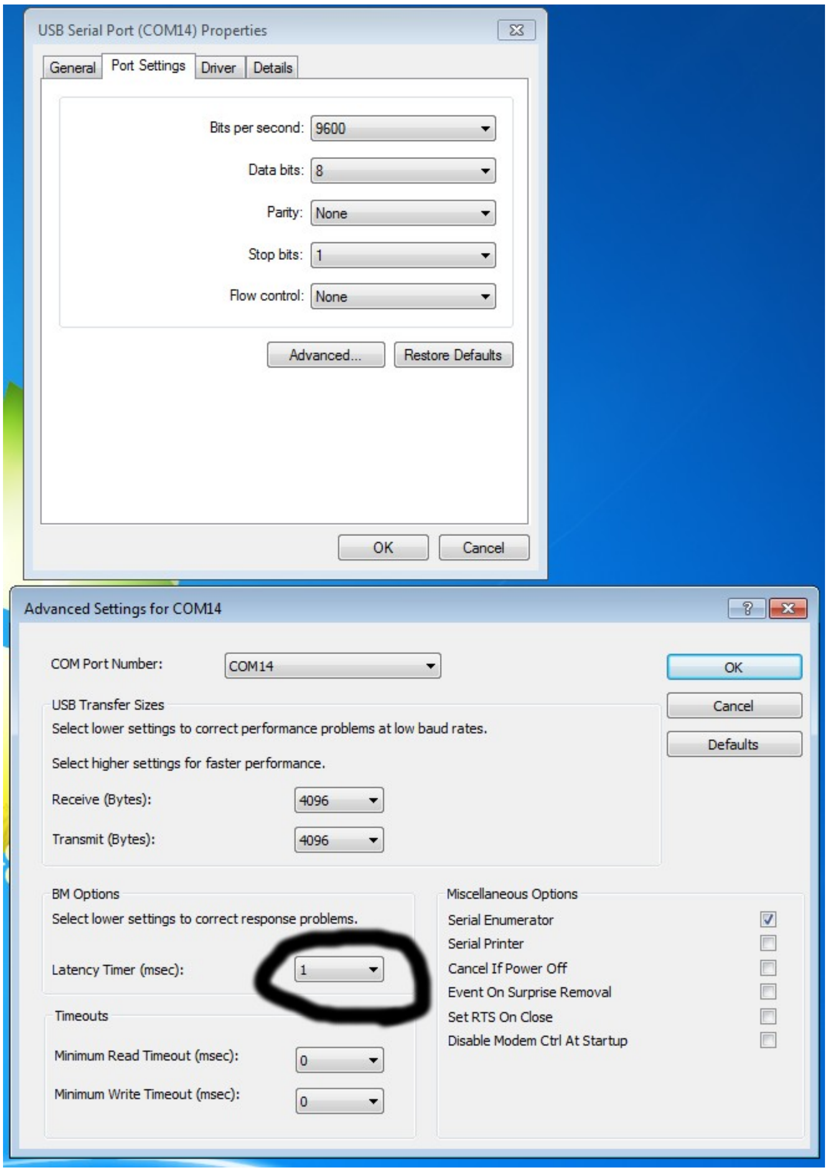


Illustration 29: Screenshot of latency timer setting

11.4.3 Linux

If serial ports do not show up, the typical cause is 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.

Spatial FOG Manager is able to run on the OpenJDK JRE but it uses significantly more system resources than when it is running on the Oracle JRE.

11.5 Main View

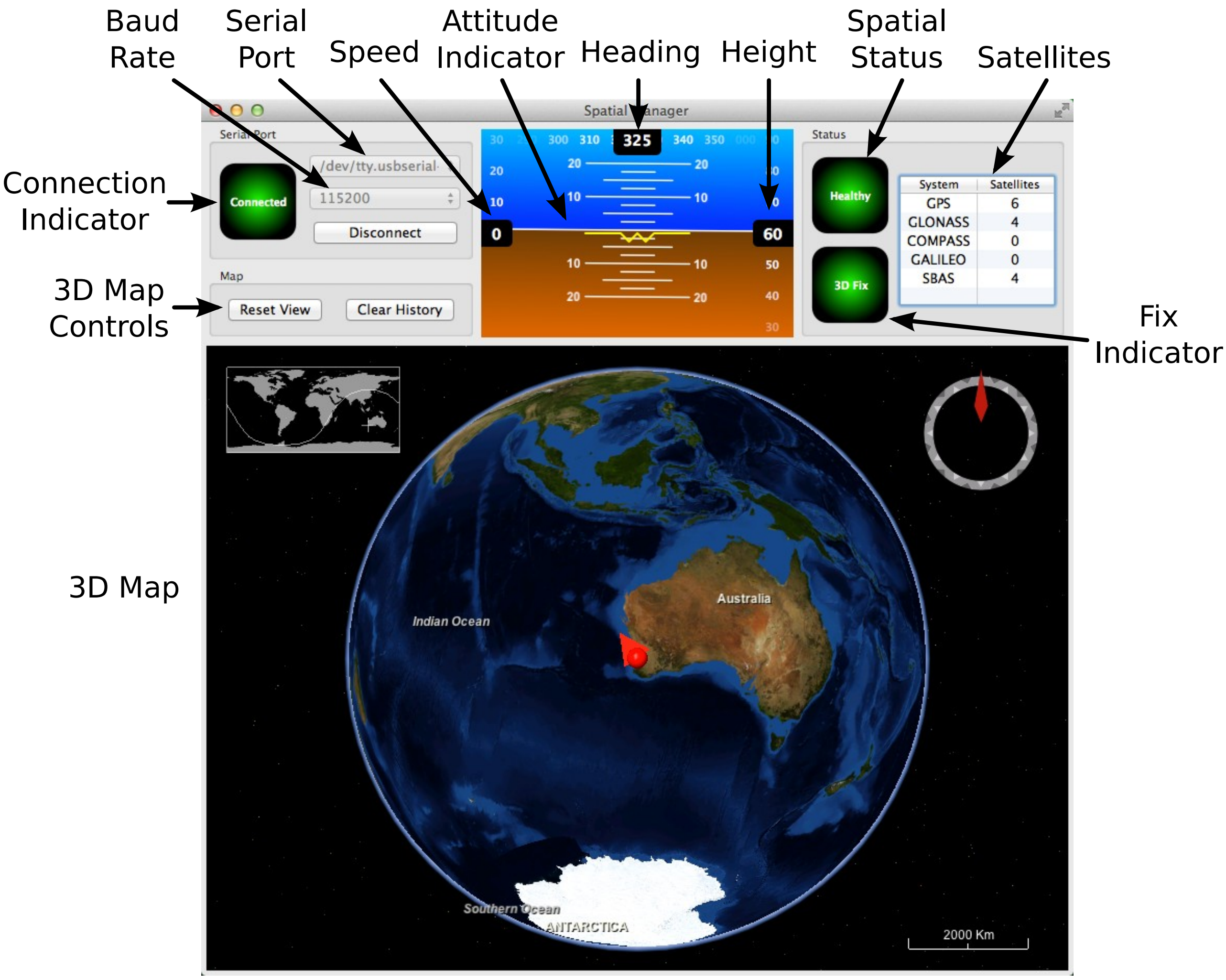


Illustration 30: Screenshot of Spatial FOG Manager main view

11.5.1 Serial Port

The serial port dialogue is used to connect to Spatial FOG. You should select a serial port and baud rate and click connect. The default baud rate of Spatial FOG is 115200. The connection indicator displays whether there is communication with a Spatial FOG unit.

11.5.2 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.

11.5.3 Status Indicator

The status indicator section contains a Spatial FOG status indicator, a fix indicator and a satellites table.

11.5.3.1 Spatial Status Indicator

This indicator shows any problems with Spatial FOG. Before a GNSS 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.

11.5.3.2 Fix Indicator

This shows the status of the GNSS 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”.

11.5.3.3 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.

11.5.4 3D Map

The 3D map shows Spatial FOG's 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 Spatial FOG's location. To move the camera click and drag on the map. To zoom in and out use the scroll wheel. To change the camera view right click and drag or shift click and drag.

11.5.5 3D Map Controls

11.5.5.1 Reset View

This resets the map view to Spatial FOG's current position.

11.5.5.2 Clear History

This clears the current position history, this is the red trail shown on the map.

11.6 Logging

Spatial FOG Manager features a fully automatic logging system. Every time the serial port connect button is clicked Spatial FOG Manager starts a new log file in either the current directory or the user's home directory. The log file is given the file name SpatialLog_date_time.anpp and contains all of the raw data received from Spatial FOG in the AN packet protocol. The log files are closed when the serial port is disconnected.

Logging can be disabled via command line -n,--logdisable, and log file location can be set via command line -l,--logpath <Path of output logfile>.

To convert these log files into easily accessible formats, the log converter dialogue in the tools menu can be used, see section 11.9.2. The log converter dialogue 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 of position that is designed to be opened with Google Earth.

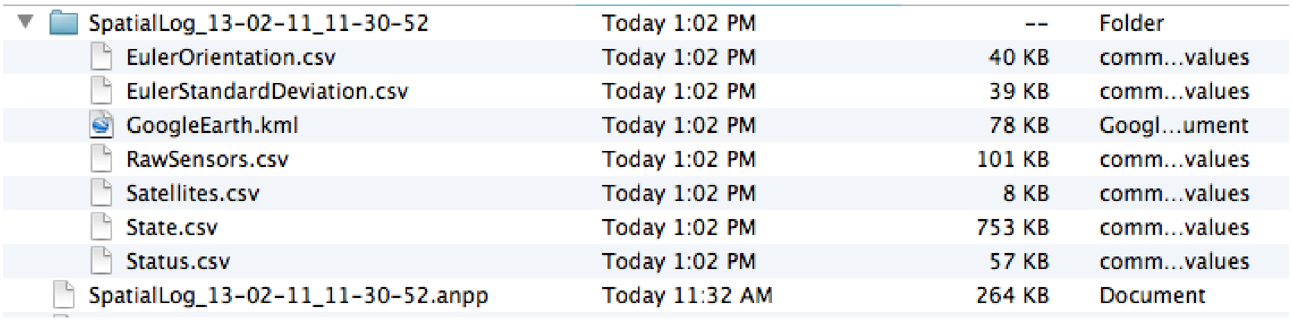


Illustration 31: Screenshot showing log file and log conversion folder

11.7 Views

The views menu contains a number of different options for viewing data from Spatial FOG.

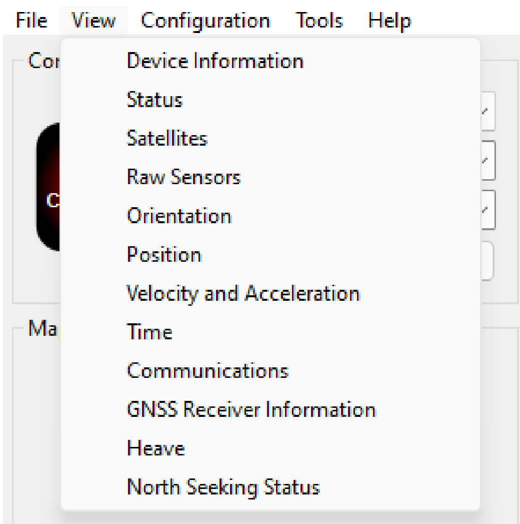


Illustration 32: Screenshot of Spatial FOG Manager views menu

11.7.1 Device Information

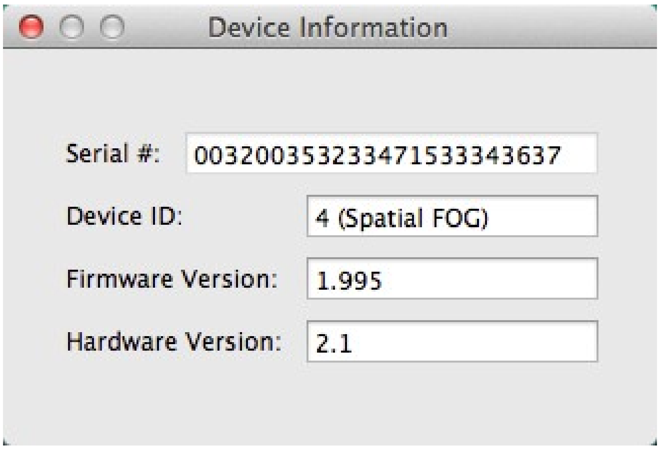


Illustration 33: Screenshot of Spatial FOG Manager device information dialogue

11.7.2 Status

Status shows Spatial FOG's complete status as contained in the system state packet detailed in section 13.9.1.1.

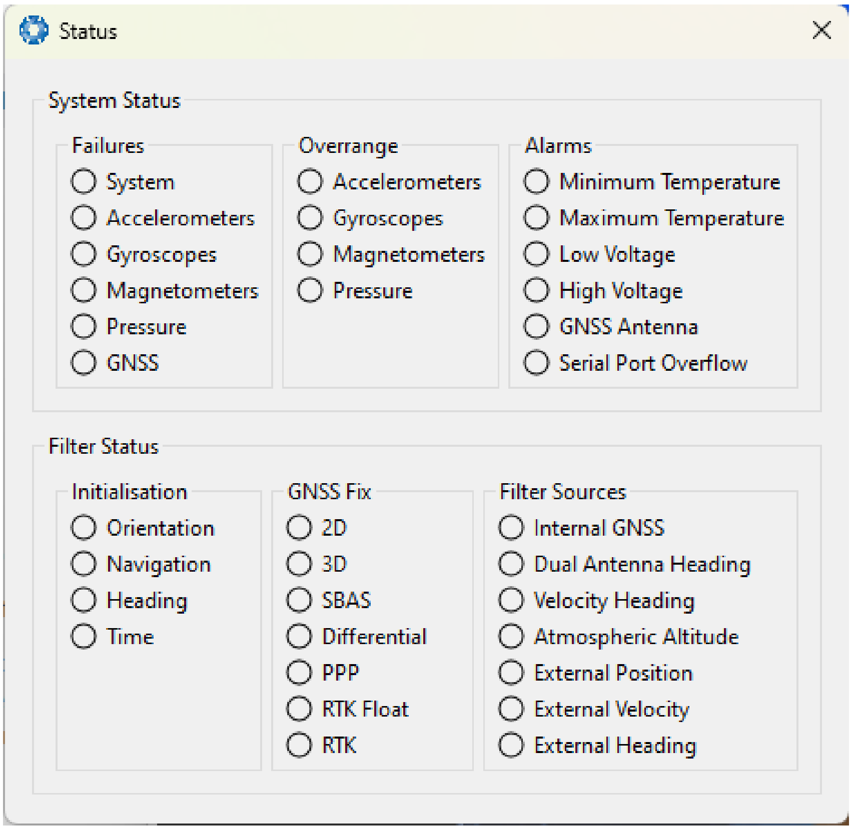
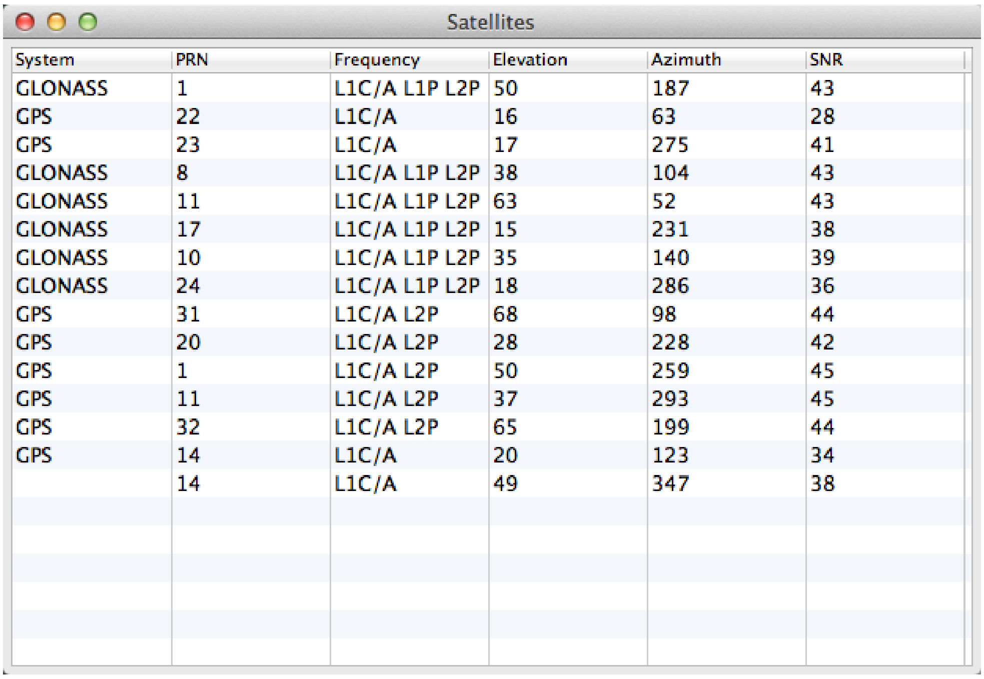


Illustration 34: Screenshot of Spatial FOG Manager status dialogue

11.7.3 Satellites

Satellites shows detailed information on the satellites that Spatial FOG's GNSS receiver is tracking. Elevation and azimuth are in units of degrees.



Satellites

System	PRN	Frequency	Elevation	Azimuth	SNR
GLONASS	1	L1C/A L1P L2P	50	187	43
GPS	22	L1C/A	16	63	28
GPS	23	L1C/A	17	275	41
GLONASS	8	L1C/A L1P L2P	38	104	43
GLONASS	11	L1C/A L1P L2P	63	52	43
GLONASS	17	L1C/A L1P L2P	15	231	38
GLONASS	10	L1C/A L1P L2P	35	140	39
GLONASS	24	L1C/A L1P L2P	18	286	36
GPS	31	L1C/A L2P	68	98	44
GPS	20	L1C/A L2P	28	228	42
GPS	1	L1C/A L2P	50	259	45
GPS	11	L1C/A L2P	37	293	45
GPS	32	L1C/A L2P	65	199	44
GPS	14	L1C/A	20	123	34
	14	L1C/A	49	347	38

Illustration 35: Screenshot of Spatial FOG Manager satellites dialogue

11.7.4 Raw Sensors

Raw sensors shows the temperature calibrated raw sensor values.

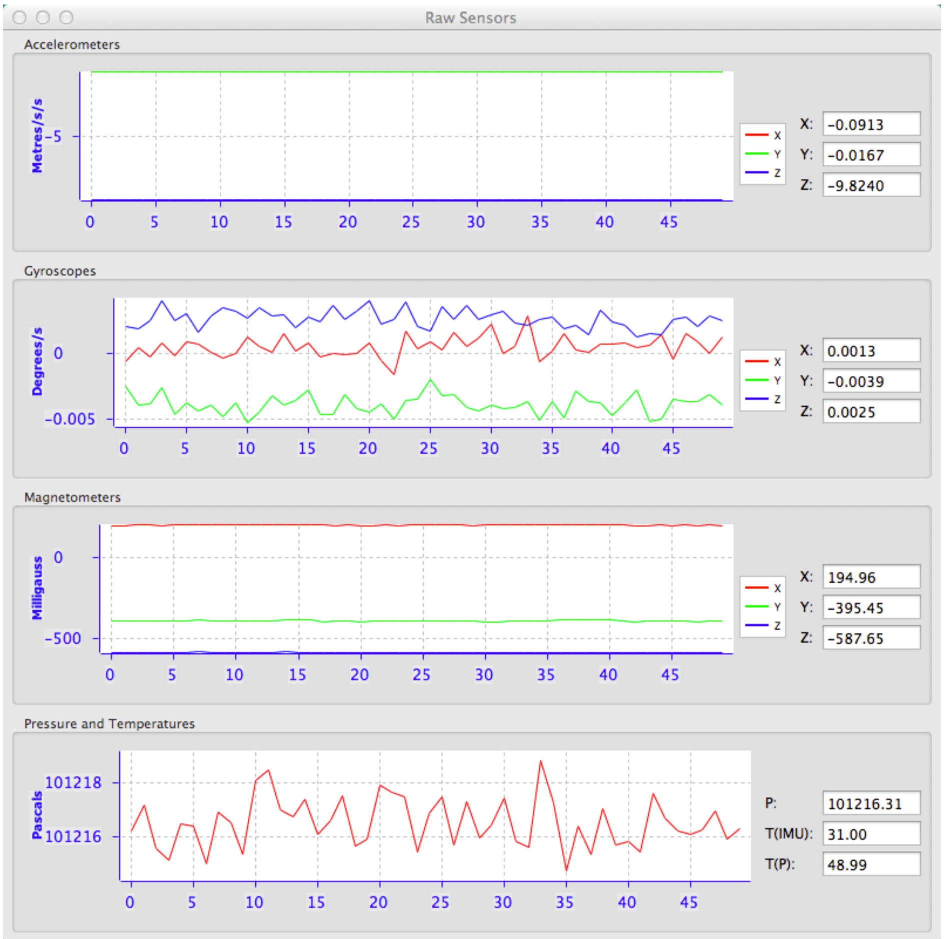


Illustration 36: Screenshot of Spatial FOG Manager raw sensors dialogue

11.7.5 Orientation

Orientation shows Spatial FOG's orientation, angular velocity and orientation error.

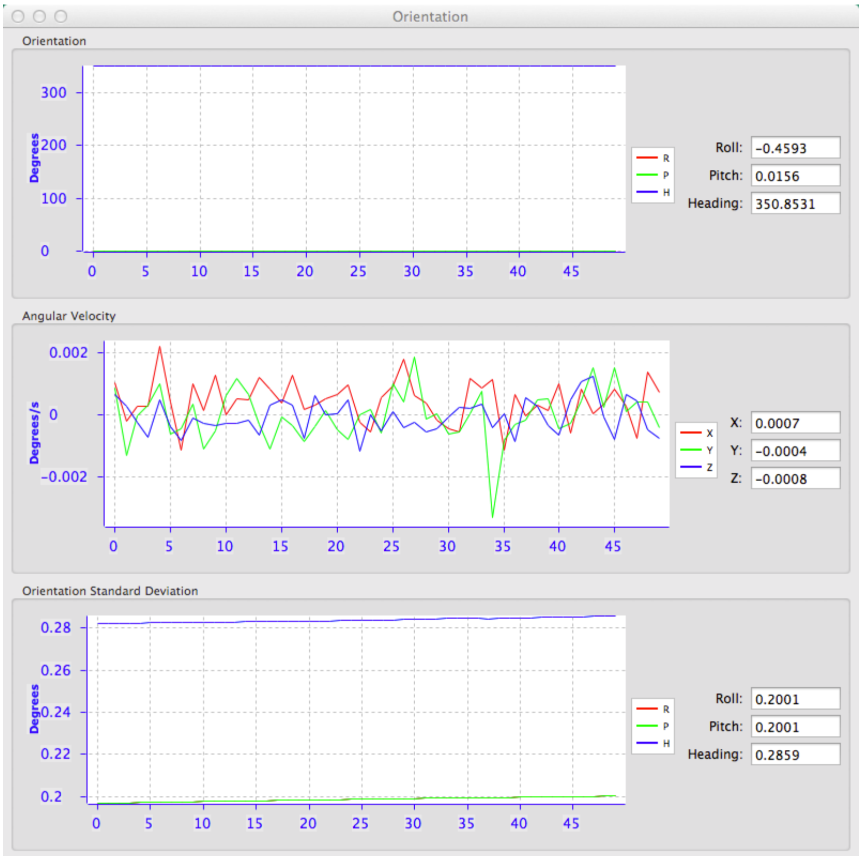


Illustration 37: Screenshot of Spatial FOG Manager orientation dialogue

11.7.6 Position

Position shows Spatial FOG's position and position error. Latitude and longitude are converted to North and East metres from a reference point that can be reset.

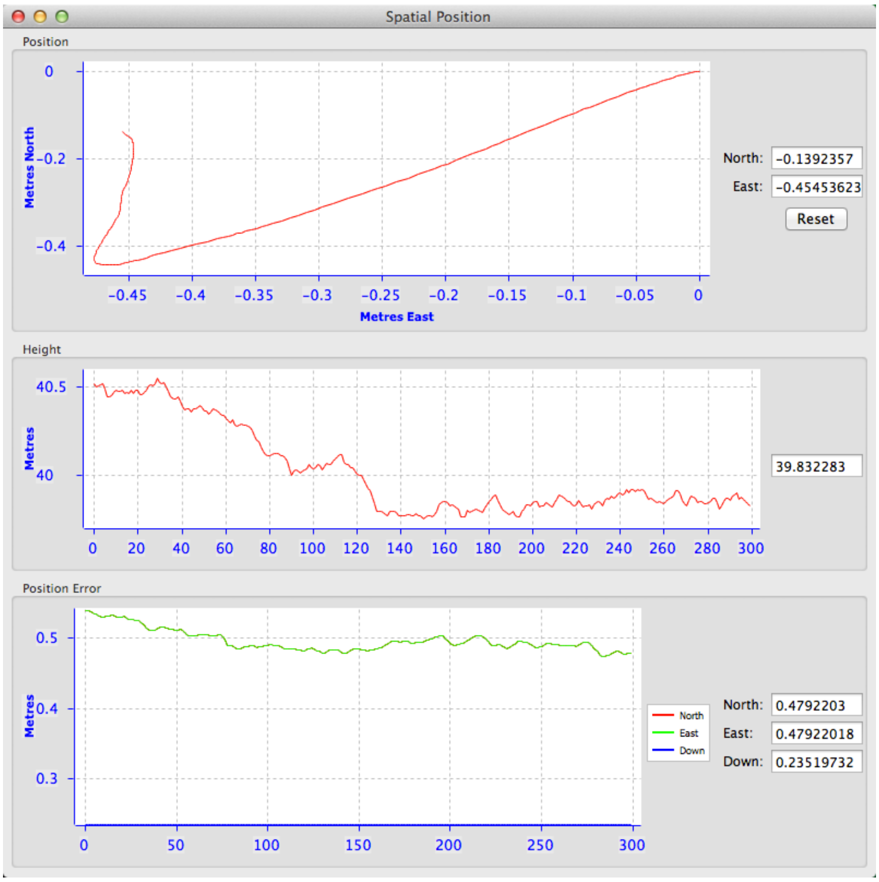


Illustration 38: Screenshot of Spatial FOG Manager position dialogue

11.7.7 Velocity and Acceleration

Velocity and Acceleration shows Spatial FOG's velocity, acceleration and g-force.

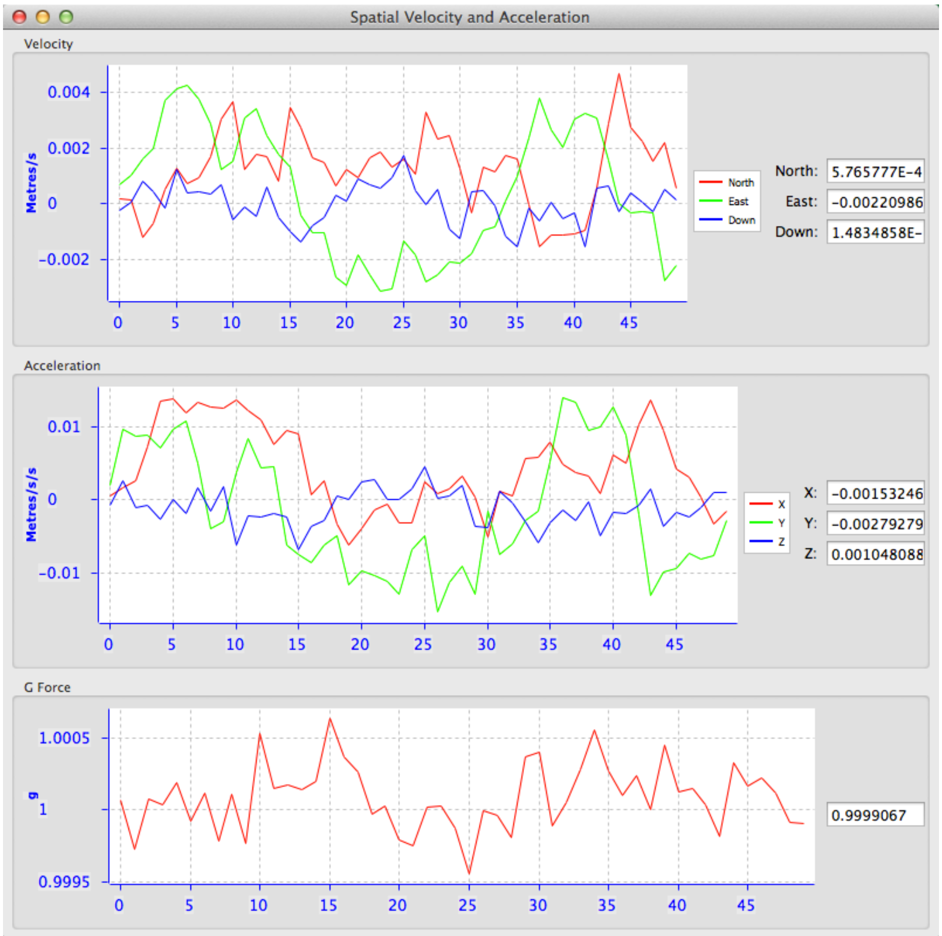


Illustration 39: Screenshot of Spatial FOG Manager velocity and acceleration dialogue

11.7.8 Communications Statistics

This dialogue shows statistics on the data packets received from Spatial FOG and can be useful in diagnosing signal integrity problems.

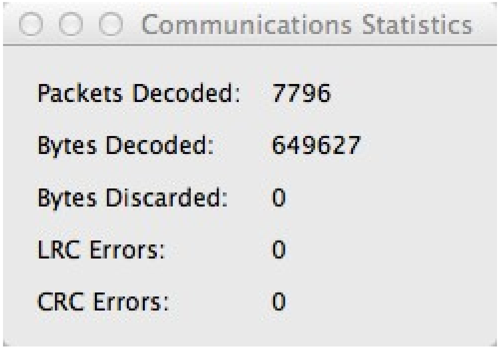


Illustration 40: Screenshot of Spatial FOG Manager communications statistics dialogue

11.7.9 GNSS Receiver Information

This dialogue shows information on the internal GNSS receiver contained inside of Spatial FOG.

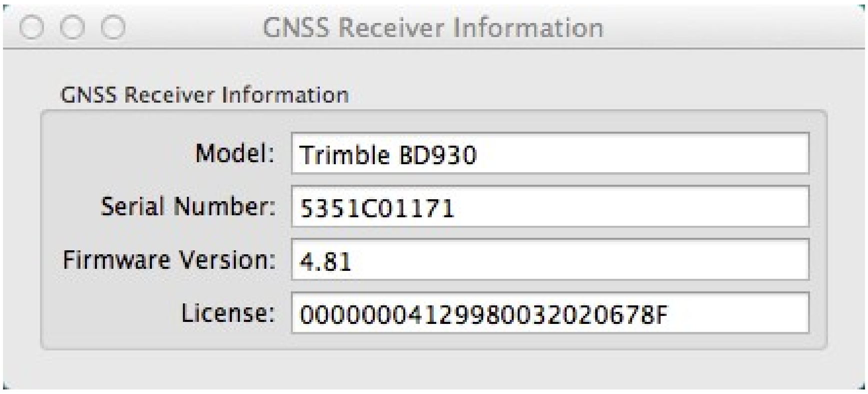


Illustration 41: Screenshot of Spatial FOG Manager GNSS receive information dialogue

11.7.10 Heave

For the heave dialogue to function the heave packet (ID 58) must be set to output periodically using the Packet Rates dialogue.

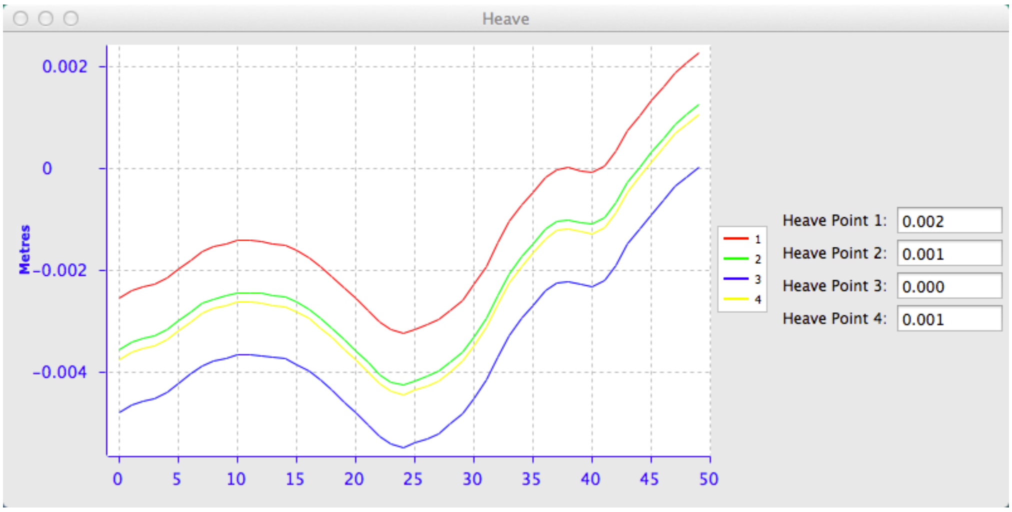


Illustration 42: Screenshot of Spatial FOG Manager heave dialogue

11.7.11 North Seeking Status

The north seeking status view guides the user through the north seeking initialisation procedure and provides feedback on the progress. It is not necessary to use this dialogue to perform the north seeking initialisation, however it can be very helpful for users getting accustomed to the process. The error value provided gives an approximation of the bias convergence accuracy. A good initialisation should yield an error of less than 10%. Each quadrant represents a 90 degree segment about the Z axis in which data must be collected and the unit starts at zero degrees in quadrant 1 when powered on, see Illustration 44.

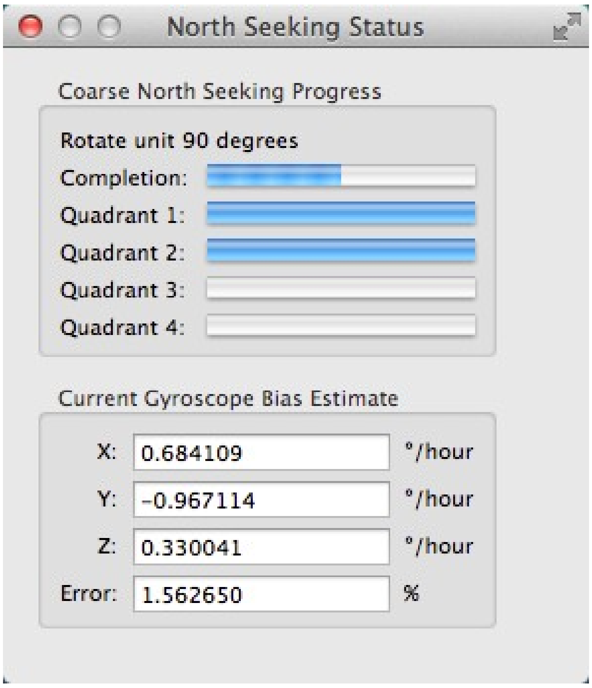


Illustration 43: Screenshot of Spatial FOG Manager north seeking status dialogue

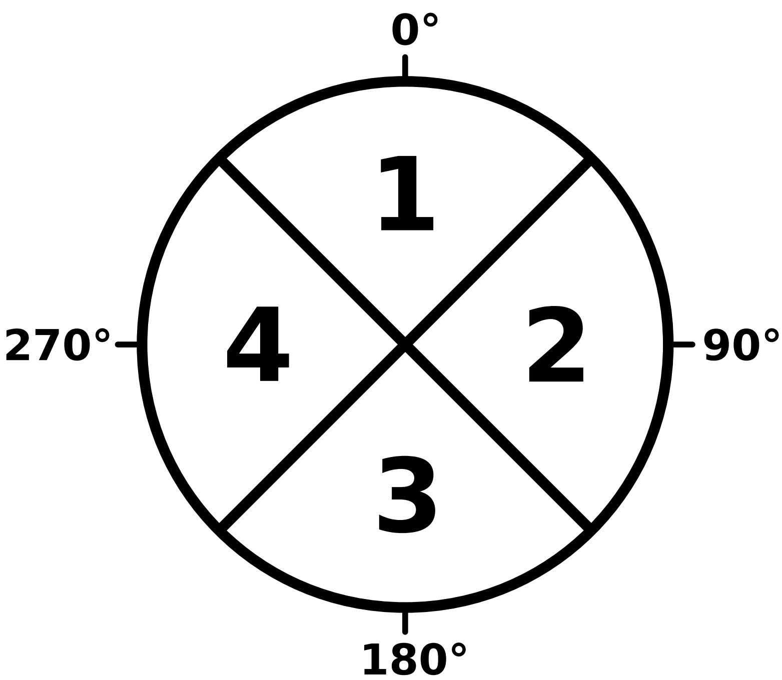


Illustration 44: North seeking quadrants around Z axis

11.8 Configuration

The configuration menu contains a number of dialogues for the configuration of Spatial FOG.

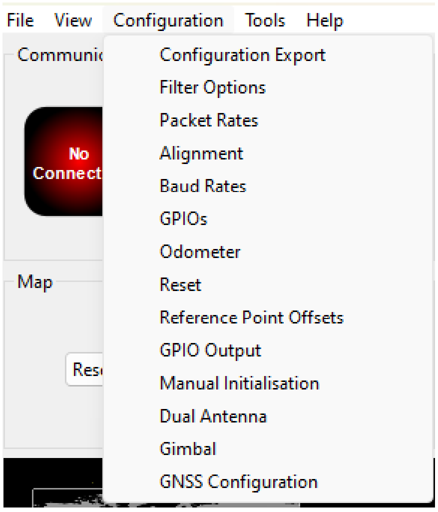


Illustration 45: Screenshot of Spatial FOG Manager configuration menu

11.8.1 Configuration Export

The configuration export dialogue can be used to export all Spatial FOG 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 preset configuration at a later date or for batch configuration of multiple units.

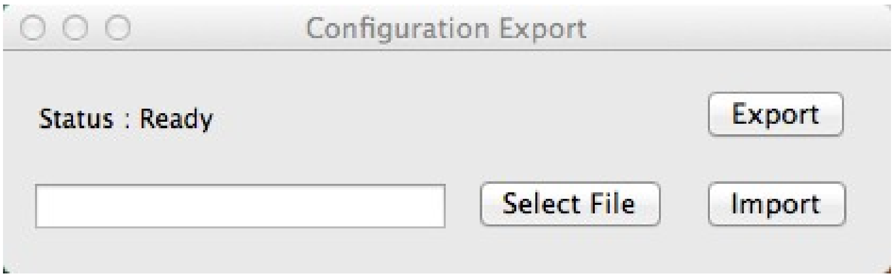


Illustration 46: Screenshot of Spatial Manager configuration export dialogue

11.8.2 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.au.

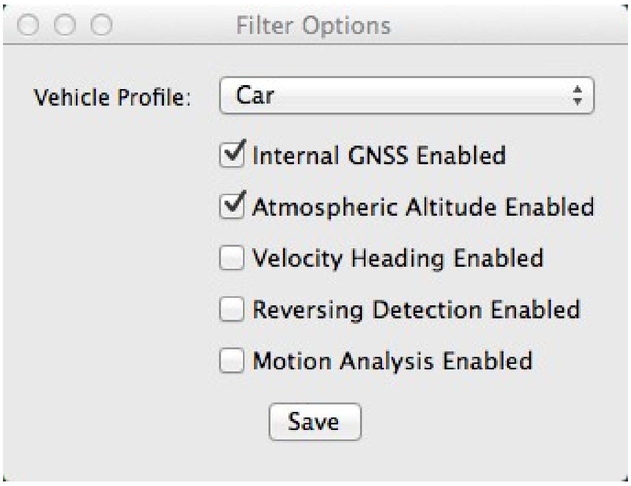


Illustration 47: Screenshot of Spatial FOG Manager filter options dialogue

11.8.3 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 Spatial FOG Manager. Other state packets can be enabled as required. Please see the Packet Summary table in section 13.7 for a list of all packets.

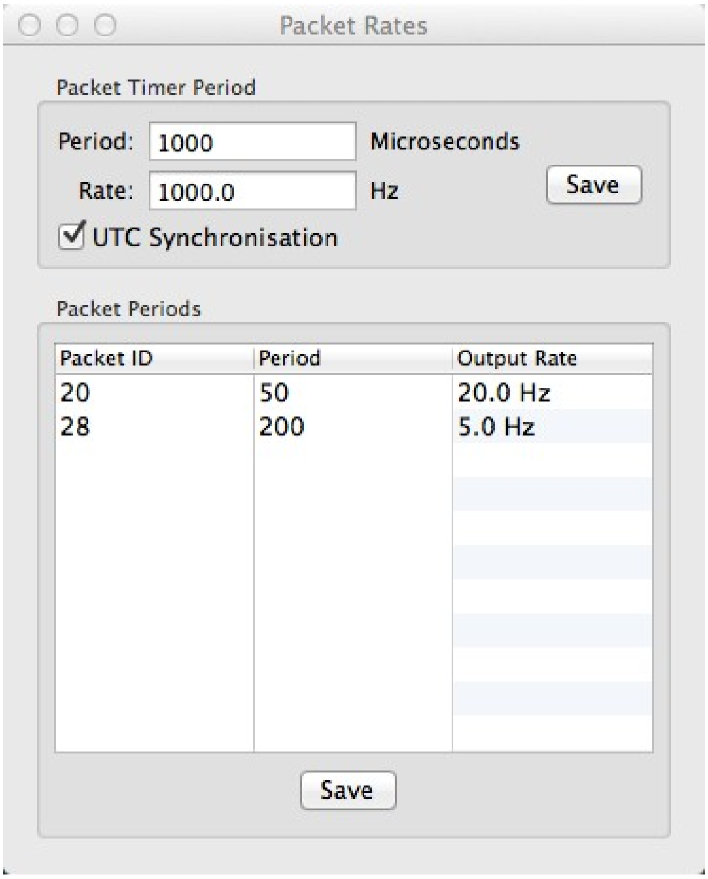


Illustration 48: Screenshot of Spatial FOG Manager packet rates dialogue

11.8.4 Alignment Configuration

The alignment configuration 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.

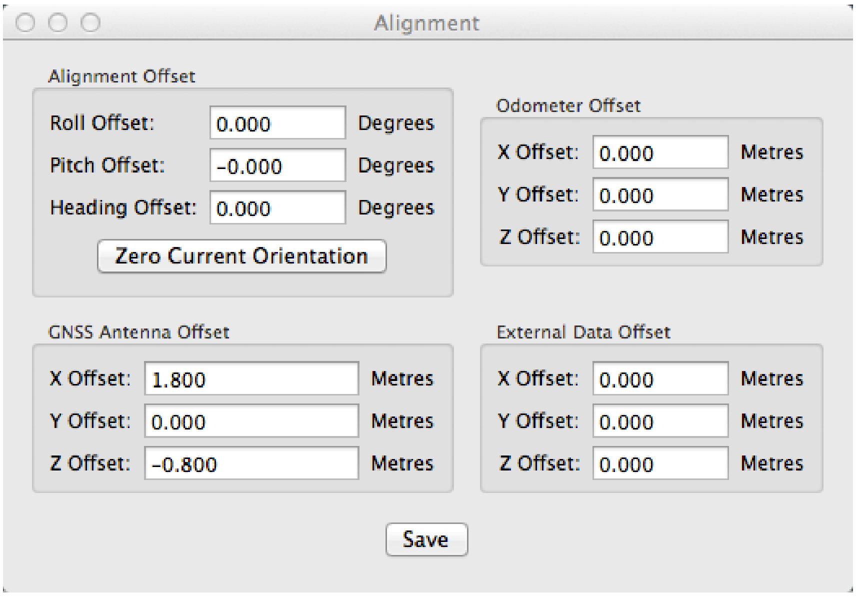


Illustration 49: Screenshot of Spatial FOG Manager alignment configuration dialogue

11.8.4.1 Alignment Offset

If Spatial FOG is installed into the vehicle with the X axis pointing forwards and the 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. Please note that this 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.

11.8.4.2 GNSS Antenna Offset

The GNSS antenna offset is measured from the centre of the Spatial FOG unit to the centre of the antenna in the body co-ordinate frame (X positive forward, Z positive down).

11.8.4.3 Odometer Offset

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

11.8.4.4 External Data Offset

These values are only required for speciality applications operating with external sources of data. Please contact support@advancednavigation.com.au for assistance with these values.

11.8.5 Baud Rates

When changing baud rates, some Microsoft Windows machines are unable to function at the higher baud rates. It is recommended to test the baud rate first with the permanent box unticked. 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.

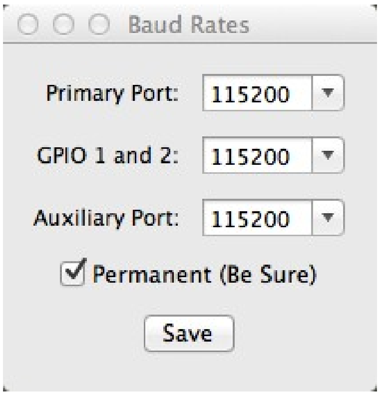


Illustration 50: Screenshot of Spatial FOG Manager baud rates dialogue

11.8.6 GPIO Configuration

This dialogue allows the user to select the function of the GPIO pins and Auxiliary RS232. These functions change dynamically and are effective immediately upon pressing save. Please note that GPIO pins function at RS232 levels for data functions and 0 to 5 volt levels for all other functions. The internal hardware automatically reconfigures based upon the selected function.

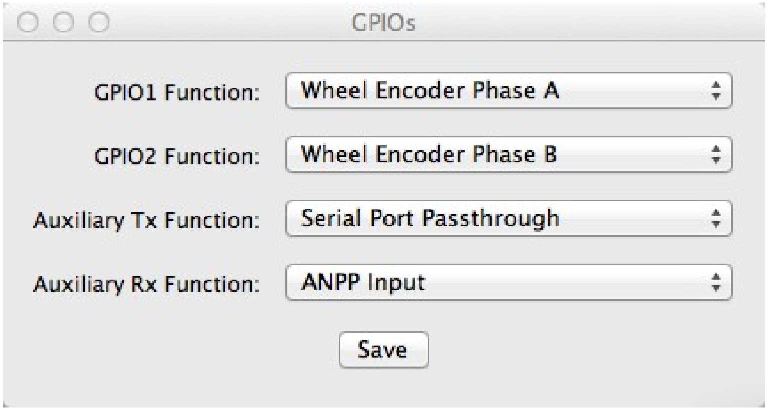


Illustration 51: Screenshot of Spatial FOG Manager GPIO configuration dialogue

11.8.7 Odometer

The odometer dialogue allows the user to configure the odometer pulse length and view the real time odometer data to verify correct operation.

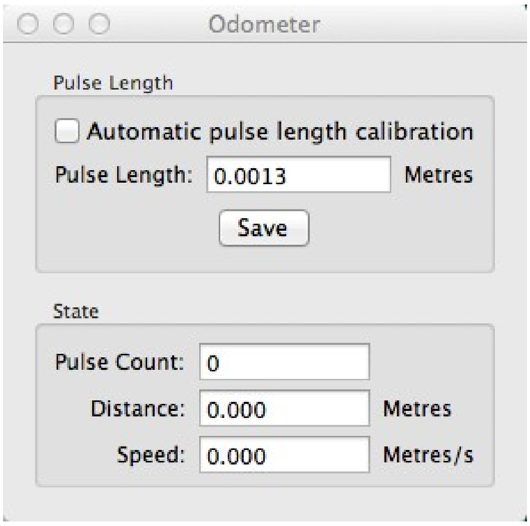


Illustration 52: Screenshot of Spatial FOG Manager odometer configuration dialogue

11.8.8 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 Reset button resets all 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.

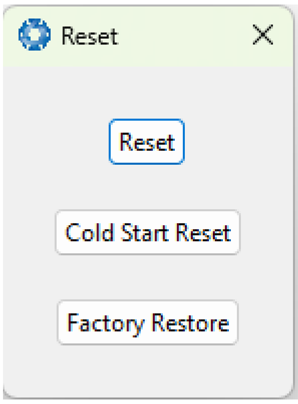


Illustration 53: Screenshot of Spatial FOG Manager reset dialogue

11.8.9 Heave Offset

The heave offset dialogue allows the user to move the heave measurement points to different positions on the vessel. When the values are zero the measurement point is the centre of the Spatial FOG unit. This can be offset to a different position on the ship by entering the offset value from the centre of the Spatial FOG unit to the desired position in the body co-ordinate frame (X positive forwards, Z positive down). Please note that 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 Spatial FOG unit.

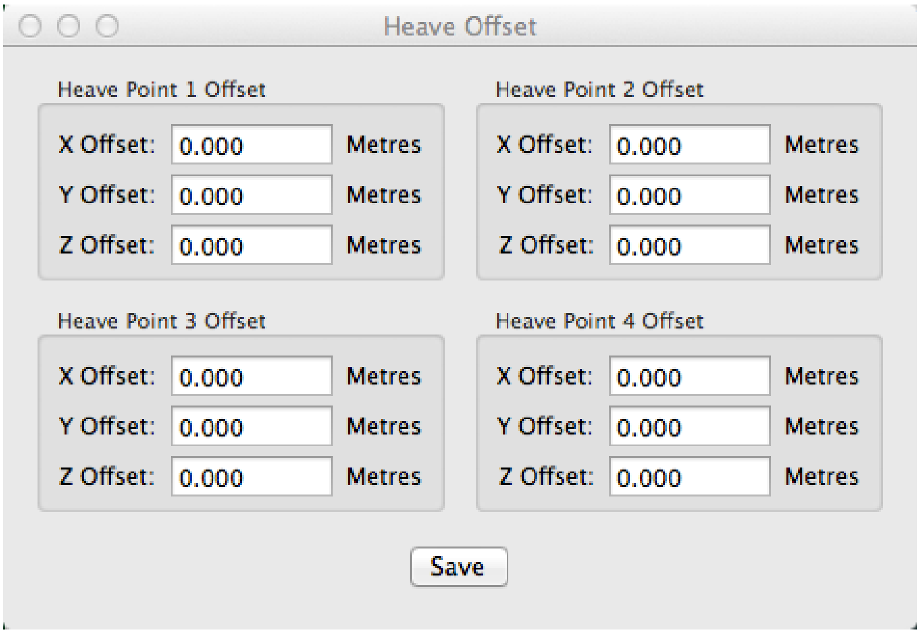


Illustration 54: Screenshot of Spatial FOG Manager heave offset dialogue

11.8.10 GPIO Output

The GPIO output configuration dialogue allows the user to configure the output rates for the GPIO and Auxiliary RS232 data functions NMEA, TSS and PASHR.

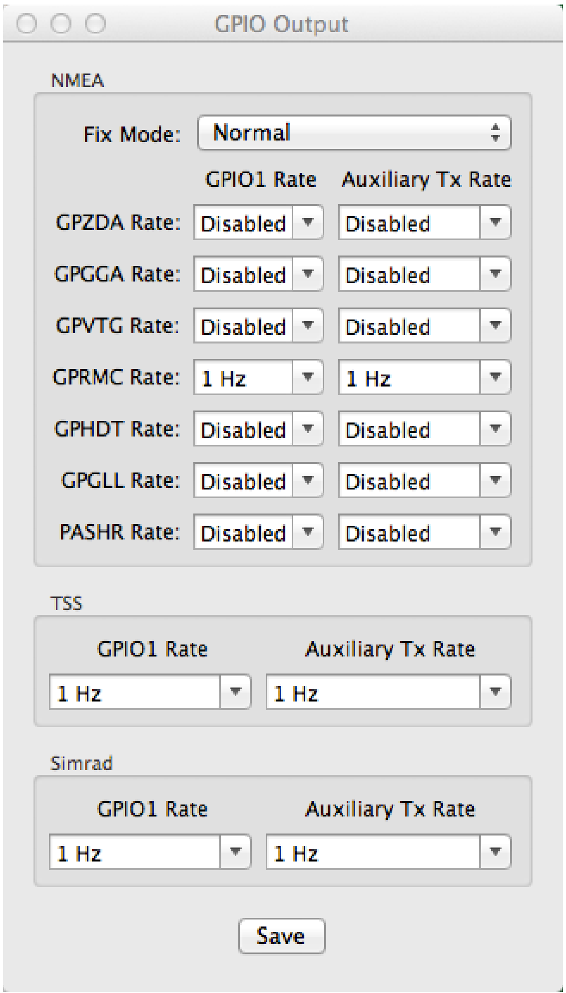


Illustration 55: Screenshot of Spatial FOG Manager GPIO output configuration dialogue

11.8.11 Manual Initialisation

The manual initialisation dialogue can be used to set the position of Spatial FOG when the unit is supplied without a GNSS receiver or when a GNSS fix is not available. Setting this value will initialise navigation. The heading value can also be set manually in the absence of a heading source, this will initialise the heading filter.

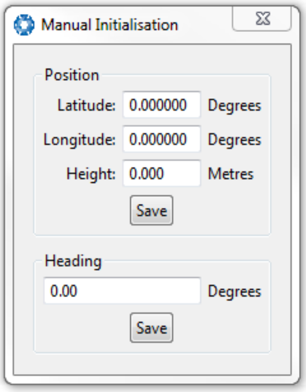


Illustration 56: Screenshot of Spatial FOG Manager Manual Initialisation configuration dialogue

11.9 Tools

The tools menu contains tools for performing procedures with Spatial FOG.

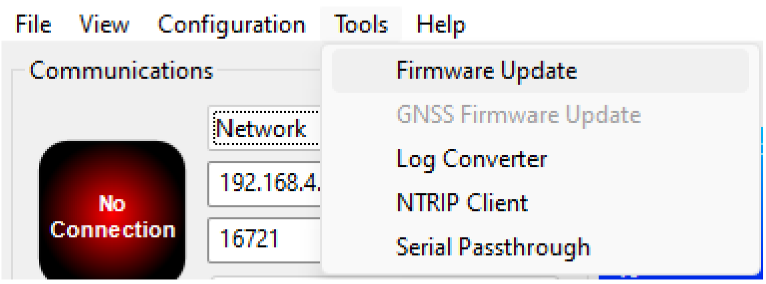


Illustration 57: Screenshot of Spatial FOG Manager tools menu

11.9.1 Firmware Update

The firmware update dialogue is used to update Spatial FOG's firmware. Advanced Navigation firmware files have the extension .anfw. The dialogue shows the version number of the firmware file along with the date and time it was generated by engineering.

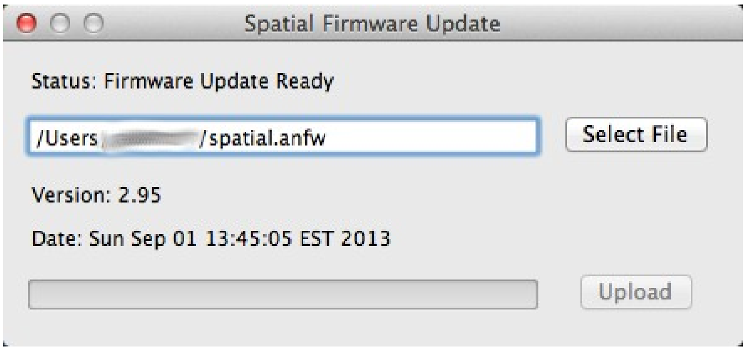


Illustration 58: Screenshot of Spatial FOG Manager firmware update dialogue

11.9.2 Log Converter

This tool allows the user to convert Spatial FOG log files into various standard formats that are readable by many programs, as well as set a user configurable log path. The position offset values can used to project the exported position to a point other than the centre of the Spatial FOG unit. For most users these values should be left at zero.

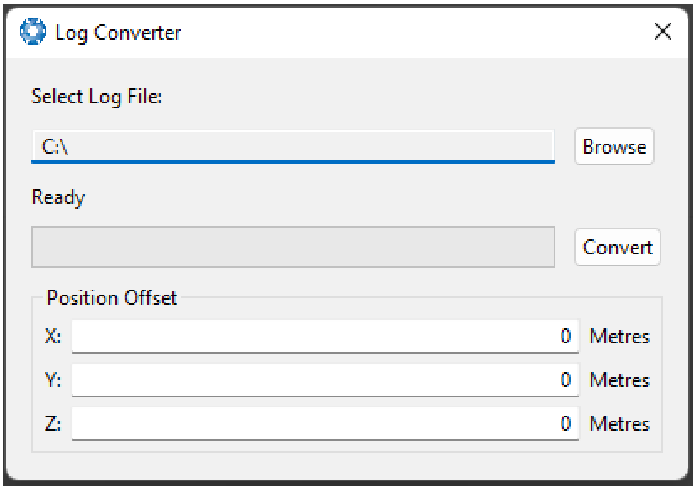


Illustration 59: Screenshot of Spatial FOG Manager Log Converter dialogue

To configure the Log path, navigate to *Settings* under the File menu

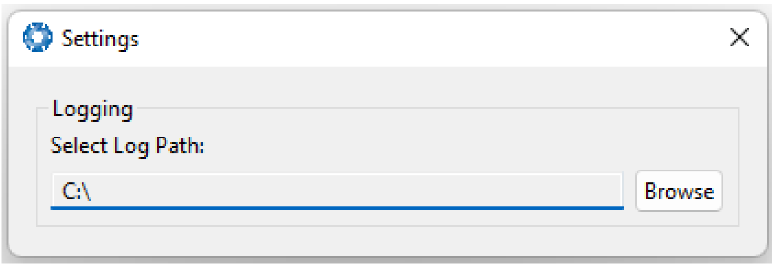


Illustration 60: Settings menu for configuring log path

11.9.3 NTRIP Client

The NTRIP client can be used to connect to a network DGPS or RTK service to stream correction data to Spatial FOG for DGPS or RTK. The NTRIP client requires an internet connection to function. Please contact support@advancednavigation.com.au for guidance on getting set up with network DGPS or RTK.

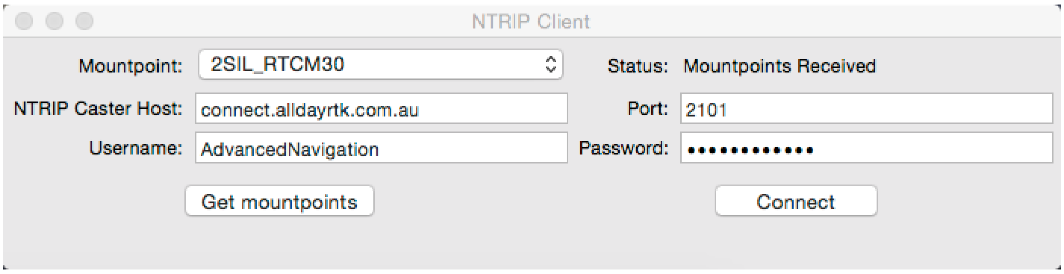


Illustration 61: Screenshot of Spatial FOG Manager NTRIP client dialogue

11.9.4 Network Connect

The network connect dialogue allows Spatial FOG Manager to make a connection to Spatial FOG over a TCP/IP network rather than the default serial port connection. This allows Spatial FOG to be used with ethernet to serial converters. Advanced Navigation recommends Lantronix ethernet to serial converters.

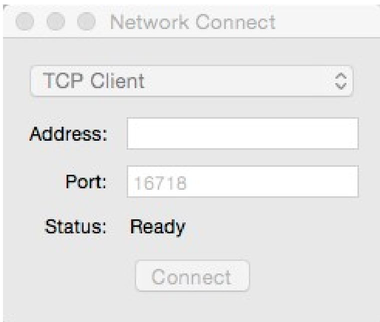


Illustration 62: Screenshot of Spatial FOG Manager network connect dialogue

12 Interfacing

12.1 Communication

Communication with Spatial FOG is over the primary RS422 or RS232 interface in the Advanced Navigation Packet Protocol (ANPP). The RS422 or RS232 format is fixed at 1 start bit, 8 data bits, 1 stop bit and no parity. See section 13 for details on the protocol.

12.1.1 Baud Rate

The default baud rate of Spatial FOG is 115,200. The primary port RS422 baud rate can be set anywhere from 2400 to 10,000,000 baud and can be modified using the Spatial FOG Manager software or the baud rate packet, see section 13.10.3. It is important to select a baud rate that is capable of carrying the amount of data that Spatial FOG is set to send. See packet rates in section 13.5 for more details on 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, then the data rate is 11,520 bytes per second.

12.2 External Data

External sources of position, velocity and/or heading can be integrated into Spatial FOG's filter solution. The data can be sent to Spatial FOG in the ANPP format over the primary port or through one of the GPIO pins in a number of different formats. If using the ANPP, please use Table 17 below to find the relevant section. If using the GPIOs, please see section 12.3.

Packet	Section
External Position and Velocity	13.9.25
External Position	13.9.26
External Velocity	13.9.27
External Body Velocity	13.9.28
External Heading	13.9.29
External Time	13.9.33
External Depth	13.9.34
External Odometer	13.9.43
External Air Data	13.9.44

Table 17: ANPP external data reference

12.3 GPIO Pins and Auxiliary RS232

Spatial FOG contains two general purpose input output pins and one auxiliary RS232 port on the main connector. These pins are multi function and can be used to extend Spatial FOG with additional peripherals, sensors and data formats. The GPIO pins have digital input, digital output, frequency input and frequency output functionality. Additionally GPIO1 can function as an RS232 serial transmit line and GPIO2 can function as an RS232 serial receive line. The GPIO serial baud rate can be configured anywhere from 2400 to 250 K baud. The auxiliary serial baud rate can be configured anywhere from 2400 to 2 M baud. Changes to these baud rates can be made by using the Baud Rates dialog box in Spatial FOG Manager (see section 11.8.5) or the Baud Rates Packet (see section 13.10.3).

The available GPIO pin functions and auxiliary RS232 functions are listed below in section 12.4. The function of a GPIO pin or auxiliary RS232 can be changed at any time using the GPIO Configuration dialogue in Spatial FOG Manager (see section 11.8.6) or the GPIO Configuration Packet (see section 13.10.6). The receive and transmit functions of the auxiliary RS232 port can be configured independently with different functionality.

12.3.1 GPIO Pins Voltage Level

GPIO1 and GPIO2 are dual voltage level pins that can function at either 0 to 5 volt levels or RS232 levels. When these pins are used for digital input, digital output, frequency input or frequency output the pins operate at standard 0 to 5 volt levels (-20 to 20 volt tolerant). When the pins are used for serial receive or serial transmit, the pins automatically switch to RS232 voltage levels.

12.3.2 GNSS RS232

The GNSS RS232 is a fixed function RS232 port that is directly connected to the internal Trimble BD940 GNSS receiver. This allows for configuration and upgrades of the internal GNSS receiver and can also be used for sending differential or RTK corrections.

12.4 Dynamic Pin Functions

Function	Type	GPIOs	Auxiliary RS232
Inactive	Tristate	All	All
1PPS Output	Digital Output	All	Transmit
GNSS Fix Output	Digital Output	All	Transmit
Odometer Input	Frequency Input	All	Receive
Zero Velocity Input	Digital Input	All	Receive
Pitot Tube Input	Frequency Input	All	Receive
NMEA Input	Serial Receive	2	Receive
NMEA Output	Serial Transmit	1	Transmit
Novatel GNSS Input	Serial Receive	2	Receive
Topcon GNSS Input	Serial Receive	2	Receive
ANPP Input	Serial Receive	2	Receive
ANPP Output	Serial Transmit	1	Transmit
Disable GNSS	Digital Input	All	Receive
Disable Pressure	Digital Input	All	Receive
Set Zero Orientation Alignment	Digital Input	All	Receive
System State Packet Trigger	Digital Input	All	Receive

Function	Type	GPIOs	Auxiliary RS232
Raw Sensors Packet Trigger	Digital Input	All	Receive
Pressure Depth Transducer	Frequency Input	All	Receive
RTCM Differential GNSS Corrections Input	Serial Receive	2	Receive
Trimble GNSS Input	Serial Receive	2	Receive
u-blox GNSS Input	Serial Receive	2	Receive
Hemisphere GNSS Input	Serial Receive	2	Receive
Teledyne DVL Input	Serial Receive	2	Receive
Tritech USBL Input	Serial Receive	2	Receive
Linkquest DVL Input	Serial Receive	2	Receive
Linkquest USBL Input	Serial Receive	2	Receive
Nortek DVL Input	Serial Receive	2	Receive
Left Wheel Speed Sensor	Frequency Input	All	Receive
Right Wheel Speed Sensor	Frequency Input	All	Receive
1PPS Input	Digital Input	All	Receive
Wheel Speed Sensor	Frequency Input	All	Receive
Wheel Encoder Phase A	Frequency Input	All	
Wheel Encoder Phase B	Frequency Input	All	
Event 1 Input	Digital Input	All	Receive
Event 2 Input	Digital Input	All	Receive
TSS1 Output	Serial Transmit	1	Transmit
Simrad 1000 Output	Serial Transmit	1	Transmit
Simrad 3000 Output	Serial Transmit	1	Transmit
Serial Port Passthrough	Serial	All	All
GNSS Receiver Passthrough	Serial	All	All
Gimbal Encoder Phase A	Frequency Input	All	
Gimbal Encoder Phase B	Frequency Input	All	
Odometer Direction, Forward Low	Digital Input	All	Receive
Odometer Direction, Forward High	Digital Input	All	Receive
Reverse Alignment, Forward Low	Digital Input	All	Receive
Reverse Alignment, Forward High	Digital Input	All	Receive
Zero Angular Velocity Input	Digital Input	All	Receive
Moving Base Corrections Output	Serial Transmit	1	Transmit

Table 18: GPIO pin functions

12.4.1 1PPS Output

In this function, the pin pulses 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 Spatial FOG has accurate time or not. It is important to note that when Spatial FOG 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.

1PPS Source	Voltage Level	Trigger
Auxiliary	-5v to 5v	Falling Edge
GPIO	0 to 5v	Rising Edge

Table 19: 1PPS Specifications

12.4.2 GNSS Fix Output

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.

12.4.3 Odometer Input

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 this odometer input function should be used, if it is less than 0.1 metres the wheel speed sensor function should be used. Please contact Advanced Navigation support for help integrating with your speed sensor.

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

Table 20: Odometer Specifications

12.4.4 Zero Velocity Input

When using this function, a high state indicates to Spatial FOG that it is stationary. The low state indicates that the vehicle is not stationary. Use of this function can significantly improve drift performance when a GNSS signal is not available.

12.4.5 Pitot Tube Input

This function is designed for fixed wing aircraft to enhance navigation through the use of a pitot tube to measure airspeed. It requires a differential pressure sensor that has a frequency output such as the Kavlico P992 (frequency output option) or the Paroscientific series 5300. Please contact Advanced Navigation support for help integrating with a pitot tube.

12.4.6 NMEA Input

This function accepts external data in the NMEA format. Advanced Navigation recommends against using NMEA where possible due to the inefficiency, inaccuracy and poor 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 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 Position
GPZDA GNZDA	Time

Table 21: Supported NMEA messages

12.4.7 NMEA Output

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 NMEA output configuration dialogue in Spatial FOG Manager. Advanced Navigation recommends against using NMEA where possible due to the inefficiency, inaccuracy and poor error checking of the format. 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,0.0,89.2,070513,12.5,W,E*02

$GPHDT,89.2,T*06

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

12.4.8 Novatel GNSS Input

This function is designed for interfacing Spatial FOG 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 (20Hz recommended). The message BESTSATSB is optional to display detailed satellite information. The message HEADINGB is also supported for ALIGN capable receivers.

12.4.9 Topcon GNSS Input

This function is designed for interfacing Spatial FOG 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.

12.4.10 ANPP Input

This function accepts data in the ANPP format as specified in section 13. All External Data packets are accepted as input as well as the RTCM differential corrections packet.

12.4.11 ANPP Output

This function outputs data in the ANPP format as specified in section 13. Packets can not be requested using this function, it is for ANPP peripheral devices only.

12.4.12 Disable GNSS

This function accepts a digital input with a low state enabling the GNSS and a high state disabling the GNSS.

12.4.13 Disable Pressure

This function accepts a digital input with a low state enabling the atmospheric pressure sensor and a high state disabling the atmospheric pressure sensor.

12.4.14 Set Zero Orientation Alignment

This function accepts a digital input. The input is normally low and a transition from low to high causes Spatial FOG to set it's 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 Installation Alignment Packet must be read and then sent back to Spatial FOG with the permanent flag set. This function requires de-bouncing if attached to a switch.

12.4.15 System State Packet Trigger

This function accepts a digital input. The input is normally low and a transition from low to high causes Spatial FOG to send the system state packet. This function requires de-bouncing if attached to a switch.

12.4.16 Raw Sensors Packet Trigger

This function accepts a digital input. The input is normally low and a transition from low to high causes Spatial FOG to send the raw sensors packet. This function requires de-bouncing if attached to a switch.

12.4.17 Pressure Depth Transducer

This function is designed for interfacing with a legacy pressure depth transducer. These are no longer available and the function is now deprecated.

12.4.18 RTCM Differential GNSS Corrections Input

This function accepts RTCM differential GPS corrections. This allows for Differential GNSS or RTK with Spatial FOG's internal GNSS receiver.

12.4.19 Trimble GNSS Input

This function is designed for interfacing Spatial FOG 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.

12.4.20 u-blox GNSS Input

This function is designed for interfacing Spatial FOG with a u-blox GNSS receiver. It accepts data in the u-blox binary format and expects message NAV-PVT at rates higher than 1Hz.

12.4.21 Hemisphere GNSS Input

This function is designed for interfacing Spatial FOG with a 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.

12.4.22 Teledyne DVL Input

This function accepts DVL data from a Teledyne DVL. For assistance with configuration please contact support@advancednavigation.com.au.

12.4.23 Tritech USBL Input

This function accepts USBL data from a Tritech USBL. For assistance with configuration please contact support@advancednavigation.com.au.

12.4.24 Linkquest DVL Input

This function accepts DVL data from a Linkquest DVL. For assistance with configuration please contact support@advancednavigation.com.au.

12.4.25 Linkquest USBL Input

This function accepts USBL data from a Linkquest USBL. For assistance with configuration please contact support@advancednavigation.com.au.

12.4.26 Nortek DVL Input

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.

12.4.27 Left Wheel Speed Sensor

This function is designed for the left wheel of a vehicle with dual wheel speed sensors.

12.4.28 Right Wheel Speed Sensor

This function is designed for the right wheel of a vehicle with dual wheel speed sensors.

12.4.29 1PPS Input

This function is designed to allow external GNSS receivers to synchronise time with Spatial FOG. It triggers on a transition from low to high.

12.4.30 Wheel Speed Sensor

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 this wheel speed sensor function should be used. Please contact Advanced Navigation support for 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 22: Wheel Speed Sensor Specifications

12.4.31 Wheel Encoder Phase A

This function is designed for interfacing with a rotary incremental quadrature encoder that is measuring the wheel speed of a ground vehicle such as a car. It should be used in combination with Wheel Encoder Phase B.

12.4.32 Wheel Encoder Phase B

This function is designed for interfacing with a rotary incremental quadrature encoder that is measuring the wheel speed of a ground vehicle such as a car. It should be used in combination with Wheel Encoder Phase A.

12.4.33 Event 1 Input

This function is designed to allow external events to be recorded inside Spatial FOG's output. The event is recorded in the filter status, see section 13.9.1.2, and resets after the next packet is output. The event triggers on a transition from low to high.

12.4.34 Event 2 Input

This function is designed to allow external events to be recorded inside Spatial FOG's output. The event is recorded in the filter status, see section 13.9.1.2, and resets after the next packet is output. The event triggers on a transition from low to high.

12.4.35 TSS1 Output

This function outputs the TSS1 format at a user configurable rate up to 50 Hz. The output rate can be configured using the GPIO output configuration dialogue in Spatial FOG Manager, see section 11.8.10.

12.4.36 Simrad 1000 Output

This function outputs the Simrad 1000 format at a user configurable rate up to 50 Hz. The output rate can be configured using the GPIO output configuration dialogue in Spatial FOG Manager, see section 11.8.10.

12.4.37 Simrad 3000 Output

This function outputs the Simrad 3000 format at a user configurable rate up to 50 Hz. The output rate can be configured using the GPIO output configuration dialogue in Spatial FOG Manager, see section 11.8.10.

12.4.38 Serial Port Passthrough

This function allows passthrough communication through either GPIO 1 and 2 or the Auxiliary RS232. To transmit data use the Serial Port Pass-through Packet. When data is received it will be sent back using the same Serial Port Pass-through Packet.

12.4.39 GNSS Receiver Passthrough

This function allows for pass through connection to the internal GNSS receiver. This is useful for firmware updates of the internal GNSS receiver.

12.4.40 Gimbal Encoder Phase A

This function is designed for interfacing with a rotary incremental quadrature encoder to measure the azimuth angle of a gimbal that Spatial FOG is installed in. It should be used in combination with Gimbal Encoder Phase B.

12.4.41 Gimbal Encoder Phase B

This function is designed for interfacing with a rotary incremental quadrature encoder to measure the azimuth angle of a gimbal that Spatial FOG is installed in. It should be used in combination with Gimbal Encoder Phase A.

12.4.42 Odometer Direction, Forward Low

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.

12.4.43 Odometer Direction, Forward High

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.

12.4.44 Reverse Alignment, Forward Low

This function is designed to reverse the alignment settings for vehicles that can have two vehicle forward directions, such as locomotives.

12.4.45 Reverse Alignment, Forward High

This function is designed to reverse the alignment settings for vehicles that can have two vehicle forward directions, such as locomotives.

12.4.46 Zero Angular Velocity Input

In this function, a high state indicates to Spatial FOG 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.

12.4.47 Moving Base Corrections Output

Certain configurations of your device can act as an RTK base station and output the corrections data. For assistance with configuration please contact support@advancednavigation.com.au.

13 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. It is used across all existing and future Advanced Navigation products.

13.1 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 23: Data type abbreviations used in the ANPP

13.2 Packet Structure

The ANPP packet structure is shown in Table 24 and the header format is shown in Table 25. Example code can be downloaded from the software section.

Header				
Header LRC	Packet ID	Packet Length	CRC16	Packet Data

Table 24: ANPP Packet Structure

ANPP Header Format				
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Header LRC, see section 13.2.1
2	1	u8	1	Packet ID, see section 13.2.2
3	2	u8	1	Packet Length, see section 13.2.3
4	3	u16	2	CRC16, see section 13.2.4

Table 25: ANPP header format

13.2.1 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. The LRC can be found using the following:

LRC = ((packet_id + packet_length + crc[0] + crc[1])^0xFF) + 1

13.2.2 Packet ID

The packet ID is used to distinguish the contents of the packet. Packet IDs range from 0 to 255.

Within this range there are three different sub-ranges, these are system packets, state packets and configuration packets.

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.

13.2.3 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.

13.2.4 CRC

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

13.3 Packet Requests

Any packet can be requested at any time using the request packet. See section 13.8.2.

13.4 Packet Acknowledgement

When configuration packets are sent to Spatial FOG, it will reply with an acknowledgement packet that indicates whether the configuration change was successful or not. For details on the acknowledgement packet, see section 13.8.1.

External data packets will also generate negative acknowledgement packets if there is a problem with the packet. Positive acknowledgements will not be sent.

13.5 Packet Rates

The packet rates can be configured either using Spatial Manager or through the Packets Period Packet. By default Spatial FOG is configured to output the System State Packet at 50Hz. 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 the packet length add five to account for the packet overhead. 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.

13.6 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 System State Packet, the Unix Time Packet or the Formatted Time Packet. For example if the Unix Time Packet, Status Packet and 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 Unix Time Packet providing the time of validity for the other two packets.

13.7 Packet Summary

Packet ID	Length	R/W	Name
System Packets			
0	4	R	Acknowledge Packet
1	Varies	W	Request Packet
2	1	R/W	Boot Mode Packet
3	24	R	Device Information Packet
4	4	W	Restore Factory Settings Packet
5	4	W	Reset Packet
10	Varies	R/W	Serial Port Pass-through Packet
State Packets			

Packet ID	Length	R/W	Name
20	100	R	System State Packet
21	8	R	Unix Time Packet
22	14	R	Formatted Time Packet
23	4	R	Status Packet
24	12	R	Position Standard Deviation Packet
25	12	R	Velocity Standard Deviation Packet
26	12	R	Euler Orientation Standard Deviation Packet
27	16	R	Quaternion Orientation Standard Deviation Packet
28	48	R	Raw Sensors Packet
29	74	R/W	Raw GNSS Packet
30	13	R	Satellites Packet
31	Varies	R	Detailed Satellites Packet
32	24	R	Geodetic Position Packet
33	24	R	ECEF Position Packet
34	25	R	UTM Position Packet
35	12	R	NED Velocity Packet
36	12	R	Body Velocity Packet
37	12	R	Acceleration Packet
38	16	R	Body Acceleration Packet
39	12	R	Euler Orientation Packet
40	16	R	Quaternion Orientation Packet
41	36	R	DCM Orientation Packet
42	12	R	Angular Velocity Packet
43	12	R	Angular Acceleration Packet
44	60	R/W	External Position & Velocity Packet
45	36	R/W	External Position Packet
46	24	R/W	External Velocity Packet
47	16 or 24	R/W	External Body Velocity Packet
48	8	R/W	External Heading Packet
49	8	R	Running Time Packet
50	12	R	Local Magnetic Field Packet
51	20	R	Odometer State Packet
52	8	R	External Time Packet
53	8	R/W	External Depth Packet

Packet ID	Length	R/W	Name
54	4	R	Geoid Height Packet
55	Varies	W	RTCM Corrections Packet
56	8	-	External Pitot Pressure Packet
57	12	R/W	Wind Packet
58	16	R	Heave Packet
59	-	R	Post Processing Packet
60	Varies	R	Raw Satellite Data Packet
61	Varies	R	Raw Satellite Ephemeris Packet
67	13	W	External Odometer Packet
68	25	W	External Air Data Packet
69	48	R/W	GNSS Receiver Information Packet
70	60	R	Raw DVL Data Packet
71	28	R	North Seeking Initialisation Status Packet
72	8	R/W	Gimbal State Packet
73	24	R	Automotive Packet
Configuration Packets			
180	4	R/W	Packet Timer Period Packet
181	Varies	R/W	Packets Period Packet
182	17	R/W	Baud Rates Packet
185	73	R/W	Installation Alignment Packet
186	17	R/W	Filter Options Packet
188	13	R/W	GPIO Configuration Packet
192	8	R/W	Odometer Configuration Packet
193	5	W	Set Zero Orientation Alignment Packet
194	49	R/W	Reference Point Offsets Packet
195	33	R/W	GPIO Output Configuration Packet
198	64	R/W	User Data Packet
199	65	R/W	GPIO Input Configuration Packet

Table 26: Packet summary

13.8 System Packets

13.8.1 Acknowledge Packet

Acknowledgement Packet				
Packet ID				0
Length				4
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	Acknowledge Result, see section 13.8.1.1

Table 27: Acknowledge packet

13.8.1.1 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 28: Acknowledge result

13.8.2 Request Packet

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

Table 29: Request packet

13.8.3 Boot Mode Packet

Boot Mode Packet				
Packet ID				2
Length				1
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Boot mode, see section 13.8.3.1

Table 30: Boot mode packet

13.8.3.1 Boot Mode Types

Value	Description
0	Bootloader
1	Main Program

Table 31: Boot mode types

13.8.4 Device Information Packet

Device Information Packet				
Packet ID				3
Length				24
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Software version
2	4	u32	4	Device ID, section 13.8.4.1
3	8	u32	4	Hardware revision
4	12	u32	4	Serial number part 1
5	16	u32	4	Serial number part 2
6	20	u32	4	Serial number part 3

Table 32: Device information packet

13.8.4.1 Device ID

Bit	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

Table 33: Device ID

13.8.5 Restore Factory Settings Packet

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

Table 34: Restore factory settings packet

13.8.6 Reset Packet

Reset Packet				
Packet ID				5
Length				4
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Verification sequence, see section 13.8.6.1

Table 35: Reset packet

13.8.6.1 Verification Sequence Values

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

Table 36: Verification sequence values

13.8.7 Serial Port Pass-through Packet

Serial Port Pass-through Packet				
Packet ID				10
Length				Variable, up to 255 bytes
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Pass-through route, see section 13.8.7.1
2	1			Pass-through data

Table 37: Serial port pass-through packet

13.8.7.1 Pass-through Routes

Value	**Description**
1	GPIO 1 and 2
2	Auxiliary RS232

Table 38: Pass-through routes

13.9 State Packets

Spatial FOG supports a large number of packets providing extensive functionality. However for the majority of users the easiest approach is to configure Spatial FOG using the Spatial Manager software and then support only the single system state packet shown below in section 13.9.1. Advanced functionality can be added as required through the other packets.

13.9.1 System State Packet

System State Packet				
Packet ID				20
Length				100
Field #	Bytes Offset	Data Type	Size	Description
1	0	u16	2	System status, see section 13.9.1.1
2	2	u16	2	Filter status, see section 13.9.1.2
3	4	u32	4	Unix time seconds, see section 13.9.1.4
4	8	u32	4	Microseconds, see section 13.9.1.5
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 39: System state packet

13.9.1.1 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.

Bit	Description
0	System Failure
1	Accelerometer Sensor Failure
2	Gyroscope Sensor Failure
3	Magnetometer Sensor Failure
4	Pressure Sensor Failure
5	GNSS Failure
6	Accelerometer Over Range
7	Gyroscope Over Range
8	Magnetometer Over Range
9	Pressure Over Range
10	Minimum Temperature Alarm
11	Maximum Temperature Alarm
12	Low Voltage Alarm
13	High Voltage Alarm
14	GNSS Antenna Short Circuit
15	Data Output Overflow Alarm

Table 40: System status

13.9.1.2 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	GNSS Fix Status, see section 13.9.1.3
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 41: Filter status

13.9.1.3 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	Omnistar/Starfire GNSS fix
6	1	1	0	RTK Float GNSS fix
7	1	1	1	RTK Fixed GNSS fix

Table 42: GNSS fix status

13.9.1.4 Unix Time Seconds

This field provides UTC time in seconds since January 1, 1970 including leap seconds.

13.9.1.5 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.

13.9.2 Unix Time Packet

Unix Time Packet				
Packet ID				21
Length				8
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Unix time seconds, see section 13.9.1.4
2	4	u32	4	Microseconds, see section 13.9.1.5

Table 43: Unix time packet

13.9.3 Formatted Time Packet

Formatted Time Packet				
Packet ID				22
Length				14
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
7	11	u8	1	Hour, 0 - 23
8	12	u8	1	Minute, 0 - 59
9	13	u8	1	Second, 0 - 59

Table 44: Formatted time packet

13.9.4 Status Packet

Status Packet				
Packet ID				23
Length				4
Field #	Bytes Offset	Data Type	Size	Description
1	0	u16	2	System status, see section 13.9.1.1
2	2	u16	2	Filter status, see section 13.9.1.2

Table 45: Status packet

13.9.5 Position Standard Deviation Packet

Position Standard Deviation Packet				
Packet ID				24
Length				12
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 46: Position standard deviation packet

13.9.6 Velocity Standard Deviation Packet

Velocity Standard Deviation Packet				
Packet ID				25
Length				12
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 47: Velocity standard deviation packet

13.9.7 Euler Orientation Standard Deviation Packet

Euler Orientation Standard Deviation Packet				
Packet ID				26
Length				12
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 48: Euler orientation standard deviation packet

13.9.8 Quaternion Orientation Standard Deviation Packet

Quaternion Orientation Standard Deviation Packet				
Packet ID				27
Length				16
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	QS standard deviation
2	4	fp32	4	QX standard deviation
3	8	fp32	4	QY standard deviation
4	12	fp32	4	QZ standard deviation

Table 49: Quaternion orientation standard deviation packet

13.9.9 Raw Sensors Packet

Raw Sensors Packet				
Packet ID				28
Length				48
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	Magnetometer X (mG)
8	28	fp32	4	Magnetometer Y (mG)
9	32	fp32	4	Magnetometer Z (mG)
10	36	fp32	4	IMU Temperature (deg C)
11	40	fp32	4	Pressure (Pascals)
12	44	fp32	4	Pressure Temperature (deg C)

Table 50: Raw sensors packet

13.9.10 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
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 section 13.9.10.1

Table 51: Raw GNSS packet

13.9.10.1 Raw GNSS Status

Bit	Description
0	GNSS Fix Status, see section 13.9.1.3
1	
2	
3	Doppler velocity valid
4	Time valid
5	External GNSS
6	Tilt valid
7	Heading valid
8	Floating ambiguity heading
9-15	Reserved (set to zero)

Table 52: Raw GNSS status

13.9.11 Satellites Packet

Satellites Packet				
Packet ID				30
Length				13
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 53: Satellites packet

13.9.12 Detailed Satellites Packet

Detailed Satellites Packet				
Packet ID				31
Length				7 x number of satellites
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Satellite system, see section 13.9.12.1
2	1	u8	1	Satellite number (PRN)
3	2	s8	1	Satellite frequencies, see section 13.9.12.2
4	3	u8	1	Elevation (deg)
5	4	u16	2	Azimuth (deg)
6	6	u8	1	SNR
+				Fields 1-6 repeat for additional satellites

Table 54: Detailed satellites packet

13.9.12.1 Satellite Systems

Value	System
0	Unknown
1	GPS
2	GLONASS
3	BeiDou
4	GALILEO
5	SBAS
6	QZSS
7	Starfire
8	Omnistar

Table 55: Satellite systems

13.9.12.2 Satellite Frequencies

Bit	Description
0	L1 C/A
1	L1 C
2	L1 P
3	L1 M
4	L2 C
5	L2 P
6	L2 M
7	L5

Table 56: Satellite frequencies

13.9.13 Geodetic Position Packet

Geodetic Position Packet				
Packet ID				32
Length				24
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 57: Geodetic position packet

13.9.14 ECEF Position Packet

ECEF Position Packet				
Packet ID				33
Length				24
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 58: ECEF position packet

13.9.15 UTM Position Packet

UTM Position Packet				
Packet ID				34
Length				26
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 59: UTM position packet

13.9.16 NED Velocity Packet

NED Velocity Packet				
Packet ID				35
Length				12
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 60: NED velocity packet

13.9.17 Body Velocity Packet

Body Velocity Packet				
Packet ID				36
Length				12
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 61: Body velocity packet

13.9.18 Acceleration Packet

This packet includes the acceleration due to gravity.

Acceleration Packet				
Packet ID				37
Length				12
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 62: Acceleration packet

13.9.19 Body Acceleration Packet

This packet does not include the acceleration due to gravity.

Body Acceleration Packet				
Packet ID				38
Length				16
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 63: Body acceleration packet

13.9.20 Euler Orientation Packet

Euler Orientation Packet				
Packet ID				39
Length				12
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 64: Euler orientation packet

13.9.21 Quaternion Orientation Packet

Quaternion Orientation Packet				
Packet ID				40
Length				16
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 65: Quaternion orientation packet

13.9.22 DCM Orientation Packet

DCM Orientation Packet				
Packet ID				41
Length				36
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 66: DCM orientation packet

13.9.23 Angular Velocity Packet

Angular Velocity Packet				
Packet ID				42
Length				12
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 67: Angular velocity packet

13.9.24 Angular Acceleration Packet

Angular Acceleration Packet				
Packet ID				43
Length				12
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 68: Angular acceleration packet

13.9.25 External Position & Velocity Packet

External Position & Velocity Packet				
Packet ID				44
Length				60
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 69: External position & velocity packet

13.9.26 External Position Packet

External Position Packet				
Packet ID				45
Length				36
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)
5	28	fp32	4	Longitude standard deviation (m)
6	32	fp32	4	Height standard deviation (m)

Table 70: External position packet

13.9.27 External Velocity Packet

External Velocity Packet				
Packet ID				46
Length				24
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 71: External velocity packet

13.9.28 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. Please ensure you 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
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	12	fp32	4	OPTIONAL: Velocity standard deviation Y (m/s)
6	12	fp32	4	OPTIONAL: Velocity standard deviation Z (m/s)

Table 72: External body velocity packet

13.9.29 External Heading Packet

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

Table 73: External heading packet

13.9.30 Running Time Packet

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

Table 74: Running time packet

13.9.31 Local Magnetic Field Packet

Local Magnetic Field Packet				
Packet ID				50
Length				12
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Local magnetic field X (mG)
2	4	fp32	4	Local magnetic field Y (mG)
3	8	fp32	4	Local magnetic field Z (mG)

Table 75: Local magnetic field packet

13.9.32 Odometer State Packet

Odometer State Packet				
Packet ID				51
Length				20
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 76: Odometer state packet

13.9.33 External Time Packet

External Time Packet				
Packet ID				52
Length				8
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Unix time (seconds), see section 13.9.1.4
2	4	u32	4	Microseconds, see section 13.9.1.5

Table 77: External time packet

13.9.34 External Depth Packet

External Depth is the measured distance below Mean Sea Level.

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

Table 78: External depth packet

13.9.35 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.

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

Table 79: Geoid height packet

13.9.36 RTCM Corrections Packet

This packet is used to encapsulate RTCM differential or RTK correction data to be sent to Spatial FOG's internal GNSS receiver for differential or RTK GNSS functionality.

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

Table 80: RTCM corrections packet

13.9.37 External Pitot Pressure Packet

This packet is no longer supported. The External Air Data packet #68 should be used.

13.9.38 Wind Packet

This packet provides Spatial FOG's current 2D wind velocity. These values are only valid when external air data is provided to Spatial FOG. This can be either through the External Pitot Pressure Packet, the 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
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 81: Wind packet

13.9.39 Heave Packet

Heave Packet				
Packet ID				58
Length				16
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 82: Heave packet

13.9.40 Post Processing Packet

No longer supported. If you need an IMR file please contact Advanced Navigation support for required settings.

13.9.41 Raw Satellite Data Packet

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

Raw Satellite Data Packet				
Packet ID				60
Length				16 + Satellites * (6 + Frequencies * 26)
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Unix time (seconds)
2	4	u32	4	Nanoseconds
3	8	s32	4	Receiver clock offset (nanoseconds)
2	12	u8	1	Receiver number
3	13	u8	1	Packet number
4	14	u8	1	Total packets
5	15	u8	1	Number of satellites
For each satellite				
7	16	u8	1	Satellite system, see section 13.9.12.1
8	17	u8	1	PRN or satellite number
9	18	u8	1	Elevation (degrees)
10	19	u16	2	Azimuth (degrees)
11	21	u8	1	Number of frequencies
For each frequency of each satellite				
12	22	u8	1	Satellite frequency, see section 13.9.41.1
13	23	u8	1	Tracking status, see 13.9.41.2
13	24	fp64	8	Carrier phase
14	32	fp64	8	Pseudo range (m)
15	40	fp32	4	Doppler frequency (Hz)
16	44	fp32	4	Signal to noise ratio (dB-Hz)

Table 83: Raw satellite data packet

13.9.41.1 Satellite Frequencies

Value	Frequency
0	Unknown
1	L1 C/A
2	L1 C
3	L1 P
4	L1 M
5	L2 C
6	L2 P
7	L2 M
8	L5

Table 84: Satellite frequencies

13.9.41.2 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	Reserved
7	Reserved

Table 85: Tracking status

13.9.42 Raw Satellite Ephemeris Packet

Spatial Manager will automatically convert this packet to RINEX 3.02 format. This packet has been left out of the reference manual due to it's length. If you need the format of this packet, please contact Advanced Navigation support.

13.9.43 External Odometer Packet

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

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, see section 13.9.43.1

Table 86: External odometer packet

13.9.43.1 Odometer flags

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

Table 87: Odometer flags

13.9.44 External Air Data Packet

External Air Data Packet				
Packet ID				68
Length				25
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, see section 13.9.44.1

Table 88: External air data packet

13.9.44.1 External Air Data Flags

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

Table 89: External air data flags

13.9.44.2 Notes

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.

13.9.45 GNSS Receiver Information Packet

GNSS Receiver Information Packet				
Packet ID				69
Length				48
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	GNSS manufacturer ID, see section 13.9.45.1
2	1	u8	1	GNSS receiver model, see section 13.9.45.2
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
10	28		20	Reserved (set to zero)

Table 90: GNSS receiver information packet

13.9.45.1 GNSS Manufacturer IDs

For Spatial FOG the GNSS Manufacturer ID will always be 1 (Trimble).

Value	**Description**
0	GNSS Manufacturer Unknown
1	Trimble

Table 91: GNSS manufacturer IDs

13.9.45.2 GNSS Receiver Models

For Spatial FOG the GNSS receiver model will always be either 1 or 2.

Value	Description
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

Table 92: GNSS receiver models

13.9.46 Raw DVL Data Packet

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 Spatial FOG Manager.

Raw DVL Data Packet				
Packet ID				70
Length				60
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Unix time seconds, see section 13.9.1.4
2	4	u32	4	Microseconds, see section 13.9.1.5
3	8	u32	4	Flags, see 13.9.46.1
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 93: Raw DVL Data packet

13.9.46.1 Raw DVL Data Flags

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

Table 94: Raw DVL data flags

13.9.47 North Seeking Initialisation Status Packet

North Seeking Initialisation Status Packet				
Packet ID				71
Length				28
Field #	Bytes Offset	Data Type	Size	Description
1	0	u16	2	Flags, see section 13.9.47.1
2	2		2	Reserved (set to zero)
3	4	u8	1	Quadrant 1 data collection progress (%)
4	5	u8	1	Quadrant 2 data collection progress (%)
5	6	u8	1	Quadrant 3 data collection progress (%)
6	7	u8	1	Quadrant 4 data collection progress (%)
7	8	fp32	4	Current rotation angle (rad), see section 13.9.47.2
8	12	fp32	4	Current gyroscope bias solution X (rad/s)
9	16	fp32	4	Current gyroscope bias solution Y (rad/s)
10	20	fp32	4	Current gyroscope bias solution Z (rad/s)
11	24	fp32	4	Current gyroscope bias solution error (%)

Table 95: North seeking initialisation status packet

13.9.47.1 North Seeking Initialisation Status Flags

Bit	Description
0	North seeking initialisation complete
1	North seeking initialisation cannot start because the position is unknown
2	North seeking initialisation paused due to excessive rolling
3	North seeking initialisation paused due to excessive pitching
4	North seeking initialisation paused due to excessive movement
5-16	Reserved (set to zero)

Table 96: North seeking initialisation status flags

13.9.47.2 North Seeking Initialisation Current Rotation Angle

Range	Quadrant
-π/4 to π/4	Quadrant 1
π/4 to 3π/4	Quadrant 2
-3π/4 to 3π/4	Quadrant 3
-3π/4 to -π/4	Quadrant 4

Table 97: North seeking initialisation current rotation angle

13.9.48 Gimbal State Packet

Gimbal State Packet				
Packet ID				72
Length				8
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Current angle (rad)
2	4		4	Reserved (set to zero)

Table 98: Gimbal state packet

13.9.49 Automotive Packet

Automotive Packet				
Packet ID				73
Length				24
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Virtual odometer distance (m)
2	4	fp32	4	Slip Angle (rad)
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 99: Automotive packet

13.10 Configuration Packets

Configuration packets can be both read from and written to the device. 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.

13.10.1 Packet Timer Period Packet

Packet Timer Period Packet				
Packet ID				180
Length				4
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u8	1	UTC synchronisation, see section 13.10.1.1
3	2	u16	2	Packet timer period, see section 13.10.1.2

Table 100: Packet timer period packet

13.10.1.1 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.

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

13.10.1.2 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 65535 (65.535 ms) or 15.30 Hz.

13.10.2 Packets Period Packet

Packets Period Packet				
Packet ID				181
Length				2 + (5 x number of packet periods)
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u8	1	Clear existing packet periods, see section 13.10.2.1
3	2	u8	1	Packet ID

4	3	u32	4	Packet period, see section 13.10.2.2
+				Fields 3-4 repeat for additional packet periods

Table 101: Packets period packet

13.10.2.1 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.

13.10.2.2 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

13.10.3 Baud Rates Packet

Baud Rates Packet				
Packet ID				182
Length				17
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u32	4	Primary RS422 port baud rate (2400 to 10,000,000)
3	5	u32	4	GPIO 1 & 2 baud rate (2400 to 250000)
4	9	u32	4	Auxiliary RS232 baud rate (2400 to 2000000)
5	13		4	Reserved (set to zero)

Table 102: Baud rates packet

13.10.4 Installation Alignment Packet

Installation Alignment Packet				
Packet ID				185
Length				73
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)
15	53	fp32	4	Odometer offset Y (m)
16	57	fp32	4	Odometer offset Z (m)
17	61	fp32	4	External data offset X (m)
18	65	fp32	4	External data offset Y (m)
19	69	fp32	4	External data offset Z (m)

Table 103: Installation alignment packet

13.10.4.1 Alignment DCM

The alignment DCM (direction cosine matrix) is used to represent an alignment offset of Spatial FOG from it's standard alignment. A DCM is used rather than euler angles for accuracy reasons. To convert euler angles to DCM please 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)

13.10.5 Filter Options Packet

Filter Options Packet				
Packet ID				186
Length				17
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u8	1	Vehicle type, see section 13.10.5.1
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	9	Reserved (set to zero)

Table 104: Filter options packet

13.10.5.1 Vehicle Types

Value	Description
0	Unconstrained
1	Bicycle or Motorcycle
2	Car
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 105: Vehicle types

13.10.6 GPIO Configuration Packet

GPIO Configuration Packet				
Packet ID				188
Length				13
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u8	1	GPIO1 function, see section 13.10.6.1
3	2	u8	1	GPIO2 function, see section 13.10.6.2
4	3	u8	1	Auxiliary RS232 transmit function, section 13.10.6.3
5	4	u8	1	Auxiliary RS232 receive function, section 13.10.6.4
8	5	u8	8	Reserved (set to zero)

Table 106: GPIO configuration packet

13.10.6.1 GPIO1 Functions

Value	Description

0	Inactive
1	1PPS Output
2	GNSS Fix Output
3	Odometer Input
4	Zero Velocity Input
5	Pitot Tube Input
7	NMEA Output
12	ANPP Output
14	Disable GNSS
15	Disable Pressure
16	Set Zero Orientation Alignment
17	System State Packet Trigger
18	Raw Sensors Packet Trigger
26	Pressure Depth Transducer
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
38	GNSS Receiver Passthrough
39	TSS1 Output
40	Simrad 1000 Output
41	Simrad 3000 Output
42	Serial Port Passthrough
43	Gimbal Encoder Phase A
44	Gimbal Encoder Phase B
45	Odometer Direction, Forward Low
46	Odometer Direction, Forward High
52	Moving Base Corrections Output
53	Reverse Alignment, Forward Low
54	Reverse Alignment, Forward High
55	Zero Angular Velocity Input

Table 107: GPIO1 functions

13.10.6.2 GPIO2 Functions

Value	Description
0	Inactive
1	1PPS Output
2	GNSS Fix Output
3	Odometer Input
4	Zero Velocity Input
5	Pitot Tube Input
6	NMEA Input
8	Novatel GNSS Input
9	Topcon GNSS Input
11	ANPP Input
14	Disable GNSS
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
31	Wheel Encoder Phase A
32	Wheel Encoder Phase B
33	Event 1 Input
34	Event 2 Input

35	Linkquest USBL Input
38	GNSS Receiver Passthrough
42	Serial Port Passthrough
43	Gimbal Encoder Phase A
44	Gimbal Encoder Phase B
45	Odometer Direction, Forward Low
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 108: GPIO2 functions

13.10.6.3 Auxiliary RS232 Transmit Functions

Value	Description
0	Inactive
1	1PPS Output
2	GNSS Fix Output
7	NMEA Output
12	ANPP Output
38	GNSS Receiver Passthrough
39	TSS1 Output
40	Simrad 1000 Output
41	Simrad 3000 Output
42	Serial Port Passthrough
52	Moving Base Corrections Output

Table 109: Auxiliary RS232 transmit functions

13.10.6.4 Auxiliary RS232 Receive Functions

Value	Description
0	Inactive
3	Odometer Input
4	Zero Velocity Input
5	Pitot Tube Input
6	NMEA Input

8	Novatel GNSS Input
9	Topcon GNSS Input
11	ANPP Input
14	Disable GNSS
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
42	Serial Port Passthrough
45	Odometer Direction, Forward Low
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 110: Auxiliary RS232 receive functions

13.10.7 Odometer Configuration Packet

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

Table 111: Odometer configuration packet

13.10.8 Set Zero Orientation Alignment Packet

This packet was modified as of firmware version 2.0 for code safety certification. Previously it was 1 byte long with no verification sequence.

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

Table 112: Set zero orientation alignment packet

13.10.9 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 Spatial FOG unit. The primary reference point offset can be used to adjust the measurement point to a different location on the vehicle. The primary reference point offset applies to all data output including NMEA etc as well as heave point 1. The other heave point offsets apply only to heave points 2-4 in the Heave Packet.

Reference Points Offset Packet				
Packet ID				194
Length				49
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	fp32	4	Primary reference point offset X (m)
3	5	fp32	4	Primary reference point offset Y (m)
4	9	fp32	4	Primary reference point offset Z (m)
5	13	fp32	4	Heave point 2 offset X (m)
6	17	fp32	4	Heave point 2 offset Y (m)
7	21	fp32	4	Heave point 2 offset Z (m)
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 113: Reference point offsets packet

13.10.10 GPIO Output Configuration Packet

GPIO Output Configuration Packet				
Packet ID				195
Length				33
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u8	1	NMEA fix behaviour, see section 13.10.10.1
3	2	u16	2	GPZDA Rates, see section 13.10.10.2
4	4	u16	2	GPGGA Rates, see section 13.10.10.2
5	6	u16	2	GPVTG Rates, see section 13.10.10.2
6	8	u16	2	GPRMC Rates, see section 13.10.10.2
7	10	u16	2	GPHDT Rates, see section 13.10.10.2
8	12	u16	2	GPGLL Rates, see section 13.10.10.2
9	14	u16	2	PASHR Rates, see section 13.10.10.2
10	16	u16	2	TSS1 Rates, see section 13.10.10.2
11	18	u16	2	Simrad Rates, see section 13.10.10.2
12	20	u16	2	GPROT Rates, see section 13.10.10.2
13	22	u16	2	GPHEV Rates, see section 13.10.10.2
14	24	u16	2	GPGSV Rates, see section 13.10.10.2
15	26	u16	2	PFECAtt Rates, see section 13.10.10.2
16	28	u16	2	PFECHve Rates, see section 13.10.10.2
17	30	u16	2	GPGST Rates, see section 13.10.10.2
18	32		1	Reserved (set to zero)

Table 114: GPIO output configuration packet

13.10.10.1 NMEA Fix Behaviour

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

Table 115: NMEA fix behaviour

13.10.10.2 GPIO Output Rates

Bit	Description
0-3	GPIO 1 rate, see 13.10.10.3
4-7	Auxiliary RS232 Transmit rate, see 13.10.10.3
8-15	Reserved (set to zero)

Table 116: GPIO output rates

13.10.10.3 GPIO Output Rates Index

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

Table 117: GPIO output rates index

13.10.11 User Data Packet

This packet is for storage of users data. The data itself is not used by Spatial FOG.

User Data Packet				
Packet ID				198
Length				64
Field #	Bytes Offset	Data Type	Size	Description
1	0		64	User Data

Table 118: User data packet

13.10.12 GPIO Input Configuration Packet

GPIO Input Configuration Packet				
Packet ID				199
Length				65
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	fp32	4	Gimbal radians per encoder tick
3	2		60	Reserved (set to zero)

Table 119: GPIO input configuration packet