Spatial Reference Manual

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1 Revision History

Version	Date	Changes
3.0	24/09/2013	Manual updated for Spatial v3.0 hardware Updated photo for Spatial v3.0 hardware Added evaluation kit, section 4 Updated mechanical drawings, section 5.1 Updated navigation specifications, section 5.2 Updated sensor specifications, section 5.3 Updated communication specifications, section 5.5 Updated hardware specifications, section 5.6 Updated electrical specifications, section 5.7 Updated connector pin-out, section 5.9 Updated mounting plate, section 6.2 Updated odometer information, section 6.5 Added reversing detection, section 7.11 Added motion analysis, section 7.12 Updated 3D magnetic calibration procedure, section 7.6.2 Integrated Spatial Manager manual, section 8 Added Auxiliary RS232 information, section 9.3 Updated NMEA input, section 9.3.6 Updated NMEA output, section 9.3.7 Added wheel speed sensor function, section 9.3.29 Added wheel encoder phase A function, section 9.3.30 Added wheel encoder phase B function, section 9.3.31 Added event 1 input, section 9.3.32 Added event 2 input, section 9.3.33 Added TSS1 output, section 9.3.34 Added Simrad 1000 output, section 9.3.35 Added Simrad 3000 output, section 9.3.36 Updated filter status, section 10.8.1.2 Added GNSS fix status, section 10.8.1.3 Updated baud rates packet, section 10.9.3 Updated filter options packet, section 10.9.6 Updated GPIO configuration packet, section 10.9.8 Added NMEA output configuration packet, section 10.9.15
2.7	27/03/2013	Added additional magnetic information, section 7.6 Added 1PPS input, section 9.3.28 Updated detailed satellites packet, section 10.8.12 Corrected geoid height packet, section 10.8.35
2.6	29/01/2013	Added heave information, section 7.16 Added RTCM corrections packet, section 10.8.36 Added external pitot pressure packet, section 10.8.37 Added wind estimation packet, section 10.8.38 Added heave packet, section 10.8.39 Added heave configuration packet, section 10.9.14
2.5	07/12/2012	Added input voltage range to electrical specifications,

Version	Date	Changes
		section 5.7 Added underwater navigation information, section 7.15 Added Linkquest DVL input, section 9.3.24 Added pressure depth transducer input, section 9.3.25 Added left wheel speed sensor input, section 9.3.26 Added right wheel speed sensor input, section 9.3.27 Added external time packet, section 10.8.33 Added external depth packet, section 10.8.34 Added geoid height packet, section 10.8.35 Updated GPIO functions tables, section 10.9.8
2.3	06/12/2012	Yaw terminology changed to heading for increased clarity Reworded installation magnetics for increased clarity, section 6.6 Reworded initialisation for increased clarity, section 7.2 Reworded operation magnetics for increased clarity, section 7.6 Added vehicle profiles information, section 7.9 Updated NMEA output, section 9.3.7 Added Tritech USBL input, section 9.3.23
2.2	19/11/2012	Installation magnetics changed, section 6.6 Heading source added, section 7.5 Disabling magnetometers changed, section 7.6.4 GPIO information updated, section 9.3 Added NMEA input GPGLL support, section 9.3.6 Added NMEA input GPHDT support, section 9.3.6 Added NMEA input HEHDT support, section 9.3.6 Updated NMEA output, section 9.3.7 Added RTCM corrections input, section 9.3.18 Added Trimble GNSS input, section 9.3.19 Added u-blox GNSS input, section 9.3.20 Added Hemisphere GNSS input, section 9.3.21 Added Teledyne DVL input, section 9.3.22 Updated GPIO functions tables, section 10.9.8
2.1	30/10/2012	Sensor specifications updated, section 5.3 Fixed error in odometer state packet, section 10.8.32
2.0	18/10/2012	Added information on sensor calibration, section 5.10 Added odometer installation information, section 6.5 Updated filter description to clarify instability, section 7.1 Added hot start information, section 7.3 Added time information, section 7.4 Added odometer pulse length information, section 7.10 Added RAIM information, section 7.14 Updated Odometer input, section 9.3.3 Updated NMEA output, section 9.3.7 Added disable magnetometers GPIO function, section 9.3.12

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		Added disable GNSS GPIO function, section 9.3.13 Added disable pressure GPIO function, section 9.3.14 Added set zero alignment GPIO function, section 9.3.15 Added system state packet trigger GPIO function, section 9.3.16 Added raw sensors packet trigger GPIO function, section 9.3.17 Updated acknowledge packet, section 10.7.1 Added running time packet, section 10.8.30 Added local magnetic field packet, section 10.8.31 Added odometer state packet, section 10.8.32 Updated installation alignment packet, section 10.9.5 Fixed error in filter options packet, section 10.9.6 Updated GPIO configuration packet, section 10.9.8 Added odometer configuration packet, section 10.9.12 Added set zero orientation alignment packet, section 10.9.13
1.0	16/09/2012	1PPS description updated, section 9.3.1 Corrected reset packet, section 10.7.6 Corrected external body velocity packet, section 10.8.28 Revised alignment packet, section 10.9.5 Grammar and spelling corrections
0.6	31/08/2012	Grammar corrections throughout Spelling corrections throughout Updated 3D magnetic calibration, section 7.6.2
0.5	28/08/2012	Corrected satellite indexes, section 10.8.12.1 Added navigation specifications, section 5.2 Added sensor specifications, section 5.3 Added GNSS specifications, section 5.4 Added communication specifications, section 5.5 Added hardware specifications, section 5.6
0.4	23/08/2012	Clarified anti aliasing, section 7.8 Added external data, section 9.2 Added GPIO information, section 9.3 Added GPIO configuration packet, section 10.9.8
0.3	11/08/2012	Magnetic calibration values packet corrected Incorrect length fixed on several packets Grammar corrections
0.2	08/08/2012	Connector pin allocation table corrected
0.1	31/07/2012	First Draft. Please email support@advancednavigation.com.au if you notice any mistakes or anything is not explained clearly.

2 Foundation Knowledge

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

2.1 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.

2.2 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.

2.3 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.

2.4 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.

2.5 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 connectors, the Z axis pointing down through the base of the unit and the Y axis pointing off to the right.

Illustration 1: Bird's eye view of Spatial showing axes marked on top

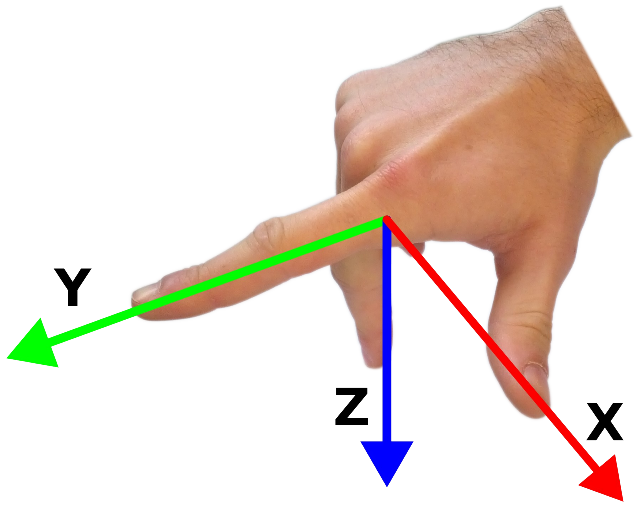


Illustration 2: First right hand rule

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.

2.6 Roll, Pitch and Heading

Orientation can be described by the three angles roll, pitch and heading, these are known as the Euler angles. They are best described visually through the Illustrations below.

2.6.1 Roll

Roll is the angle around the X axis. See Illustration 3 for the positive direction of roll and Illustration 4 for an example of a roll of 90 degrees.

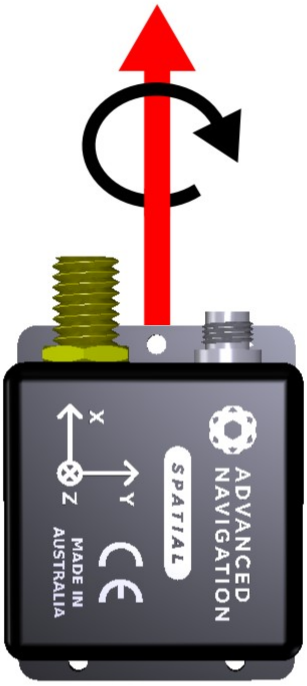


Illustration 3: Spatial with black arrow indicating positive direction of roll

Illustration 4: Spatial after a roll of 90 degrees

2.6.2 Pitch

Pitch is the angle around the Y axis. See Illustration 5 for the positive direction of pitch and Illustration 6 for an example of a pitch of 90 degrees.

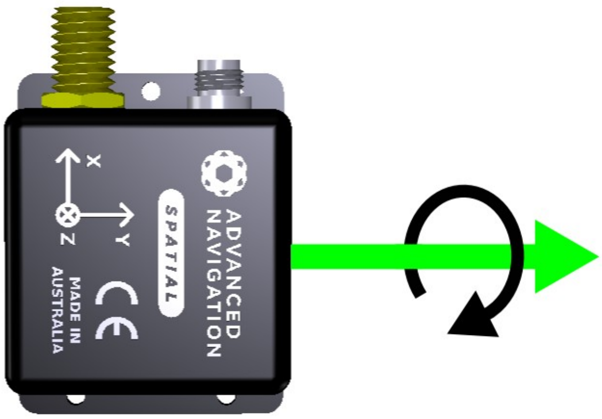


Illustration 5: Spatial with black arrow indicating positive direction of pitch

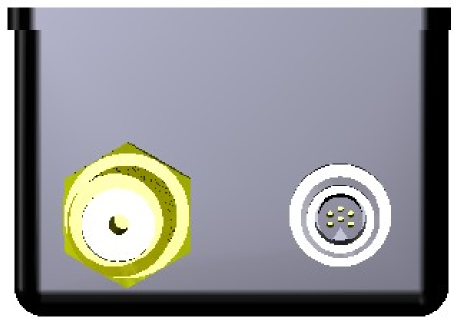


Illustration 6: Spatial after a pitch of 90 degrees

2.6.3 Heading

Heading is the angle around the Z axis. See Illustration 7 for the positive direction of heading and Illustration 8 for an example of a heading change of 90 degrees. 0 degrees heading is when the positive X axis points North and 180 degrees heading is when the positive X axis points South.

Illustration 7: Spatial with black arrow indicating positive direction of heading

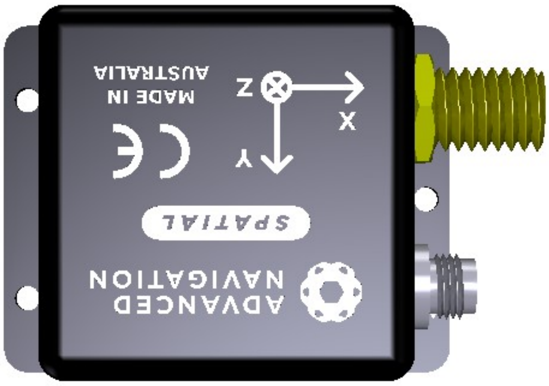


Illustration 8: Spatial after a heading change of 90 degrees

2.6.4 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 2.5. The second right hand rule shown in Illustration 9 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.

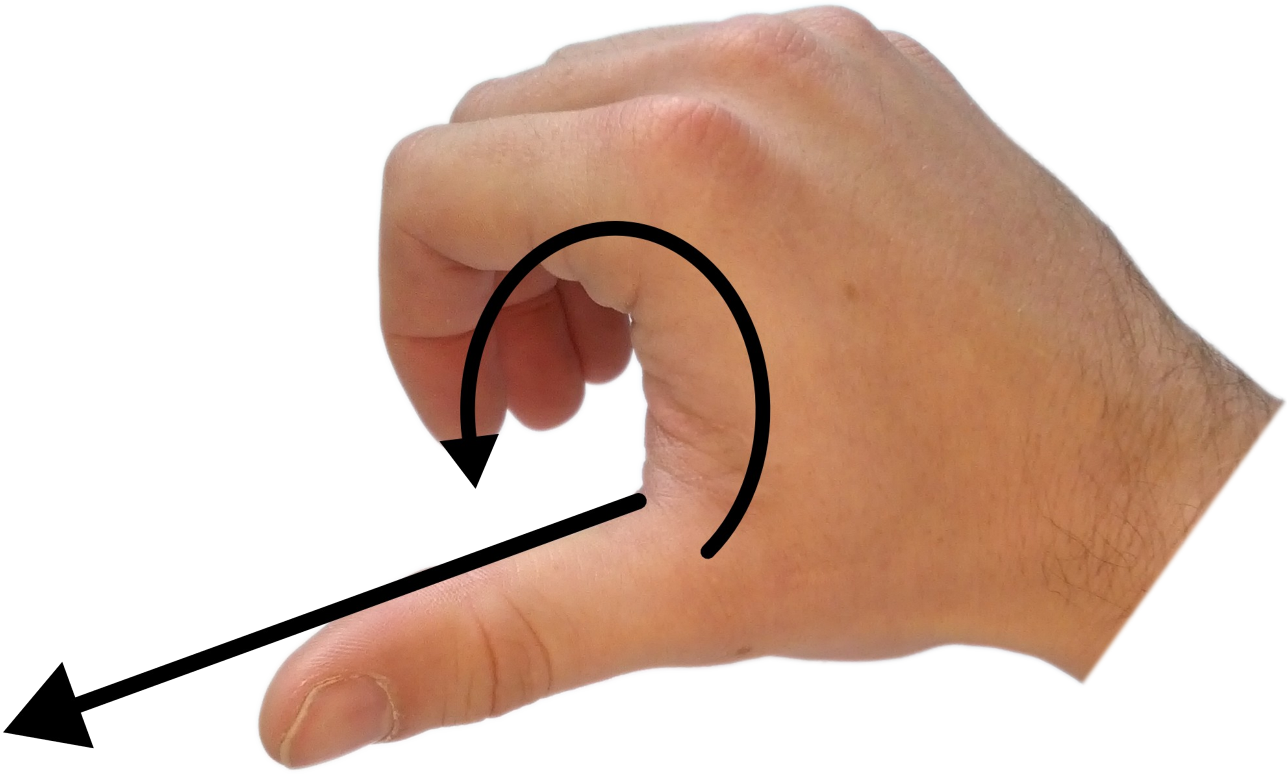


Illustration 9: Second right hand rule

2.6.5 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 with your hand whilst watching the orientation plot in real time on the computer.

2.7 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. Latitude is the angle that specifies the north to south position of a point on the Earth's surface. Longitude is the angle that specifies the east to west position of a point on the Earth's surface. The line of zero latitude is the equator and the line of zero longitude is the prime meridian. Illustration 10 shows how latitude and longitude angles are used to describe a position on the surface of the Earth.

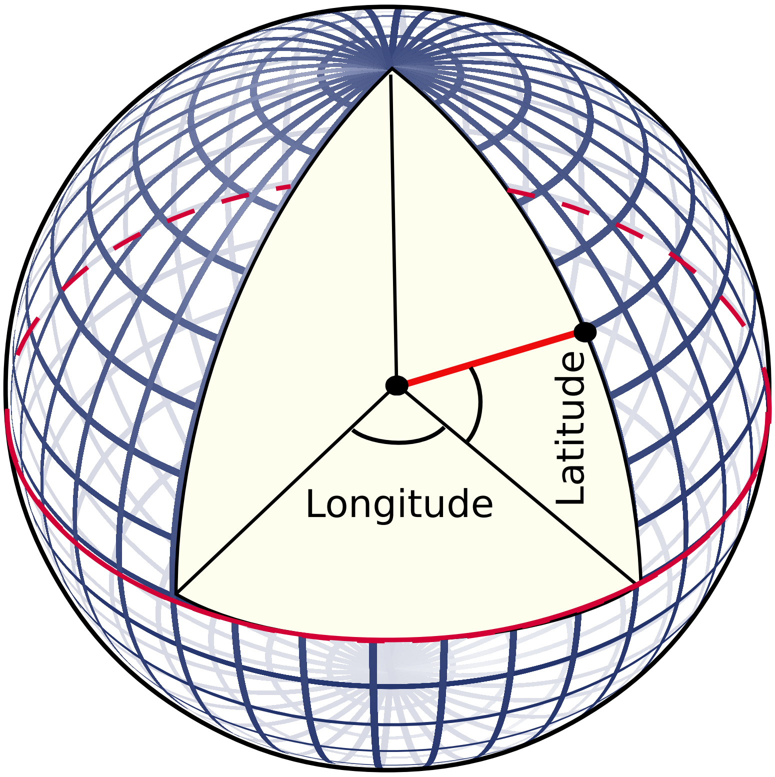


Illustration 10: Latitude and longitude represented visually to describe a position

Illustration 11 below shows latitude and longitude on a map of the world.

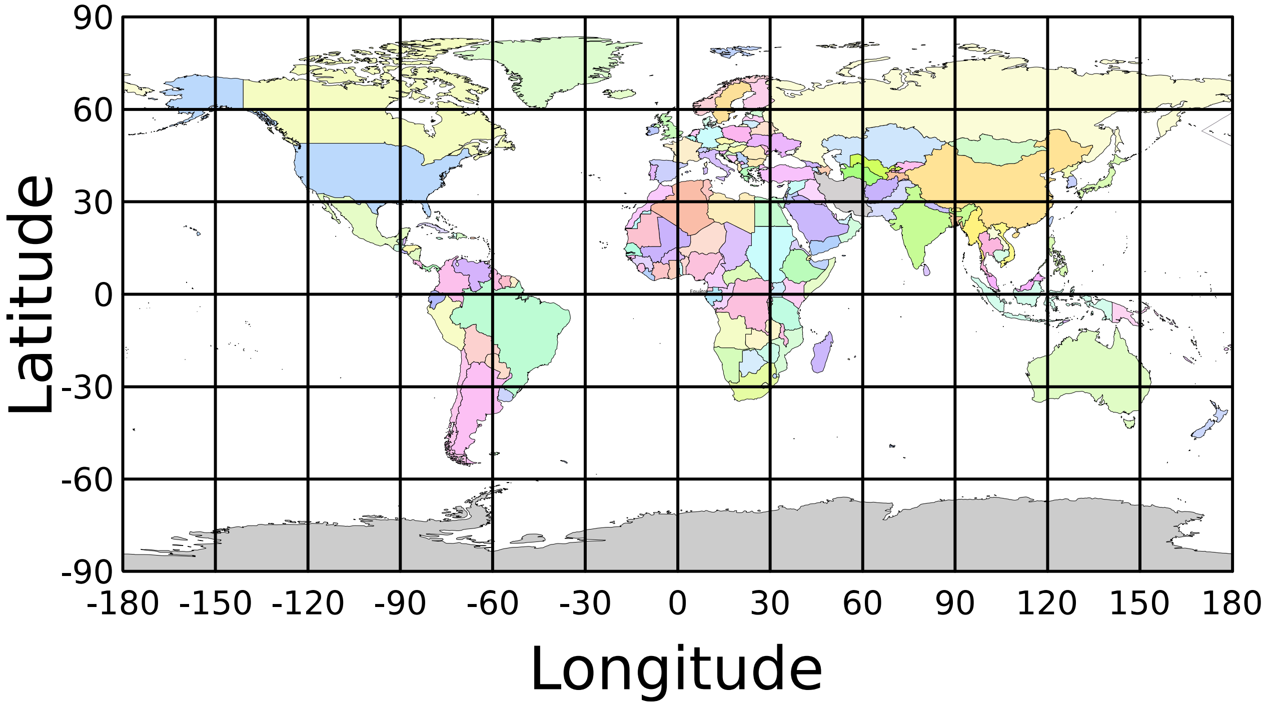


Illustration 11: World map showing latitudes and longitudes

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.

Height is the height above the WGS84 reference ellipsoid. The WGS84 reference ellipsoid is a model used to approximate sea level across the Earth. Therefore the height should be considered approximately relative to sea level. Due to the approximate nature of the WGS84 model, the WGS84 height will not be the same as the actual sea level. For example, in Australia, the WGS84 height at sea level is 9 metres at some points.

2.8 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 latitude at that point. The east axis points perpendicular to the north axis and parallel to the line of longitude at that point. The down axis points directly down towards the centre of the Earth. See Illustration 12 for a graphical representation of the NED co-ordinate frame at a position on the Earth.

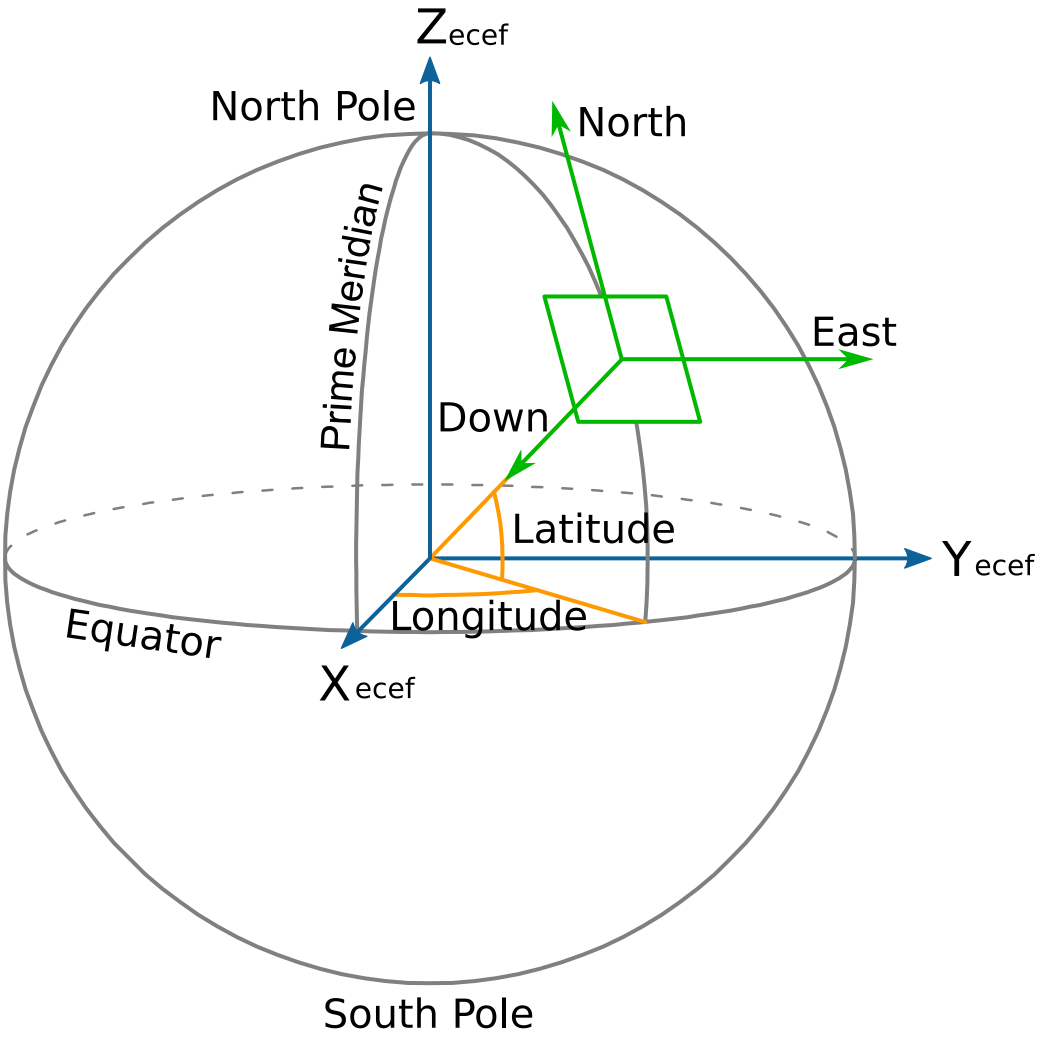


Illustration 12: Graphic showing geodetic, NED and ECEF co-ordinates

2.9 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 12. ECEF positions can be retrieved from Advanced Navigation products however the geodetic system is used as the default.

3 Introduction

Spatial is a miniature GNSS/INS & AHRS system that provides accurate position, velocity, acceleration and orientation under almost the most demanding conditions. It combines temperature calibrated accelerometers, gyroscopes, magnetometers and a pressure sensor with an advanced GNSS receiver. These are coupled in a sophisticated fusion algorithm to deliver accurate and reliable navigation and orientation.

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

The Spatial Manager software is downloadable from the software section of the Advanced Navigation website. It allows Spatial to be easily configured and operated. For more information on Spatial Manager please see section 8.

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

4 Evaluation Kit

Spatial 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 plastic carry case to protect the equipment during shipping.

Illustration 13: Spatial Evaluation Kit

4.1 Evaluation Kit Contents

1. Spatial GNSS/INS
2. Rugged IP67 multi-constellation GNSS antenna
3. Spatial connector to USB interface cable

4.2 Quick Start

1. Position the GNSS antenna in a level orientation with a clear view of the sky.
2. Connect the coaxial antenna cable to Spatial.
3. Plug the interface cable into Spatial.
4. Plug the USB end of the interface cable into your computer.
5. Download the Spatial Manager software from the Spatial 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.
6. Click the connect button in Spatial Manager.
7. The various windows in Spatial Manager can be used to view the real time data.
8. If the Spatial unit is mounted on a vehicle, it will require a magnetic calibration to provide accurate heading. Please see section 7.6.

9. To view the data logs, click disconnect in Spatial 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 Manager software.

4.3 Troubleshooting

1. If you are having trouble opening Spatial Manager, please try reinstalling Java.
2. If you are having problems connecting to Spatial, please try reinstalling the latest FTDI driver from the FTDI website: http://www.ftdichip.com/Drivers/VCP.htm
3. If you are running Spatial at a high update rate under Windows the latency timer will need to be adjusted. To do this please open control panel → system → device manager → ports → right click USB Serial Port → properties → port settings → advanced. In this window change the latency timer to 1 millisecond.

5 Specifications

5.1 Mechanical Drawings

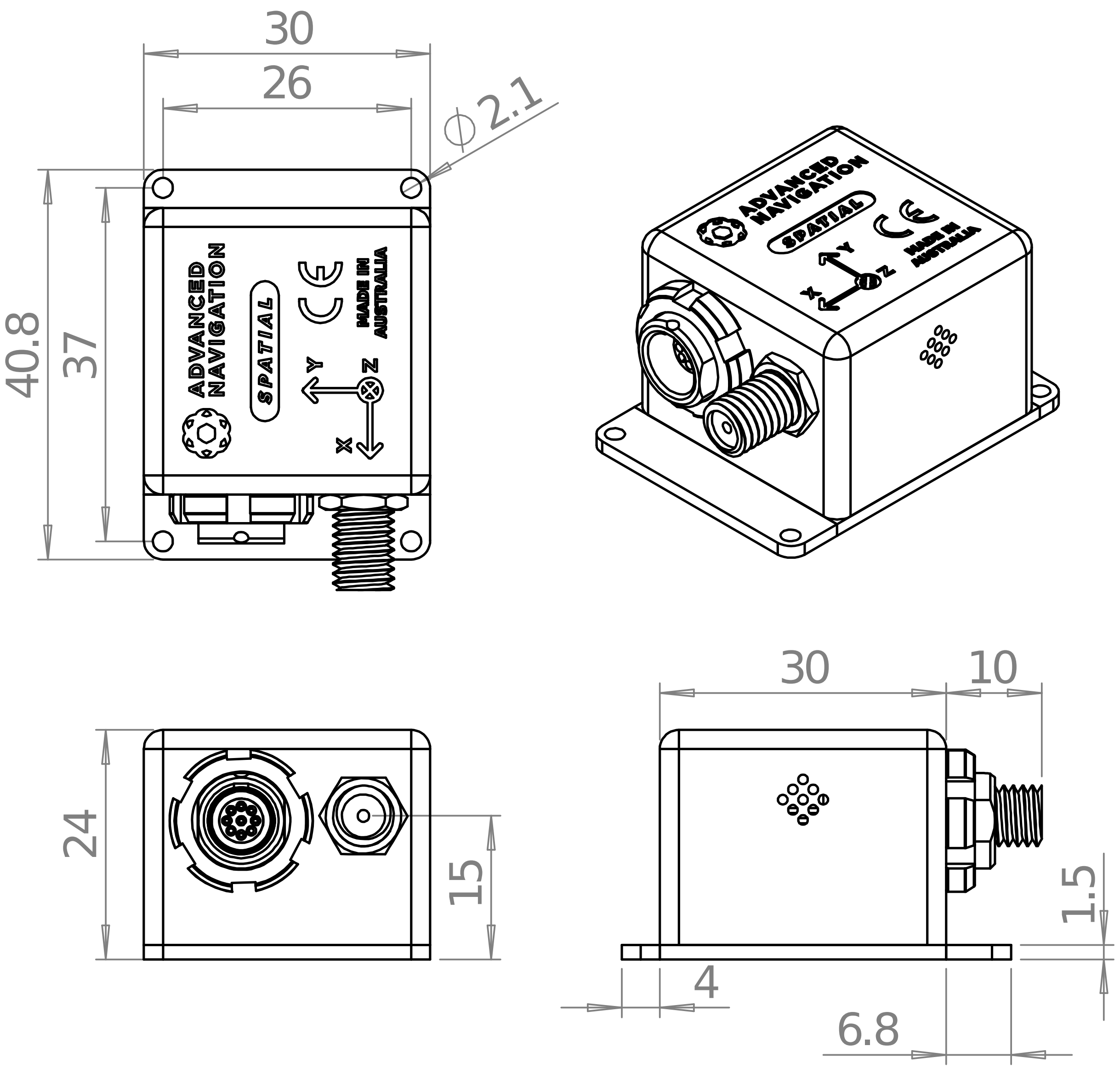


Illustration 14: Mechanical drawings of Spatial

5.2 Navigation Specifications

Parameter	Value
Horizontal Position Accuracy	2.0 m
Vertical Position Accuracy	3.0 m
Horizontal Position Accuracy (with DGNSS)	0.6 m
Vertical Position Accuracy (with DGNSS)	1.0 m
Velocity Accuracy	0.05 m/s
Roll & Pitch Accuracy (Static)	0.1 °
Heading Accuracy (Static)	0.5 °
Roll & Pitch Accuracy (Dynamic)	0.2 °
Heading Accuracy (Dynamic with GNSS)	0.2 °
Heading Accuracy (Dynamic, magnetic only)	0.8 °
Heave Accuracy	5 % or 0.05 m
Orientation Range	Unlimited
Hot Start Time	500 ms
Internal Filter Rate	1000 Hz
Output Data Rate	Up to 1000 Hz

Table 1: Navigation specifications

5.3 Sensor Specifications

Parameter	Accelerometers	Gyroscopes	Magnetometers	Pressure
Range (dynamic)	2 g 4 g 16 g	250 °/s 500 °/s 2000 °/s	2 G 4 G 8 G	10 to 120 KPa
Noise Density	150 ug/√Hz	0.008 °/s/√Hz	210 uG/√Hz	0.56 Pa/√Hz
Non-linearity	< 0.05 %	< 0.05 %	< 0.05 %	-
Bias Stability	60 ug	3 °/hr	-	100 Pa/yr
Scale Factor Stability	< 0.05 %	< 0.05 %	< 0.05 %	-
Cross-axis Alignment Error	< 0.05 °	< 0.05 °	0.05 °	-
Bandwidth	400 Hz	400 Hz	110 Hz	50 Hz

Table 2: Sensor specifications

5.4 GNSS Specifications

Parameter	Value
Supported Navigation Systems	GPS L1 GLONASS L1 GALILEO E1 BeiDou B1
Supported SBAS Systems	WAAS EGNOS MSAS GAGAN QZSS
Update Rate	10 Hz
Cold Start Sensitivity	-143 dBm
Tracking Sensitivity	-160 dBm
Hot Start First Fix	3 s
Cold Start First Fix	30 s
Horizontal Position Accuracy	2.5 m
Horizontal Position Accuracy (with SBAS)	2 m
Velocity Accuracy	0.05 m/s
Timing Accuracy	25 ns
Acceleration Limit	5 g

Table 3: GNSS Specifications

5.5 Communication Specifications

Parameter	Value
Interface	RS232
Speed	4800 to 1M baud
Protocol	AN Packet Protocol NMEA TSS
Peripheral Interface	2x GPIO and Auxiliary RS232
GPIO Level	5 – 20 V

Table 4: Communication specifications

5.6 Hardware Specifications

Parameter	Value
Operating Voltage	5 to 36 V
Input Protection	± 40 V
Power Consumption	100 mA @ 5 V (typical)
Hot Start Battery Capacity	> 24 hrs
Hot Start Battery Charge Time	30 mins
Hot Start Battery Endurance	> 10 years
Operating Temperature	-40 °C to 85 °C
Environmental Sealing	IP67 MIL-STD-810G
Shock Limit	2000 g
Dimensions (excluding tabs)	30 x 30 x 24 mm
Dimensions (including tabs)	30 x 40.6 x 24 mm
Weight	37 grams

Table 5: Hardware specifications

5.7 Electrical Specifications

Parameter	Minimum	Typical	Maximum
Power Supply			
Input Supply Voltage	5 V		36 V
Input Protection Range	-40 V		40 V
RS232			
Tx Voltage Low		-5.7 V	-5 V
Tx Voltage High	5 V	6.2 V	
Tx Short Circuit Current		±35 mA	±70 mA
Rx Threshold Low	0.8 V	1.3 V	
Rx Threshold High		1.7 V	2.5 V
GPIO			
Output Voltage Low	0 V		0.3 V
Output Voltage High	4.8 V		5 V
Input Voltage	-20 V		20 V
Input Threshold Low			1.5 V
Input Threshold High	3.5 V		
Output Current			5 mA
GNSS Antenna			
Active Antenna Supply Voltage	2.5 V	2.65 V	2.8 V
Antenna Supply Current			57 mA

Table 6: Electrical specifications

5.8 Power Consumption

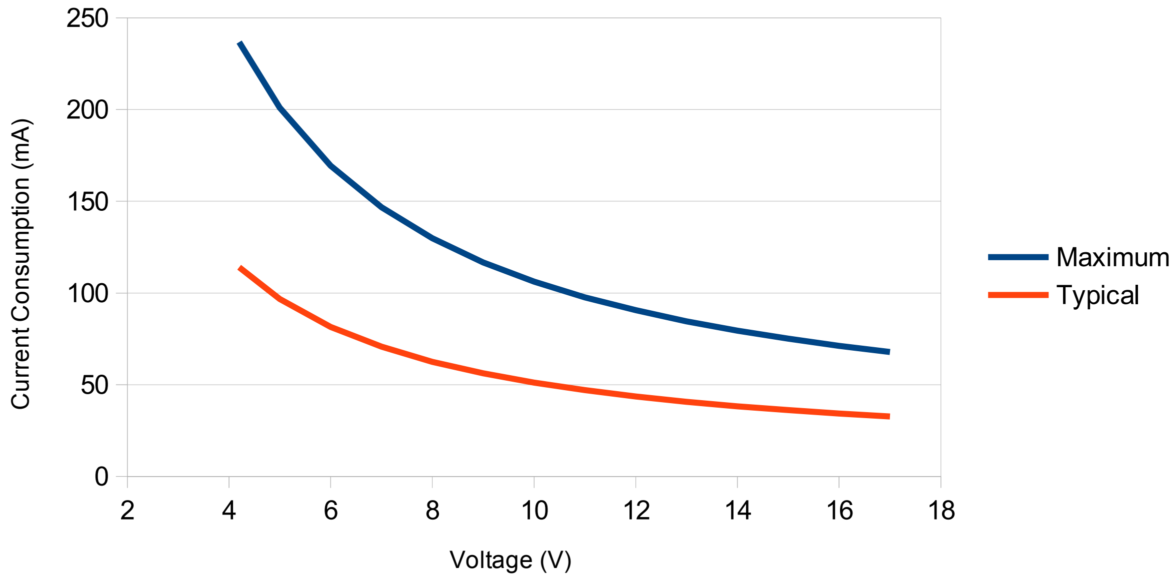


Illustration 15: Maximum and typical current consumption across operating voltage

5.9 Connector Pin-out

Power supply and signal connections are made through a ODU Mini-Snap Series B 9 pin connector. The connector provides a reliable and rugged connection to Spatial under demanding conditions and is rated to IP68 in the mated condition. Plugs are supplied with 2 metres of unterminated shielded cable with an outer protective jacket. Each individual wire is colour coded PFA coated 28AWG wire with an external shield and insulation. Custom cable lengths can be ordered by request.

Illustration 16: ODU B series mating plug for Spatial

Pin	Colour	Function
1	Black	Ground
2	Brown	Power Supply
3	White	GPIO 1
4	Green	GPIO 2
5	Red	Primary RS232 Transmit
6	Orange	Primary RS232 Receive
7	Yellow	Auxiliary RS232 Transmit
8	Blue	Auxiliary RS232 Receive
9		NC

Table 7: Pin allocation table

5.10 Sensor Calibration

Spatial's sensors are calibrated for bias, sensitivity, misalignment, cross-axis sensitivity, non-linearity and gyroscope linear acceleration sensitivity across the full operating temperature range and for each of the three sensor ranges.

6 Installation

6.1 Position and Alignment

When installing Spatial 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 should be mounted away from high levels of vibration where possible.
2. Spatial should be mounted in an area that is not going to exceed it's temperature range.
3. If atmospheric altitude is going to be used the two vents on the sides of Spatial should not be obstructed.
4. If magnetic heading is going to be used, Spatial should be mounted at least 10cm away from sources of dynamic magnetic interference i.e. high current wiring, large motors.
5. Spatial should be mounted close to the centre of gravity of the vehicle where possible.
6. Spatial should be mounted within several metres of the GNSS antenna where possible.

6.1.1 Alignment

The easiest way to align Spatial 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. Examples of this are shown below in Illustration 17, Illustration 18 and Illustration 19.

If aligning Spatial 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 Spatial Manager software, see section 8.8.4. For precise alignment, the set zero orientation button in the Spatial Manager alignment dialog can be used to set the current orientation as the zero orientation alignment, see section 8.8.4.

Illustration 17: Spatial axes aligned with car axes

Illustration 18: Spatial axes aligned with boat axes

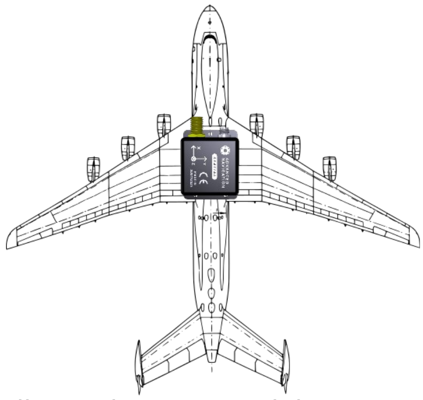


Illustration 19: Spatial axes aligned with plane axes

6.2 Mounting Plate

Spatial's mounting plate and hole guide is shown below in Illustration 20. The holes are designed for M2 cap screws.

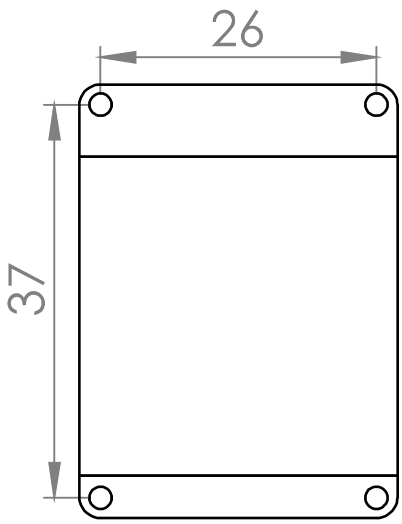


Illustration 20: Spatial mounting plate

6.3 Power Supply

A high level of power supply filtering has been built into Spatial, however it is still recommended that the power supply be free of significant noise. As the communications ground is shared with the supply ground, it is important to ensure that ground wiring is routed to avoid power supply noise from other systems corrupting data communications.

A power supply should be selected that can provide at least the maximum current calculated from the graph in Illustration 15.

Spatial 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 4.2 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 4.7 V or more to avoid issues associated with this.

6.4 GNSS Antenna

The GNSS antenna should be installed level with a clear view of the sky and close to the Spatial unit where possible. The antenna cable should be routed away from high energy noise sources. The optimum mounting configuration is above the Spatial unit. If the antenna has to be installed more than 1 metre away from the Spatial unit, this antenna offset should be configured in the Spatial unit by using the Spatial Manager software, see section 8.8.4. It is very important to set the antenna offset accurately as Spatial corrects for lever arm velocities. Incorrect GNSS antenna offset will lead to performance degradation under turning and angular rotations.

It is important to note that most GNSS antennas contain magnets for mounting. If you are using an antenna with magnets you will need to either keep it a minimum distance away from Spatial or remove the magnets to ensure that it doesn't interfere with Spatial's magnetometers.

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:

- Centre frequency of 1590 MHz and a bandwidth of 35 MHz
- Gain of 20 dB
- Antenna noise factor of < 2 dB
- Out of band rejection of 35 dB @ ±70 MHz

6.5 Odometer

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

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

6.5.1 Factory VSS Signal

Most road cars since 1980 contain a VSS (vehicle speed sensor) signal that can be wired directly into one of Spatial'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 odometer input using Spatial Manager, see section 8.8.6. The odometer pulse length must then be set either manually or automatically, please see section 7.10 for more information.

For more information on the GPIO signal and it's requirements please see section 9.3.3.

6.5.2 OBDII Odometer Interface

For applications where it is undesirable to modify the vehicle or the system needs to be used with multiple vehicles, an 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 with odometer data, please see Illustration 21. These units are priced at approximately AUD 500. Please contact Advanced Navigation support for more information.

Illustration 21: Spatial OBDII odometer interface

6.5.3 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 22: Aftermarket wheel speed sensor

6.5.4 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 23: Radar speed sensor

6.6 Magnetics

Spatial contains magnetometers which it uses to measure the Earth's magnetic field in order to determine it's heading. The principle is the same as that of a compass. When operating Spatial with magnetic heading enabled, sources of magnetic interference can degrade Spatial's solution if not compensated for. There are two types of magnetic interference, these are static and dynamic.

Static magnetic interference is caused by steel and other magnetic materials mounted in the vehicle. Static disturbances are easily compensated for by running a magnetic calibration, see section 7.6. A magnetic calibration should always be run after installation into a vehicle.

Dynamic magnetic interference is generally a much bigger issue. Sources of dynamic magnetic interference include high current wiring, electric motors, servos, solenoids and large masses of steel that don't move with Spatial. Spatial should be mounted as far as possible from these interference sources.

Spatial contains a special algorithm to remove the effects of dynamic magnetic interference. This is able to compensate for most typical interference sources encountered, however certain types of prolonged dynamic interference cannot be compensated for. The best way to check for dynamic magnetic interference is to use the raw sensors view in Spatial Manager and watch the magnetometer outputs whilst the vehicle is operating but stationary, see section 8.7.4. The values should be constant, if the values are fluctuating there is dynamic magnetic interference present.

If dynamic magnetic interference is causing performance problems and there is no way to mount Spatial away from the interference source, the magnetometers should be disabled, see section 7.6.4.

6.7 Vibration

Spatial is able to tolerate a high level of vibration compared to other inertial systems. This is due to a unique gyroscope design and a special filtering algorithm. There is however a limit to the amount of vibration that Spatial can tolerate and large levels of vibration will cause Spatial's accuracy to degrade.

When mounting Spatial to a platform with vibration there are several options. It is recommended to first try mounting Spatial and see whether it can tolerate the vibrations. The raw sensor view in the Spatial Manager software can give you a good idea of how bad the vibrations are, see section 8.7.4. If the vibrations are causing the sensors to go over range you will need to increase the sensors range, see section 7.7.

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

1. Try to find a mounting point with less vibration.
2. Spatial can be mounted with 3M foam rubber double sided tape or a small flat piece of rubber.
3. Spatial can be mounted to a plate which is then mounted to the platform through vibration isolation mounts.

7 Operation

7.1 Filter

Spatial contains a very sophisticated filter which it uses to fuse all it's sensors into a state estimation. The filter is a set of custom algorithms that have similar principles to a kalman filter, but operate differently. Spatial's custom filter makes decisions based upon context and history which greatly improves performance and makes it more resilient to error sources than a standard kalman filter.

Under rare conditions, when there are large errors present that Spatial's filter cannot compensate for, it can become unstable. If Spatial's filter does become unstable a monitoring process will immediately reset the filter to the last known good state. The filter initialised flag will remain reset until the filter stabilises again. In real time control applications it is very important to monitor Spatial's filter status, so that data can be ignored if a situation occurs causing the filter to reset.

7.2 Initialisation

When Spatial 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 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 movements and start with a small orientation error. In this scenario Spatial will progressively correct the orientation error over a period of several seconds.

After orientation detection, Spatial's filter takes several minutes to achieve it's full accuracy. It is recommended to wait two minutes after power on for applications requiring high accuracy.

7.3 Hot Start

Spatial is the first GNSS/INS on the market with hot start functionality. This allows Spatial to start inertial navigation within 500 milliseconds and obtain a GNSS fix in as little as 3 seconds. Spatial's hot start is always on and fully automatic.

A next generation backup battery system within Spatial provides the hot start ability for more than 24 hours without power. When Spatial hot starts it assumes that it is in the same position 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 will jump to the new position without causing any side effects to the filter.

Whilst Spatial 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'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.

7.4 Time

Spatial was designed to provide a highly accurate time reference. When a GNSS fix is available Spatial's time is accurate to within 50 nanoseconds. When a GNSS fix is lost, Spatial's time accuracy typically remains within 10 microseconds over extended time periods. When Spatial 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's high accuracy time, both the packet protocol and a 1PPS line must be used.

7.5 Heading Source

There are three different heading sources available for Spatial. The heading source can be selected using the filter options dialog in Spatial Manager, see section 8.8.2. It is possible to use multiple heading sources and this can often provide performance benefits.

7.5.1 Magnetic Heading

This is the default heading source and works well in the majority of cases. When using magnetic heading, calibration is required every time Spatial's installation changes. The downside of magnetic heading is that prolonged dynamic magnetic interference sources can cause heading errors.

7.5.2 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. The benefits of velocity heading are that it is immune to magnetic interference and no calibration is required when Spatial's installation changes.

7.5.3 External Heading

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

7.6 Magnetics

Static magnetic interference is resolved through magnetic calibration and dynamic magnetic interference is compensated by a filter algorithm but should be minimised where possible through installation location. Please see section 6.6 for more information on magnetic interference. To compensate for static magnetic interference, magnetic calibration should be performed any time Spatial's installation changes.

Spatial contains a dynamic magnetic compensation filter that is able to mitigate the effects of short term magnetic interference sources while in operation. For example if Spatial is installed in a car and the car drives over a large piece of magnetised steel, this will be compensated for. Another example is driving through a tunnel which is built from heavily reinforced concrete. It is important to note that for Spatial's dynamic magnetic compensation filter to operate correctly, Spatial needs to get a GNSS fix at least once every time it is moved more than 50km. Each time Spatial moves more than 50km the new position is stored permanently and allows Spatial to update it's world magnetic model values.

There are three types of magnetic calibration available, these are 2D calibration, 3D calibration and automatic calibration. 2D calibration involves three level rotations about the Z axis and is designed for vehicles that cannot easily or safely be turned upside down, such as full size cars, planes and boats. 3D calibration involves rotating through all orientations and is designed for vehicles that can easily and safely be rotated upside down, such as model size vehicles. 3D calibration offers slightly better performance and is recommended where possible. Automatic magnetic calibration continuously and automatically calibrates for static magnetic interference. It is not as accurate as the 2D or 3D calibration, however it is very convenient for applications where Spatial is swapped between vehicles and needs to just work without user intervention.

Please note that if Spatial is going to be used in a vehicle, the calibration should be performed while Spatial is mounted in and fixed to that vehicle. This means that the whole vehicle must be moved to perform the calibration. The calibration needs to be performed in an area away from sources of magnetic interference. For example if Spatial is installed in a car, the calibration should not involve driving over steel drains or reinforced concrete etc. If Spatial is being calibrated to operate standalone, the calibration should not be done on a desk with a steel frame.

7.6.1 2D Magnetic Calibration

The following procedure should be used to perform a 2D magnetic calibration.

7.6.1.1 Using the Spatial Manager Software

1. The unit should be powered on while the vehicle is in a level orientation and kept stationary.
2. After power on wait 5 minutes for the temperature and filter to stabilise.
3. Open Spatial Manager and connect to the device. Ensure that the device has a GNSS fix before proceeding.
4. In the Tools menu, open Magnetic Calibration. Click the 2D Calibration button. See section 8.9.2.
5. Whilst keeping as level as possible, rotate the vehicle in either direction through three full rotations. In a car this can be achieved by driving in three circles.
6. Check the status in the Magnetic Calibration window to ensure that the calibration completed successfully. If not successful click Cancel, wait 2 minutes and repeat from step 4.

7.6.1.2 Using the Packet Protocol

1. The unit should be powered on while the vehicle is in a level orientation and kept stationary.
2. After power on wait 5 minutes for the temperature and filter to stabilise.
3. Ensure that the device has a GNSS fix before proceeding
4. Send the Magnetic Calibration Configuration Packet with the action Start 2D Magnetic Calibration.
5. Whilst keeping as level as possible, rotate the vehicle in either direction through three full rotations. In a car this can be achieved by driving in three circles.
6. Read the Magnetic Calibration Status Packet to ensure that the calibration completed successfully. If not successful, send the Magnetic Calibration Configuration Packet with the action Cancel, wait 2 minutes and repeat from step 4.

7.6.2 3D Magnetic Calibration

The following procedure should be used to perform a 3D magnetic calibration.

7.6.2.1 Using the Spatial Manager Software

1. The unit should be powered on and the vehicle kept stationary.
2. After power on wait 5 minutes for the temperature and filter to stabilise.
3. Open Spatial Manager and connect to the device. Ensure that the device has a GNSS fix before proceeding.
4. In the Tools menu, open Magnetic Calibration. Click the 3D Calibration button. See section 8.9.2. The following steps 5, 6 and 7 can be performed in any order.
5. Slowly rotate the vehicle twice around the X axis (roll).
6. Slowly rotate the vehicle twice around the Y axis (pitch).
7. Slowly rotate the vehicle twice around the Z axis (heading).
8. Check the status in the Magnetic Calibration window to ensure that the calibration completed successfully. If not successful click Cancel, wait 2 minutes and repeat from step 4.

7.6.2.2 Using the Packet Protocol

1. The unit should be powered on and the vehicle kept stationary.
2. After power on wait 5 minutes for the temperature and filter to stabilise.
3. Ensure that the device has a GNSS fix before proceeding
4. Send the Magnetic Calibration Configuration Packet with the action Start 3D Magnetic Calibration. The following steps 5, 6 and 7 can be performed in any order.
5. Slowly rotate the vehicle twice around the X axis (roll).

6. Slowly rotate the vehicle twice around the Y axis (pitch).
7. Slowly rotate the vehicle twice around the Z axis (heading)
8. Read the Magnetic Calibration Status Packet to ensure that the calibration completed successfully. If not successful, send the Magnetic Calibration Configuration Packet with the action Cancel, wait 2 minutes and repeat from step 4.

7.6.3 Automatic Magnetic Calibration

Automatic magnetic calibration is an algorithm that continuously and automatically calibrates for static magnetic interference. After power on, the algorithm takes a little time to initialise and magnetic heading will not reach full accuracy until the Spatial unit has rotated through 360 degrees of heading or moved through some different orientations. Automatic magnetic calibration is not as accurate as 2D or 3D calibration, however it is sufficient for most vehicles and allows Spatial to be installed into vehicles and operated without user intervention. By default automatic magnetic calibration is disabled. It can be enabled using the filter options dialog in Spatial Manager, see section 8.8.2.

7.6.4 Disabling Magnetometers

In situations where there is very strong dynamic magnetic disturbances present, it is recommended to disable the magnetometers. When the magnetometers are disabled a secondary heading source is required otherwise may become inaccurate. Please see section 7.5 for information on heading sources. The magnetometers can be disabled using the filter options dialog in Spatial Manager, see section 8.8.2.

7.7 Sensors Range

Spatial supports dynamic ranging on it's sensors. Each of the three sensors have three different range levels. At lower ranges the sensor performance is better, but at higher ranges Spatial can be used in more extreme dynamics. It is important to choose a range that your application won't exceed.

Sensor over range events can be detected through the Filter Status. In Spatial manager the status indicator will go orange indicating that a sensor has gone over range. When a sensor goes over range this causes the filter solution to become inaccurate and in some cases it can cause the filter to reset.

By default Spatial comes configured in the lowest sensor ranges. In this configuration it is possible to send the gyroscopes over range by quickly rotating the unit in your hand. It is recommended to watch what happens in Spatial Manager when you do this.

The sensor ranges can be set through the sensor ranges dialog in the configuration menu in Spatial Manager, see section 8.8.1.

7.8 Data Anti Aliasing

Internally Spatial's filters update at 1000 Hz. When Spatial 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 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.

7.9 Vehicle Profiles

Spatial 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 dialog in Spatial Manager, see section 8.8.2. For a list of the different vehicle profiles please see section 10.9.6.1. Please note that if the wrong vehicle profile is selected it can cause a significant decrease in performance.

7.10 Odometer Pulse Length

For Spatial 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. To enter the pulse length manually, please use the odometer configuration dialog in Spatial Manager, see section 8.8.7. To automatically calibrate the odometer pulse length please use the procedure listed below in section 7.10.1. By default the odometer will automatically calibrate itself.

7.10.1 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 dialog in Spatial Manager, see section 8.8.6.
2. Open Spatial Manager, connect to Spatial and open the odometer configuration dialog, see section 8.8.7. In the odometer configuration dialog tick the automatic pulse length calibration check box and press the write button.
3. Wait until Spatial has a continuous GNSS fix and then drive 1000 metres over flat terrain with as little turning as possible.
4. If Spatial 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 dialog to ensure that it has passed 1000m.
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.

7.11 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 is fitted to a vehicle that does not reverse or doesn't use velocity heading or odometer, this function should be disabled. For all other applications it is best to leave it enabled. Reversing detection is enabled by default and it can be disabled using the filter configuration window in Spatial Manager, see section 8.8.2.

7.12 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 moving slowly or 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 Manager, see section 8.8.2.

7.13 Vents

Spatial contains a sophisticated venting system that allows it to measure air pressure whilst keeping water out. There are two sets of vent holes on either side of the enclosure. It is very important that these remain clean and clear of debris. Should debris get into the vents they should be rinsed with fresh water. Foreign bodies should never be poked into the vent holes, this will break the environmental seal and void the warranty on the unit.

7.14 RAIM

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

7.15 Underwater Navigation

Spatial is able to provide accurate absolute navigation underwater when combined with appropriate peripherals. There are several options for underwater navigation detailed below.

7.15.1 DVL (Doppler Velocity Log) Peripheral

DVLs provide 3D velocity underwater and allow Spatial to provide positional accuracy of approximately 0.3% of distance travelled.

A DVL works by tracking velocity relative to the sea floor. They typically have a range of approximately 100m. When the sea floor is beyond this range, the DVL provides velocity relative to the water layer, however this is unable to account for water currents which can cause positional accuracy to degrade faster.

When operating with a DVL, Spatial must have a starting position to navigate from. This can be achieved by either allowing Spatial to get a GNSS fix while the underwater vehicle is on the surface, or by manually entering the starting co-ordinates using the External Position Packet. The typical setup for obtaining a GNSS fix is a waterproof glass dome housing the GNSS antenna, mounted on the top of the vehicle.

Spatial contains built in support for DVLs from Teledyne and Linkquest and these systems can be directly connected to Spatial using the GPIO pins. Advanced Navigation recommends Teledyne DVL systems.

7.15.2 USBL (Ultra-short Baseline) Peripheral

USBLs provide relative 3D positioning underwater and allow Spatial to provide positional accuracy of approximately 4m.

A USBL setup consists of a surface transponder, an underwater responder and two Spatial units. The surface transponder is typically mounted on a ship and is connected to a Spatial unit. Another Spatial unit is mounted on the underwater vehicle along with the responder. The surface Spatial unit communicates with the underwater Spatial unit over a serial connection through a tether. Please see Illustration 24. USBL systems typically have a maximum range from transponder to responder of between 500 and 4000 metres.

Spatial contains built in support for USBLs from Tritech and these systems can be directly connected to Spatial using the GPIO pins.

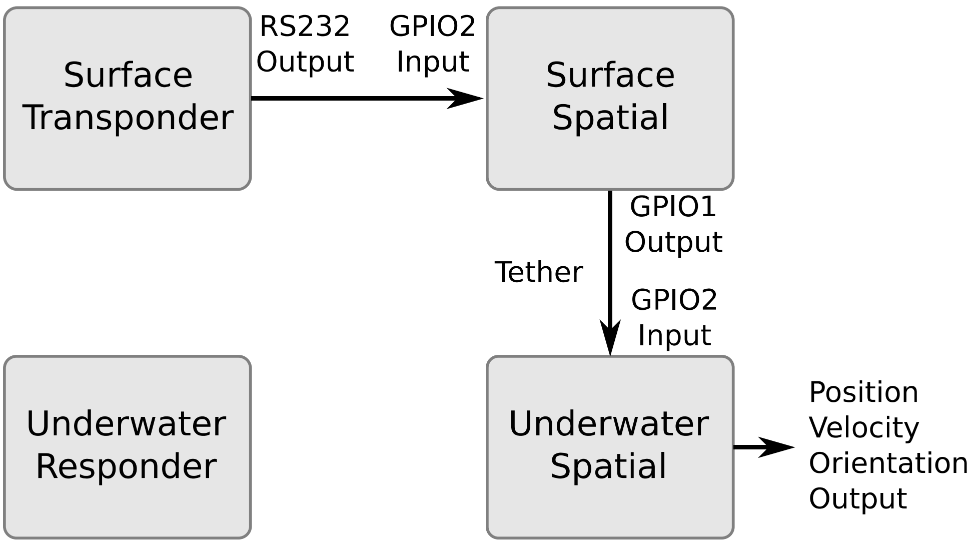


Illustration 24: Spatial USBL Setup

7.15.3 Depth

For Spatial's intelligent filter to operate correctly and provide maximum performance, Spatial requires continuous updates of depth information. This can be achieved by adding a pressure depth transducer to Spatial. Spatial supports frequency output pressure depth transducers using the GPIO pins, please see section 9.3.25. Alternatively if depth is already known, it can be fed into Spatial using the External Depth Packet. Some Teledyne DVLs feature a built in pressure sensor, in this case Spatial will automatically use the DVL pressure to determine depth.

7.15.4 DVL and USBL Combined Systems

For systems that require the highest accuracy, Spatial can be combined with both a DVL and USBL. By using both the DVL velocity and USBL position, Spatial is able to provide very accurate underwater navigation.

7.16 Heave

Spatial can provide vertical heave position at four different points on a ship. Spatial's heave filter is always on and fully automatic. After power on, Spatial 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 has a GNSS fix.

By default Spatial provides heave from the point at which the Spatial 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 dialog in Spatial Manager, see section 8.8.9.

7.17 Environmental Exposure

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

Spatial is only protected when it's connector is mated and an IP67 SMA GNSS antenna is attached to it. When either of these two connections are not finger tightly closed the unit offers no environmental protection.

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

7.17.1 Temperature

Spatial should not be subjected to temperature's outside of it's operating range. If the temperature rises above 90 degrees Celsius, Spatial will automatically shut off power to it's sensors and GNSS in an attempt to prevent damage, this will also send the filters into reset. Subjecting Spatial to temperature's outside of the storage range can effect the factory sensor calibration which will cause a permanent performance degradation.

7.17.2 Water

Spatial is water-proof to the IP67 standard which means that it can be submersed in water to a depth of up to 1 metre only. Submersion to depths beyond 1 metre can cause water entry and destruction of the internal electronics.

7.17.3 Salt

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

7.17.4 Dirt and Dust

Spatial 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 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.

7.17.5 PH Level

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

7.17.6 Shocks

Spatial can tolerate shocks to 2000g, however continuous shocks of this severity are likely to cause premature failure. Shocks above 2000g can effect the factory sensor calibration and degrade performance. Normally shocks to Spatial 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's enclosure can more easily go over the limit however so care should be taken when handling the unit prior to mounting.

8 Spatial Manager

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

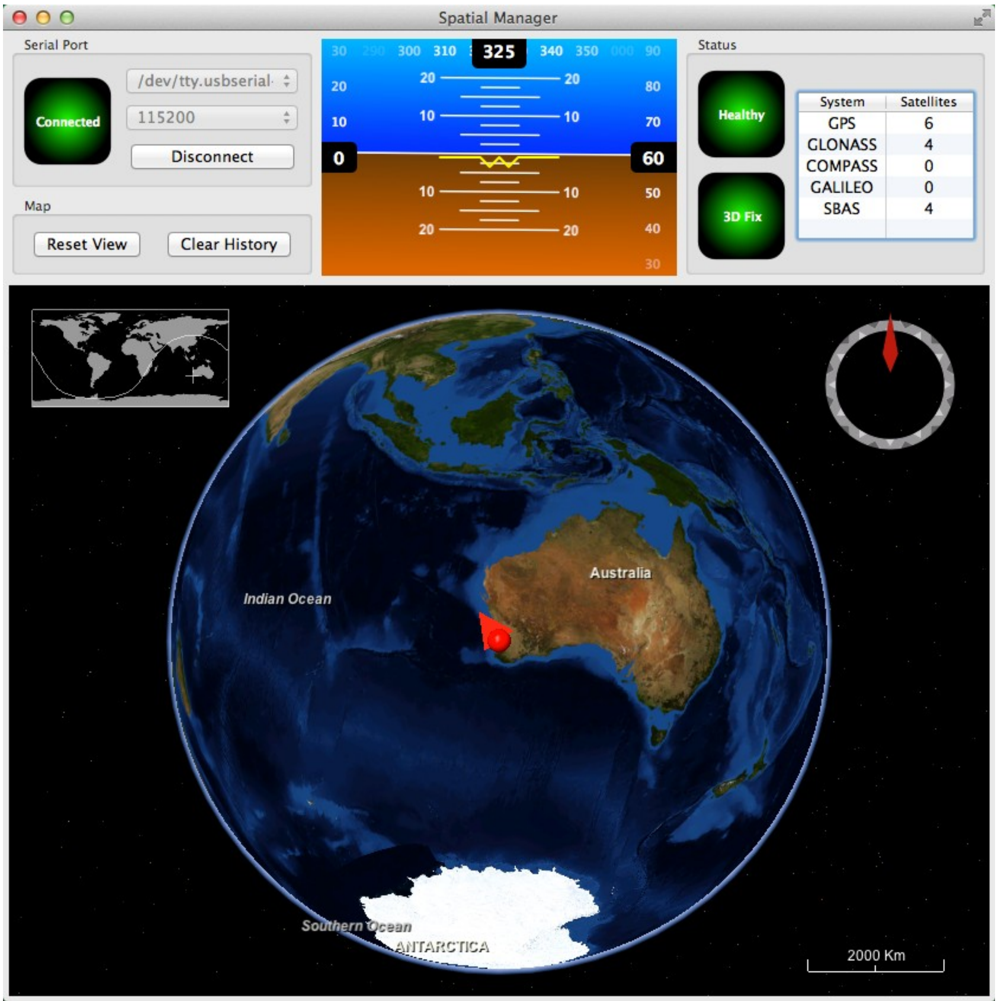


Illustration 25: Screenshot of Spatial Manager

8.1 Software Changelog

Version	Date	Changes
3.0	13/09/2013	Significantly reduced CPU usage Minor interface enhancements New options added to filter options dialog Added NMEA output configuration dialog Added position configuration dialog, section
2.4	27/03/2013	Minor interface enhancements Updated GPIO functions Detailed satellites dialog updated to show frequencies Experimental post-processing log export function added
2.3	14/02/2013	Added Chinese language translation Changed logging system to binary format Added heave offset dialog Firmware date added to firmware update dialog Minor changes
2.0	22/10/2012	Added odometer configuration dialog Added log converter tool Spatial Manager will now disconnect automatically if USB serial port is removed Firmware update will now change the baud rate automatically when entering bootloader mode Alignment configuration dialog updated
1.0	16/09/2012	Mac disconnect issue resolved
0.5	23/08/2012	Initial Release

8.2 System Requirements

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

8.3 Installation

Spatial Manager does not need to be installed and can be run from any directory by double clicking on it. Spatial Manager requires a recent version of Java, available at http://www.java.com. On some systems to open the program it may be necessary to right click and select open with → Java Runtime Environment.

Both the Spatial evaluation kit and the Spatial OEM development kit make use of an FTDI USB device. The drivers are normally installed automatically, if not they are available from http://www.ftdichip.com/Drivers/VCP.htm.

8.4 Troubleshooting

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

8.4.1 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.

8.4.2 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 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 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 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 26.

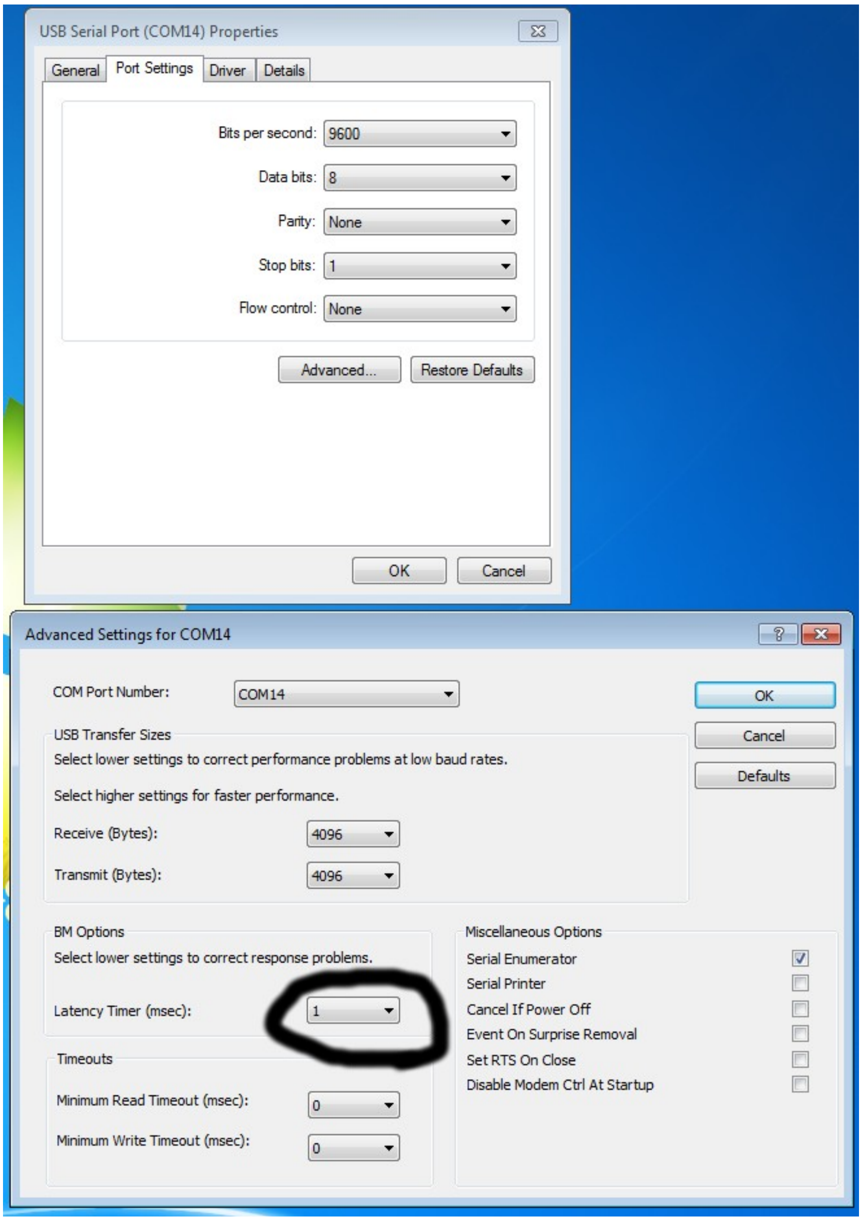


Illustration 26: Screenshot of latency timer setting

8.4.3 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.

8.5 Main View

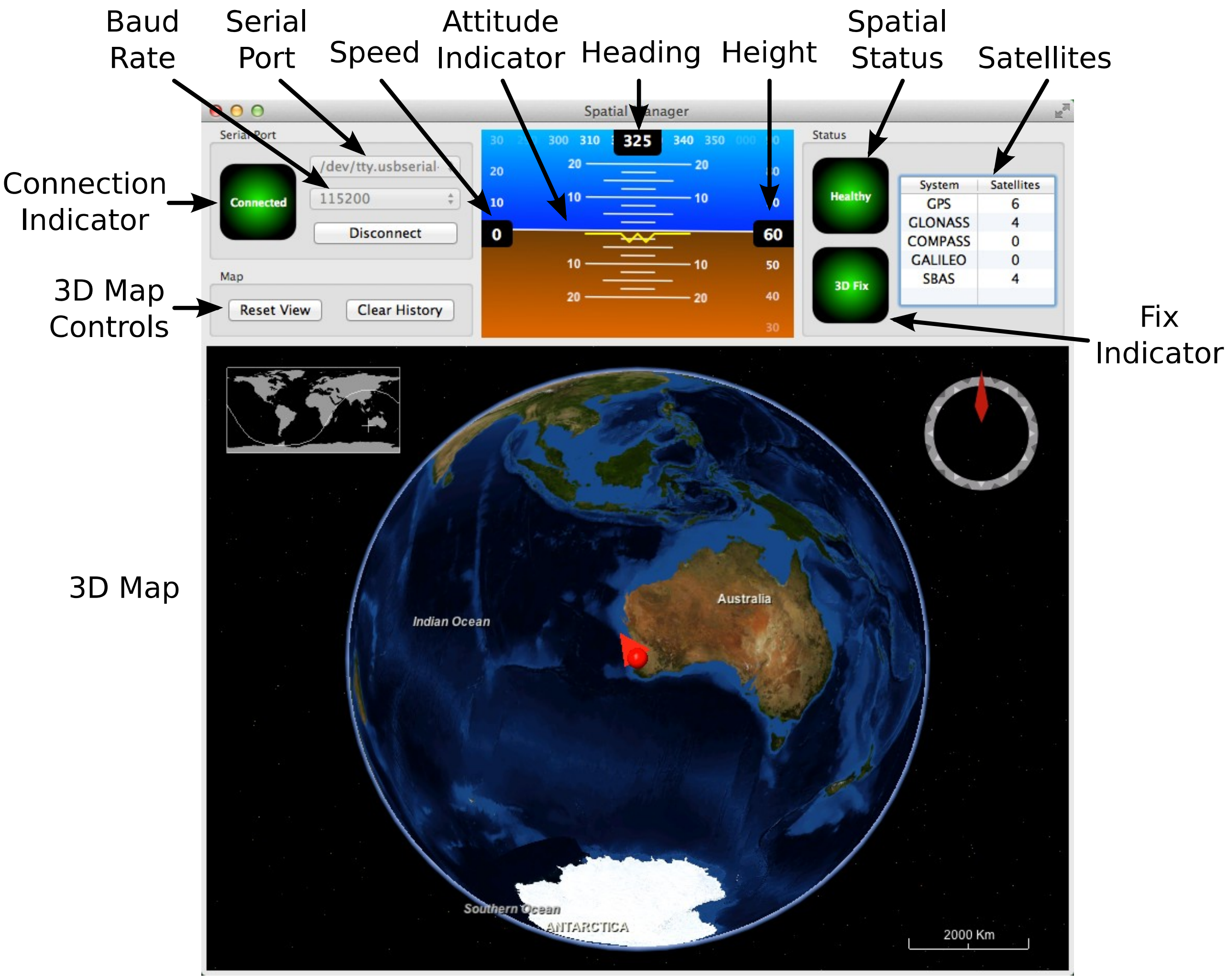


Illustration 27: Screenshot of Spatial Manager main view

8.5.1 Serial Port

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

8.5.2 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.

8.5.3 Status Indicator

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

8.5.3.1 Spatial Status Indicator

This indicator shows any problems with Spatial. 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.

8.5.3.2 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”.

8.5.3.3 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.

8.5.4 3D Map

The 3D map shows Spatial'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'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.

8.5.5 3D Map Controls

8.5.5.1 Reset View

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

8.5.5.2 Clear History

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

8.6 Logging

Spatial Manager features a fully automatic logging system. Every time the serial port connect button is clicked Spatial 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 in the AN packet protocol. The log files are closed when the serial port is disconnected. To convert these log files into easily accessible formats, the log converter dialog in the tools menu can be used, see section 8.9.4. The log converter dialog creates a folder and generates files in the CSV (comma seperated values) format that can be easily opened with Microsoft Excel, Matlab, libreoffice and most other data analysis programs. It also creates a GPX file of position that is designed to be opened with Google Earth.

SpatialLog_13-02-11_11-30-52	Today 1:02 PM	--	Folder
EulerOrientation.csv	Today 1:02 PM	40 KB	comm...values
EulerStandardDeviation.csv	Today 1:02 PM	39 KB	comm...values
GoogleEarth.kml	Today 1:02 PM	78 KB	Googl...ument
RawSensors.csv	Today 1:02 PM	101 KB	comm...values
Satellites.csv	Today 1:02 PM	8 KB	comm...values
State.csv	Today 1:02 PM	753 KB	comm...values
Status.csv	Today 1:02 PM	57 KB	comm...values
SpatialLog_13-02-11_11-30-52.anpp	Today 11:32 AM	264 KB	Document

Illustration 28: Screenshot showing log file and log conversion folder

8.7 Views

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

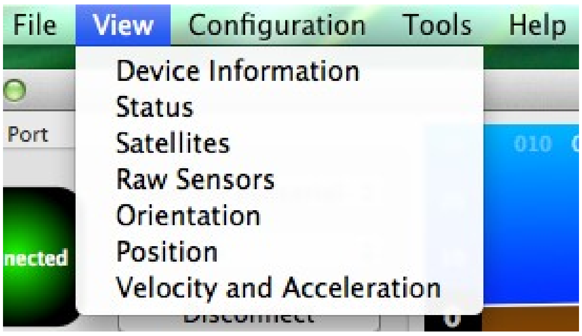


Illustration 29: Screenshot of Spatial Manager view menu

8.7.1 Device Information

Device information is mostly useful during technical support.

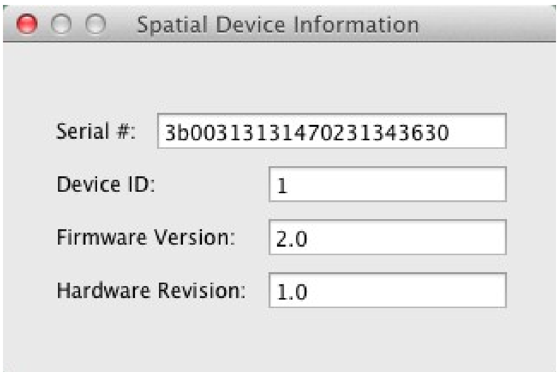


Illustration 30: Screenshot of Spatial Manager device information dialog

8.7.2 Status

Status shows Spatial's complete status as contained in the system state packet detailed in section 10.8.1.1.

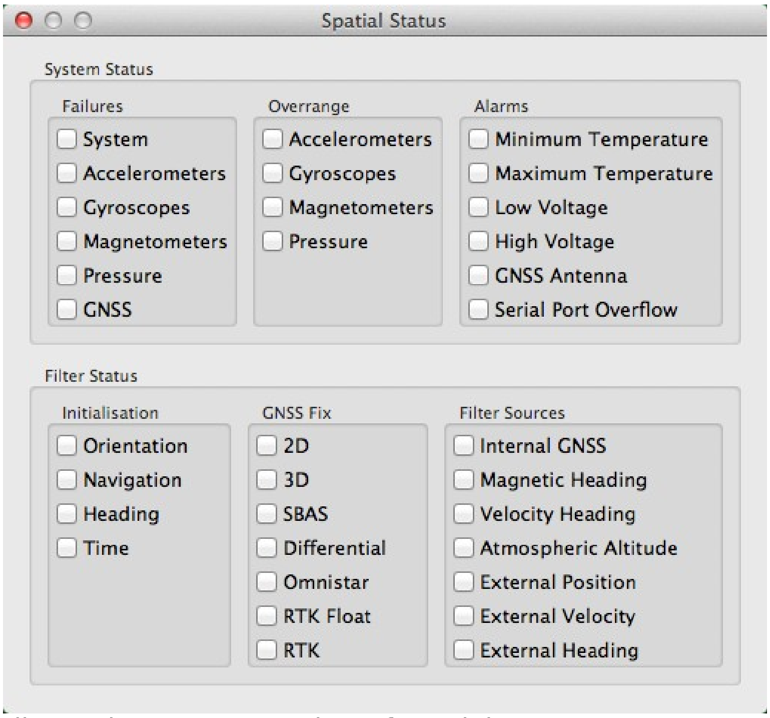
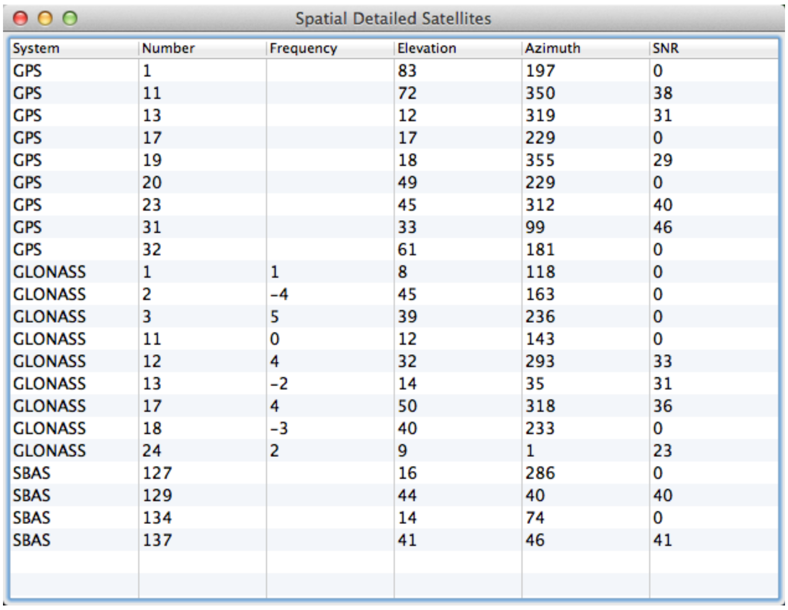


Illustration 31: Screenshot of Spatial Manager status dialog

8.7.3 Satellites

Satellites shows detailed information on the satellites that Spatial's GNSS receiver is tracking.



System	Number	Frequency	Elevation	Azimuth	SNR
GPS	1		83	197	0
GPS	11		72	350	38
GPS	13		12	319	31
GPS	17		17	229	0
GPS	19		18	355	29
GPS	20		49	229	0
GPS	23		45	312	40
GPS	31		33	99	46
GPS	32		61	181	0
GLONASS	1	1	8	118	0
GLONASS	2	-4	45	163	0
GLONASS	3	5	39	236	0
GLONASS	11	0	12	143	0
GLONASS	12	4	32	293	33
GLONASS	13	-2	14	35	31
GLONASS	17	4	50	318	36
GLONASS	18	-3	40	233	0
GLONASS	24	2	9	1	23
SBAS	127		16	286	0
SBAS	129		44	40	40
SBAS	134		14	74	0
SBAS	137		41	46	41

Illustration 32: Screenshot of Spatial Manager satellites dialog

8.7.4 Raw Sensors

Raw sensors shows the temperature calibrated raw sensor values.

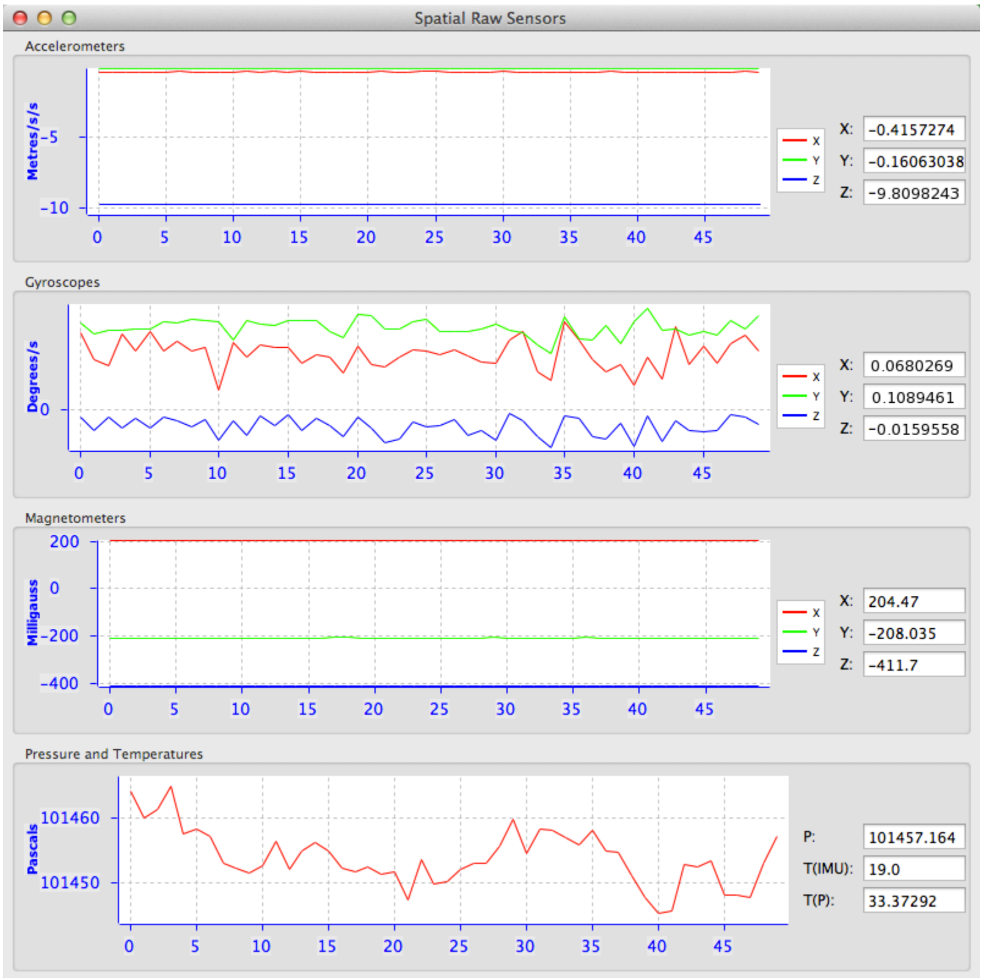


Illustration 33: Screenshot of Spatial Manager raw sensors dialog

8.7.5 Orientation

Orientation shows Spatial's orientation and angular velocity.

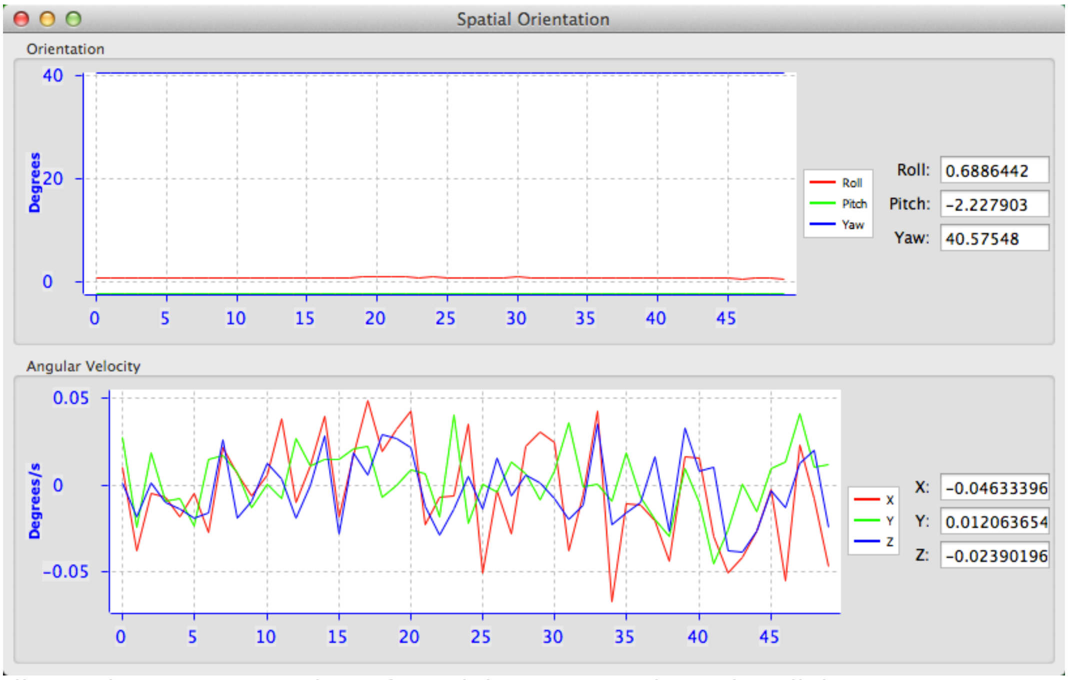


Illustration 34: Screenshot of Spatial Manager orientation dialog

8.7.6 Position

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

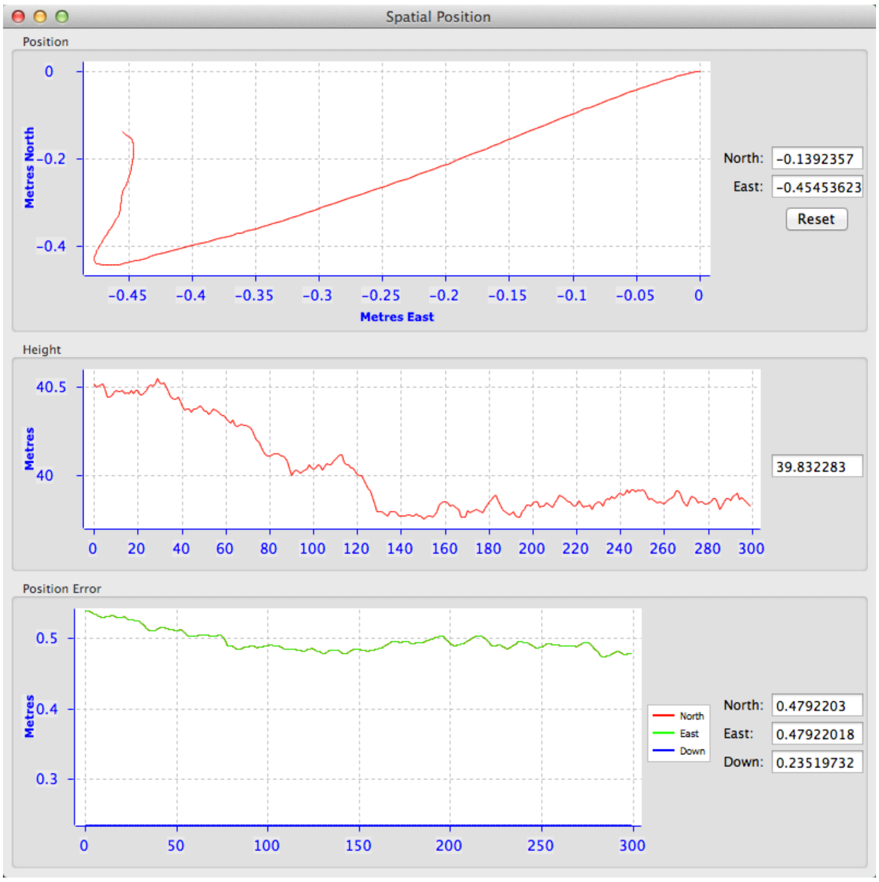


Illustration 35: Screenshot of Spatial Manager position dialog

8.7.7 Velocity and Acceleration

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

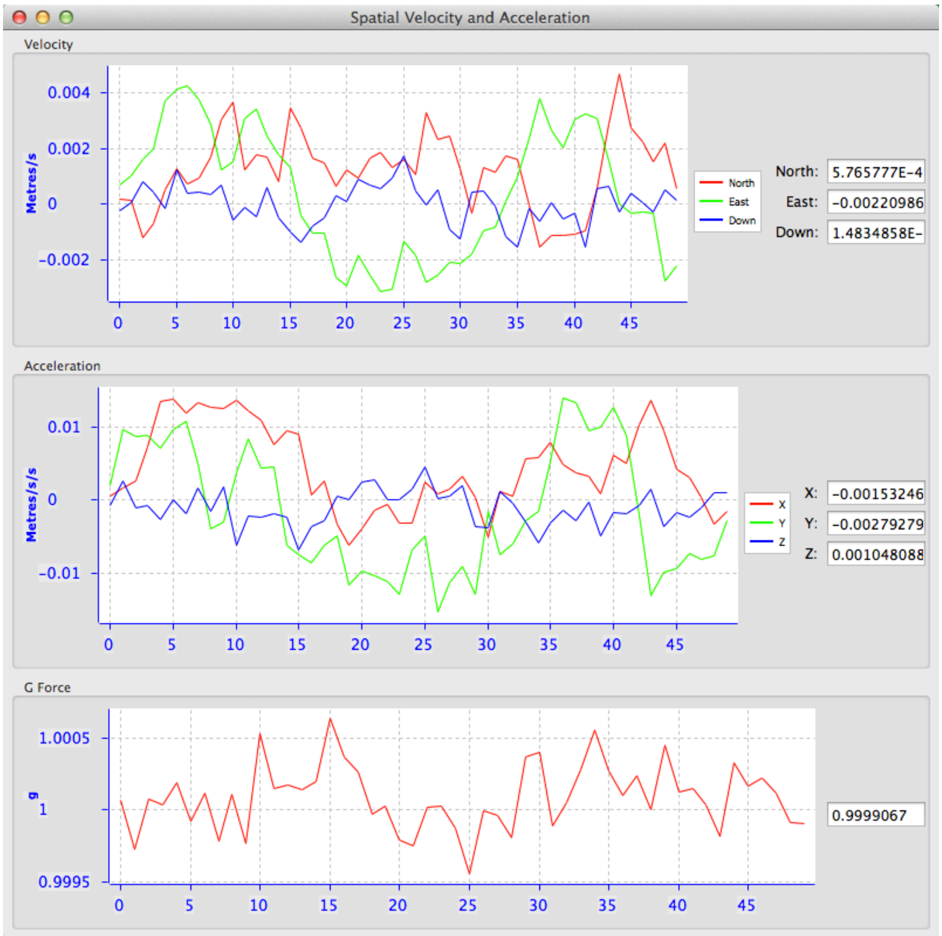


Illustration 36: Screenshot of Spatial Manager velocity and acceleration dialog

8.8 Configuration

The configuration menu contains a number of dialogs for the configuration of Spatial.

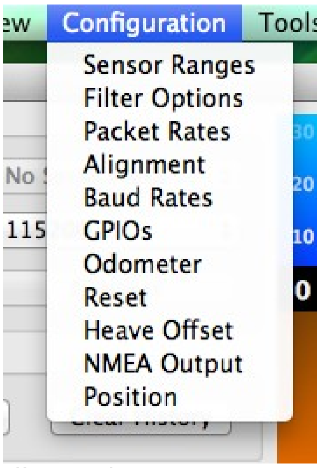


Illustration 37: Screenshot of Spatial Manager configuration menu

8.8.1 Sensor Ranges

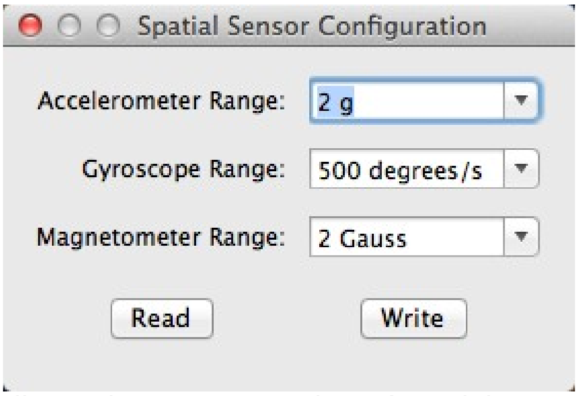


Illustration 38: Screenshot of Spatial Manager sensor ranges dialog

8.8.2 Filter Options

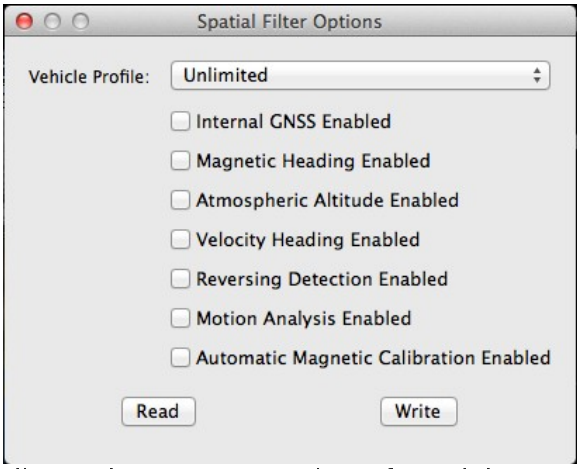


Illustration 39: Screenshot of Spatial Manager filter options dialog

8.8.3 Packet Rates

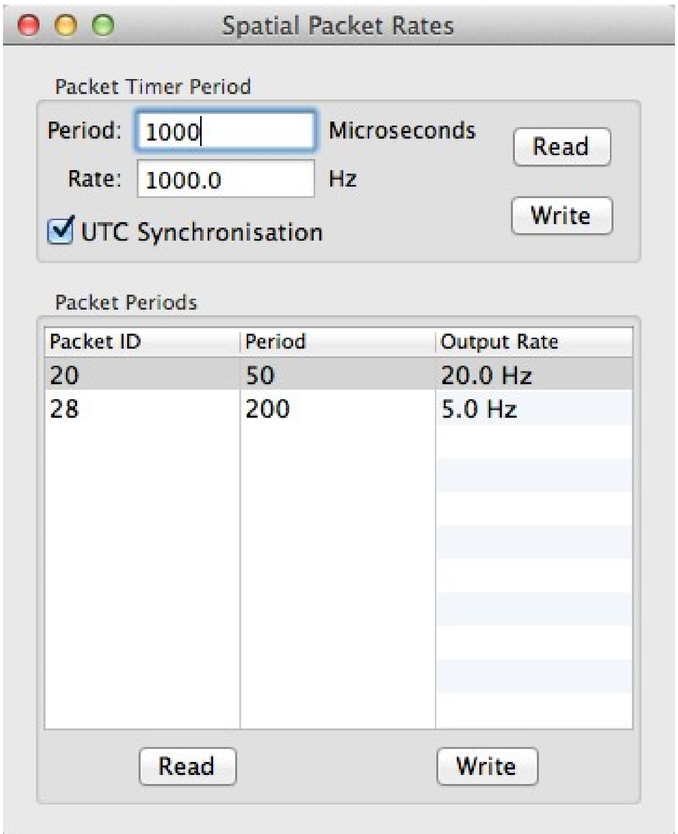


Illustration 40: Screenshot of Spatial Manager packet rates dialog

8.8.4 Alignment Configuration

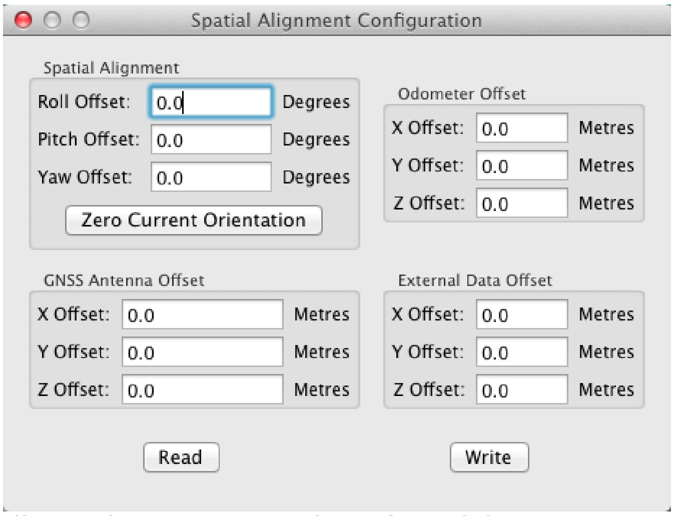


Illustration 41: Screenshot of Spatial Manager alignment configuration dialog

8.8.5 Baud Rates

When changing baud rates, some 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.

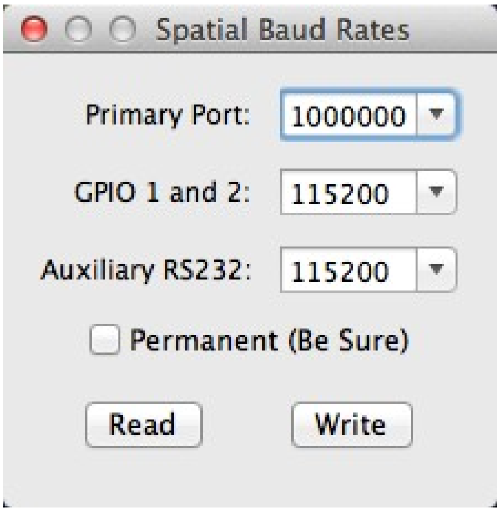


Illustration 42: Screenshot of Spatial Manager baud rates dialog

8.8.6 GPIO Configuration

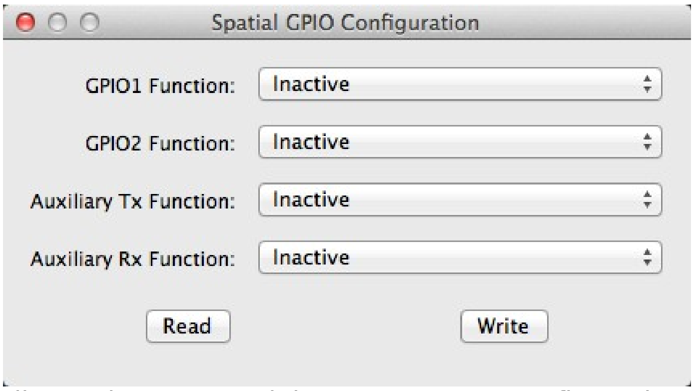


Illustration 43: Spatial Manager GPIO configuration dialog

8.8.7 Odometer

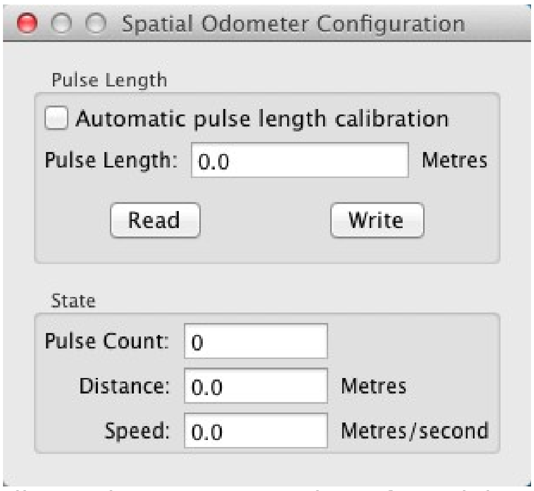


Illustration 44: Screenshot of Spatial Manager odometer configuration dialog

8.8.8 Reset

Illustration 45: Screenshot of Spatial Manager reset dialog

8.8.9 Heave Offset

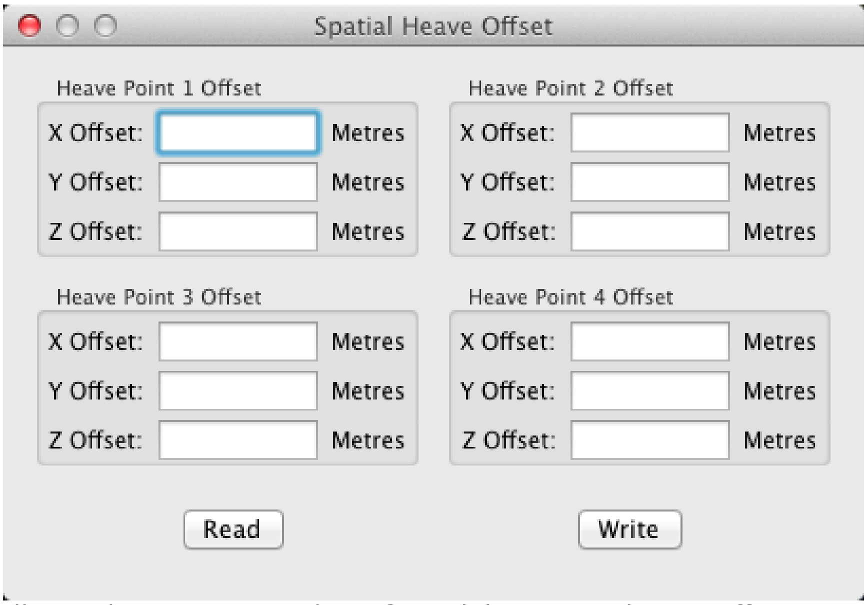


Illustration 46: Screenshot of Spatial Manager heave offset dialog

8.8.10 Position Configuration

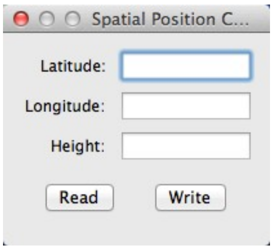


Illustration 47: Screenshot of Spatial Manager position configuration dialog

8.9 Tools

The tools menu contains tools for performing procedures with Spatial.

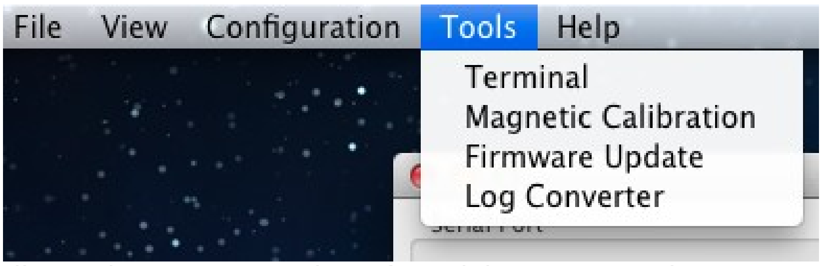


Illustration 48: Screenshot of Spatial Manager tools menu

8.9.1 Terminal

The terminal is only used during specialised technical support with Advanced Navigation engineers.

8.9.2 Magnetic Calibration

The magnetic calibration dialog allows the user to perform magnetic calibration as well as view and modify the magnetic calibration values.

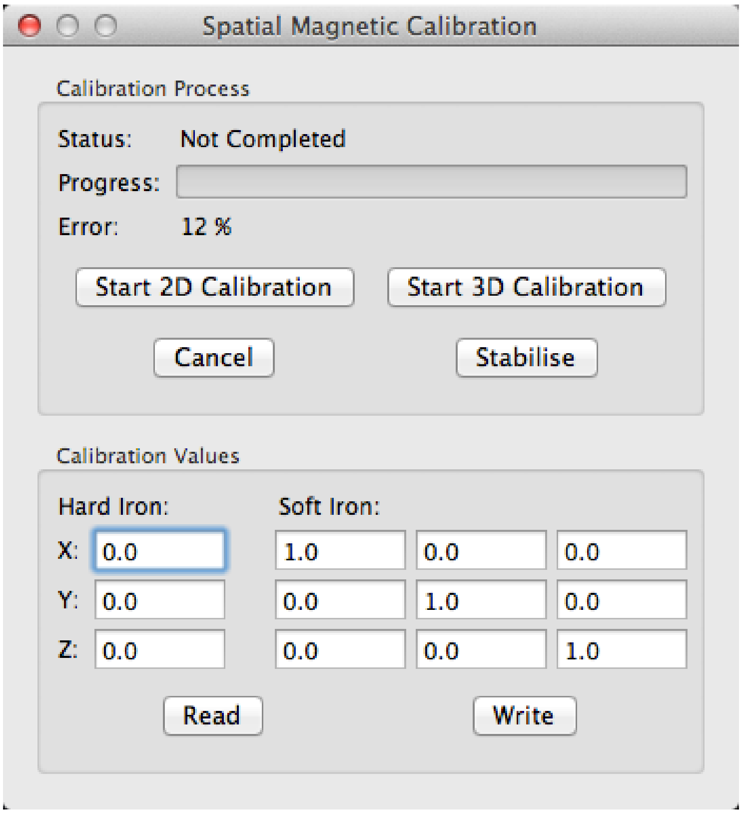


Illustration 49: Screenshot of Spatial Manager magnetic calibration dialog

8.9.3 Firmware Update

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

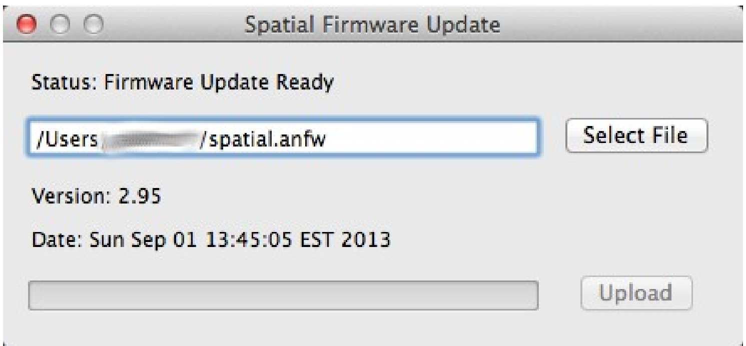


Illustration 50: Screenshot of Spatial Manager firmware update dialog

8.9.4 Log Converter

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

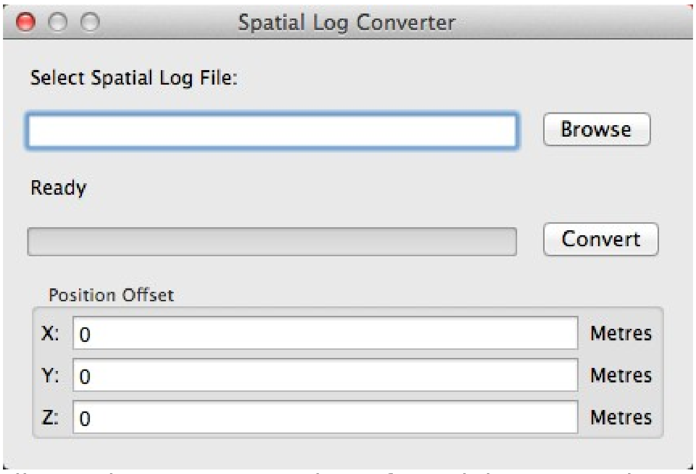


Illustration 51: Screenshot of Spatial Manager log converter dialog

9 Interfacing

9.1 Communication

All communication to the Spatial module is over the RS232 interface in the Advanced Navigation Packet Protocol (ANPP). The RS232 format is fixed at 1 start bit, 8 data bits, 1 stop bit and no parity. See section 10 for details on the protocol.

9.1.1 Baud Rate

The default baud rate of Spatial is 115200. The baud rate can be set anywhere from 100 to 1000000 baud and can be modified using the Spatial Manager software or the baud rate packet, see section 10.9.3. It is important to select a baud rate that is capable of carrying the amount of data that Spatial is set to send. See packet rates in section 10.5 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 115200, then the data rate is 11520 bytes per second.

9.2 External Data

External sources of position, velocity, heading, time, depth and pitot pressure can be integrated into Spatial's filter solution. The data can be sent to Spatial in the ANPP format over the main RS232 port or through one of the GPIO pins in a number of different formats. If using the ANPP, please use Table 8 below to find the relevant section. If using the GPIOs, please see section 9.3.

Packet	Section
External Position and Velocity	10.8.25
External Position	10.8.26
External Velocity	10.8.27
External Body Velocity	10.8.28
External Heading	10.8.29
External Time	10.8.33
External Depth	10.8.34
External Pitot Pressure	10.8.37

Table 8: ANPP External Data Reference

9.3 GPIO Pins and Auxiliary RS232

Spatial contains two general purpose input output pins and an auxiliary RS232 port on the main connector. These pins are multi function and can be used to extend Spatial with additional peripherals, sensors and data formats. Both GPIO pins have digital input, digital output, frequency input and frequency output functionality. Additionally GPIO1 can function as a TTL serial transmit line and GPIO2 can act as a TTL serial receive line. The GPIO serial and auxiliary RS232 baud rate can be configured anywhere from 1200 to 1000000 baud by using the baud rate configuration dialog in Spatial Manager.

The GPIO pin and auxiliary RS232 functions available are listed below. The function of a GPIO pin can be changed at any time using the GPIO configuration dialog in Spatial Manager.

Function	Type	GPIOs	Auxiliary RS232
Inactive	Tristate	All	All
1PPS Output	Digital Output	All	
GNSS Fix Output	Digital Output	All	
Odometer Input	Frequency Input	All	
Stationary Input	Digital Input	All	
Pitot Tube Input	Frequency Input	All	
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 Magnetometers	Digital Input	All	
Disable GNSS	Digital Input	All	
Disable Pressure	Digital Input	All	
Set Zero Orientation Alignment	Digital Input	All	
System State Packet Trigger	Digital Input	All	
Raw Sensors Packet Trigger	Digital Input	All	
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
Pressure Depth Transducer Input	Frequency Input	All	
Left Wheel Speed Sensor	Frequency Input	All	
Right Wheel Speed Sensor	Frequency Input	All	
1PPS Input	Digital Input	All	

Function	Type	GPIOs	Auxiliary RS232
Wheel Speed Sensor	Frequency Input	All	
Wheel Encoder Phase A	Frequency Input	All	
Wheel Encoder Phase B	Frequency Input	All	
Event 1 Input	Digital Input	All	
Event 2 Input	Digital Input	All	
TSS1 Output	Serial Transmit	1	Transmit
Simrad 1000 Output	Serial Transmit	1	Transmit
Simrad 3000 Output	Serial Transmit	1	Transmit

Table 9: GPIO pin functions

9.3.1 1PPS Output

In this function, the pin is normally low and pulses high for 50 milliseconds to signal the precise second. The 1PPS line starts pulsing approximately 100 milliseconds after power up and always fires irrespective of whether Spatial has accurate time or not. It is important to note that when Spatial 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.

9.3.2 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.

9.3.3 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 the 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 10: Odometer Specifications

9.3.4 Stationary Input

In this function, a high state indicates to Spatial that the vehicle is stationary. The low state indicates that the vehicle could be moving. Use of this function can significantly improve performance when a GNSS signal is not available.

9.3.5 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.

9.3.6 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 11: Supported NMEA messages

9.3.7 NMEA Output

This function outputs a configurable combination of the NMEA messages GPZDA, GPGGA, GPVTG, GPRMC, GPHDT and PASHR at up to 20 Hz. The messages output and the output rate can be configured using the NMEA output configuration dialog in

Spatial 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

9.3.8 Novatel GNSS Input

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

9.3.9 Topcon GNSS Input

This function is designed for interfacing Spatial 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.

9.3.10 ANPP Input

This function accepts data in the ANPP format as specified in section 10.

9.3.11 ANPP Output

This function outputs data in the ANPP format as specified in section 10. For packets to be sent out they must be requested through another GPIO functioning as ANPP input. This function is also used when connecting two Spatial units together, for example when using a USBL.

9.3.12 Disable Magnetometers

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

9.3.13 Disable GNSS

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

9.3.14 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.

9.3.15 Set Zero Orientation Alignment

This function accepts a digital input. The input is normally low and a transition from low to high causes Spatial 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 with the permanent flag set. This function requires de-bouncing if attached to a switch.

9.3.16 System State Packet Trigger

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

9.3.17 Raw Sensors Packet Trigger

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

9.3.18 RTCM Differential GNSS Corrections Input

This function accepts RTCM SC-104 differential GNSS corrections. This allows for Differential GNSS with Spatial's internal GNSS receiver.

9.3.19 Trimble GNSS Input

This function is designed for interfacing Spatial with a 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.

9.3.20 u-blox GNSS Input

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

9.3.21 Hemisphere GNSS Input

This function is designed for interfacing Spatial 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.

9.3.22 Teledyne DVL Input

This function is designed for interfacing with Teledyne DVL systems. This allows Spatial to navigate underwater. It accepts data in the PD0 output data format at rates 1Hz or higher. Please see section 7.15 for more information on underwater navigation using Spatial.

9.3.23 Tritech USBL Input

This function is designed for interfacing with a Tritech micronnav USBL system. This allows Spatial to navigate underwater. It accepts data in the Raw XYZ format. Please note that the setup with a Tritech USBL requires two Spatial units. Please see section 7.15 for more information on underwater navigation using Spatial.

9.3.24 Linkquest DVL Input

This function is designed for interfacing with Linkquest DVL systems. This allows Spatial to navigate underwater. It accepts data in the NQ1 output data format at rates 1Hz or higher. Please see section 7.15 for more information on underwater navigation using Spatial.

9.3.25 Pressure Depth Transducer Input

This function is designed for interfacing with frequency output pressure depth transducers. It requires a pressure transducer with a frequency output such as the AST4700 from American Sensor Technologies. Please see section 7.15 for more information on underwater navigation using Spatial.

9.3.26 Left Wheel Speed Sensor

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

9.3.27 Right Wheel Speed Sensor

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

9.3.28 1PPS Input

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

9.3.29 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 the wheel speed sensor function should be used. Please contact Advanced Navigation support for help integrating with your speed sensor.

9.3.30 Wheel Encoder Phase A

This function is designed for rotary incremental quadrature encoders. It should be used in combination with Wheel Encoder Phase B.

9.3.31 Wheel Encoder Phase B

This function is designed for rotary incremental quadrature encoders. It should be used in combination with Wheel Encoder Phase A.

9.3.32 Event 1 Input

This function is designed to allow external events to be recorded inside Spatial's output. The event is recorded in the filter status, see section 10.8.1.2, and resets after the next packet is output. The event triggers on a transition from low to high.

9.3.33 Event 2 Input

This function is designed to allow external events to be recorded inside Spatial's output. The event is recorded in the filter status, see section 10.8.1.2, and resets after the next packet is output. The event triggers on a transition from low to high.

9.3.34 TSS1 Output

This function outputs the TSS1 format at 20Hz.

9.3.35 Simrad 1000 Output

This function outputs the Simrad 1000 format at 20Hz.

9.3.36 Simrad 3000 Output

This function outputs the Simrad 3000 format at 20Hz.

10 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.

10.1 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 12: Data type abbreviations used in the ANPP

10.2 Packet Structure

The ANPP packet structure is shown in Table 13 and the header format is shown in Table 14. Example code can be downloaded from the software section.

Header				
Header LRC	Packet ID	Packet Length	CRC16	Packet Data

Table 13: ANPP Packet Structure

ANPP Header Format				
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Header LRC, see section 10.2.1
2	1	u8	1	Packet ID, see section 10.2.2
3	2	u8	1	Packet Length, see section 10.2.3
4	3	u16	2	CRC16, see section 10.2.4

Table 14: ANPP header format

10.2.1 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

10.2.2 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.

10.2.3 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.

10.2.4 CRC

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

10.3 Packet Requests

Any of the state and configuration packets can be requested at any time using the request packet. See section 10.7.2.

10.4 Packet Acknowledgement

When configuration packets are sent to Spatial, 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 10.7.1.

10.5 Packet Rates

The packet rates can be configured either using Spatial Manager or through the Packets Period Packet. By default Spatial 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.

10.6 Packet Summary

Packet ID	Length	R/W	Name
System Packets			
0	4	R	Acknowledge Packet
1	-	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
State Packets			
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

Packet ID	Length	R/W	Name
26	12	R	Euler Orientation Standard Deviation Packet
27	16	R	Quaternion Orientation Standard Deviation Packet
28	48	R	Raw Sensors Packet
29	36	R	Raw GNSS Packet
30	13	R	Satellites Packet
31	-	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	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/W	External Time Packet
53	8	R/W	External Depth Packet
54	4	R	Geoid Height Packet
55	-	W	RTCM Corrections Packet
56	8	R/W	External Pitot Pressure Packet
57	12	R	Wind Estimation Packet
58	16	R	Heave Packet
Configuration Packets			

Packet ID	Length	R/W	Name
180	4	R/W	Packet Timer Period Packet
181	-	R/W	Packets Period Packet
182	17	R/W	Baud Rates Packet
184	4	R/W	Sensor Ranges Packet
185	73	R/W	Installation Alignment Packet
186	17	R/W	Filter Options Packet
187	-	R/W	Advanced Filter Parameters Packet
188	13	R/W	GPIO Configuration Packet
189	49	R/W	Magnetic Calibration Values Packet
190	1	W	Magnetic Calibration Configuration Packet
191	3	R	Magnetic Calibration Status Packet
192	8	R/W	Odometer Configuration Packet
193	1	W	Set Zero Orientation Alignment Packet
194	49	R/W	Heave Offset Packet
195	13	R/W	NMEA Output Configuration Packet

10.7 System Packets

10.7.1 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 10.7.1.1

Table 15: Acknowledge packet

10.7.1.1 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 16: Acknowledge result

10.7.2 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 17: Request packet

10.7.3 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 10.7.3.1

Table 18: Boot mode packet

10.7.3.1 Boot Mode Types

Value	Description
0	Bootloader
1	Main Program

Table 19: Boot mode types

10.7.4 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
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 20: Device information packet

10.7.5 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 21: Restore factory settings packet

10.7.6 Reset Packet

Reset Packet				
Packet ID				5
Length				4
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Verification Sequence (set to 0x21057A7E)

Table 22: Reset packet

10.8 State Packets

Spatial supports a large number of packets providing extensive functionality. However for the majority of users the easiest approach is to configure Spatial using the Spatial Manager software and then support only the single system state packet shown below in section 10.8.1. Advanced functionality can be added as required through the other packets.

10.8.1 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 10.8.1.1
2	2	u16	2	Filter status, see section 10.8.1.2
3	4	u32	4	Unix time (seconds), see section 10.8.1.4
4	8	u32	4	Microseconds, see section 10.8.1.5
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 23: System state packet

10.8.1.1 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 Disconnected
15	Data Output Overflow Alarm

Table 24: System status

10.8.1.2 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 10.8.1.3
5	
6	
7	Event 1 Occurred
8	Event 2 Occurred
9	Internal GNSS Enabled
10	Magnetic Heading Active
11	Velocity Heading Enabled
12	Atmospheric Altitude Enabled
13	External Position Active
14	External Velocity Active
15	External Heading Active

Table 25: Filter Status

10.8.1.3 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 26: GNSS fix status

10.8.1.4 Unix Time Seconds

This field provides UTC time in seconds since January 1, 1970, not counting leap seconds.

10.8.1.5 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.

10.8.2 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 10.8.1.4
2	4	u32	4	Microseconds, see section 10.8.1.5

Table 27: Unix time packet

10.8.3 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 28: Formatted time packet

10.8.4 Status Packet

Status Packet				
Packet ID				23
Length				4
Field #	Bytes Offset	Data Type	Size	Description
1	0	u16	2	System status, see section 10.8.1.1
2	2	u16	2	Filter status, see section 10.8.1.2

Table 29: Status packet

10.8.5 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 30: Position standard deviation packet

10.8.6 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 31: Velocity standard deviation packet

10.8.7 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 32: Euler orientation standard deviation packet

10.8.8 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	Q0 standard deviation
2	4	fp32	4	Q1 standard deviation
3	8	fp32	4	Q2 standard deviation
4	12	fp32	4	Q3 standard deviation

Table 33: Quaternion orientation standard deviation packet

10.8.9 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 34: Raw sensors packet

10.8.10 Raw GNSS Packet

Raw GNSS Packet				
Packet ID				29
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	Velocity north (m)
5	28	fp32	4	Velocity east (m)
6	32	fp32	4	Velocity down (m)

Table 35: Raw GNSS packet

10.8.11 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 36: Satellites packet

10.8.12 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 10.8.12.1
2	1	u8	1	Satellite number (PRN)
3	2	s8	1	Satellite frequencies, see section 10.8.12.2
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 37: Detailed satellites packet

10.8.12.1 Satellite Systems

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

Table 38: Satellite systems

10.8.12.2 Satellite Frequencies

Bit	Description
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 39: Satellite frequencies

10.8.13 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 40: Geodetic position packet

10.8.14 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 41: ECEF position packet

10.8.15 UTM Position Packet

UTM Position Packet				
Packet ID				34
Length				25
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	s8	1	Zone character

Table 42: UTM position packet

10.8.16 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 43: NED velocity packet

10.8.17 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 44: Body velocity packet

10.8.18 Acceleration Packet

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 45: Acceleration packet

10.8.19 Body Acceleration Packet

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 46: Body acceleration packet

10.8.20 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 47: Euler orientation packet

10.8.21 Quaternion Orientation Packet

Quaternion Orientation Packet				
Packet ID				40
Length				16
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Q0
2	4	fp32	4	Q1
3	8	fp32	4	Q2
4	12	fp32	4	Q3

Table 48: Quaternion orientation packet

10.8.22 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 49: DCM orientation packet

10.8.23 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 50: Angular velocity packet

10.8.24 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 51: Angular acceleration packet

10.8.25 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 52: External position & velocity packet

10.8.26 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 53: External position packet

10.8.27 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 54: External velocity packet

10.8.28 External Body Velocity Packet

External Body Velocity Packet				
Packet ID				47
Length				16
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 standard deviation (m/s)

Table 55: External body velocity packet

10.8.29 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 56: External heading packet

10.8.30 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 57: Running time packet

10.8.31 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 58: Local magnetic field packet

10.8.32 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 59: Odometer state packet

10.8.33 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 10.8.1.4
2	4	u32	4	Microseconds, see section 10.8.1.5

Table 60: External time packet

10.8.34 External Depth Packet

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 61: External depth packet

10.8.35 Geoid Height Packet

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

Mean Sea Level Height = Height – Geoid Height

Depth = Geoid Height – Height

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

Table 62: Geoid height packet

10.8.36 RTCM Corrections Packet

This packet is used to encapsulate RTCM SC-104 differential correction data to be sent to Spatial's internal GNSS receiver for differential 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 63: RTCM corrections packet

10.8.37 External Pitot Pressure Packet

This packet is used to interface a pitot tube to Spatial for enhanced navigation using aircraft airspeed. The packet should contain differential pressure in pascals. If outside air temperature is available it should be set in the message for increased accuracy, otherwise this field should be set to 15 degrees.

External Pitot Pressure Packet				
Packet ID				56
Length				8
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Differential pressure (pascals)
2	4	fp32	4	Outside air temperature (deg C)

Table 64: External pitot pressure packet

10.8.38 Wind Estimation Packet

This packet provides Spatial's current estimate of 3D wind velocity. These values are only valid when a pitot tube is interfaced to Spatial.

Wind Estimation Packet				
Packet ID				57
Length				12
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Wind velocity north
2	4	fp32	4	Wind velocity east
3	8	fp32	4	Wind velocity down

Table 65: Wind estimation packet

10.8.39 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 66: Heave packet

10.9 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.

10.9.1 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 10.9.1.1
3	2	u16	2	Packet timer period, see section 10.9.1.2

Table 67: Packet timer period packet

10.9.1.1 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

10.9.1.2 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.

10.9.2 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 10.9.2.1
3	2	u8	1	Packet ID
4	3	u32	4	Packet period, see section 10.9.2.2
+				Fields 3-4 repeat for additional packet periods

Table 68: Packets period packet

10.9.2.1 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.

10.9.2.2 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

10.9.3 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	RS232 baud rate (1200 to 1000000)
3	5	u32	4	GPIO 1 & 2 baud rate (1200 to 1000000)
4	9	u32	4	Auxiliary RS232 Baud Rate (1200 to 1000000)
5	12		4	Reserved (set to zero)

Table 69: Baud rates packet

10.9.4 Sensor Ranges Packet

Sensor Ranges Packet				
Packet ID				184
Length				4
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u8	1	Accelerometers range, see section 10.9.4.1
3	2	u8	1	Gyroscopes range, see section 10.9.4.2
4	3	u8	1	Magnetometers range, see section 10.9.4.3

Table 70: Sensor ranges packet

10.9.4.1 Accelerometers Range

Value	**Description**
0	2 g (19.62 m/s/s)
1	4 g (39.24 m/s/s)
2	16 g (156.96 m/s/s)

Table 71: Accelerometers range

10.9.4.2 Gyroscopes Range

Value	Description
0	250 degrees/second
1	500 degrees/second
2	2000 degrees/second

Table 72: Gyroscopes range

10.9.4.3 Magnetometers Range

Value	Description
0	2 Gauss
1	4 Gauss
2	8 Gauss

Table 73: Magnetometers range

10.9.5 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 74: Installation alignment packet

10.9.5.1 Alignment DCM

The alignment DCM (direction cosine matrix) is used to represent an alignment offset of Spatial 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)

10.9.6 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 10.9.6.1
3	2	u8	1	Internal GNSS enabled (boolean)
4	3	u8	1	Magnetometers enabled (boolean)
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		9	Reserved (set to zero)

Table 75: Filter options packet

10.9.6.1 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

Table 76: Vehicle types

10.9.7 Advanced Filter Parameters Packet

Please contact Advanced Navigation support.

10.9.8 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 10.9.8.1
3	2	u8	1	GPIO2 Function, see section 10.9.8.2
4	3	u8	1	Auxiliary RS232 transmit function, see section 10.9.8.3
5	4	u8	1	Auxiliary RS232 receive function, see section 10.9.8.4
6	5		8	Reserved (set to zero)

Table 77: GPIO configuration packet

10.9.8.1 GPIO1 Functions

Value	Description
0	Inactive
1	1PPS Output
2	GNSS Fix Output
3	Odometer Input
4	Stationary Input
5	Pitot Tube Input
7	NMEA Output
12	ANPP Output
13	Disable Magnetometers
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 Input
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
39	TSS1 Output
40	Simrad 1000 Output
41	Simrad 3000 Output

Table 78: GPIO1 functions

10.9.8.2 GPIO2 Functions

Value	Description
0	Inactive
1	1PPS Output
2	GNSS Fix Output
3	Odometer Input
4	Stationary Input
5	Pitot Tube Input
6	NMEA Input
8	Novatel GNSS Input
9	Topcon GNSS Input
11	ANPP Input
13	Disable Magnetometers
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 Input
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

Table 79: GPIO2 functions

10.9.8.3 Auxiliary RS232 Transmit Functions

Value	Description
0	Inactive
7	NMEA Output
12	ANPP Output
39	TSS1 Output
40	Simrad 1000 Output
41	Simrad 3000 Output

Table 80: Auxiliary RS232 transmit functions

10.9.8.4 Auxiliary RS232 Receive Functions

Value	Description
0	Inactive
6	NMEA Input
8	Novatel GNSS Input
9	Topcon GNSS Input
11	ANPP Input
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

Table 81: Auxiliary RS232 receive functions

10.9.9 Magnetic Calibration Values Packet

Magnetic Calibration Values Packet				
Packet ID				189
Length				49
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	fp32	4	Hard iron bias X
3	5	fp32	4	Hard iron bias Y
4	9	fp32	4	Hard iron bias Z
5	13	fp32	4	Soft iron transformation XX
6	17	fp32	4	Soft iron transformation XY
7	21	fp32	4	Soft iron transformation XZ
8	25	fp32	4	Soft iron transformation YX
9	29	fp32	4	Soft iron transformation YY
10	33	fp32	4	Soft iron transformation YZ
11	37	fp32	4	Soft iron transformation ZX
12	41	fp32	4	Soft iron transformation ZY
13	45	fp32	4	Soft iron transformation ZZ

Table 82: Magnetic calibration values packet

10.9.10 Magnetic Calibration Configuration Packet

Magnetic Calibration Configuration Packet				
Packet ID				190
Length				1
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Magnetic calibration action, see section 10.9.10.1

Table 83: Magnetic calibration configuration packet

10.9.10.1 Magnetic Calibration Actions

Value	Description
0	Cancel magnetic calibration
2	Start 2D magnetic calibration
3	Start 3D magnetic calibration

Table 84: Magnetic calibration action

10.9.11 Magnetic Calibration Status Packet

Magnetic Calibration Status Packet				
Packet ID				191
Length				3
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Magnetic calibration status, see section 10.9.11.1
2	1	u8	1	Magnetic calibration progress (%)
3	2	u8	1	Local magnetic error (%)

Table 85: Magnetic calibration status packet

10.9.11.1 Magnetic Calibration Status

Value	Description
0	Magnetic calibration not completed
1	2D magnetic calibration completed
2	3D magnetic calibration completed
3	Custom values magnetic calibration completed
4	Stabilising in progress
5	2D calibration in progress
6	3D calibration in progress
7	2D calibration error: excessive roll
8	2D calibration error: excessive pitch
9	Calibration error: sensor over range event
10	Calibration error: time-out
11	3D calibration error: not enough points

Table 86: Magnetic calibration status

10.9.12 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		2	Reserved (set to zero)
5	4	fp32	4	Pulse length (m)

Table 87: Odometer configuration packet

10.9.13 Set Zero Orientation Alignment Packet

Set Zero Orientation Alignment Packet				
Packet ID				193
Length				1
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent

Table 88: Set zero orientation alignment packet

10.9.14 Heave Offset Packet

Heave Offset Packet				
Packet ID				194
Length				49
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	fp32	4	Heave point 1 offset X (m)
3	5	fp32	4	Heave point 1 offset Y (m)
4	9	fp32	4	Heave point 1 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 89: Heave offset packet

10.9.15 NMEA Output Configuration Packet

NMEA Output Configuration Packet				
Packet ID				195
Length				13
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u8	1	NMEA Period, see section 10.9.15.1
3	2	u8	1	GPZDA Enabled
4	3	u8	1	GPGGA Enabled
5	4	u8	1	GPVTG Enabled
6	5	u8	1	GPRMC Enabled
7	6	u8	1	GPHDT Enabled
8	7	u8	1	PASHR Enabled
9	8	u8	1	GPGSA Enabled
10	9	u8	1	Output Fix Mode, see section 10.9.15.2
11	10	u8	3	Reserved (set to zero)

Table 90: NMEA configuration packet

10.9.15.1 NMEA Period

The NMEA period is specified in units of 50ms. An NMEA period of 1 therefore equates to a period of 50ms and rate of 20Hz. An NMEA period of 20 equates to a period of 1000ms and a rate of 1Hz.

10.9.15.2 Output Fix Mode

When set to zero the output fix behaviour is normal and in line with NMEA standards. When set to one the output fix type remains as 3D GPS fix even when the system is dead reckoning. This behaviour is required to continue operating with some software while dead reckoning.