Orientus Reference Manual

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1 Revision History

Version	Date	Changes
1.2	15/03/2013	Connector pin-out updated, section 4.8
1.1	01/02/2013	Connector pin-out updated, section 4.8 Body acceleration packet removed
1.0	06/12/2012	Initial Release

2 Foundation Knowledge

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

2.1 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. The alternative name for an AHRS is an orientation sensor and this is the naming convention preferred by Advanced Navigation.

2.2 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 Orientus showing axes marked on top

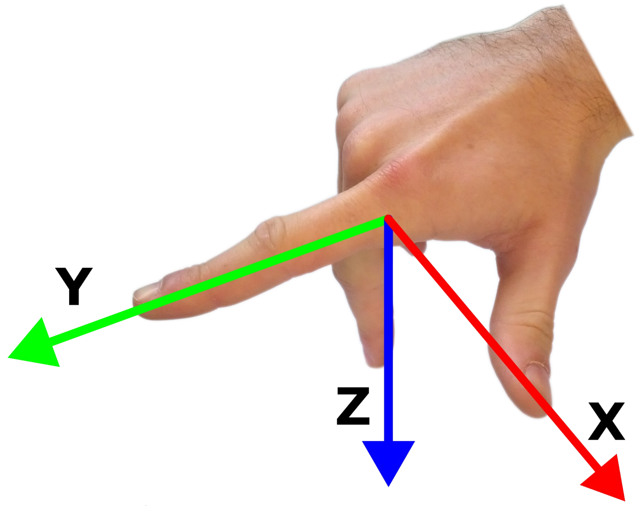

Illustration 2: First right hand rule

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.

2.3 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.

2.3.1 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.

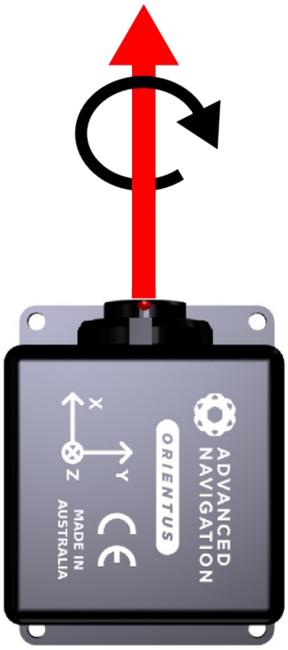

Illustration 3: Orientus with black arrow indicating positive direction of roll

Illustration 4: Orientus after a roll of 90 degrees

2.3.2 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.

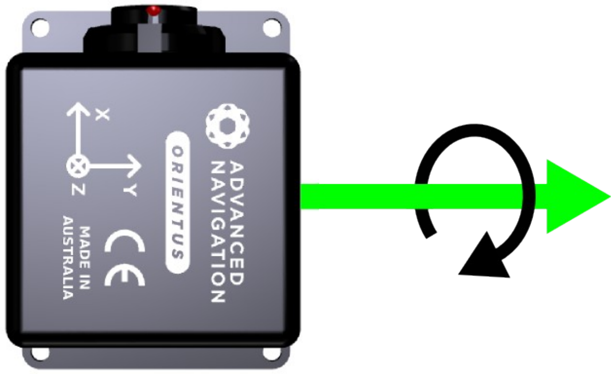

Illustration 5: Orientus with black arrow indicating positive direction of pitch

Illustration 6: Orientus after a pitch of 90 degrees

2.3.3 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: Orientus with black arrow indicating positive direction of heading

Illustration 8: Orientus after a heading change of 90 degrees

2.3.4 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 2.2. 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.

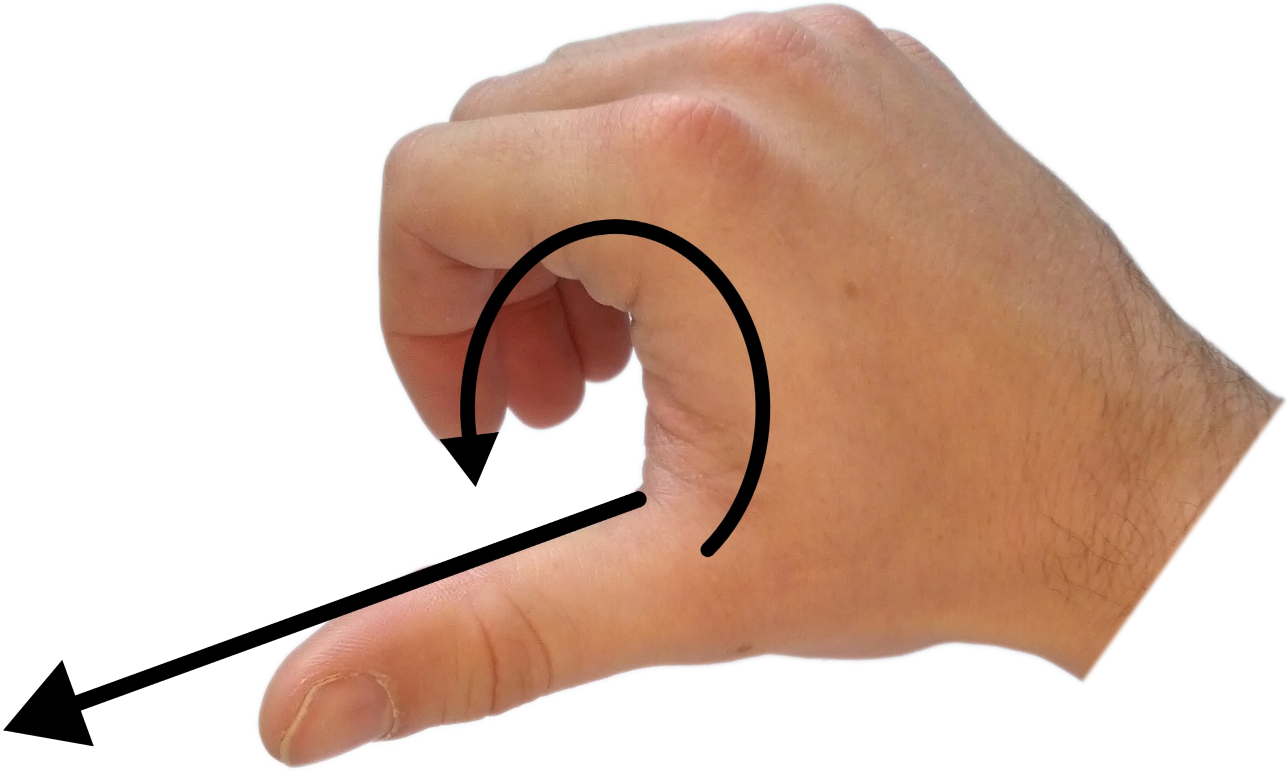

Illustration 9: Second right hand rule

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

3 Introduction

Orientus is a ruggedized miniature orientation sensor and AHRS that provides accurate orientation under the most demanding conditions. It combines temperature calibrated accelerometers, gyroscopes and magnetometers in a sophisticated fusion algorithm to deliver accurate and reliable orientation.

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

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

4 Specifications

4.1 Mechanical Drawings

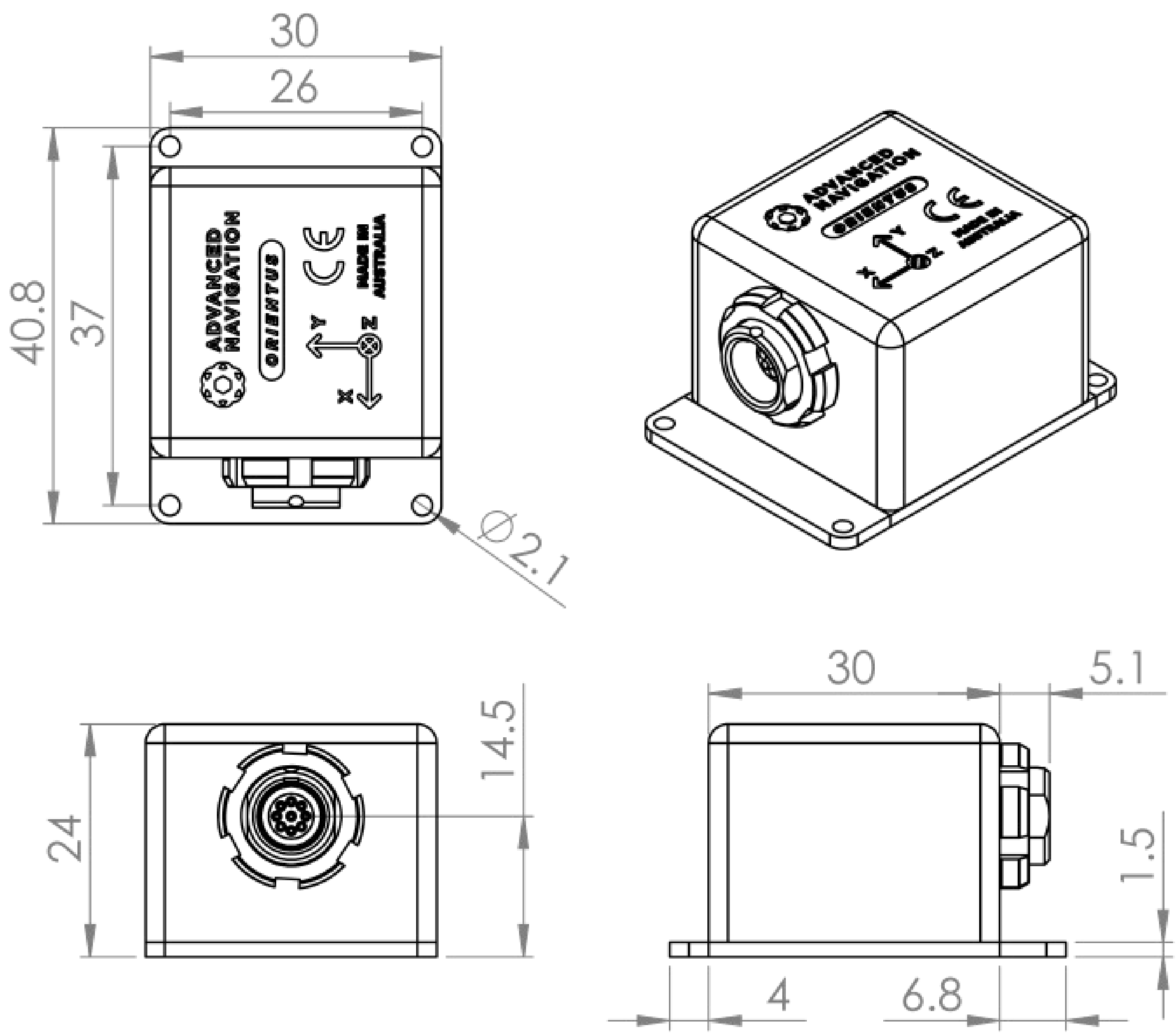

Illustration 10: Mechanical drawings of Orientus

4.2 Orientation Specifications

Parameter	Value
Roll & Pitch Accuracy (Static)	0.2 °
Heading Accuracy (Static)	0.5 °
Roll & Pitch Accuracy (Dynamic)	0.6 °
Heading Accuracy (Dynamic)	1.0 °
Orientation Range	Unlimited
Turn On Time	500 ms
Internal Filter Rate	1000 Hz
Output Data Rate	Up to 1000 Hz

Table 1: Orientation specifications

4.3 Sensor Specifications

Parameter	Accelerometers	Gyroscopes	Magnetometers
Range (Dynamic)	2 g 4 g 16 g	250 °/s 500 °/s 2000 °/s	2 G 4 G 8 G
Noise Density	400 ug/√Hz	0.005 °/s/√Hz	210 uG/√Hz
Non-linearity	< 0.05 %	< 0.05 %	< 0.05 %
Bias Stability	60 ug	18 °/hr	-
Scale Factor Stability	< 0.05 %	< 0.05 %	< 0.05 %
Cross-axis Alignment Error	< 0.05 °	< 0.05 °	0.05 °
Bandwidth	256 Hz	256 Hz	110 Hz

Table 2: Sensor specifications

4.4 Communication Specifications

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

Table 3: Communication specifications

4.5 Hardware Specifications

Parameter	Value
Operating Voltage	4 to 36 V
Input Protection	± 40 V
Power Consumption	65 mA @ 5 V (typical)
Operating Temperature	-40 °C to 85 °C
Environmental Sealing	IP68
Shock Limit	2000 g
Dimensions (excluding tabs)	30 x 30 x 24 mm
Dimensions (including tabs)	30 x 40.8 x 24 mm
Weight	25 grams

Table 4: Hardware specifications

4.6 Electrical Specifications

Parameter	Minimum	Typical	Maximum
Power Supply			
Input Supply Voltage	4 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

Table 5: Electrical specifications

4.7 Power Consumption

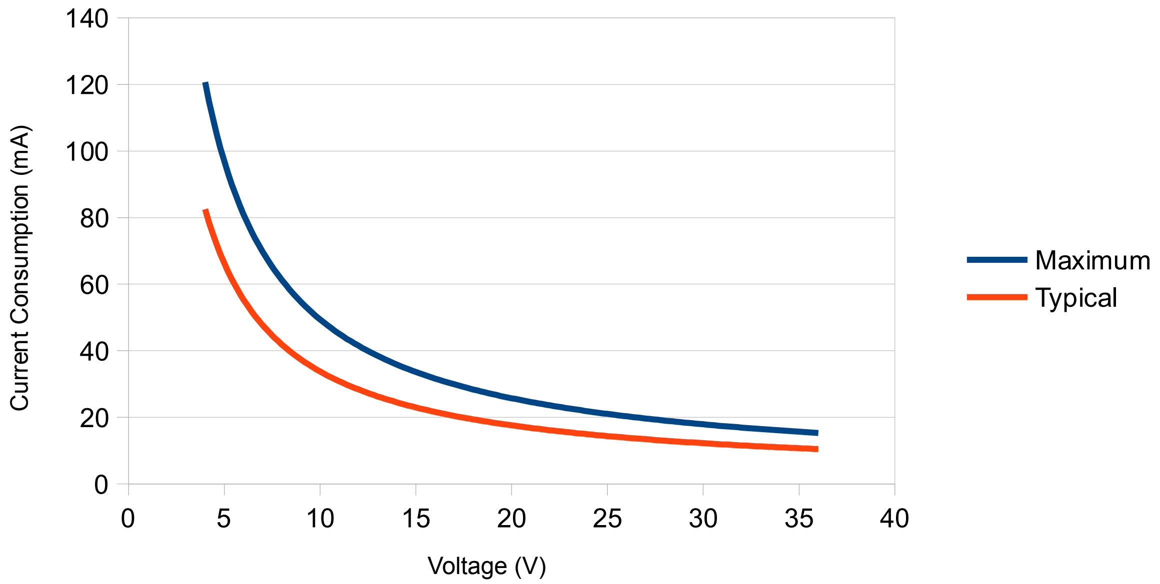

Illustration 11: Maximum and typical current consumption across operating voltage

4.8 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 Orientus under demanding conditions and is rated to IP68 in the mated condition. Plugs are supplied with 2 metres of unterminated 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 12: ODU B series mating plug for Orientus

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 6: Pin allocation table

4.9 Sensor Calibration

Orientus'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.

5 Installation

5.1 Position and Alignment

When installing Orientus 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. Orientus should be mounted close to the centre of gravity of the vehicle.
2. Orientus should be mounted as far from sources of dynamic magnetic interference as possible i.e. high current wiring, large motors.
3. Orientus should be mounted away from vibration where possible.
4. Orientus should be mounted in an area that is not going to exceed it's temperature range.

5.1.1 Alignment

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

If aligning Orientus with the vehicle axes is not possible or not optimal, it may be mounted in a different alignment and the alignment offset must be configured using either the Orientus Manager software or the Installation Alignment Packet. For precise alignment, the Set Zero Orientation Alignment Packet can be used to set the current orientation as the zero orientation alignment.

For more information on setting the alignment please see the Orientus Manager software manual or the alignment packet in section 8.9.5.

5.2 Mounting Plate

Orientus's mounting plate and hole guide is shown below in Illustration 13. The holes are designed for M2 cap screws.

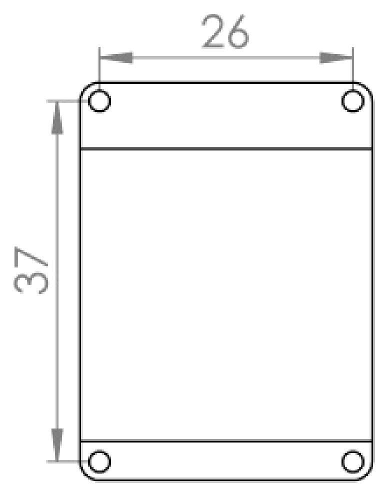

Illustration 13: Mounting plate drawing

5.3 Power Supply

A high level of power supply filtering has been built into Orientus, 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 11.

Orientus 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.

5.4 Magnetics

Orientus 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. Sources of magnetic interference can degrade Orientus'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 6.3. 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 Orientus. Orientus should be mounted as far as possible from these interference sources.

Orientus 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 Orientus Manager and watch the magnetometer outputs whilst the vehicle is operating but stationary. 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 Orientus away from the interference source, the magnetometers should be disabled, see section 6.3.3.

5.5 Vibration

Orientus 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 Orientus can tolerate and large levels of vibration will cause Orientus's accuracy to degrade.

When mounting Orientus to a platform with vibration there are several options. It is recommended to first try mounting Orientus and see whether it can tolerate the vibrations. The raw sensor view in the Orientus Manager software can give you a good idea of how bad the vibrations are. If the vibrations are causing the sensors to go over range you will need to increase the sensors range, see section 6.6.

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

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

6 Operation

6.1 Initialisation

When Orientus 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, Orientus 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 bad orientation. In this scenario Orientus will progressively correct the orientation error over a period of several seconds.

After orientation detection, Orientus'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.

6.2 Heading Source

There are three different heading sources available for Orientus. The heading source can be selected using the filter options dialog in Orientus Manager or the Filter Options Packet. It is possible to use multiple heading sources and this can often provide performance benefits.

6.2.1 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 Orientus's installation changes. The downside of magnetic heading is that dynamic magnetic interference sources can cause heading errors.

6.2.2 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 2 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 Orientus's installation changes. Orientus must have an external GNSS receiver connected to use velocity heading.

6.2.3 External Heading

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

6.3 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 5.4 for more information on magnetic interference. To compensate for static magnetic interference, magnetic calibration should be performed any time Orientus's installation changes.

Orientus 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 Orientus 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 Orientus's dynamic magnetic compensation filter to operate correctly, Orientus needs to have it's position set every time it is moved more than 50km. The position can be updated using the position configuration dialog in Orientus Manager or using the External Position Packet. Orientus requires the position to update it's world magnetic model values.

There are two types of magnetic calibration available, these are 2D calibration and 3D calibration. 2D calibration involves two 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.

6.3.1 2D Magnetic Calibration

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

6.3.1.1 Using the Orientus Manager Software

1. The unit should be powered in a level orientation and kept stationary.
2. After power on wait 5 minutes for the temperature and filter to stabilise.
3. Open Orientus Manager and connect to the device.
4. Set the approximate device position through the Position Configuration dialog. This can be determined using Google maps. This is to make sure the world magnetic model is correct.
5. In the Tools menu, open Magnetic Calibration. Click the 2D Calibration button.
6. Whilst keeping as level as possible, rotate the unit in either direction through three full rotations.
7. 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.

6.3.1.2 Using the Packet Protocol

1. The unit should be powered 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 position has been set using the External Position Packet before proceeding. This is to make sure the world magnetic model is correct.
4. Send the Magnetic Calibration Configuration Packet with the action Start 2D Magnetic Calibration.
5. Whilst keeping as level as possible, rotate the unit in either direction through three full rotations.
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.

6.3.2 3D Magnetic Calibration

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

6.3.2.1 Using the Orientus Manager Software

1. The unit should be powered in a level orientation and kept stationary.
2. After power on wait 5 minutes for the temperature and filter to stabilise.
3. Open Orientus Manager and connect to the device.
4. Set the approximate device position through the Position Configuration dialog. This can be determined using Google maps. This is to make sure the world magnetic model is correct.
5. In the Tools menu, open Magnetic Calibration. Click the 3D Calibration button.
6. From a level orientation, slowly rotate the unit twice around the X axis (roll).
7. From a level orientation, slowly rotate the unit twice around the Y axis (pitch).
8. From a level orientation, slowly rotate the unit through as many orientations as possible.
9. 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.

6.3.2.2 Using the Packet Protocol

1. The unit should be powered 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 position has been set using the External Position Packet before proceeding. This is to make sure the world magnetic model is correct.
4. Send the Magnetic Calibration Configuration Packet with the action Start 3D Magnetic Calibration.
5. From a level orientation, slowly rotate the unit twice around the X axis (roll).
6. From a level orientation, slowly rotate the unit twice around the Y axis (pitch).
7. From a level orientation, slowly rotate the unit through as many orientations as possible.
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.

6.3.3 Disabling Magnetometers

In situations where there is strong dynamic magnetic disturbances present that cannot be avoided, it is recommended to disable the magnetometers. When the magnetometers are disabled a secondary heading source is required otherwise the heading will slowly drift. Please see section 6.2 for information on alternative heading sources. The magnetometers can be disabled using the filter options dialog in Orientus Manager or the Filter Options Packet.

6.4 Linear Acceleration

Orientus uses the gravity vector from it's accelerometers to make corrections to it's orientation. The accelerometers measure the gravity vector combined with any linear accelerations the unit is experiencing. Orientus is able to separate the gravity vector from linear accelerations for short time periods, however for longer time periods this becomes more difficult and a small error in either the roll or pitch can accumulate. If this occurs, Orientus will quickly correct any error once the vehicle stops accelerating.

This issue is not experienced in the majority of applications. An example of an application that does experience the problem is a road car that accelerates from 0 – 100 km/h over a period of 30 seconds. In this case without external aiding an error of up to 2 degrees in pitch may accumulate.

If you are experiencing this issue there are two solutions to resolving the problem:

1. Connect an external GNSS receiver to Orientus. See section 6.5. This allows Orientus to compensate for linear accelerations while the GNSS receiver has a fix.
2. Use Spatial instead of Orientus. Spatial's internal GNSS and pressure sensor combined with it's advanced filter means there is no performance decrease under continuous linear accelerations. Spatial can also continue to compensate for linear acceleration without a GNSS fix.

6.5 External GNSS

Connecting an external GNSS receiver to Orientus can provide the following benefits:

1. Orientus is able to compensate for linear accelerations. See section 6.4.
2. Orientus is able to determine heading from the GNSS velocity for forward driving vehicles. See section 6.2 for more information on heading sources.
3. Orientus is able to continuously and automatically update it's world magnetic model. This saves having to update it manually each time the unit is moved more than 50km.

Orientus supports a wide range of external GNSS receiver options through it's GPIO pins and auxiliary RS232. Please see section 7.3 for more information. Advanced Navigation recommends u-blox GNSS receivers. Please note that Orientus does not provide any form of positioning when an external GNSS receiver is connected. For applications requiring inertially aided positioning, Spatial should be used.

6.6 Sensors Range

Orientus 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 Orientus 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 Orientus 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 to become completely inaccurate and in some cases it can cause the filter to reset.

By default Orientus 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 Orientus Manager when you do this.

The sensor range can be set through the sensors option in the configuration menu in Orientus Manager or through the Sensor Ranges Packet.

6.7 Data Anti Aliasing

Internally Orientus's filters update at 1000 Hz. When Orientus 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, Orientus 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 orientation.

6.8 Vehicle Profiles

Orientus 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 Orientus Manager or the Filter Options Packet. For a list of the different vehicle profiles please see section 8.9.6.1. Please note that if the wrong vehicle profile is selected it can cause a significant decrease in performance.

6.9 Environmental Exposure

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

Orientus is only protected when it's connector is mated. When the connector is not mated the unit offers no environmental protection.

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

6.9.1 Temperature

Orientus should not be subjected to temperature's outside of it's operating range. Subjecting Orientus to temperature's outside of the storage range can effect the factory sensor calibration which will cause a permanent performance degradation.

6.9.2 Water

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

6.9.3 Salt

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

6.9.4 Dirt and Dust

Orientus is completely sealed against dirt and dust entry. It is important to note that this is only the case when the connector is mated. When un-mating the connector if the Orientus 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 connector which can cause it to fail.

6.9.5 PH Level

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

6.9.6 Shocks

Orientus 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 Orientus 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 Orientus's enclosure can more easily go over the limit however so care should be taken when handling the unit prior to mounting.

7 Interfacing

7.1 Communication

All communication to the Orientus 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 8 for details on the protocol.

7.1.1 Baud Rate

The default baud rate of Orientus is 115200. The baud rate can be set anywhere from 100 to 1000000 baud and can be modified using the Orientus Manager software or the baud rate packet, see section 8.9.3. It is important to select a baud rate that is capable of carrying the amount of data that Orientus is set to send. See packet rates in section 8.5 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.

7.2 External Data

External sources of position, velocity and/or heading can be integrated into Orientus's filter solution. The data can be sent to Orientus in the ANPP format over the main RS232 port. Alternatively data can be sent through one of the GPIOs or the auxiliary RS232 in a number of different formats. If using the ANPP, please use Table 7 below to find the relevant section. If using the GPIOs or auxiliary RS232, please see section 7.3.

Packet	Section
External Position and Velocity	8.8.13
External Position	8.8.14
External Velocity	8.8.15
External Heading	8.8.16

Table 7: ANPP External Data Reference

7.3 GPIOs and Auxiliary RS232

Orientus 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 Orientus with additional peripherals, sensors and data formats. The GPIO pins have digital input, digital output, frequency input and frequency output functionality. Additionally GPIO1 can function as 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 Orientus Manager or the Baud Rates Packet.

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

Function	Type	GPIOs	Auxiliary RS232
Inactive	Tristate	All	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	
Set Zero Orientation Alignment	Digital Input	All	
System State Packet Trigger	Digital Input	All	
Raw Sensors Packet Trigger	Digital Input	All	
Trimble GNSS Input	Serial Receive	2	Receive
u-blox GNSS Input	Serial Receive	2	Receive
Hemisphere GNSS Input	Serial Receive	2	Receive

Table 8: GPIO functions

7.3.1 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.

Message ID	Description
GPGGA	3D position
GPGLL	2D position
GPRMC	2D position, 2D velocity and coarse time
GPVTG	2D velocity
GPHDT	Heading
HEHDT	Heading

Table 9: Supported NMEA messages

7.3.2 NMEA Output

This function outputs the NMEA message GPHDT at 10 Hz. 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.

$GPHDT,164.4,T*32

7.3.3 Novatel GNSS Input

This function is designed for interfacing Orientus 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.

7.3.4 Topcon GNSS Input

This function is designed for interfacing Orientus 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.

7.3.5 ANPP Input

This function accepts data in the ANPP format as specified in section 8.

7.3.6 ANPP Output

This function outputs data in the ANPP format as specified in section 8. For packets to be sent out they must be requested through another GPIO functioning as ANPP input.

7.3.7 Disable Magnetometers

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

7.3.8 Set Zero Orientation Alignment

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

7.3.9 System State Packet Trigger

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

7.3.10 Raw Sensors Packet Trigger

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

7.3.11 Trimble GNSS Input

This function is designed for interfacing Orientus with a Trimble GNSS receiver. It accepts data in the Trimble binary format GSOF and expects packet 0x40 with records 1, 2 and 8 at rates higher than 1Hz.

7.3.12 u-blox GNSS Input

This function is designed for interfacing Orientus 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.

7.3.13 Hemisphere GNSS Input

This function is designed for interfacing Orientus 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.

8 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.

8.1 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 10: Data type abbreviations used in the ANPP

8.2 Packet Structure

The ANPP packet structure is shown in Table 11 and the header format is shown in Table 12. Example code can be downloaded from the software section.

Header				
Header LRC	Packet ID	Packet Length	CRC16	Packet Data

Table 11: ANPP Packet Structure

ANPP Header Format				
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Header LRC, see section 8.2.1
2	1	u8	1	Packet ID, see section 8.2.2
3	2	u8	1	Packet Length, see section 8.2.3
4	3	u16	2	CRC16, see section 8.2.4

Table 12: ANPP header format

8.2.1 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

8.2.2 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.

8.2.3 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.

8.2.4 CRC

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

8.3 Packet Requests

Any of the state and configuration packets can be requested at any time using the request packet. See section 8.7.2.

8.4 Packet Acknowledgement

When configuration packets are sent to Orientus, 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 8.7.1.

8.5 Packet Rates

The packet rates can be configured either using Orientus Manager or through the Packets Period Packet. By default Orientus is configured to output the Status Packet and Euler Orientation 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.

8.6 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	Time Packet
23	4	R	Status Packet
26	12	R	Euler Orientation Standard Deviation Packet
27	16	R	Quaternion Orientation Standard Deviation Packet
28	48	R	Raw Sensors Packet
37	12	R	Acceleration Packet
39	12	R	Euler Orientation Packet

Packet ID	Length	R/W	Name
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
48	8	R/W	External Heading Packet
49	8	R	Running Time Packet
50	12	R	Local Magnetic Field Packet
Configuration Packets			
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
193	1	W	Set Zero Orientation Alignment Packet

8.7 System Packets

8.7.1 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 8.7.1.1

Table 13: Acknowledge packet

8.7.1.1 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 14: Acknowledge result

8.7.2 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 15: Request packet

8.7.3 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 8.7.3.1

Table 16: Boot mode packet

8.7.3.1 Boot Mode Types

Value	Description
0	Bootloader
1	Main Program

Table 17: Boot mode types

8.7.4 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 18: Device information packet

8.7.5 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 19: Restore factory settings packet

8.7.6 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 20: Reset packet

8.8 State Packets

Orientus supports a large number of packets providing extensive functionality. However for the majority of users the easiest approach is to configure Orientus using the Orientus Manager software and then support only the Status Packet and Euler Orientation Packet. Advanced functionality can be added as required through the other packets.

8.8.1 System State Packet

This packet is included in Orientus for the purpose of compatibility with Spatial.

System State Packet				
Packet ID				20
Length				100
Field #	Bytes Offset	Data Type	Size	Description
1	0	u16	2	System status, see section 8.8.1.1
2	2	u16	2	Filter status, see section 8.8.1.2
3	4	u32	4	Time seconds, see section 8.8.1.3
4	8	u32	4	Microseconds, see section 8.8.1.4
5	12	fp64	8	Reserved
6	20	fp64	8	Reserved
7	28	fp64	8	Reserved
8	36	fp32	4	Reserved
9	40	fp32	4	Reserved
10	44	fp32	4	Reserved
11	48	fp32	4	Reserved
12	52	fp32	4	Reserved
13	56	fp32	4	Reserved
14	60	fp32	4	Reserved
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	Reserved
22	92	fp32	4	Reserved
23	96	fp32	4	Reserved

Table 21: System state packet

8.8.1.1 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	Reserved
5	Reserved
6	Accelerometer Over Range
7	Gyroscope Over Range
8	Magnetometer Over Range
9	Reserved
10	Minimum Temperature Alarm
11	Maximum Temperature Alarm
12	Low Voltage Alarm
13	High Voltage Alarm
14	Reserved
15	Data Output Overflow Alarm

Table 22: System status

8.8.1.2 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	Reserved
2	Heading Initialised
3	Reserved
4	Reserved
5	Reserved
6	Reserved
7	Reserved
8	Reserved
9	Reserved
10	Magnetometers Enabled
11	Velocity Heading Enabled
12	Reserved
13	External Position Active
14	External Velocity Active
15	External Heading Active

Table 23: Filter Status

8.8.1.3 Time Seconds

This field provides the time in seconds since Orientus was powered on.

8.8.1.4 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.

8.8.2 Time Packet

Time Packet				
Packet ID				21
Length				8
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Time seconds, see section 8.8.1.3
2	4	u32	4	Microseconds, see section 8.8.1.4

Table 24: Time packet

8.8.3 Status Packet

Status Packet				
Packet ID				23
Length				4
Field #	Bytes Offset	Data Type	Size	Description
1	0	u16	2	System status, see section 8.8.1.1
2	2	u16	2	Filter status, see section 8.8.1.2

Table 25: Status packet

8.8.4 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 26: Euler orientation standard deviation packet

8.8.5 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 27: Quaternion orientation standard deviation packet

8.8.6 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	Reserved
12	44	fp32	4	Reserved

Table 28: Raw sensors packet

8.8.7 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 29: Acceleration packet

8.8.8 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 30: Euler orientation packet

8.8.9 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 31: Quaternion orientation packet

8.8.10 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 32: DCM orientation packet

8.8.11 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 33: Angular velocity packet

8.8.12 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 34: Angular acceleration packet

8.8.13 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 35: External position & velocity packet

8.8.14 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 36: External position packet

8.8.15 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 37: External velocity packet

8.8.16 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 38: External heading packet

8.8.17 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 39: Running time packet

8.8.18 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	4	fp32	4	Local magnetic field Z (mG)

Table 40: Local magnetic field packet

8.9 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.

8.9.1 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	Reserved (set to zero)
3	2	u16	2	Packet timer period, see section 8.9.1.1

Table 41: Packet timer period packet

8.9.1.1 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.

8.9.2 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 8.9.2.1
3	2	u8	1	Packet ID
4	3	u32	4	Packet period, see section 8.9.2.2
+				Fields 3-4 repeat for additional packet periods

Table 42: Packets period packet

8.9.2.1 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.

8.9.2.2 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

8.9.3 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	Primary RS232 baud rate (1200 to 1000000)
3	5	u32	4	GPIO 1 & 2 baud rate (1200 to 115200)
4	9	u32	4	Auxiliary RS232 baud rate (1200 to 1000000)
5	13	u32	4	Reserved (set to zero)

Table 43: Baud rates packet

8.9.4 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 8.9.4.1
3	2	u8	1	Gyroscopes range, see section 8.9.4.2
4	3	u8	1	Magnetometers range, see section 8.9.4.3

Table 44: Sensor ranges packet

8.9.4.1 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 45: Accelerometers range

8.9.4.2 Gyroscopes Range

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

Table 46: Gyroscopes range

8.9.4.3 Magnetometers Range

Value	Description
0	2 Gauss
1	4 Gauss
2	8 Gauss

Table 47: Magnetometers range

8.9.5 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	Reserved (set to zero)
12	41	fp32	4	Reserved (set to zero)
13	45	fp32	4	Reserved (set to zero)
14	49	fp32	4	Reserved (set to zero)
15	53	fp32	4	Reserved (set to zero)
16	57	fp32	4	Reserved (set to zero)
17	61	fp32	4	Reserved (set to zero)
18	65	fp32	4	Reserved (set to zero)
19	69	fp32	4	Reserved (set to zero)

Table 48: Installation alignment packet

8.9.5.1 Alignment DCM

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

8.9.6 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 8.9.6.1
3	2	u8	1	Reserved (set to zero)
4	3	u8	1	Magnetometers enabled (boolean)
5	4	u8	1	Reserved (set to zero)
6	5	u8	1	Velocity heading enabled (boolean)
7	6	u8	1	Reserved (set to zero)
8	7	u8	1	Reserved (set to zero)
9	8	u8	1	Reserved (set to zero)
10	9	u8	1	Reserved (set to zero)
11	10	u8	1	Reserved (set to zero)
12	11	u8	1	Reserved (set to zero)
13	12	u8	1	Reserved (set to zero)
14	13	u8	1	Reserved (set to zero)
15	14	u8	1	Reserved (set to zero)
16	15	u8	1	Reserved (set to zero)
17	16	u8	1	Reserved (set to zero)

Table 49: Filter options packet

8.9.6.1 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 50: Vehicle types

8.9.7 Advanced Filter Parameters Packet

Please contact Advanced Navigation support.

8.9.8 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 8.9.8.1
3	2	u8	1	GPIO2 Function, see section 8.9.8.2
4	3	u8	1	Auxiliary RS232 Transmit Function, see section 8.9.8.3
5	4	u8	1	Auxiliary RS232 Receive Function, see section 8.9.8.4
6	5		8	Reserved

Table 51: GPIO configuration packet

8.9.8.1 GPIO1 Functions

Value	Description
0	Inactive
7	NMEA Output
12	ANPP Output
13	Disable Magnetometers
16	Set Zero Orientation Alignment
17	System State Packet Trigger
18	Raw Sensors Packet Trigger

Table 52: GPIO1 functions

8.9.8.2 GPIO2 Functions

Value	Description
0	Inactive
6	NMEA Input
8	Novatel GNSS Input
9	Topcon GNSS Input
11	ANPP Input
13	Disable Magnetometers
16	Set Zero Orientation Alignment
17	System State Packet Trigger
18	Raw Sensors Packet Trigger
20	Trimble GNSS Input
21	u-blox GNSS Input
22	Hemisphere GNSS Input

Table 53: GPIO2 functions

8.9.8.3 Auxiliary RS232 Transmit Functions

Value	Description
0	Inactive
7	NMEA Output
12	ANPP Output

Table 54: Auxiliary RS232 transmit functions

8.9.8.4 Auxiliary RS232 Receive Functions

Value	Description
0	Inactive
6	NMEA Input
8	Novatel GNSS Input
9	Topcon GNSS Input
11	ANPP Input
20	Trimble GNSS Input
21	u-blox GNSS Input
22	Hemisphere GNSS Input

Table 55: Auxiliary RS232 receive functions

8.9.9 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 56: Magnetic calibration values packet

8.9.10 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 8.9.10.1

Table 57: Magnetic calibration configuration packet

8.9.10.1 Magnetic Calibration Actions

Value	Description
0	Cancel magnetic calibration
1	Stabilise heading
2	Start 2D magnetic calibration
3	Start 3D magnetic calibration

Table 58: Magnetic calibration action

8.9.11 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 8.9.11.1
2	1	u8	1	Magnetic calibration progress (%)
3	2	u8	1	Local magnetic error (%)

Table 59: Magnetic calibration status packet

8.9.11.1 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 60: Magnetic calibration status

8.9.12 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 61: Set zero orientation alignment packet