Sublocus DVL Reference Manual

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1 Revision History

Version	Date	Changes
2.0	18/08/2014	Updated manual for hardware version 2.0 Updated cover page image to new hardware Added firmware changelog, section 2 Added hardware changelog, section 3 Updated mechanical drawings, section 6.1 Updated GPS specifications, section 6.4 Updated hardware specifications, section 6.7 Updated electrical specifications, section 6.8 Updated connector pin-out, section 6.10 Updated GPS antenna connector, section 6.11 Updated mounting, section 7.2 Updated GPS antenna, section 7.4 Updated initialisation, section 8.3 Updated enclosure maintenance, section 9.1.2 Updated housing finish, section 9.5 Updated raw GNSS packet, section 11.8.10 Updated GPIO output configuration packet, section 11.9.10
1.1	06/09/2013	Updated specifications, section 6.2
1.0	29/05/2013	Initial release

2 Firmware Changelog

Version	Date	Changes
2.0	18/08/2014	Firmware has support added for hardware v2.0 (same firwmare also supported on hardware v1.0) Enhanced north seeking algorithm
1.0	29/05/2013	Initial release

3 Hardware Changelog

Version	Date	Changes
2.0	18/08/2014	Enclosure changed from aluminium to titanium Enclosure shape has changed (mounting and dimensions remain the same) GNSS receiver updated to Trimble BD930 Main connector changed to SEACON MINI-CON Type K Co-axial connector changed to Advanced Navigation Poseidon series
1.0	29/05/2013	Initial release

4 Foundation Knowledge

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

4.1 INS

INS stands for inertial navigation system. An inertial navigation system can provide position and velocity similar to GPS 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 significantly.

4.2 Sensor Fusion

By combining INS together with a number of analysis techniques and other sensors in a sensor fusion algorithm, it is possible to take advantage of the benefits of INS short term accuracy while minimising any long term error growth. This provides an overall enhanced position and velocity solution that is superior to any one of the data sources.

4.3 GPS

GPS stands for global positioning system. GPS consists of a number of satellites in space that broadcast navigation signals. These navigation signals can be picked up by a GPS receiver on the earth to determine that receiver’s position and velocity.

GPS is excellent for navigational purposes and provides fairly accurate position (2 metres) and velocity (0.03 metres/second). The main drawback of GPS is that the receiver must have a clear signal from at least 4 satellites to function. GPS satellite signals are very weak and cannot penetrate though water and other obstacles. In underwater navigation the main purpose of GPS is to determine the starting position of the system before it submerges and also correct for any errors that may have accumulated each time it surfaces.

4.4 DVL

DVL stands for doppler velocity log. A DVL works by sending out acoustic sound wave pulses that bounce off the sea floor and debris in the water. When the acoustic pulses bounce back to the DVL the doppler effect is measured which allows the DVL to determine it's velocity relative to the water column and sea floor. A DVL also measures the altitude above the sea floor. A DVL does not require any external equipment and can operate on a standalone vessel. Sublocus DVL contains a Teledyne RDI DVL which greatly improves position and velocity navigation accuracy.

4.5 LBL, SBL and USBL Systems

LBL (Long Baseline), SBL (Short Baseline) and USBL (Ultra-short Baseline) systems are types of underwater acoustic positioning systems. These systems can be considered similar to having a GPS system underwater. They require a number of transponders installed at the work site to operate and the vessel must operate within a limited range of these transponders.

LBL has the highest accuracy and longest range of these systems. It can provide positional accuracy down to 0.01m and ranges of up to 8000m from the transponders. LBL systems typically require 3 or more transponders that are mounted to the seafloor. They are the most expensive of the three systems and the most work to set up.

SBL systems are similar to LBL systems, however the transponders are typically mounted on the hull of a marine vessel. SBL accuracy is typically around 1m. SBL systems are faster to deploy than LBL systems because they do not require seafloor mounted transponders.

USBL systems use a single transponder that is typically mounted on the hull of a marine vessel. USBL accuracy is typically around 4m with ranges of 500 to 4000 metres. USBL is the most cost effective and least work to deploy of the three systems.

4.6 Logs

Logs measure the speed of the underwater vehicle relative to the surrounding water. There are a number of different log technologies available including waterwheel, pitometer, magnetic, ultrasonic, acoustic and optical. Although Sublocus DVL already contains a DVL, attaching a secondary log can still be useful in situations where the DVL is unable to track.

4.7 AHRS

AHRS stands for attitude and heading reference system. An AHRS uses multiple sources of information such as accelerometers and gyroscopes combined in a sensor fusion algorithm to provide orientation. Orientation consists of the three body angles roll, pitch and heading.

4.8 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 shown in Illustration 1 below with the X axis pointing forwards, the Z axis pointing down and the Y axis pointing starboard.

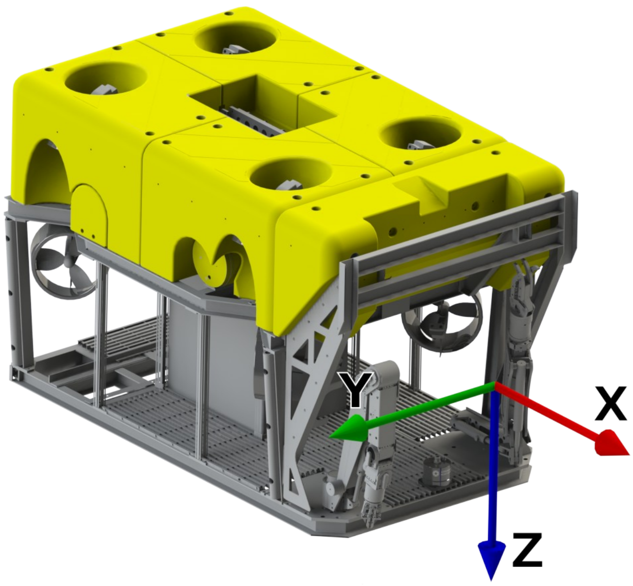

Illustration 1: Sublocus DVL installed in an ROV with axes shown

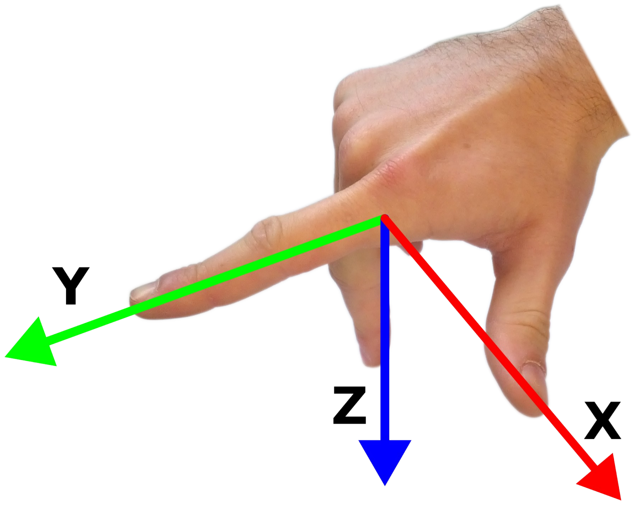

Illustration 2: First right hand rule

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.

4.9 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.

4.9.1 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 45 degrees.

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

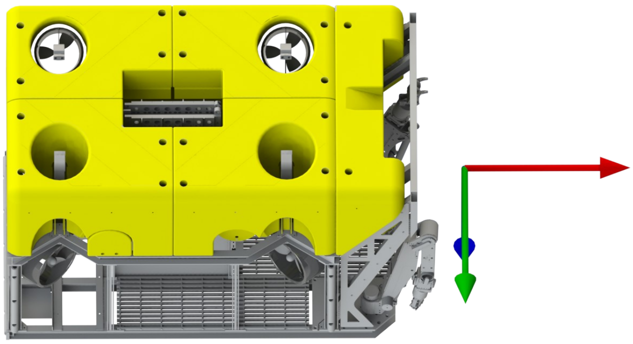

Illustration 4: ROV after a positive roll of 45 degrees

4.9.2 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 45 degrees.

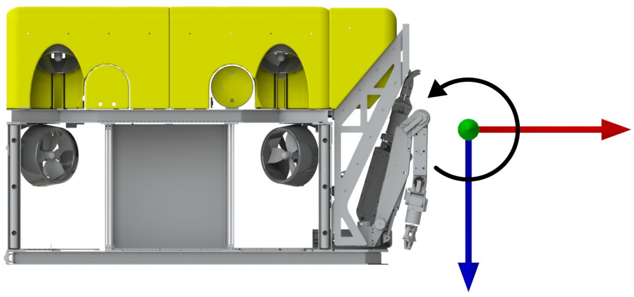

Illustration 5: ROV with black arrow indicating positive direction of pitch

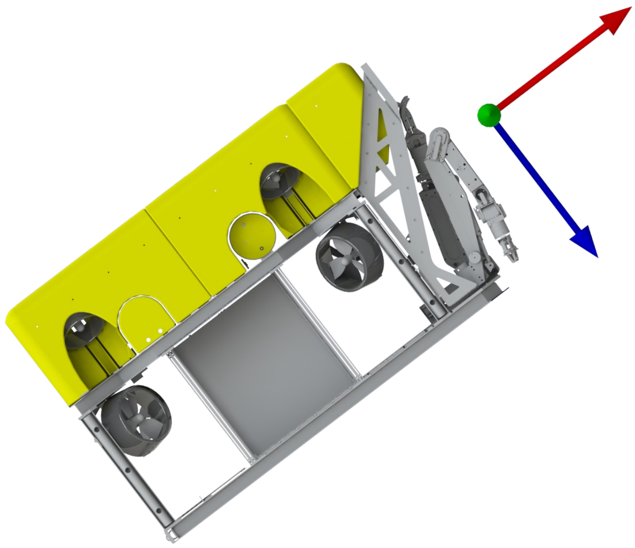

Illustration 6: ROV after a positive pitch of 45 degrees

4.9.3 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 45 degrees. 0 degrees heading is when the positive X axis points true north and 180 degrees heading is when the positive X axis points south.

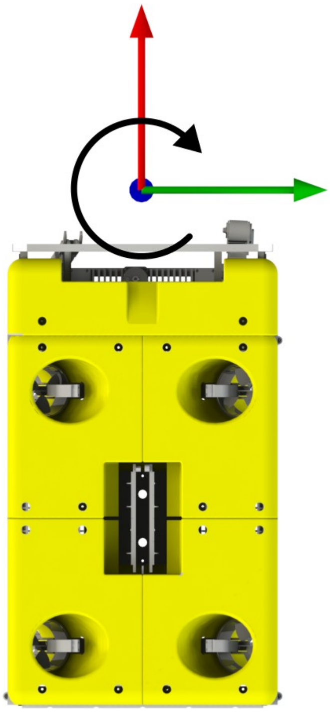

Illustration 7: ROV with black arrow indicating positive direction of heading

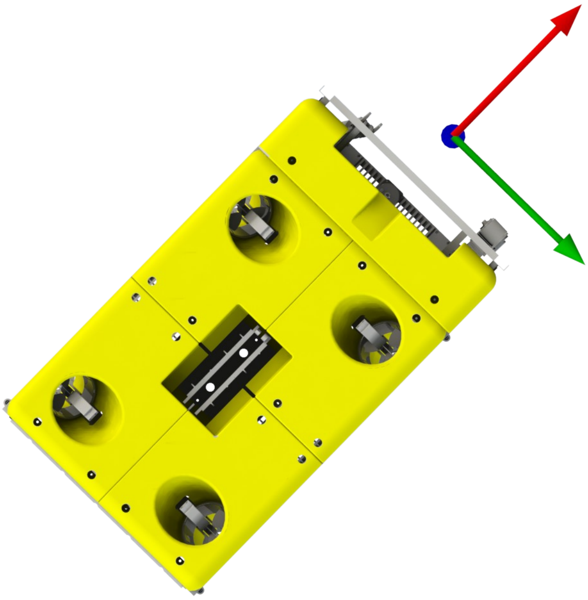

Illustration 8: ROV after a positive heading change of 45 degrees

4.9.4 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 4.8. 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.

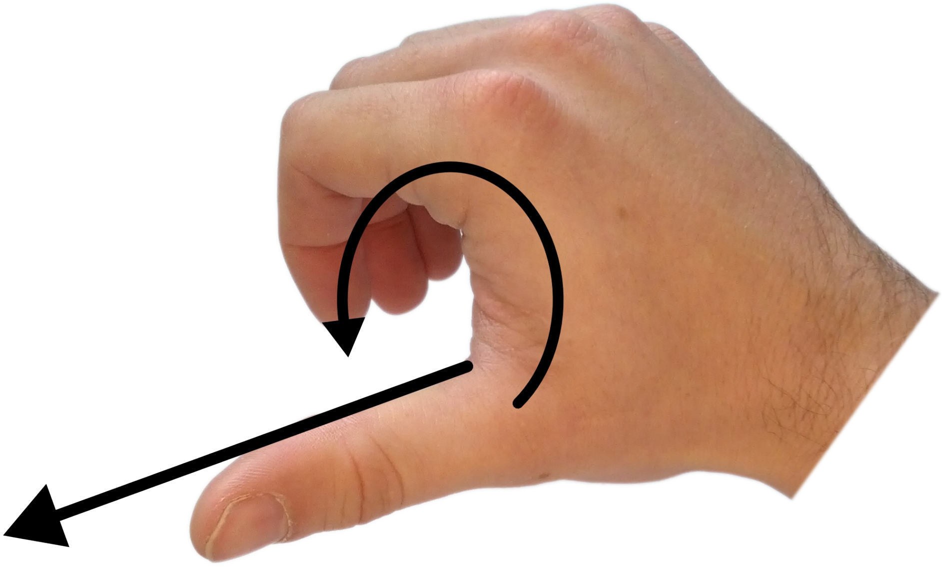

Illustration 9: Second right hand rule

4.9.5 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.

4.10 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.

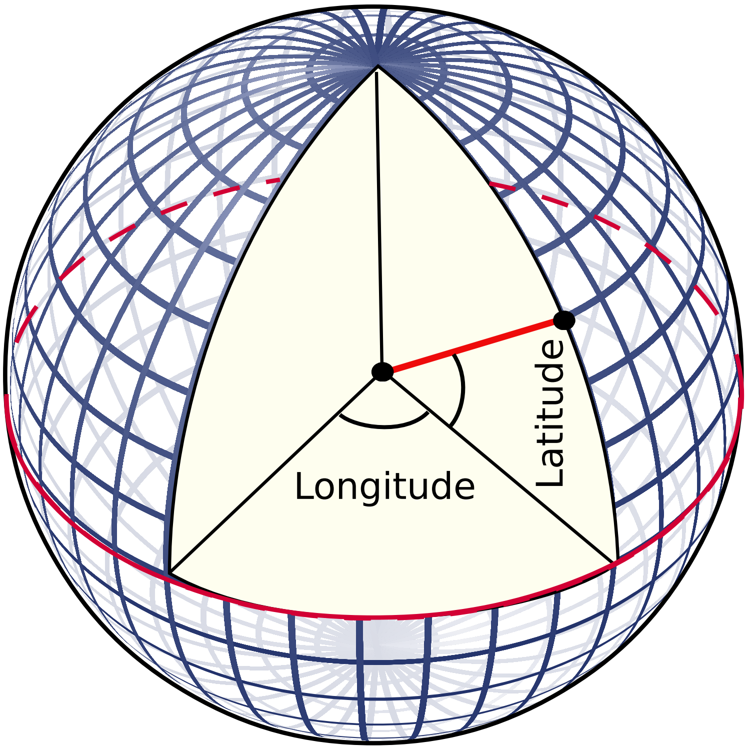

Illustration 10: Latitude and longitude represented visually to describe a position

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

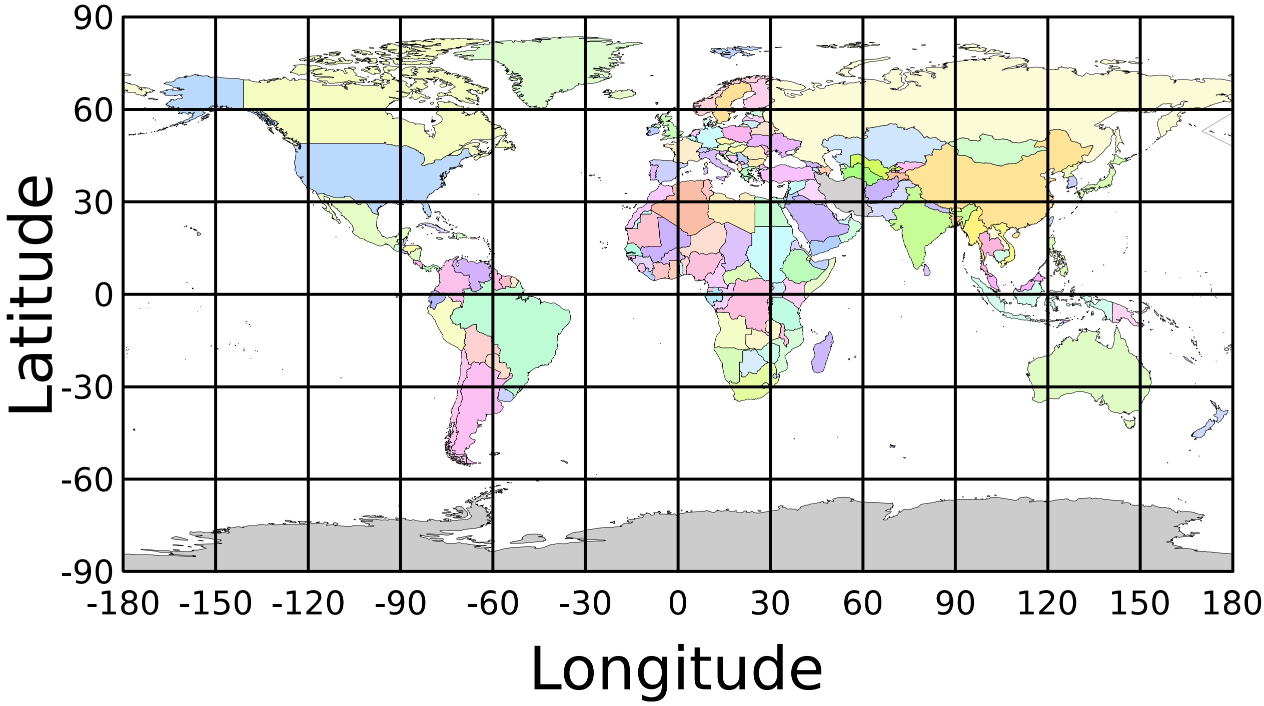

Illustration 11: World map showing latitudes and longitudes

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.

4.11 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.

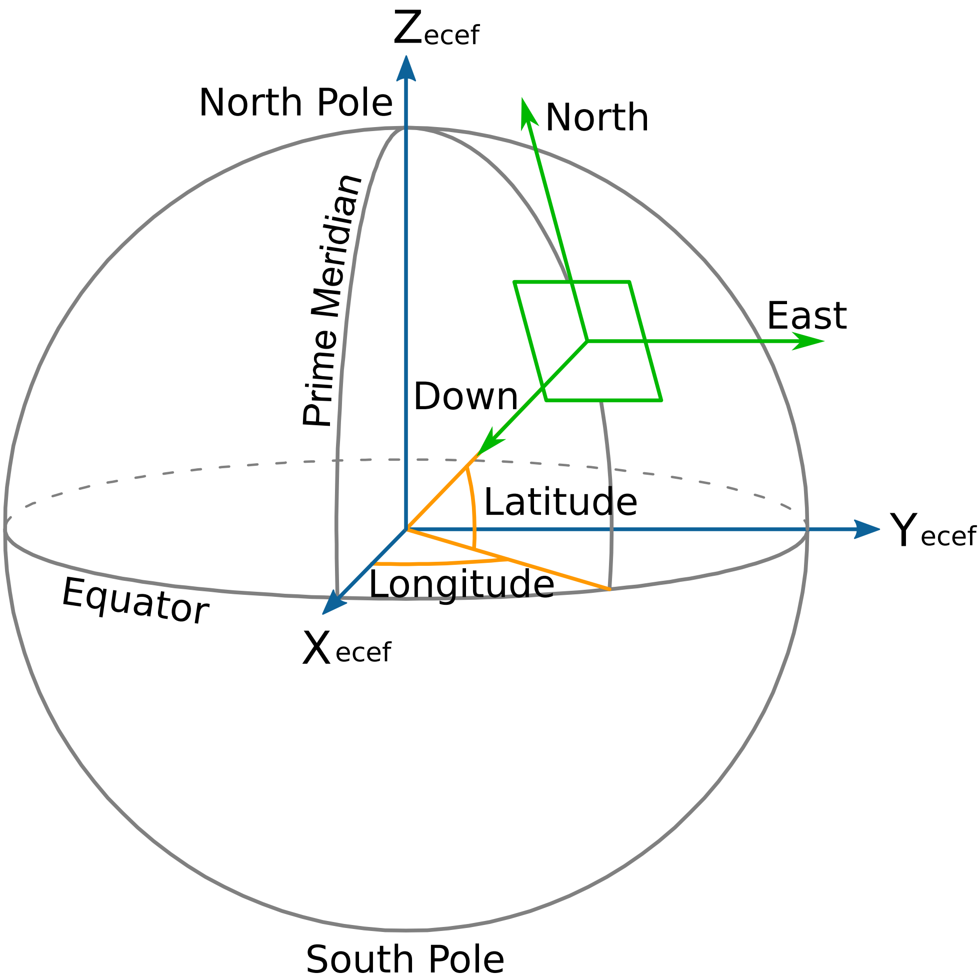

Illustration 12: Graphic showing geodetic, NED and ECEF co-ordinates

4.12 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.

5 Introduction

Sublocus DVL is an underwater acoustic and inertial navigation system that provides accurate position, velocity and orientation at depths of up to 3000 metres. It features a doppler velocity log, high accuracy north seeking fibre optic gyroscopes, accelerometers, an internal GPS receiver and a pressure depth sensor. It accepts external aiding from speed logs, propeller speeds, USBLs, SBLs and LBLs.

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

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

6 Specifications

6.1 Mechanical Drawings

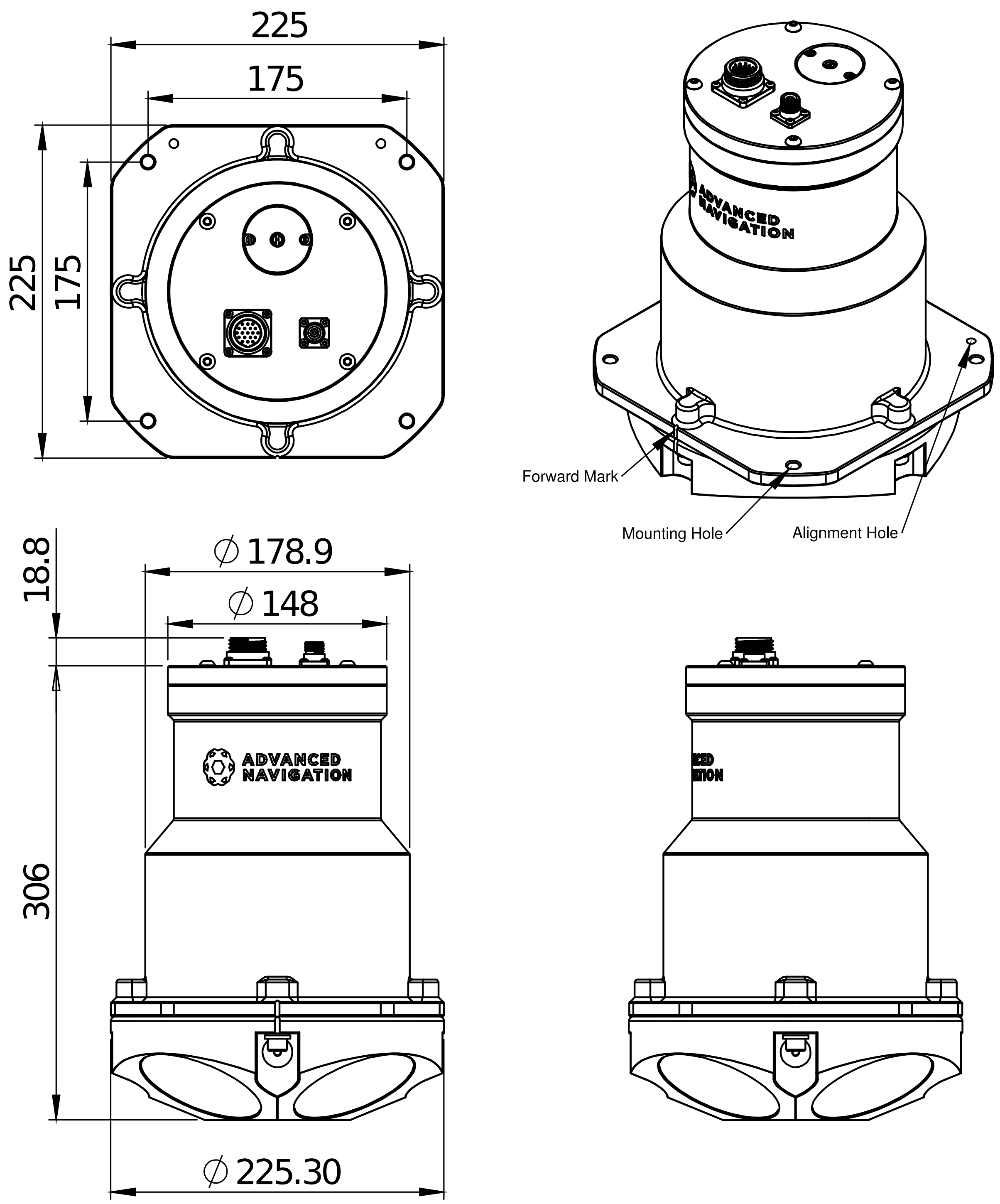

Illustration 13: Sublocus DVL mechanical drawings

6.2 Navigation Specifications

Parameter	Value
Horizontal Position Accuracy (GPS)	0.8 m
Horizontal Position Accuracy	0.08 % distance travelled
Depth Accuracy	0.4 m
Roll & Pitch Accuracy	0.01 °
Heading Accuracy	0.25 ° secant latitude
Orientation Range	Unlimited
Hot Start Time	2 s
North Seeking Time	From 10 seconds to 10 minutes
Internal Filter Rate	1000 Hz
Output Data Rate	Up to 1000 Hz

Table 1: Navigation specifications

6.3 Sensor Specifications

Parameter	Accelerometers	Gyroscopes	Magnetometers	Pressure
Range	10 g	490 °/s	8 G	400 bar
Noise Density	300 ug/√Hz	0.0002 °/s/√Hz	210 uG/√Hz	-
Non-linearity	< 0.03 %	< 0.005 %	< 0.05 %	-
Bias Stability	50 ug	0.05 °/hr	-	-
Scale Factor Stability	< 0.06 %	< 0.02 %	< 0.05 %	-
Cross-axis Alignment Error	< 0.05 °	< 0.02 °	0.05 °	-
Bandwidth	200 Hz	440 Hz	110 Hz	10 Hz

Table 2: Sensor specifications

6.4 GPS Specifications

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

Table 3: GPS Specifications

6.5 DVL Specifications

Parameter	Value
Model	Teledyne RDI Workhorse Navigator
Frequency	600KHz
Bottom Tracking Minimum Altitude	0.7 m
Bottom Tracking Maximum Altitude	90 m
Maximum Speed	10 m/s
Ping Rate	7 Hz

Table 4: DVL specifications

6.6 Communication Specifications

Parameter	Value
Interface	RS232 or RS422
Speed	1200 to 10M baud
Protocol	AN Packet Protocol
Peripheral Interface	2x GPIO and 1x Auxiliary RS232
GPIO Level	5 V or RS232

Table 5: Communication specifications

6.7 Hardware Specifications

Parameter	Value
Depth Rating	3000 m
Operating Voltage	20 to 50 V
Input Protection	-36 to 100 V
Power Consumption	9 W (typical)
Hot Start Battery Capacity	> 24 hrs
Hot Start Battery Charge Time	30 mins
Hot Start Battery Endurance	> 10 years
Operating Temperature	-5 °C to 45 °C
Storage Temperature	-30 °C to 60 °C
MTBF	> 36,000 hours
Shock Limit	25 g
Dimensions	225 x 225 x 306 mm
Weight in Air	16 kg
Weight in Water	7.1 kg

Table 6: Hardware specifications

6.8 Electrical Specifications

Parameter	Minimum	Typical	Maximum
Power Supply			
Input Supply Voltage	20 V		50 V
Input Protection Range	-36 V		100 V
RS232			
Tx Voltage Low		-5.4 V	-5 V
Tx Voltage High	5 V	5.4 V	
Tx Short Circuit Current			±60 mA
Rx Threshold Low	0.6 V	1.2 V	
Rx Threshold High		1.5 V	2.0 V
RS422			
Tx Differential Output	1.5 V		
Tx Short Circuit Current			±250 mA
Rx Differential Threshold	-0.2 V		-0.05 V
GPIO			
Output Voltage Low	0 V		0.3 V
Output Voltage High	4.8 V		5 V
Input Voltage	-20 V		20 V
Input Threshold Low			1.5 V
Input Threshold High	3.5 V		
Output Current			5 mA
GPS Antenna			
Active Antenna Supply Voltage	4.8 V		5 V
Antenna Supply Current			150 mA

Table 7: Electrical specifications

6.9 Power Consumption

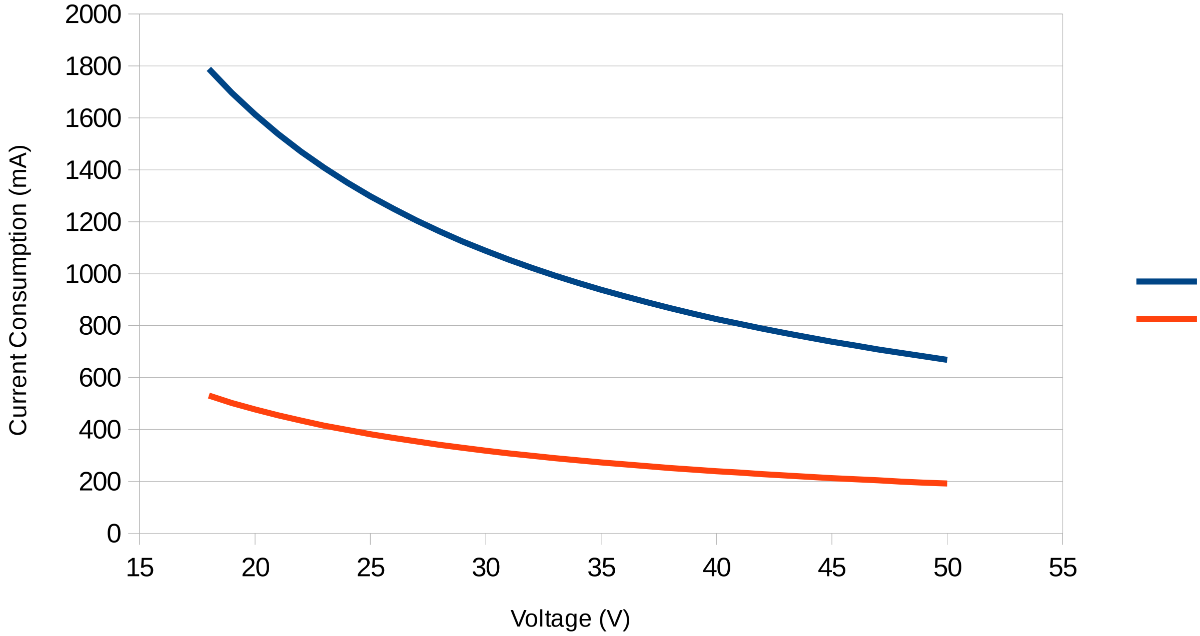

Illustration 14: Typical and maximum current consumption of Sublocus DVL

6.10 Connector Pin-out

Power supply and signal connections are made through one SEACON MINI-CON size K 19 pin connector. These connectors are rated to 20,000 PSI in the mated condition. They are not rated for open face operation. Connectors are manufactured from titanium.

Illustration 15 shows the connector pin numbering when looking into the bulkhead connector on Sublocus DVL. Connector Pin functions are shown in Table 8 below. Systems can be supplied with either RS232 or RS422 standard communication on the main communication port. The required communication standard should be specified when placing an order.

Advanced Navigation can organise custom interface cables per customer's specifications. Alternatively customers can contact SEACON for their local supplier's details.

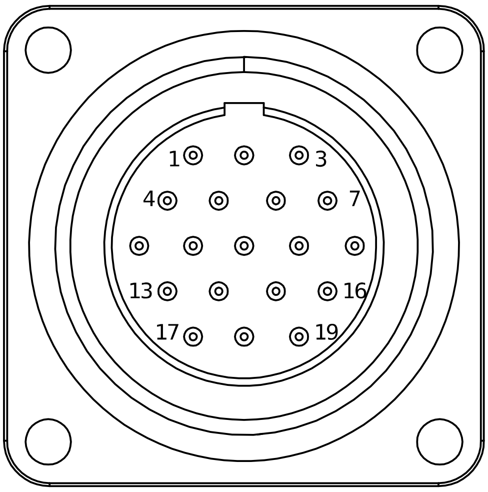

Illustration 15: Sublocus DVL connector pin numbering

Pin	Function
1	Primary RS422 Tx(+) / Primary RS232 Tx
2	Primary RS422 Tx(-)
3	Auxiliary RS232 Tx
4	Primary RS422 Rx(+) / Primary RS232 Rx
5	Primary RS422 Rx(-)
6	Auxiliary RS232 Rx
7	NC
8	Power Supply
9	Power Ground
10	GNSS RS232 Rx
11	NC
12	Signal Ground (for Auxiliary RS232)
13	GPIO 1
14	GPIO 2
15	NC
16	NC
17	Signal Ground (for Primary RS232/RS422, GPIOs and GNSS)
18	NC
19	NC

Table 8: Pin allocation table

6.11 GPS Antenna Connector

GPS antenna connection is made through an Advanced Navigation Poseidon series coaxial connector. These connectors are rated to 8,700 PSI and manufactured from 316 stainless steel, passivated as per QQ-P-35 Type VI.

All Sublocus DVL systems are supplied with an Advanced Navigation Poseidon 3000m depth rated GPS antenna. The antenna comes with a 3 metre cable and appropriate Poseidon connector. Customers who require a different length of cable should specify their desired length when placing their order.

Please see section 9.4 for connector care guidelines.

7 Installation

7.1 Alignment

When installing Sublocus DVL into a vehicle, accurate alignment will help to achieve good performance.

The easiest way to align Sublocus DVL 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. When aligned in this way the forward mark points towards the front of the vehicle and the unit is level when the vehicle is level.

If aligning Sublocus DVL with the vehicle axes is not possible or not optimal, it may be mounted in a different alignment and the alignment offset should be configured using the alignment configuration dialog in Sublocus Manager software.

7.2 Mounting

Sublocus DVL needs to be mounted level on the ROV, with the DVL at the bottom of the vehicle facing down without any obstacles in it's way. The mounting plate dimensions for Sublocus DVL are shown in Illustration 16 below. The system is secured by four M8 bolts. Sublocus DVL units are supplied with shoulder washers to isolate the mounting bolts from Sublocus DVL's housing and ensure that the housing surface is not damaged by overtightened bolts. Customers should use either nyloc nuts or split washers to ensure that the M8 bolts remain secure during operation.

The recommended method for mounting Sublocus DVL is from above onto a plate with a hole cutout for the DVL to protrude through. Alternatively the unit can be clamped around the enclosure from the side. If Sublocus is clamped there must be isolation (e.g. rubber) between it's enclosure and the clamp.

Illustration 17 shows the recommended mounting hardware to be used to mount Sublocus DVL to the ROV. Spare shoulder washers are provided with every system and customers should contact Advanced Navigation if they require more shoulder washers.

Two precision alignment holes measuring 6mm in diameter can be used for precise and repeatable alignment of Sublocus DVL. Customers can use alignment pins through these holes to accurately align Sublocus DVL before the four M8 bolts are tightened.

If Sublocus DVL is mounted on a rough or uneven surface, an isolator pad should be placed between Sublocus DVL and the mounting surface. This ensures that Sublocus DVL does not cause galvanic corrosion to other dissimilar metals.

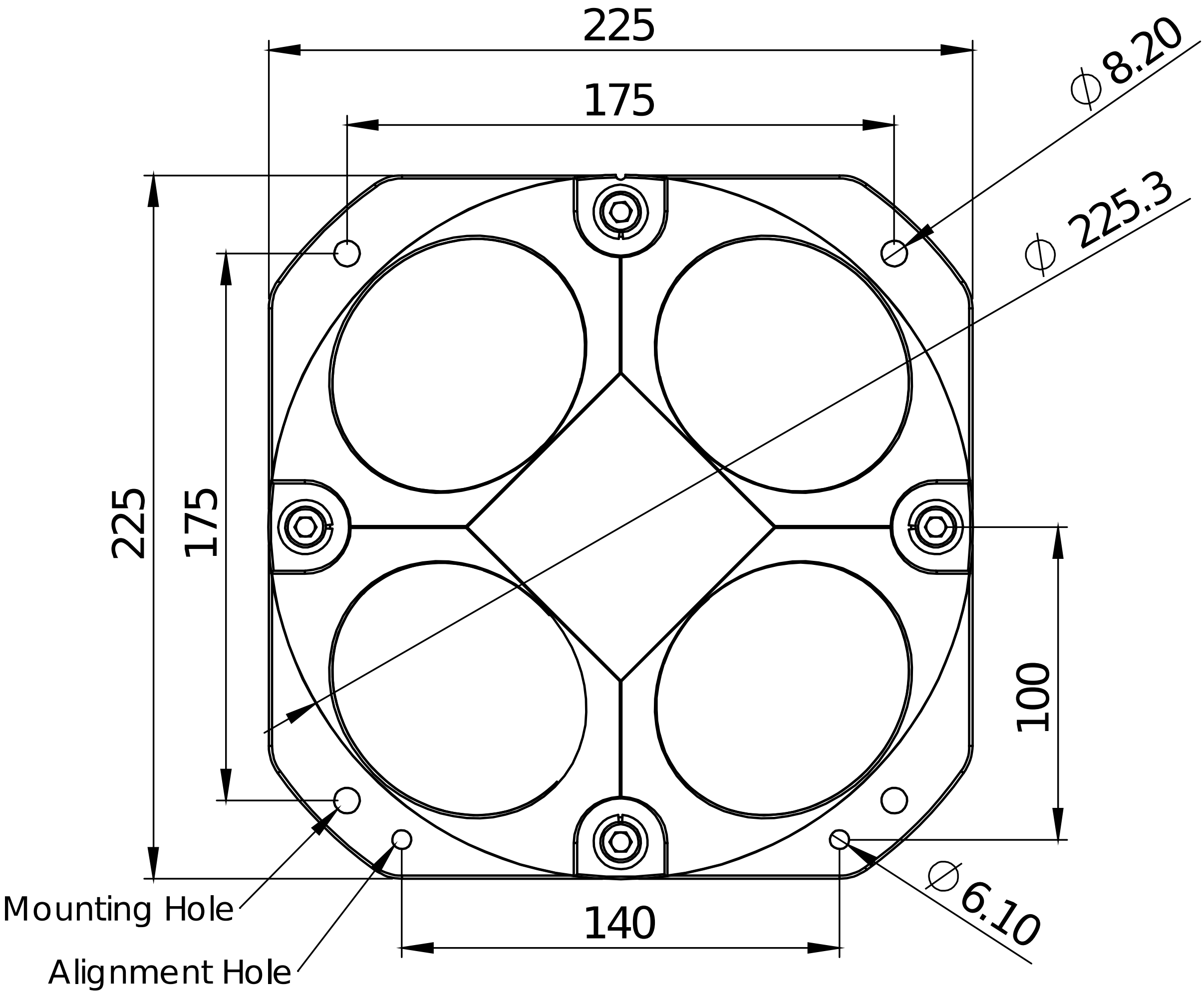

Illustration 16: Sublocus DVL mounting base dimensions

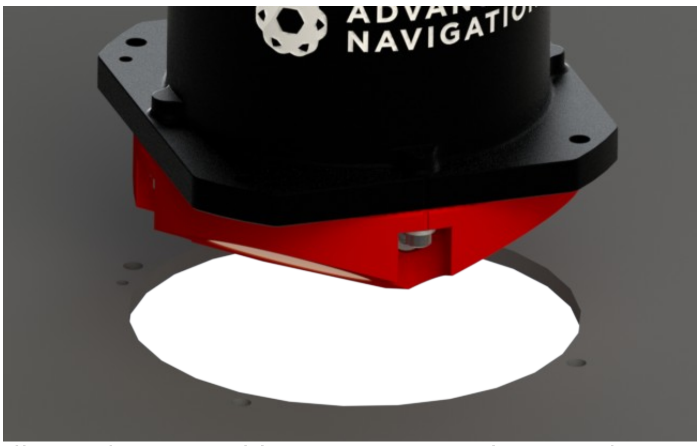

Illustration 17: Sublocus DVL example mounting cutout

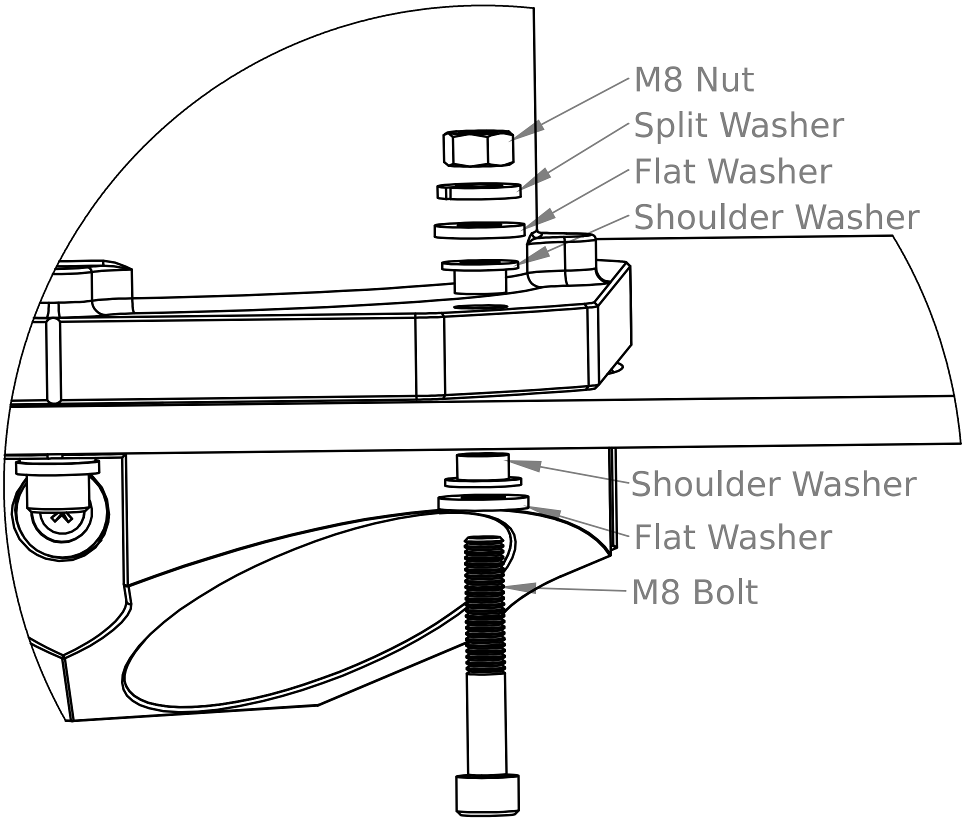

Illustration 18: Sublocus DVL mounting hardware

7.3 Power Supply

A high level of power supply filtering has been built into Sublocus DVL to allow for reliable operation in demanding environments.

The power supply input is galvanically isolated from the onboard electronics. Because of this both the power ground and signal ground can be used separately when installing the system. The power ground should be connected to the power supply source or as close as possible to it. The signal ground should be connected to the system communicating with Sublocus DVL. Please contact Advanced Navigation support for advice on connecting your grounds.

A power supply should be selected that can provide at least the maximum current calculated from the graph in Illustration 14.

Best performance from the DVL is achieved by running the system at 48V.

Sublocus DVL 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 20 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 22 V or more to avoid issues associated with this.

7.4 GPS Antenna

The GPS antenna should be installed level with a clear view of the sky and as high as possible on the vehicle. The antenna cable should be routed away from high energy noise sources such as motors, motor controllers and power supplies. The optimum mounting configuration is above the Sublocus DVL unit. If the antenna has to be installed more than 1 metre away from the Sublocus DVL unit, this antenna offset should be configured using the alignment offset configuration dialog in Sublocus Manager. Incorrect GPS antenna offset can lead to performance degradation under angular rotations.

Sublocus DVL is supplied with the Advanced Navigation Poseidon GPS/GLONASS L1 subsea antenna. The antenna is rated to depths of 3000 metres and weighs 320 grams. It is manufactured out of 316 stainless steel. See Illustration 19 for mechanical drawings of the antenna. The recommended mounting procedure is to use four 316 stainless bolts screwed into the tapped M4 holes in the base from below.

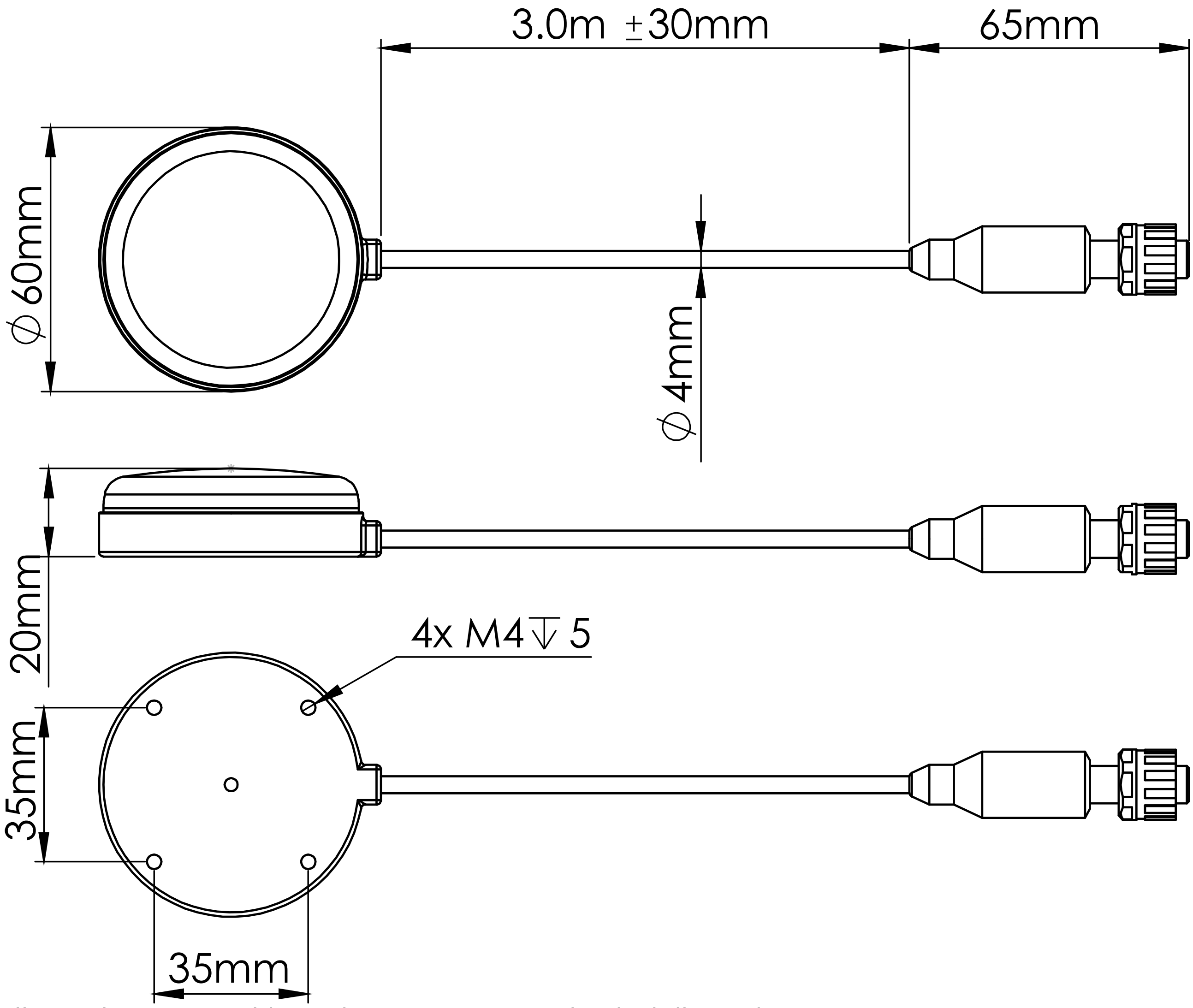

Illustration 19: Poseidon subsea antenna mechanical dimensions

7.5 Pressure Sensor

Sublocus DVL includes an integrated pressure sensor that is used to calculate depth. The standard operating range of this sensor is 4000m or 400bar. Other pressure sensor operating ranges are available on request.

The pressure sensor port is located on the top of Sublocus DVL and the sensing element is protected by a plastic cover with a vented screw to ensure that the sensor is not damaged by any large foreign objects, see Illustration 20. Sublocus DVL should be installed such that the pressure sensor port is not covered or obstructed. The pressure sensor port should also be out of the path of turbulent water from thrusters. Refer to section 9.2 for servicing of the pressure sensor.

The salinity of the water in which Sublocus DVL is operating has a small effect on the accuracy of the calculated depth. For typical open ocean operating environments Sublocus DVL's default salinity does not need to be changed. For environments of very high salinity or when operating in fresh water the salinity should be set to ensure that depth is calculated to the highest accuracy. This setting can be changed in the salinity configuration dialog in Sublocus Manager.

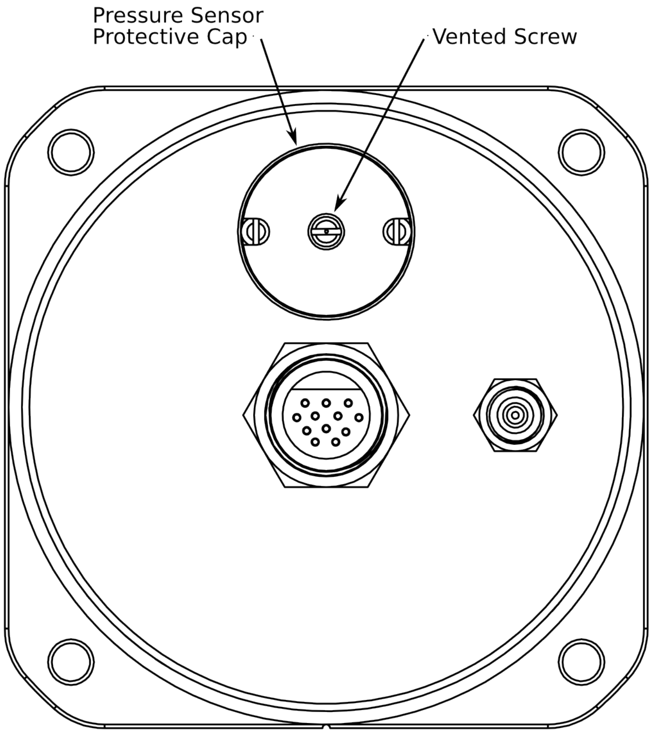

Illustration 20: Sublocus DVL pressure port

7.6 External Sensors

Other sensors such as DVLs, LBLs, SBLs, USBLs and Logs can be connected to Sublocus DVL over the auxiliary RS232 port or GPIO pins. The Tx wire of the external sensor should be connected to Auxiliary Rx for RS232 or GPIO 2 for TTL. The signal ground should also be connected to the external sensor. The function of the Auxiliary RS232 port and the GPIO pins can be selected in the GPIO configuration dialogue of Sublocus Manager.

8 Operation

8.1 Deployment Check-list

Prior to each deployment it is recommended to visually inspect Sublocus DVL paying particular attention to the following:

1. Check pressure sensor vented screw for blockages.
2. Check housing for any damage.
3. Check that all mounting hardware is securely fastened and in good condition.
4. Check connectors are fully mated and secure. Apply silicon lubricant on male pins and female socket before reconnection. If a connector is not in use, it must be fitted with a cap.
5. Check that the DVL transducer faces are clean and that there is no damage to the DVL. Check the DVL anodes for erosion. If the mounting bolt is in less than 75% contact with the anode, they need to be replaced.

8.2 Filter

Sublocus DVL 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. Sublocus DVL'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 very large errors present that Sublocus DVL's filter cannot compensate for, it can become unstable. If Sublocus DVL'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 Sublocus DVL's filter status, so that data can be ignored if a situation occurs causing the filter to reset.

8.3 Initialisation

When Sublocus DVL 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, Sublocus DVL 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 an orientation error. In this scenario Sublocus DVL will progressively correct the orientation error over a period of several seconds.

Sublocus DVL's north seeking algorithm requires that the unit be moved through 4 different positions to initialise the gyrocompass heading. In each position the unit must remain completely stationary. This initialisation takes approximately 20 minutes after power up. If Sublocus DVL is moved in this time the north seeking initialisation will continue once it becomes stationary again. The recommended north seeking procedure is as follows:

1. Power the system on. If the system has moved more than 50km since it's last position fix, it will require a position update. This can be achieved by either allowing the unit to acquire a GPS fix or manually entering a position.
2. After power on, keep the unit completely stationary for 5 minutes.
3. Rotate the unit around the Z axis by approximately 90 degrees in either direction and then keep the unit completely stationary for 5 minutes.
4. Rotate the unit around the Z axis by approximately 90 degrees in the same direction and then keep the unit completely stationary for 5 minutes.
5. Rotate the unit around the Z axis by approximately 90 degrees in the same direction and then keep the unit completely stationary for 5 minutes.
6. The heading initialised flag should now be set in the filter status indicating that the heading has converged and the system is ready for operation.

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

8.4 North Seeking Gyrocompass Heading

Sublocus DVL's high accuracy gyroscopes allow it to detect the rotation of the earth and seek north with a high degree of accuracy. This process of north seeking takes approximately 20 minutes and will not achieve full accuracy until the unit is moved through a number of orientations. Please see section 8.3 for the north seeking initialisation procedure.

For full accuracy north seeking gyrocompass heading, Sublocus DVL needs to know it's approximate position. It is recommended to allow the Sublocus DVL unit to attain a GPS fix at least every time the unit is moved more than 50km.

8.5 External Heading

It is possible to feed in external heading into Sublocus DVL. This can be useful to speed up the north seeking gyrocompass initialisation on start-up. Heading can be fed into Sublocus DVL using the External Heading Packet or NMEA Input.

8.6 Hot Start

Sublocus DVL is the first inertial navigation system on the market with hot start functionality. This allows Sublocus DVL to initialise orientation and start inertial navigation within 2 seconds as well as obtain a GPS fix in as little as 3 seconds after power up. Sublocus DVL's hot start is always on and fully automatic.

A next generation backup battery system within Sublocus DVL provides the hot start ability for more than 24 hours without power. When Sublocus DVL hot starts it assumes that it is in the same position it was when it lost power and begins navigating from that position. It also runs a test to determine if the heading has changed, if this test returns false the heading will be initialised with the heading the unit had on power down. The hot start also provides ephemeris, almanac and time information to the GPS receiver which allows it to achieve a fix far more quickly than it otherwise would. When the GPS achieves it's first fix, if this position deviates from the hot start position, Sublocus DVL will jump to the new position without causing any side effects to the filter.

Whilst Sublocus DVL 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.

The primary benefits of Sublocus DVL's hot start are immunity and fast recovery from power failure as well as fast startup time.

8.7 Time

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

8.8 DVL

Sublocus DVL contains a Teledyne RDI Workhorse Navigator DVL. The DVL provides several very important pieces of navigational data. When the DVL is within 90 metres of the sea floor it is able to provide the distance to the sea floor (altitude) and also the ROV's velocity relative to the sea floor. This is known as bottom velocity and it is not subject to errors from water currents which makes it very accurate. When the DVL is over 90 metres from the sea floor, it provides the velocity relative to the water layer around it. This is subject to errors from water currents. Therefore best navigational performance is achieved when Sublocus DVL is within 90 metres of the sea floor.

8.9 Data Anti Aliasing

Internally Sublocus DVL's filters update at 1000 Hz. When Sublocus DVL 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, Sublocus DVL will low pass filter the values of the time dependent data between packets to prevent aliasing. This is only the case when a packet is set up to output at a certain rate. If the packet is simply requested no anti aliasing will occur. Additionally there is no anti aliasing for non time dependent fields such as position.

8.10 Motion Analysis

Motion analysis is an artificial intelligence algorithm that associates patterns in high frequency inertial data with the speed of the vehicle. After power on it takes some time to match patterns with speed before it will become active. Motion analysis only activates when dead reckoning and is most effective when the vehicle is near stationary. Motion analysis does not work in all situations. When active it can be recognised by 2Hz steps in velocity data. Motion analysis is enabled by default and can be configured using the filter configuration window in Sublocus Manager

8.11 Heave

Sublocus DVL can provide vertical heave position at four different points on the ROV. Sublocus DVL's heave filter is always on and fully automatic. After power on, Sublocus DVL requires approximately 5 minutes for it's heave filter to converge upon an accurate solution.

By default Sublocus DVL provides heave at the point at the centre of the Sublocus DVL unit, however it can be configured to provide heave at four different offset points on the ROV. To set the heave offsets, use the heave configuration dialog in Sublocus Manager.

8.12 Ingress Sensor

Sublocus DVL contains ingress sensors that can detect the slightest leakage into it's enclosure. While ingress into the enclosure is extremely unlikely to occur, the sensors can give an early warning that allow a problem to be rectified before it causes damage to the electronics. The ingress detection is available in the system status.

9 Maintenance

Sublocus DVL has been designed for very high reliability and low maintenance. It requires minimal servicing apart from inspections and cleaning as detailed below.

9.1 Inspections

9.1.1 Pressure Sensor

Every time the system is deployed the pressure sensor vent screw should be inspected for blockages. The vent screw is located on top of the unit, see Illustration 20. If the screw is blocked follow the service procedure in section 9.2.

9.1.2 Enclosure

Every time the system is deployed the enclosure should be inspected for both damage and biofouling.

9.1.2.1 Damage

Look for deep scratches, corrosion and cracks. If there are any signs of damage please contact Advanced Navigation support.

9.1.2.2 Biofouling

Look for biofouling such as barnacles and other marine growth. Follow the service procedure in section 9.6 for removal of biofouling.

9.1.3 Mounting Hardware

Every time the system is deployed inspect all bolts, washers and split washers for signs of corrosion. All mounting hardware supplied by Advanced Navigation is coated with an anti-corrosion treatment and should provide many years of operation without signs of corrosion. If there are signs of corrosion the mounting hardware should be replaced.

9.1.4 Connectors

Every time the system is deployed the connectors and cables should be inspected for damage and checked to ensure they are fully mated.

Every time the connectors are un-mated the inside should be inspected for bent or damaged pins and cracked or damaged o-rings. Silicon lubricant should be applied to the male pins and the female socket prior to remating.

9.1.5 DVL

Every time the system is deployed the DVL should be inspected. The transducer faces should be clean. The housing should be inspected for signs of corrosion. The anodes should be checked. The anodes need to be replaced when they are eroded to the extent that the mounting bolt is in less than 75% contact with the anode.

9.2 Pressure Sensor Servicing

For Sublocus DVL to accurately measure depth, water must be able to flow through the vented screw in the top of the pressure sensor assembly. When the screw becomes blocked follow the procedure below to clean it. Do not attempt to clear the vented screw by poking objects into it while it is still mounted, this can cause damage to the pressure sensor below.

1. Using a flat head screw driver, remove the two nylon screws that hold the protective cover in place. Be careful not to scratch the Sublocus DVL enclosure.
2. Remove the protective cover and clean cover with soapy water.
3. Clear the vented screw using a small needle.
4. If the vented screw is damaged or corroded it should be replaced.
5. Brush the nylon screws with a light amount of grease
6. Reinstall the protective cover. The nylon screws should only be finger tight. Over tightening the screws will shear them off into the unit and require return to factory for repair.

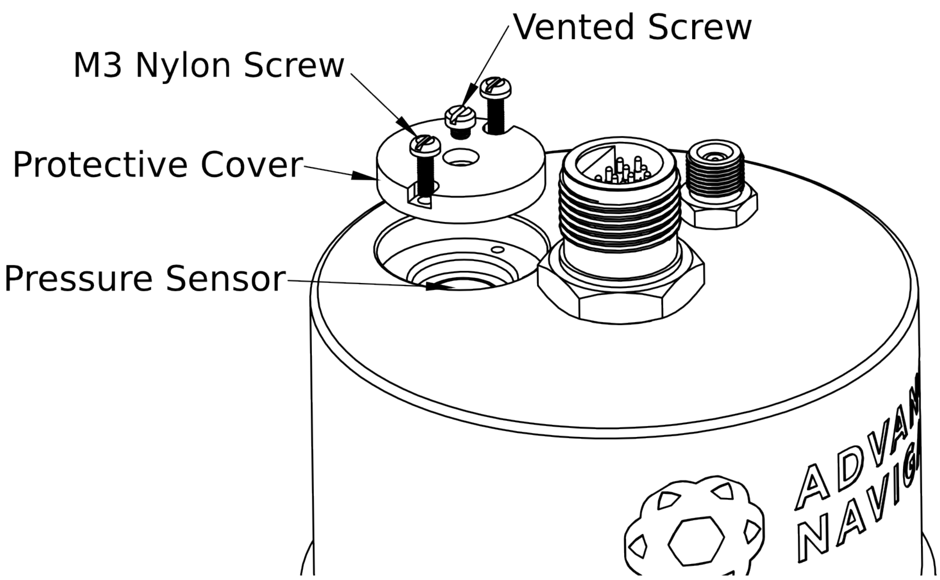

Illustration 21: Sublocus DVL pressure sensor breakout view

9.3 Replacing DVL Anodes

The anodes need to be replaced when they are eroded to the extent that the mounting bolt is in less than 75% contact with the anode. Replacing the anodes involves removing the bolts that hold the DVL to the housing. If all bolts are removed at once the calibrated DVL alignment will be lost and Sublocus DVL must be returned to the factory for calibration. Therefore it is very important to replace the anodes one at a time. Never remove more than one of the DVL bolts at a time. The following procedure should be followed for anode replacement:

1. Unscrew and remove the M8 bolt, split washer, flat washer and shoulder washer.
2. Remove the RTV silicone from the anode screw head.
3. Remove the anode mounting screw.
4. Remove the anode. If the anode is stuck, protect the transducer face and housing and gently strike the anode to loosen it.
5. Clean the bonding area under the anode. Remove all foreign matter and corrosion. Apply a continuous 1-2mm bead of RTV silicone around each screw hole.
6. Set a new anode in place and fasten with a new screw.
7. Fill the hole above the screw head with RTV silicone.
8. Replace the M8 bolt. A torque wrench should be used to fasten the bolt to the specified torque. Be very careful not to overtighten this bolt.

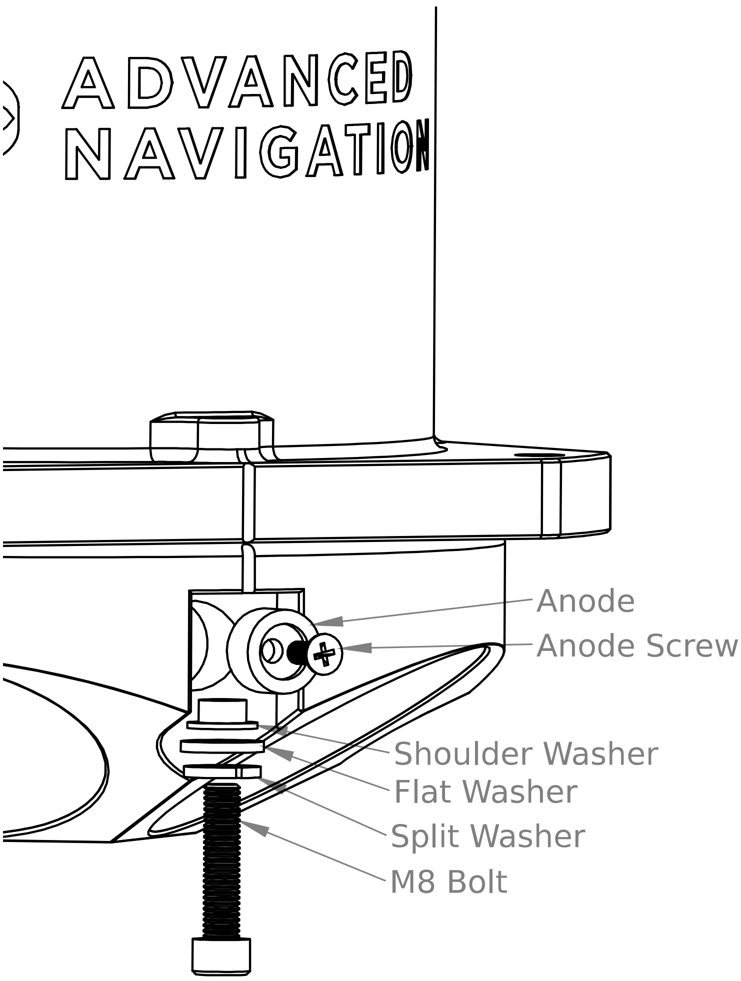

Illustration 22: Sublocus DVL anode breakout view

9.4 Connector Guidelines

To ensure a long and trouble free service life of connectors the following guidelines should be observed:

- Use dust caps and keep connectors clean to prevent damage when in storage and service.
- Keep o-ring grooves clean and avoid cuts, nick and tears on the rubber surfaces
- Clean plugs and receptacles with soap and fresh water. Rinse out with alcohol and allow connector to air dry.
- O-rings will deteriorate if exposed to direct sunlight or high ozone levels for extended periods of time.

9.5 Housing Finish

Sublocus DVL is manufactured from titanium alloy which offers very low maintenance, tough protection and very good corrosion resistance.

9.6 Removing Biofouling

Sublocus DVL's polished outer surface makes it very difficult for marine life to attach to. Typically any biofouling such as barnacles can be easily brushed off with a soft brush.

Remove soft marine growth with soapy water and a low stiffness brush. Do not use abrasive cleaning products or high pressure spray cleaners. For hard marine growth such as barnacles it is recommended to use a cleaning product that dissolves lime and a low stiffness brush. After cleaning rinse the system and dry with compressed air.

9.7 Factory Calibration

The system should be sent back to Advanced Navigation for factory calibration and servicing every 2 years.

10 Interfacing

10.1 Communication

Communications to the Sublocus DVL unit over the primary interface is in the Advanced Navigation Packet Protocol (ANPP). The RS232 or RS422 format is fixed at 1 start bit, 8 data bits, 1 stop bit and no parity. See section 11 for details on the protocol.

Communications over the auxiliary interface is available in a number of different selectable formats, please see section 10.3.

10.1.1 Baud Rate

The default baud rate of Sublocus DVL is 115200. The baud rate can be set anywhere from 1200 to 10,000,000 baud and can be modified using the Sublocus Manager software. It is important to select a baud rate that is capable of carrying the amount of data that Sublocus DVL is set to send. See packet rates in section 11.5 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.

10.2 External Data

External sources of position, velocity and/or heading can be integrated into Sublocus DVL's filter solution. The data can be sent to Sublocus DVL in the ANPP format over the primary interface or through the auxiliary RS232 or GPIO pins in a number of different formats. If using the ANPP, please use Table 9 below to find the relevant section. If using the GPIOs, please see section 10.3.

Packet	Section
External Position and Velocity	11.8.25
External Position	11.8.26
External Velocity	11.8.27
External Body Velocity	11.8.28
External Heading	11.8.29
External Time	11.8.32
External Depth	11.8.33

Table 9: ANPP External Data Reference

10.3 GPIO Pins and Auxiliary RS232

Sublocus DVL 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 Sublocus DVL 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 or RS232 serial transmit line and GPIO2 can function as a TTL or RS232 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 Sublocus Manager.

The GPIO pin functions and auxiliary RS232 functions available are listed below in section 10.4. The function of a GPIO pin or auxiliary RS232 can be changed at any time using the GPIO configuration dialog in Sublocus Manager. The receive and transmit functions of the auxiliary RS232 ports can be configured independently with different functionality.

10.3.1 GPIO Pins Voltage Level

GPIO1 and GPIO2 are normally 5 volt TTL level pins, however they feature special converters that can transform the pins into RS232 voltage levels. This functionality can be enabled or disabled using the GPIO configuration dialog in Sublocus Manager.

10.4 Dynamic Pin Functions

Function	Type	GPIOs	Auxiliary RS232
Inactive	Tristate	All	All
1PPS Output	Digital Output	All	
GPS Fix Output	Digital Output	All	
Zero Velocity Input	Digital 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 GPS	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 GPS 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
1PPS Input	Digital Input	All	
Event 1 Input	Digital Input	All	
Event 2 Input	Digital Input	All	
Linkquest USBL Input	Serial Receive	2	Receive
IXBlue Input	Serial Receive	2	Receive
Sonardyne Input	Serial Receive	2	Receive

Table 10: GPIO pin functions

10.4.1 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 Sublocus DVL has accurate time or not. It is important to note that when Sublocus DVL acquires time corrections from it's GPS receiver, the 1PPS signal may fire at an interval of less than 1 second. This typically only occurs the first time the GPS 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.

10.4.2 GPS Fix Output

In this function, the pin is low when there is no GPS fix or a 2D fix and high when there is a 3D, SBAS, Differential or RTK GPS fix.

10.4.3 Zero Velocity Input

When using this function, a high state indicates to Sublocus DVL that it is stationary. The low state indicates that the vehicle is not stationary. This can significantly improve performance when a GPS signal is not available.

10.4.4 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

10.4.5 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 Sublocus 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

10.4.6 Novatel GNSS Input

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

10.4.7 Topcon GNSS Input

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

10.4.8 ANPP Input

This function accepts data in the ANPP format as specified in section 11.

10.4.9 ANPP Output

This function outputs data in the ANPP format as specified in section 11. For packets to be sent out they must be requested through another GPIO functioning as ANPP input.

10.4.10 Disable GPS

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

10.4.11 Disable Pressure

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

10.4.12 Set Zero Orientation Alignment

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

10.4.13 System State Packet Trigger

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

10.4.14 Raw Sensors Packet Trigger

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

10.4.15 RTCM Differential GPS Corrections Input

This function accepts RTCM v2.3 SC-104 differential GPS corrections. This allows for Differential GPS with Sublocus DVL's internal GPS receiver.

10.4.16 Trimble GNSS Input

This function is designed for interfacing Sublocus DVL 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.

10.4.17 u-blox GNSS Input

This function is designed for interfacing Sublocus DVL 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.

10.4.18 Hemisphere GNSS Input

This function is designed for interfacing Sublocus DVL 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.

10.4.19 Teledyne DVL Input

This function is designed for interfacing with Teledyne DVL systems. It accepts data in the PD0 output data format at rates 1Hz or higher.

10.4.20 Tritech USBL Input

This function is designed for interfacing with a Tritech micronnav USBL system. It accepts data in the Raw XYZ format. Please note that the setup with a Tritech USBL requires two Sublocus DVL units.

10.4.21 Linkquest DVL Input

This function is designed for interfacing with Linkquest DVL systems. It accepts data in the NQ1 output data format at rates 1Hz or higher.

10.4.22 1PPS Input

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

10.4.23 Event 1 Input

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

10.4.24 Event 2 Input

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

10.4.25 Linkquest USBL Input

This function is designed for interfacing with Linkquest USBL systems.

10.4.26 IXBlue Input

This function is designed for interfacing with IXBlue systems.

10.4.27 Sonardyne Input

This function is designed for interfacing with Sonardyne systems.

11 Advanced Navigation Packet Protocol

The Advanced Navigation Packet Protocol (ANPP) is a binary protocol designed with high error checking, high efficiency and safe design practices. It has a well defined specification and is very flexible. It is used across all existing and future Advanced Navigation products.

11.1 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

11.2 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 11.2.1
2	1	u8	1	Packet ID, see section 11.2.2
3	2	u8	1	Packet Length, see section 11.2.3
4	3	u16	2	CRC16, see section 11.2.4

Table 14: ANPP header format

11.2.1 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

11.2.2 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.

11.2.3 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.

11.2.4 CRC

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

11.3 Packet Requests

Any of the state and configuration packets can be requested at any time using the request packet. See section 11.7.2.

11.4 Packet Acknowledgement

When configuration packets are sent to Sublocus DVL, 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 11.7.1.

11.5 Packet Rates

The packet rates can be configured either using Sublocus Manager or through the Packets Period Packet. By default Sublocus DVL 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 = (112 (packet length) + 5 (fixed packet overhead)) * 50 (rate)

Data throughput = 5850 bytes per second

Minimum baud rate = data throughput x 11 = 64350 Baud

Closest standard baud rate = 115200 Baud

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

11.6 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	112	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
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
58	16	R	Heave Packet
59	-	R	Post Processing Packet
60	-	R	Raw Satellite Data Packet
61	-	R	Raw Satellite Ephemeris Packet
62	16	R	Depth Packet

Packet ID	Length	R/W	Name
63	-	R	DVL Water Profiling Packet
Configuration Packets			
180	4	R/W	Packet Timer Period Packet
181	-	R/W	Packets Period Packet
182	17	R/W	Baud Rates Packet
185	73	R/W	Installation Alignment Packet
186	17	R/W	Filter Options Packet
187	-	R/W	Advanced Filter Parameters Packet
188	13	R/W	GPIO Configuration Packet
193	1	W	Set Zero Orientation Alignment Packet
194	49	R/W	Heave Offset Packet
195	13	R/W	GPIO Output Configuration Packet
196	9	R/W	Salinity Configuration Packet

11.7 System Packets

11.7.1 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 11.7.1.1

Table 15: Acknowledge packet

11.7.1.1 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

11.7.2 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

11.7.3 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 11.7.3.1

Table 18: Boot mode packet

11.7.3.1 Boot Mode Types

Value	Description
0	Bootloader
1	Main Program

Table 19: Boot mode types

11.7.4 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

11.7.5 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

11.7.6 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

11.8 State Packets

Sublocus DVL supports a large number of packets providing extensive functionality. However for the majority of users the easiest approach is to configure Sublocus DVL using the Sublocus Manager software and then support only the single system state packet shown below in section 11.8.1. Advanced functionality can be added as required through the other packets.

11.8.1 System State Packet

System State Packet				
Packet ID				20
Length				112
Field #	Bytes Offset	Data Type	Size	Description
1	0	u16	2	System status, see section 11.8.1.1
2	2	u16	2	Filter status, see section 11.8.1.2
3	4	u32	4	Unix time seconds, see section 11.8.1.4
4	8	u32	4	Microseconds, see section 11.8.1.5
5	12	fp64	8	Latitude (rad)
6	20	fp64	8	Longitude (rad)
7	28	fp64	8	WGS84 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)
24	100	fp32	4	Depth (m)
25	104	fp32	4	Altitude (m), see section 11.8.1.6
26	108	fp32	4	Heave (m)

Table 23: System state packet

11.8.1.1 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	Reserved
4	Pressure Sensor Failure
5	GPS Failure
6	Accelerometer Over Range
7	Gyroscope Over Range
8	Reserved
9	Pressure Over Range
10	Minimum Temperature Alarm
11	Maximum Temperature Alarm
12	DVL Failure
13	Ingress Alarm
14	GPS Antenna Disconnected
15	Data Output Overflow Alarm

Table 24: System status

11.8.1.2 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	GPS Fix Status, see section 11.8.1.3
5	
6	
7	Event 1 Occurred
8	Event 2 Occurred
9	Internal GPS Enabled
10	DVL Tracking Active
11	Bottom Tracking Active
12	Pressure Sensor Enabled
13	External Position Active
14	External Velocity Active
15	External Heading Active

Table 25: Filter Status

11.8.1.3 GPS Fix Status

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

Table 26: GPS fix status

11.8.1.4 Unix Time Seconds

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

11.8.1.5 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.

11.8.1.6 Altitude

This value represents the distance of Sublocus DVL above the sea floor. It is only valid when the DVL is bottom tracking. The bottom tracking active field in the filter status can be used to determine if this value is valid.

11.8.2 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 11.8.1.4
2	4	u32	4	Microseconds, see section 11.8.1.5

Table 27: Unix time packet

11.8.3 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

11.8.4 Status Packet

Status Packet				
Packet ID				23
Length				4
Field #	Bytes Offset	Data Type	Size	Description
1	0	u16	2	System status, see section 11.8.1.1
2	2	u16	2	Filter status, see section 11.8.1.2

Table 29: Status packet

11.8.5 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

11.8.6 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

11.8.7 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

11.8.8 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

11.8.9 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

11.8.10 Raw GNSS Packet

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

Raw GNSS Packet				
Packet ID				29
Length				58
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Unix time stamp (seconds)
2	4	u32	4	Microseconds
3	8	fp64	8	Latitude (rad)
4	16	fp64	8	Longitude (rad)
5	24	fp64	8	Height (m)
6	32	fp32	4	Velocity north (m)
7	36	fp32	4	Velocity east (m)
8	40	fp32	4	Velocity down (m)
9	44	fp32	4	Latitude standard deviation (m)
10	48	fp32	4	Longitude standard deviation (m)
11	52	fp32	4	Height standard deviation (m)
12	56	u16	2	Status, see section 11.8.10.1

Table 35: Raw GNSS packet

11.8.10.1 Raw GNSS Status

Bit	Description
0	GNSS Fix Status, see section 11.8.1.3
1	
2	
3	Doppler velocity valid
4	Time valid
5	External GNSS
6	Reserved
7	Reserved
8	Reserved
9	Reserved
10	Reserved
11	Reserved
12	Reserved
13	Reserved
14	Reserved
15	Reserved

Table 36: Raw GNSS Status

11.8.11 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 37: Satellites packet

11.8.12 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 11.8.12.1
2	1	u8	1	Satellite number (PRN)
3	2	s8	1	Satellite frequencies, see section 11.8.12.2
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 38: Detailed satellites packet

11.8.12.1 Satellite Systems

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

Table 39: Satellite systems

11.8.12.2 Satellite Frequencies

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

Table 40: Satellite frequencies

11.8.13 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 41: Geodetic position packet

11.8.14 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 42: ECEF position packet

11.8.15 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 43: UTM position packet

11.8.16 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 44: NED velocity packet

11.8.17 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 45: Body velocity packet

11.8.18 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 46: Acceleration packet

11.8.19 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 47: Body acceleration packet

11.8.20 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 48: Euler orientation packet

11.8.21 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 49: Quaternion orientation packet

11.8.22 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 50: DCM orientation packet

11.8.23 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 51: Angular velocity packet

11.8.24 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 52: Angular acceleration packet

11.8.25 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 53: External position & velocity packet

11.8.26 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 54: External position packet

11.8.27 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 55: External velocity packet

11.8.28 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 56: External body velocity packet

11.8.29 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 57: External heading packet

11.8.30 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 58: Running time packet

11.8.31 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 59: Local magnetic field packet

11.8.32 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 11.8.1.4
2	4	u32	4	Microseconds, see section 11.8.1.5

Table 60: External time packet

11.8.33 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

11.8.34 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 through the following equation:

Mean Sea Level Height = Height – Geoid 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

11.8.35 RTCM Corrections Packet

This packet is used to encapsulate RTCM differential correction data to be sent to Sublocus DVL's internal GPS receiver for differential GPS 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

11.8.36 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 64: Heave packet

11.8.37 Post Processing Packet

Sublocus Manager will automatically convert this packet to IMR format. This packet has been left out of the reference manual as it is very rare for a customer's requirements. If you need the format of this packet, please contact Advanced Navigation support.

11.8.38 Raw Satellite Data Packet

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

Raw Satellite Data Packet				
Packet ID				60
Length				16 + Satellites * (6 + Frequencies * 26)
Field #	Bytes Offset	Data Type	Size	Description
1	0	u32	4	Unix time (seconds)
2	4	u32	4	Nanoseconds
3	8	s32	4	Receiver clock offset (nanoseconds)
2	12	u8	1	Receiver number
3	13	u8	1	Packet number
4	14	u8	1	Total packets
5	15	u8	1	Total satellites
For each satellite				
7	16	u8	1	Satellite system, see section 11.8.12.1
8	17	u8	1	PRN or satellite number
9	18	u8	1	Elevation (degrees)
10	19	u16	2	Azimuth (degrees)
11	21	u8	1	Number of frequencies
For each frequency of each satellite				
12	22	u8	1	Satellite frequency, see section 11.8.38.1
13	23	u8	1	Tracking status, see 11.8.38.2
13	24	fp64	8	Carrier phase
14	32	fp64	8	Pseudo range (m)
15	40	fp32	4	Doppler frequency (Hz)
16	44	fp32	4	Signal to noise ratio (dB-Hz)

Table 65: Raw satellite data packet

11.8.38.1 Satellite Frequencies

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

Table 66: Satellite frequencies

11.8.38.2 Tracking Status

Bit	Description
1	Carrier phase valid
2	Carrier phase cycle slip detected
3	Carrier phase half-cycle ambiguity
4	Pseudo range valid
5	Doppler valid
6	SNR valid
7	Reserved
8	Reserved

Table 67: Tracking status

11.8.39 Raw Satellite Ephemeris Packet

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

11.8.40 Depth Packet

Depth Packet				
Packet ID				62
Length				16
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Depth (m)
2	4	fp32	4	WGS84 Height (m)
3	8	fp32	4	EGM96 Ellipsoid Height (m)
4	12	fp32	4	Altitude (m), see section 11.8.1.6

Table 68: Depth packet

11.8.41 DVL Water Profiling Packet

DVL Water Profiling Packet				
Packet ID				63
Length				Number of depth cells * 16
Field #	Bytes Offset	Data Type	Size	Description
1	0	fp32	4	Depth cell 1 velocity north (m/s)
2	4	fp32	4	Depth cell 1 velocity east (m/s)
3	8	fp32	4	Depth cell 1 velocity down (m/s)
4	12	fp32	4	Depth cell 1 velocity standard deviation (m/s)
+				Fields 1-4 repeat for additional depth cells

Table 69: DVL water profiling packet

11.9 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 permanently stored in flash.

11.9.1 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 11.9.1.1
3	2	u16	2	Packet timer period, see section 11.9.1.2

Table 70: Packet timer period packet

11.9.1.1 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.

11.9.1.2 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. To get the rate use the following.

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

11.9.2 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 11.9.2.1
3	2	u8	1	Packet ID
4	3	u32	4	Packet period, see section 11.9.2.2
+				Fields 3-4 repeat for additional packet periods

Table 71: Packets period packet

11.9.2.1 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.

11.9.2.2 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

11.9.3 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 interface baud rate (1200 to 1000000)
3	5	u32	4	Auxiliary interface baud rate (1200 to 1000000)
4	9	u32	4	GPIO 1 & 2 baud rate (1200 to 1000000)
5	13		4	Reserved

Table 72: Baud rates packet

11.9.4 Installation Alignment Packet

Installation Alignment Packet				
Packet ID				185
Length				73
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	fp32	4	Alignment DCM[0][0]
3	5	fp32	4	Alignment DCM[0][1]
4	9	fp32	4	Alignment DCM[0][2]
5	13	fp32	4	Alignment DCM[1][0]
6	17	fp32	4	Alignment DCM[1][1]
7	21	fp32	4	Alignment DCM[1][2]
8	25	fp32	4	Alignment DCM[2][0]
9	29	fp32	4	Alignment DCM[2][1]
10	33	fp32	4	Alignment DCM[2][2]
11	37	fp32	4	GPS antenna offset X (m)
12	41	fp32	4	GPS antenna offset Y (m)
13	45	fp32	4	GPS antenna offset Z (m)
14	49		12	Reserved (set to zero)
15	61	fp32	4	External data offset X (m)
16	65	fp32	4	External data offset Y (m)
17	69	fp32	4	External data offset Z (m)

Table 73: Installation alignment packet

11.9.4.1 Alignment DCM

The alignment DCM (direction cosine matrix) is used to represent an alignment offset of Sublocus DVL's axes from the ROV axes. 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)

11.9.5 Filter Options Packet

Filter Options Packet				
Packet ID				186
Length				17
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u8	1	Reserved (set to zero)
3	2	u8	1	Internal GPS enabled (boolean)
4	3		1	Reserved (set to zero)
5	4	u8	1	Pressure depth sensor enabled (boolean)
6	5		2	DVL Enabled
7	7	u8	1	Motion analysis enabled (boolean)
8	8		9	Reserved (set to zero)

Table 74: Filter options packet

11.9.6 Advanced Filter Parameters Packet

Please contact Advanced Navigation support.

11.9.7 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 11.9.7.1
3	2	u8	1	GPIO2 Function, see section 11.9.7.2
4	3	u8	1	Auxiliary Transmit Function, see section 11.9.7.3
5	4	u8	1	Auxiliary Receive Function, see section 11.9.7.4
6	5		2	Reserved (set to zero)
7	7	u8	1	GPIO1 RS232 Mode Enabled
8	8	u8	1	GPIO2 RS232 Mode Enabled
9	9		4	Reserved (set to zero)

Table 75: GPIO configuration packet

11.9.7.1 GPIO1 Functions

Value	Description
0	Inactive
1	1PPS Output
2	GPS Fix Output
4	Zero Velocity Input
7	NMEA Output
12	ANPP Output
14	Disable GPS
15	Disable Pressure
16	Set Zero Orientation Alignment
17	System State Packet Trigger
18	Raw Sensors Packet Trigger
29	1PPS Input
33	Event 1 Input
34	Event 2 Input

Table 76: GPIO1 functions

11.9.7.2 GPIO2 Functions

Value	Description
0	Inactive
1	1PPS Output
2	GPS Fix Output
4	Zero Velocity Input
6	NMEA Input
8	Novatel GNSS Input
9	Topcon GNSS Input
11	ANPP Input
14	Disable GPS
15	Disable Pressure
16	Set Zero Orientation Alignment
17	System State Packet Trigger
18	Raw Sensors Packet Trigger
19	RTCM Differential GPS 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
29	1PPS Input
33	Event 1 Input
34	Event 2 Input
35	Linkquest USBL Input
36	IXBlue Input
37	Sonardyne Input

Table 77: GPIO2 functions

11.9.7.3 Auxiliary Transmit Functions

Value	Description
0	Inactive
7	NMEA Output
12	ANPP Output

Table 78: Auxiliary transmit functions

11.9.7.4 Auxiliary Receive Functions

Value	Description
0	Inactive
6	NMEA Input
8	Novatel GNSS Input
9	Topcon GNSS Input
11	ANPP Input
19	RTCM Differential GPS 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
35	Linkquest USBL Input
36	IXBlue Input
37	Sonardyne Input

Table 79: Auxiliary receive functions

11.9.8 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 80: Set zero orientation alignment packet

11.9.9 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 81: Heave offset packet

11.9.10 GPIO Output Configuration Packet

GPIO Output Configuration Packet				
Packet ID				195
Length				32
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u8	1	NMEA fix behaviour, see section 11.9.10.1
3	2	u16	2	GPZDA Rates, see section 11.9.10.2
4	4	u16	2	GPGGA Rates, see section 11.9.10.2
5	6	u16	2	GPVTG Rates, see section 11.9.10.2
6	8	u16	2	GPRMC Rates, see section 11.9.10.2
7	10	u16	2	GPHDT Rates, see section 11.9.10.2
8	12	u16	2	GPGLL Rates, see section 11.9.10.2
9	14	u16	2	PASHR Rates, see section 11.9.10.2
10	16	u16	2	TSS1 Rates, see section 11.9.10.2
11	18	u16	2	Simrad Rates, see section 11.9.10.2
12	20		12	Reserved (set to zero)

Table 82: GPIO output configuration packet

11.9.10.1 NMEA Fix Behaviour

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

Table 83: NMEA fix behaviour

11.9.10.2 GPIO Output Rates

Bit	Description
0-3	GPIO 1 rate, see 11.9.10.3
4-7	Auxiliary RS232 Tx rate, see 11.9.10.3
8-15	Reserved (set to zero)

Table 84: GPIO output rates

11.9.10.3 GPIO Output Rates Index

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

Table 85: GPIO output rates index

11.9.11 Salinity Configuration Packet

Salinity Configuration Packet				
Packet ID				196
Length				9
Field #	Bytes Offset	Data Type	Size	Description
1	0	u8	1	Permanent
2	1	u32	4	Salinity (ppm)
3	5		4	Reserved (set to zero)

Table 86: Salinity configuration packet