Introduction

This commissioning guide will provide the information required to install the VERIPOS LD900 unit with INS, by detailing how an LD900 should be configured and how an IMU should be mounted, interfaced and configured.

Contents

The VERIPOS INS system consists of an LD900 (LD900 or LD900M model) receiver, authorised for INS use and operating in PPP mode with active GNSS heading. The LD900 presently supports integration with two Novatel IMU models, the IMU-ISA-100C and IMU-µIMU-IC:

Novatel IMU-ISA-100C (left) and Novatel IMU-µIMU-IC (right)

INS operations can be configured and monitored using the LD900 MMI, or an interfaced Quantum software system. This guide will provide details for both options.

Prerequisites

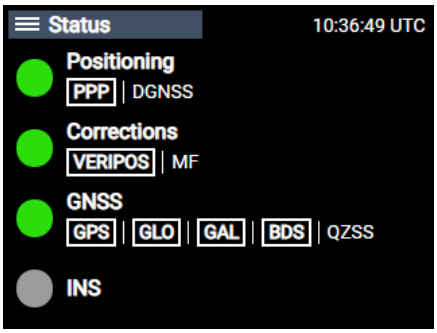
Prior to starting LD900 and INS commissioning the system must:

1. Have a high-quality antenna installation.
2. Have an AUTH code for INS (which includes Heading)
3. Be activated and receiving VERIPOS PPP correction services.

Appendix-A provides a comprehensive equipment listing including part numbers. Also refer to LD900 and Quantum support documentation if required.

INS Authorisation

The LD900 must be correctly authorised before it can be used for INS operations. If required obtain an INS authorisation code by contacting your VERIPOS project manager, or by email (support.veripos@hexagon.com). The Auth Code will be supplied with a guide explaining how the codes can be applied to the LD900. Note the INS authorisation code includes the GNSS heading functionality.



A simple way to check if the LD900 is authorised for INS operations is to check if INS is present on the LD900 status screen, as shown in the above image. If there is no INS status icon visible, then the LD900 is not yet authorised for INS use.

GNSS Heading Antenna Installation

Consideration for the placement of the primary and secondary antennas is required to ensure reliable and accurate LD900 GNSS reception and heading calculation. Please also consider the INS installation requirements detailed in section IMU Placement.

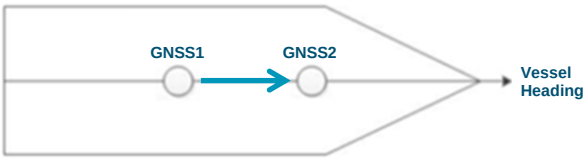
Antenna Separation

The GNSS heading accuracy is largely determined by the distance between the primary and secondary antennas. The larger the antenna separation, the better the heading accuracy will be. VERIPOS recommend a minimum antenna separation of 2m.

Antenna Separation	Accuracy
2m	0.08°
4m	0.05°
10m	0.02°

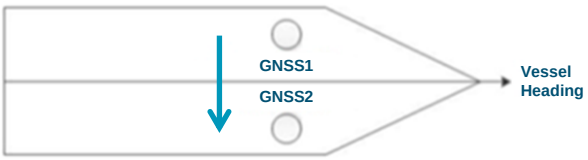
Antenna Installation

The heading orientation is computed from the **GNSS1** antenna to **GNSS2** antenna as illustrated below. In this configuration, the GNSS heading closely reflects the actual vessel heading. A small offset (or C-O) must be applied to the LD900.



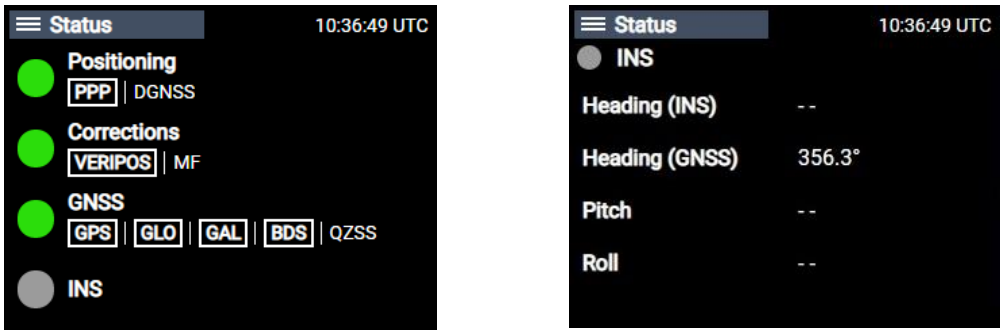
Along ship antenna installation

Where along ship installation is not possible, GNSS1 and GNSS2 can be installed across-ship. The offset would need to align the GNSS heading to the alignment of the actual vessel heading. In the example below, this will typically be around 90° off from the true vessel heading:



Across-ship antenna installation

When the LD900 is authorised for INS operations there will be no dedicated Heading icon, as this will have been replaced by the INS icon. However, the GNSS heading status can be checked by selecting the INS icon and pressing tick. The heading calculation will always be shown irrespective of the INS status and measurements.



*LD900 **Status** page* (left) *and **Status > INS** page (right)*

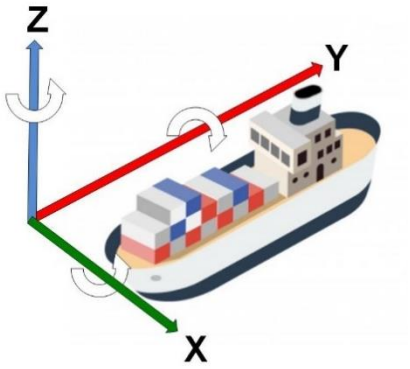
Reference Frames

It is important to have a basic understanding of reference frames when dealing with INS. Reference frames are especially important when configuring the systems rotational offsets. Two types of reference frames will be considered, the Vessel Reference Frame and the IMU Body Frame.

Vessel Reference Frame

The definition of the Vessel Frame is as follows:

X-axis – points out the starboard side of the vessel
Y-axis – points out the front of the vessel in the direction of travel
Z-axis – points up vertically on the vessel

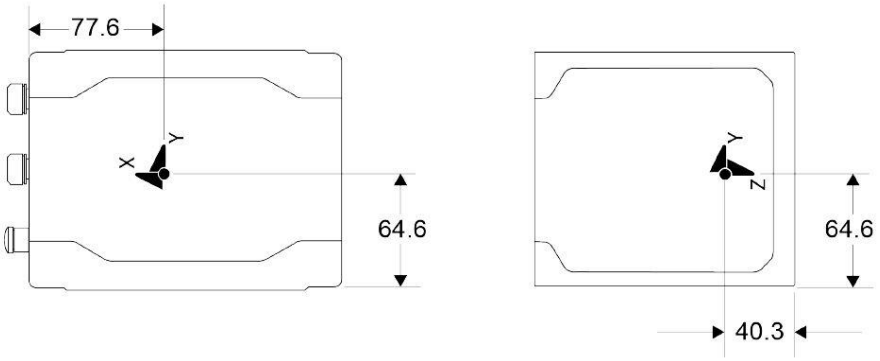


Vessel Reference Frame

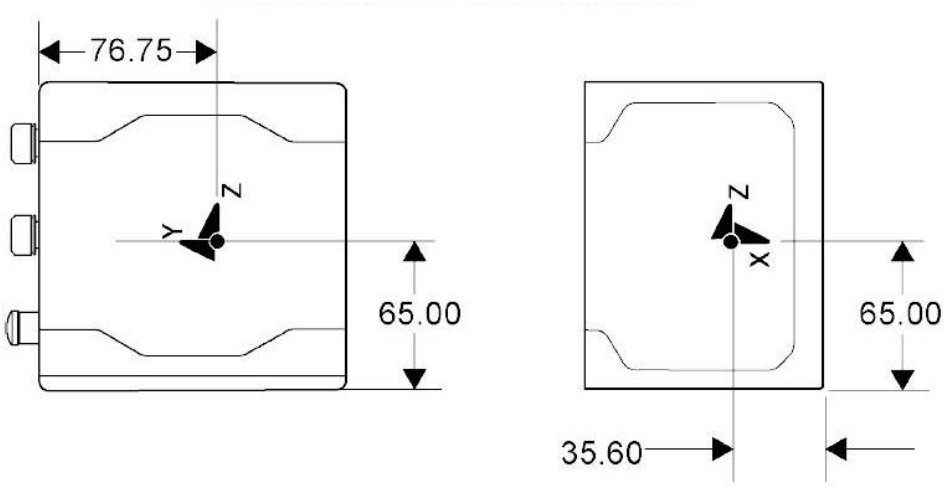
IMU Body Frame

The definition of the IMU Body frame is given by the physical axes of the IMU and represents how the sensors are mounted inside the IMU. Both the IMU Body frame axes and Centre of Navigation markers are on two of the IMU enclosure sides

The Centre of Navigation markers highlight the centre of the Rotational axes of the IMU, the actual centre of navigation lies internally in the IMU where the XYZ rotational axes intersect. Therefore, If the user measures all translational offsets to a single Centre of Navigation **marker** then two of the translational offsets must be adjusted to be aligned with the Centre of Navigation. The figure below illustrates the position of the Centre of Navigation markers and the dimensions in millimetres.

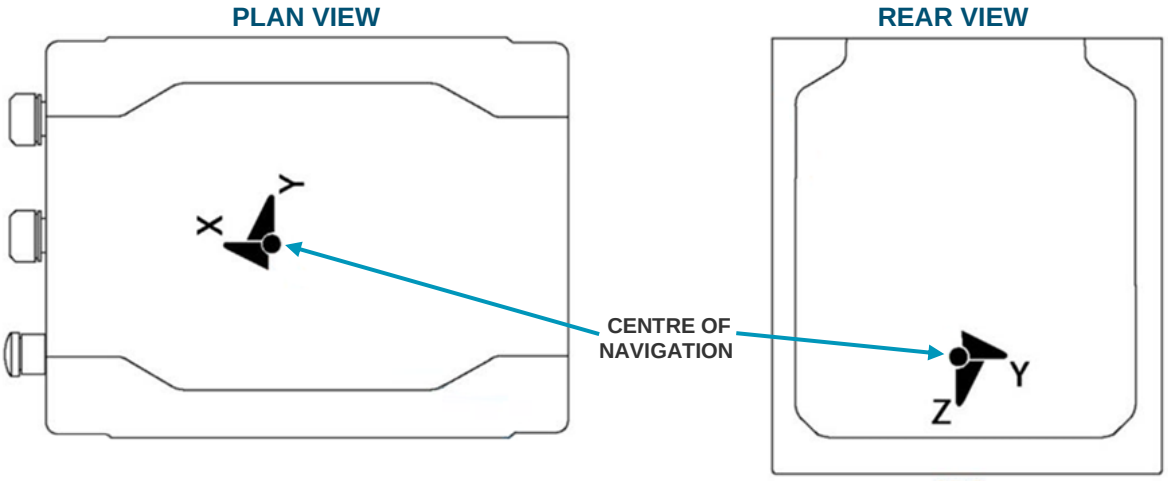


IMU-ISA-100C Centre of Navigation Markers

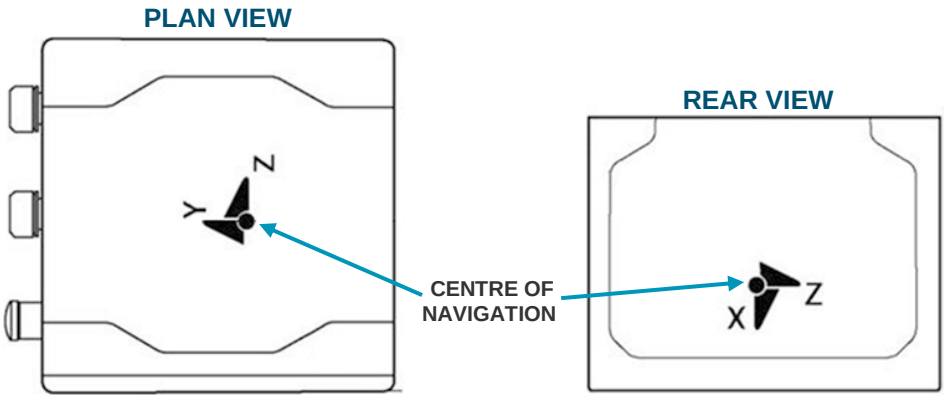


IMU-µIMU-IC Centre of Navigation Markers

The two figures following show the IMU Body Frame for both supported IMU models. These diagrams highlight the centre of navigation differences between the IMU-ISA-100C and IMU-µIMU-IC models. The different IMU frameworks have pre-configured rotational offsets applied by the system configuration when selected, with the premise of the IMU being mounted with the connectors facing forward along the vessel frame Y-axis.



IMU-ISA-100C IMU Body Frame

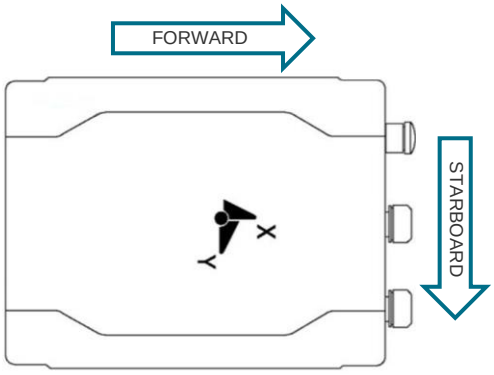


IMU-µIMU-IC Body Frame

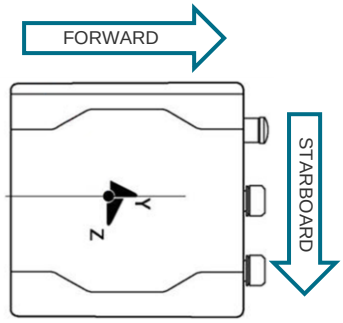
IMU Placement

The following factors need to be considered when installing the IMU.

- Placing the IMU closer to GNSS1 antenna will reduce the impact of lever arm errors
- Mounted on a fabricated plate secured to a flat level surface within the vessel frame.
- Mounted with connectors facing forward
- The IMU base plate must have clearance to allow IMU to be securely bolted.
- Mount in a secure location where it will not be damaged
- Avoid locations that have a strong vibration.
- The installation engineer should endeavour to align the IMU axes as closely as possible with the vessel frame using a general arrangement diagram, or by referencing available surfaces such as walls or floor welds. Refer to the below figure, following the arrows to orientate the IMU with the vessel frame:

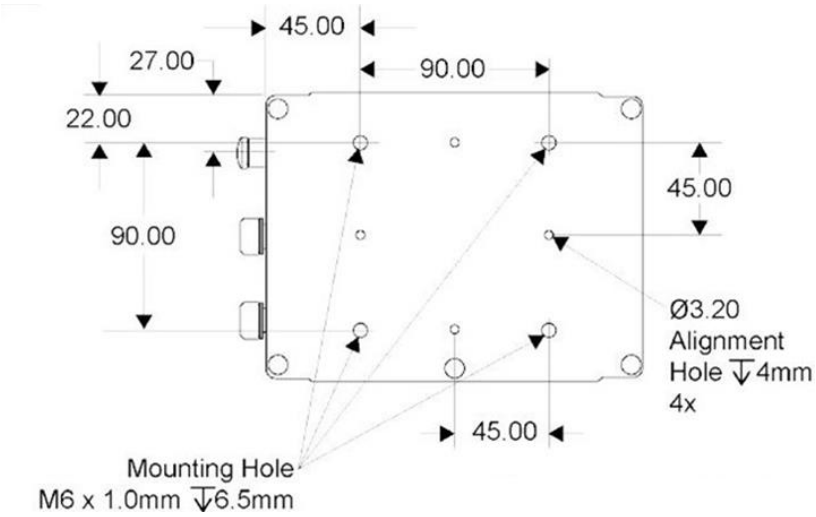


IMU-ISA-100C – Plan View

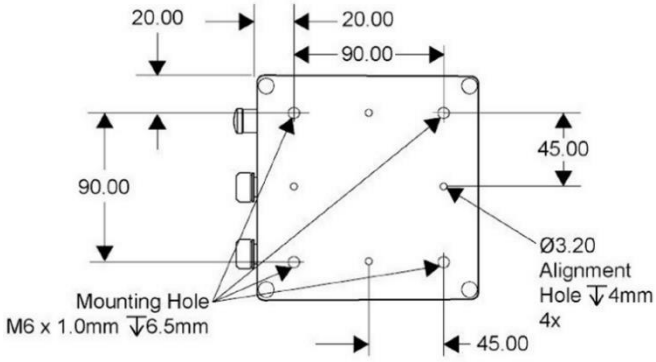


IMU-µIMU-IC - Plan View

As shown below, the IMU baseplates feature four mounting holes, threaded for M6 bolts. The IMU must be securely bolted to the IMU baseplate on a level surface, with the connectors facing forward to the vessel bow. By mounting the IMU in a fixed position a constant distance and orientation between the IMU to the GNSS antenna can be maintained.



IMU-ISA-100C Base Plate



IMU-µIMU-IC Base Plate

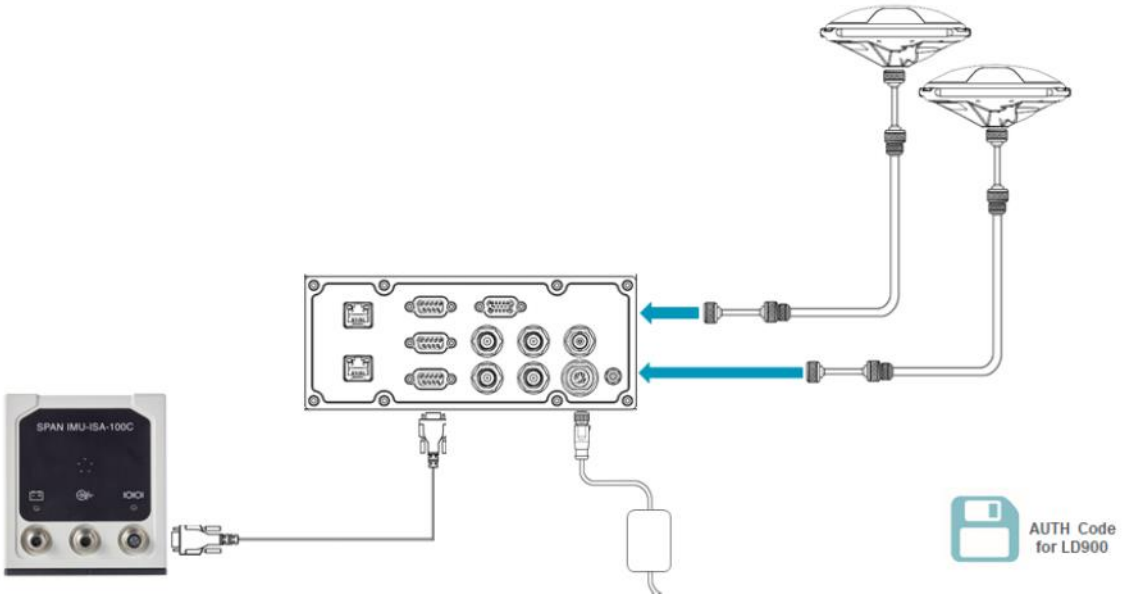
When the IMU has been mounted in the correct orientation, pre-set rotational offsets will be automatically applied (when the IMU is selected within the LD900 or Quantum), aligning the IMU Frame with the Vessel Frame. Any computed offsets should be added or subtracted from these pre-set values. The pre-set rotational offsets for the two models are shown in the table below:

IMU	X Rotation	Y Rotation	Z Rotation
IMU-ISA - 100C	+180	0	+90
IMU-µIMU-IC	0	-90	0

IMU Interfacing

Cabling

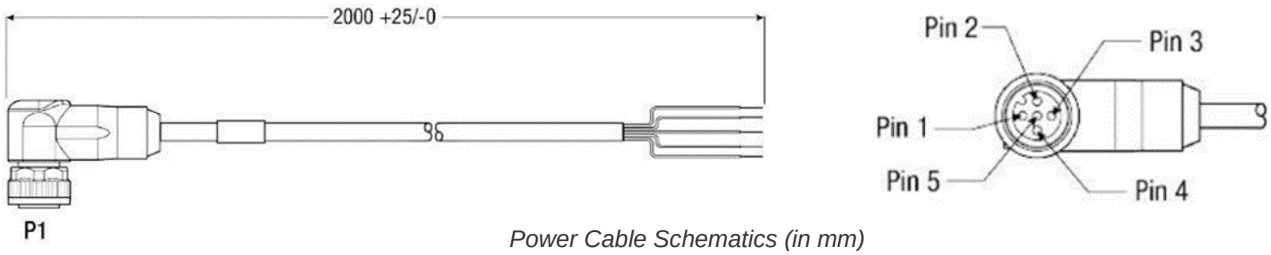
The LD900 will be interfaced to the IMU using RS422 serial data-communications. This section details the LD900 and IMU requirements for INS operations. The diagram below provides an overview of the principal system component interconnections:



INS Schematic Example

IMU DC Power

A 2-metre long DC power supply cable is supplied with the IMU, this consists of an M12 Male connector to five bare cable ends as shown below:



Power Cable Schematics (in mm)

P1 Pinout (M12)	Function	Wire Colour
1	VIN-	Brown
2	VIN+	White
3	VIN+	Blue
4	VIN-	Black
5	Chassis	Grey

IMU port pinout

Two isolated DC power sources can be used to power the IMU. Alternatively, the two VIN- and two VIN+ pins can be connected in parallel and connected to a single DC power supply. Ensure that the positive is connected to VIN+ and that negative is connected to VIN-. The supply voltage must be within the range of 10 to 38 VDC. Chassis can be connected to a common earthing point in an equipment rack.

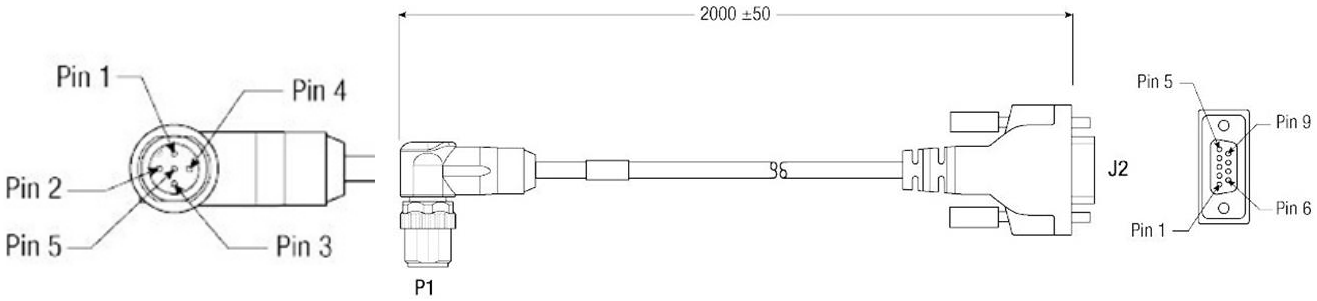
When checking the health of the IMU DC power, the Power ( ) LED on the IMU can be used as reference:

LED	State	Meaning
●	Off	No power to IMU
●	On	An error occurred during boot or initialisation
●	Slow Flash	Booting up / IMU initialisation
●	On	No error occurred during boot or initialisation

IMU Power LED

RS422 Interfacing

A 2-metre long interface cable is supplied with the IMU, this consists of an M12 Male connector (IMU) to a DB9 Male connector (LD900):



Supplied INS RS422 Data Cable (dimensions in mm)

P1 Pinout (M12)	IMU Function	J2 Pinout (DB9 Male)	LD900 Function
1	TX+	8	RX+
2	RX+	2	TX+
3	TX-	7	RX-
4	RX-	3	TX-
5	GND	5	GND
Chasis	Shield	Shield	Shield

RS422 cable pinouts

With the use of quality shielded data cable, the RS422 interface cable should not exceed 50 metres. Avoid running the interface cable close to noisy power lines, or other electrical noise sources.

When checking the IMU health the COM (IOIO) LED on the IMU can be used as a reference:

LED	State	Meaning
●	Off	No communication between IMU and LD900
●	On	IMU is transmitting and receiving data without errors
●	Slow Flash	IMU is receiving data from the LD900 but not transmitting
●	Fast Flash	IMU is transmitting data but not receiving data from the LD900

IMU COM LED

Alignment / Calibration

The IMU and antenna placements must be aligned to the vessel frame. The system configuration requires the following measurements;

- Lever arm (IMU to Antenna 1)
  - X (Starboard Positive)
  - Y (Forward Positive)
  - Z (Up Positive)
- Heading
  - Rotational offset from GNSS1 to GNSS2 antennas
- IMU Rotational Offsets
  - X (Pitch)
  - Y (Roll)
  - Z (Yaw)

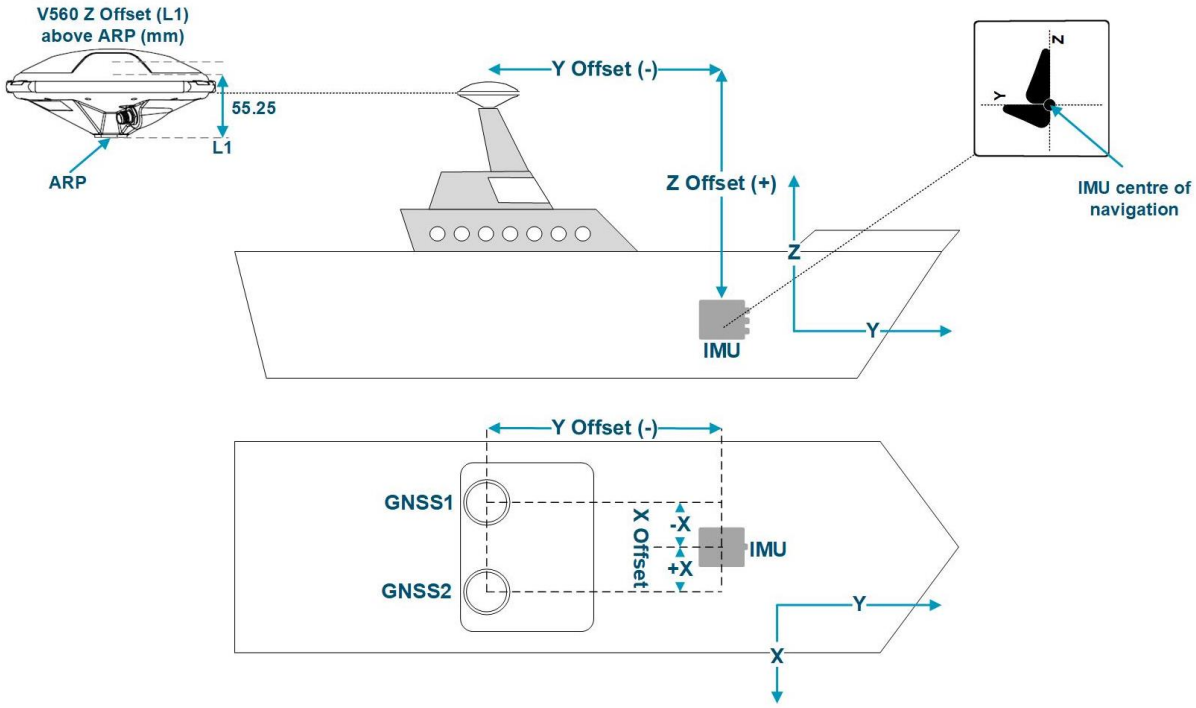
Precise offsets can be determined by performing a dimensional control survey of the vessel while alongside or in dock. The dimensional survey measurements should be taken using an independent system, free of installation or misalignment errors.

In addition to the IMU rotational offsets, the heading alignment offset should also be computed between the two GNSS antennas and these results used to adjust the rotational offsets to precise values.

Note: If the rotational offsets are greater than +/- 1º accuracy the INS computations may still initialise, but the solution will be negatively impacted and not maintain a converged solution, once vessel motion occurs.

It is also important to accurately measure the lever arm distance (XYZ) from the IMU centre of navigation to the antenna reference point (ARP) of the GNSS1 antenna. These translational offsets can be measured as part of the dimensional survey. Ensure the ARP to phase centre Z offset is adjusted in the final application of the offsets. The translational offset measurements must be accurate to within +/- 1cm.

To fully converge the system, vessel movement will be required. Typical vessel movement during transit may be adequate for convergence however optimal performance will be achieved through movement consisting of S-turns, figure 8 turns and changes of speed. This calibration process is performed automatically by the system and does not require any user interaction.



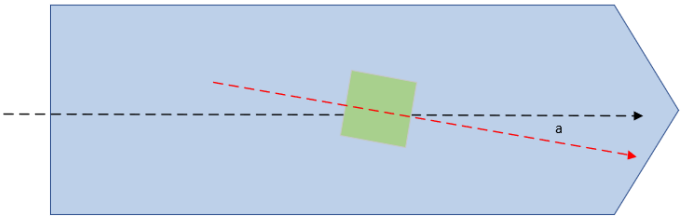
INS Translational Offsets

Rotational Offset Adjustment

This section will illustrate how the measured rotational alignment offsets (precise offsets) should be adjusted to the default course offset. The following illustrates the adjustments methods for two supported IMU models.

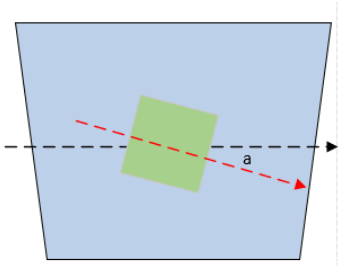
IMU-ISA-100C

When the X axis of the IMU is offset to starboard by angle “a”. The Installation Rotation Z +90 value is reduced by the measured angle:



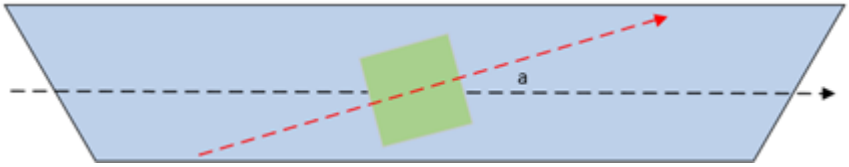
INS Rotational Offsets – Vessel Plan View

When the Y axis of the IMU is offset down to the starboard by angle “a”. The Installation Rotation X +180 value is reduced by the measured angle:



INS Rotational Offsets – Forward View (from vessel Aft)

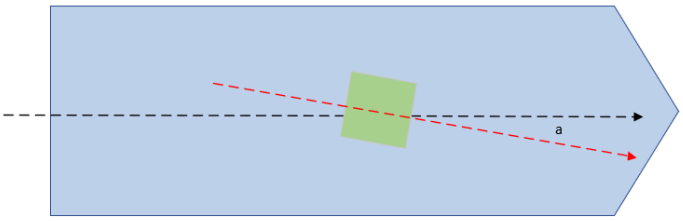
When the Z axis of the IMU is offset up to the bow by angle “a”. The Installation Rotation Y 0 value is reduced by the measured angle:



INS Rotational Offsets – Side View (into Starboard Side)

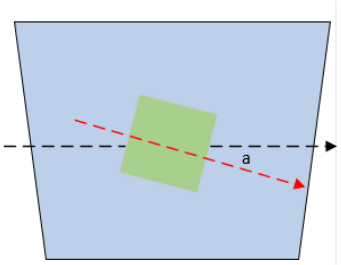
IMU-µIMU-IC

When the Y axis of the IMU is offset to starboard by angle “a”. The Installation Rotation X 0 value is reduced by the measured angle.



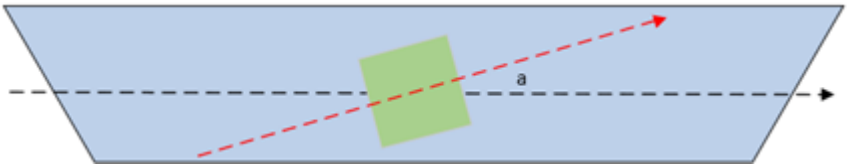
INS Rotational Offsets – Vessel Plan View

When the Z axis of the IMU is offset to starboard by angle “a”. The Installation Rotation Y -90 value is reduced by the measured angle (If the measured value for ‘a’ was 10 degrees the value would reduce to -100)



INS Rotational Offsets – Forward View (into vessel Aft)

When the X axis of the IMU is offset to starboard by angle “a”. The Installation Rotation Z 0 value is reduced by the measured angle.



INS Rotational Offsets – Side View (into Starboard Side)

Configuration

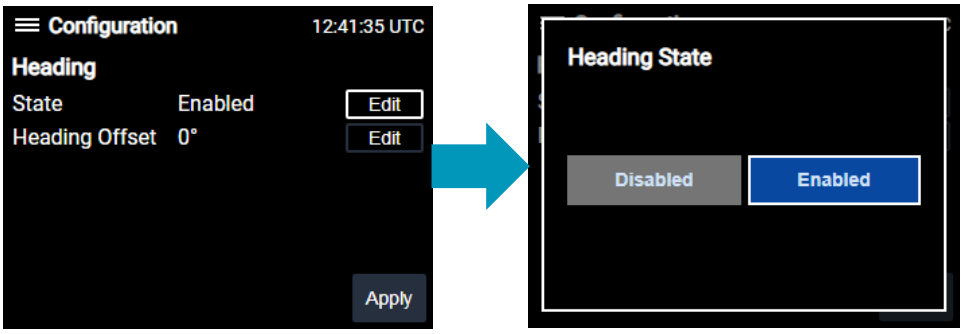
At this stage, the IMU is securely mounted with offsets determined, powered up and connected to a LD900 COM port. The LD900 has been activated for PPP solution, which is converged and stable and the LD900 is ready for configuration. The LD900 can be configured via the MMI as detailed in the next section, or by using Quantum.

LD900 Configuration

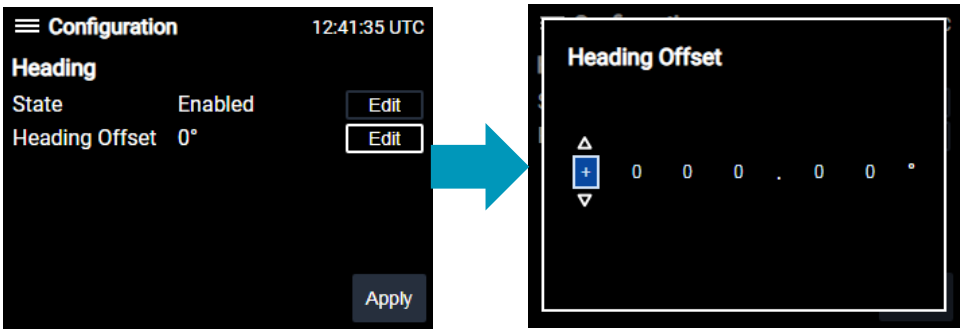
Heading

Accessing the menu **Configuration > Heading** within the LD900 MMI will allow for the LD900 heading to be set-up.

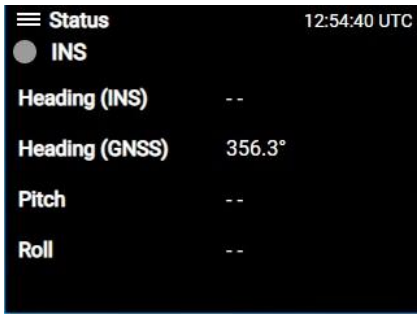
State controls if heading is computed and available from the system. While **Edit** on the same row as **State** is selected, use tick to bring up the **Heading State** and using the arrow keys select **Enabled**, followed by tick. Then use the arrow keys to select **Apply**, right to select **Yes** and tick to apply:



To configure the heading offset (C-O) select **Edit** for the **Heading Offset** row, followed by tick. Then use the arrow buttons and tick to enter the GNSS heading offset. Use the arrow keys to select **Apply**, right to select **Yes** and tick to apply the change:



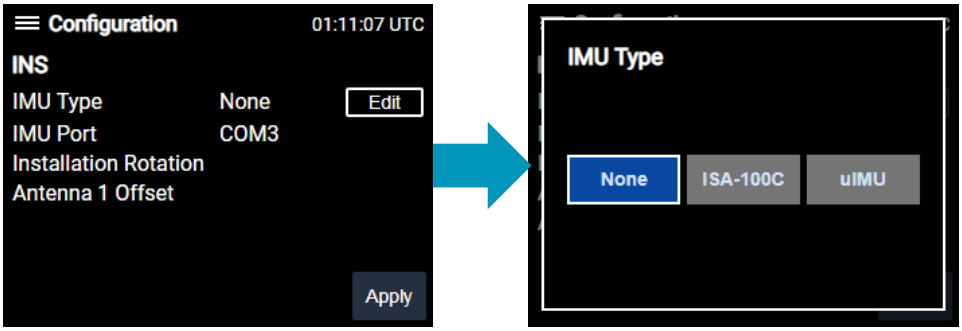
Return to the home screen and INS status will be unchanged (grey). The GNSS heading can be observed within the INS status. The reported GNSS heading should show alignment with the vessel heading, no other values will be present at this stage.



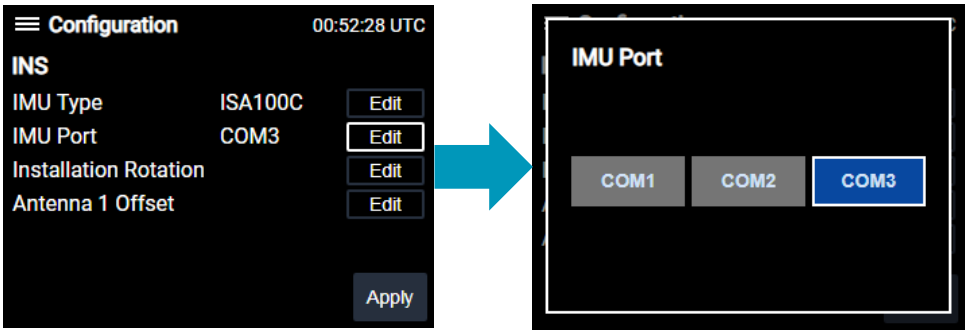
IMU Type & Serial Port

Accessing the menu **Configuration > INS** within the MMI will allow for the LD900 to be set-up for INS Operations.

The **IMU Type** can be selected within the menu **Configuration > INS**. While **Edit** is selected on the **IMU Type** row press tick and using the arrow keys select **IMU-ISA-100C** or **IMU-µIMU-IC** as required, followed by tick. Then use the arrow keys and tick to select **Apply**, right to select **Yes** and tick to apply the change:



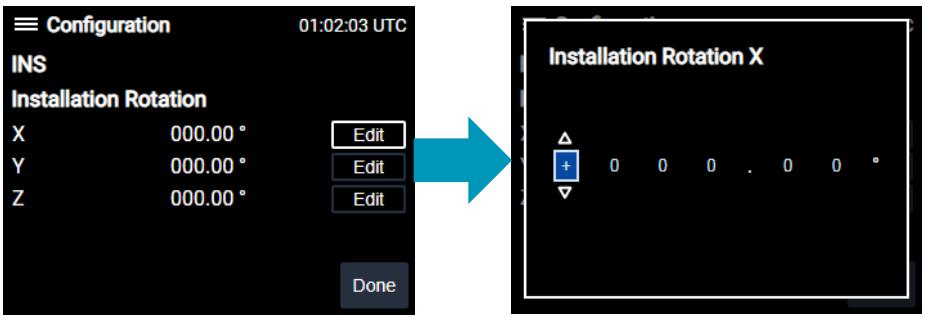
Once the IMU Type has been selected the **IMU Port** can be selected. While **Edit** is selected on the **IMU Port** row press tick and using the arrow keys and tick select **COM1**, **COM2** or **COM3** (default) as required, followed by tick. Then use the arrow keys to select **Apply**, tick to select **Yes** and tick to apply the change:



Installation Rotation

The following details how the X (Pitch), Y (Roll) and Z (Yaw) rotational offsets are entered into the LD900.

While **Installation Rotation** is selected click on **Edit**, followed by tick and using the arrow buttons and tick enter an **X** value within +/- 180.00. Use the arrow keys and tick to select **Done**, then use the arrow keys and tick to select **Apply**, right to select **Yes** and tick to apply the change. Repeat for the same process for the **Y** and **Z** offsets.

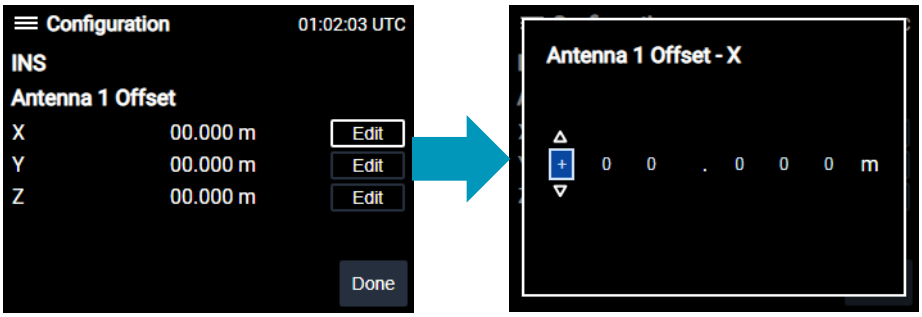


Antenna 1 Offset (Lever-Arm)

When entering the lever arm offset (IMU to GNSS1 antenna) the following table can be used as reference:

Vessel Axis	Positive	Negative
X	Starboard	Port
Y	Forward	Aft
Z	Up	Down

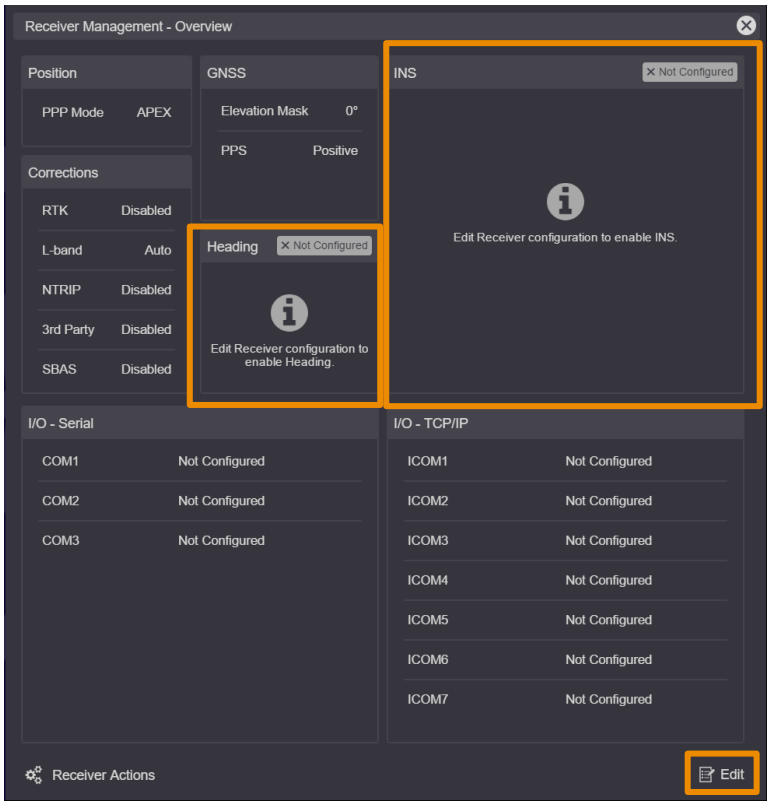
While **Antenna Offset 1** is highlighted click on **Edit**, followed by tick. Then use the arrow buttons and tick to enter an **X** value within +/- 99.999 meters. Use the arrow and tick keys to select **Done**, then use the arrow and tick keys to select **Apply**, right to select **Yes** and tick to apply the change.



Quantum Configuration

Receiver Management

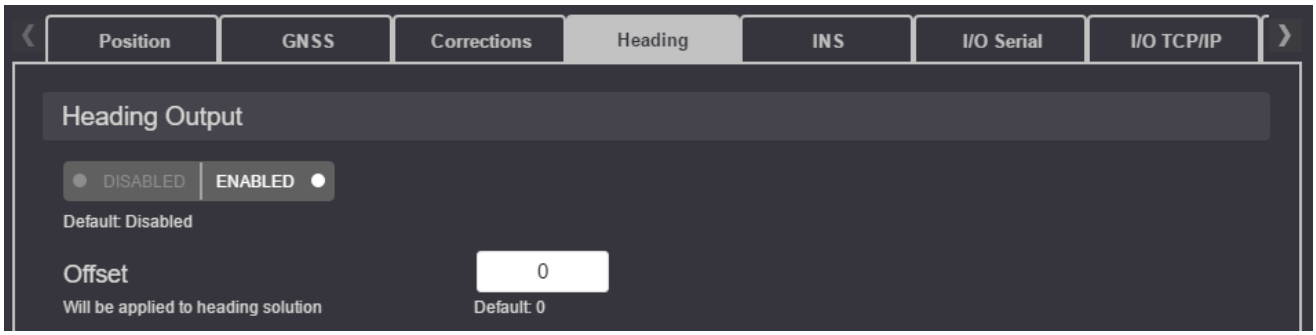
When correctly authorised, both **Heading** and **INS** areas will be displayed within **SETTINGS > System Configuration > Receiver Management** showing **X Not Configured**. If no such areas are shown, then request a Quantum Heading license from the VERIPOS Helpdesk. Click on **Edit**, found at the bottom right-hand corner of the screen:



SETTINGS > System Configuration > Receiver Management – Overview page

Enabling Heading

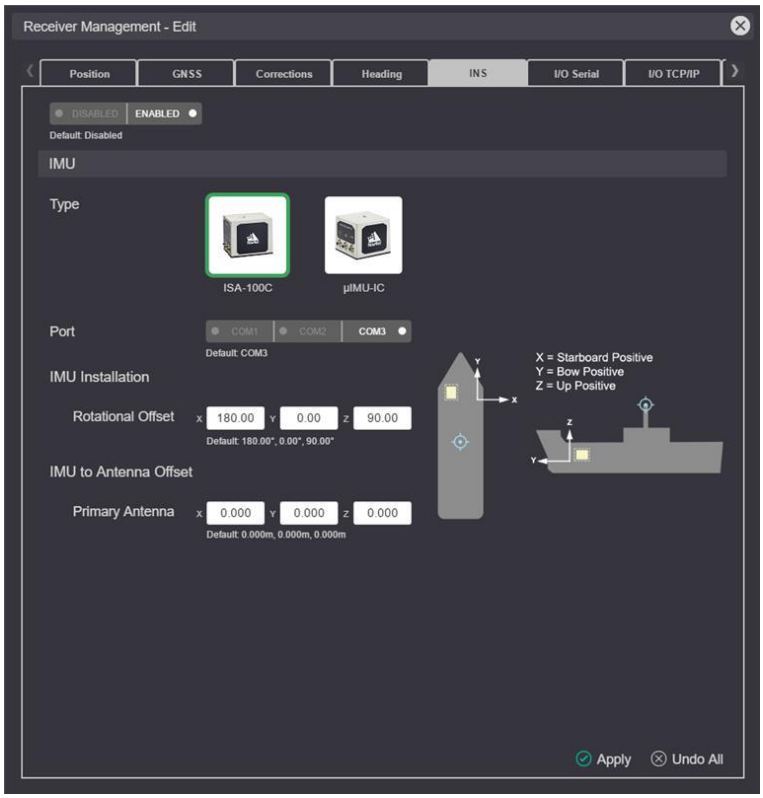
Within the **Heading** tab toggle **Heading Output** to **ENABLED**. Doing so will reveal the **Offset** setting where the GNSS heading offset should be entered. Once heading has been configured click on **Apply**.



Quantum Heading configuration page

Enabling INS

Within the **INS** tab initially, only one option will be available, allowing for INS to be **DISABLED** (or) **ENABLED**. Toggle this to **ENABLED** to reveal additional options:



INS Tab within Quantum

Type

The two INS IMUs supported for use within Quantum are the **IMU-ISA-100C** and the **IMU-µIMU-IC**.

Port

The LD900 COM port which the IMU is being interfaced on (**COM1**, **COM2** or **COM3**) should be selected here.

IMU Installation > Rotational Offset

This field allows the user to enter Rotational Offset **X**, **Y** and **Z** values within a -180.00° to +180.00° range.

IMU to Antenna Offset > Primary Antenna

This field allows the user to enter Primary Antenna Offset **X**, **Y** and **Z** values within a range of -99.99 to +99.99 metres.

Once all options are fully configured click **Apply** to confirm changes and apply configuration to the LD900 and IMU.

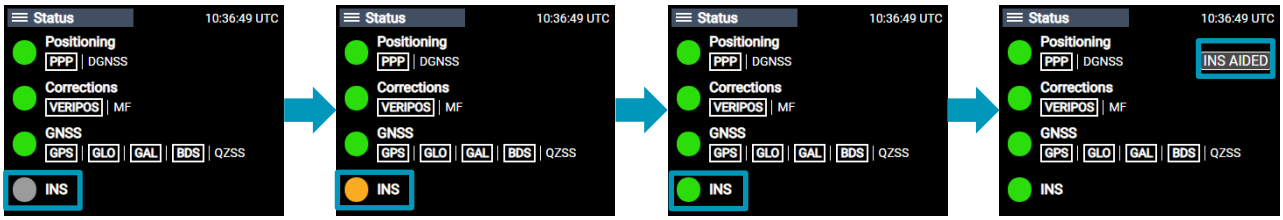
Operation

The successful configuration of INS can be determined by checking the LD900 MMI ***Status*** page and, if used, within the Quantum main page.

INS Status (LD900 MMI)

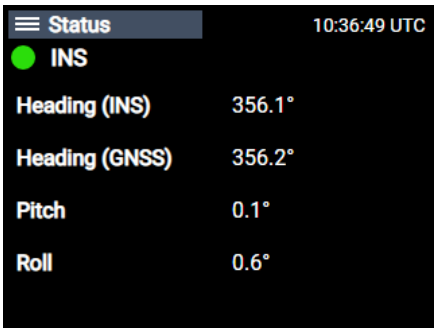
The LD900 INS status can be viewed on the MMI by pressing the home button.

Before configuration, the INS Icon will be Grey and once configured this will change from Grey to Amber. Once an INS solution is calculated the icon will turn Green and once there has been significant vessel motion an '**INS Aided**' notification will appear, confirming a blended GNSS and INS solution. If there is a problem with either the configuration or the hardware, then the status of the INS Icon will be Red. The INS transition sequence is illustrated below:



Authorised, not configured | *Configured and aligning* | *Aligned* | *Fully converged and INS solution active*

Selecting the INS status with the cursor and presenting tick will reveal additional details. Once the INS solution is operational the GNSS heading will closely match the INS heading (provided all configuration steps have been followed).

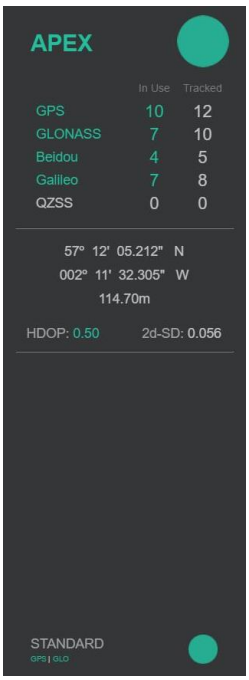


INS Status details

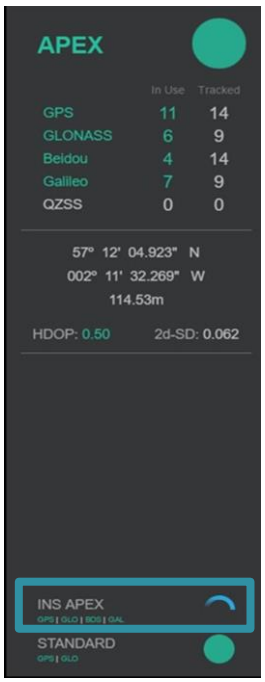
INS Status (Quantum)

INS status or configuration will be visible in Quantum once the LD900 is authorised for INS operations. The status of INS operations is visible within the Quantum sidebar as shown in the figures below.

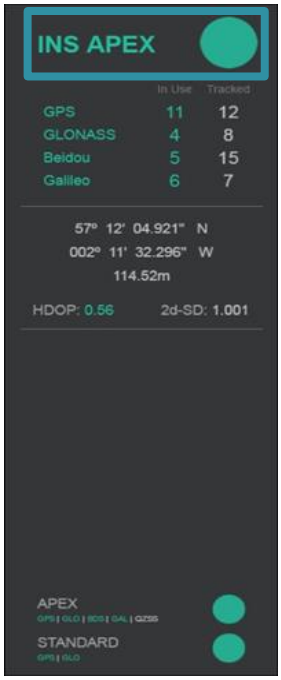
Once the INS solution has converged the Quantum Sidebar will display a primary solution of **INS APEX**. The primary solution is now a blended GNSS / INS solution. The LD900 MMI will also display an **INS Aided** Message, to the right of the **Positioning** status.



INS Solution not active or configured

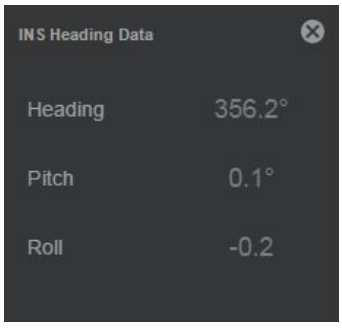


INS Solution aligning and converging



INS Solution converged and active

Within Quantum detailed INS information can be made available on the main Quantum screen by adding the **INS Heading Data** tile (from the Quantum main screen select ☰ > ＋ > ▭ > ◎). Within the LD900 MMI selecting the **INS** icon and pressing tick will reveal more detailed INS information:



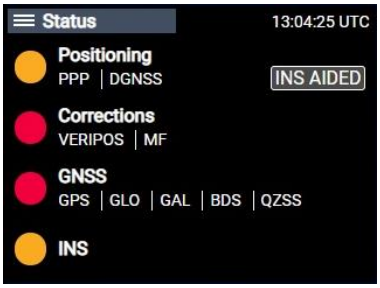
*Quantum **INS Heading Data** Tile*

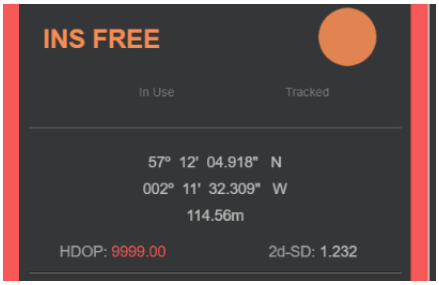
The Heading, Pitch and Roll should vary in agreement with the vessel motion. Significant variance which is not in agreement with the vessel motion may be due to incorrectly entered offset values, or incorrect mounting orientation.

Where practical it is advisable to perform a series of manoeuvres (or a series of turns and ideally figure of eights for optimal performance) to ensure the IMU is fully initialised. During the manoeuvres, the INS status should remain constant.

Dead Reckoning (Loss of GNSS)

If the GNSS position is lost, INS algorithms within the LD900 will switch to INS FREE (dead reckoning), and the LD900 will continue to output a position, based solely on the inertial measurements.





Output Sentences During Dead Reckoning

The NMEA talker identifier serves to define the nature of the data being transmitted. The talker is the first 2 characters after the $ sign within the NMEA sentence. NMEA GGA and ZDA output sentences have fixed talker ID's of '**GP**' regardless of solution. All other NMEA sentences will use a talker ID defined by the constellation in use (for instance '**GN**' for multiple constellations), changing to '**IN**' when in dead reckoning mode:

$INVTG,61.804,T,61.804,M,0.010,N,0.018,K,D*3E

Below is an example of a GGA sentence that has transitioned to dead reckoning mode:

$GPGGA,073832.00,5712.08206,N,00211.53784,W,6,00,0.6,64.02,M,50.40,M,009,0481*75

Two key values have been highlighted above. The first value is that of the Differential Quality Indicator (DQI) flag, which has changed to a '6'. The second is that of the satellite count, which has dropped to 0 indicating that no satellites are being used in the calculation.

Once the GNSS tracking is restored the VERIPOS PPP solution will begin to re-converge recovering to a blended GNSS / INS solution.

For more information on LD900 Output Sentences see the LD900 Installation and Operations Manual.

Troubleshooting

This section details the most common issues observed when commissioning and operating the LD900 and INS system.

INS Solution is aligned but not converging

- Check the GNSS Heading solution is operation and correct.
- Ensure offsets are correctly entered as per the computed/measured offsets.
- Ensure there has been sufficient vessel motion.

Dropping to Dead Reckoning

- Check GNSS Signal reception for masking or blockage.
- Confirm the GNSS1 cable and connectors are in a good state with no degradation or visible weathering.

INS indications remaining in a Red (or Amber State)

- Check LED indication on IMU, refer to the tables for guidance
- Confirm INS configuration
- Confirm port configuration
- Confirm data connections and cables

GNSS Heading and INS heading are not aligned

- Ensure offsets are accurately entered as per the computed/measured offsets.
- Ensure the INS options are configured correctly.
- Check IMU LED indication refer to the tables for guidance.
- If the GNSS and INS heading are misaligned by 180º, check antenna connections (GNSS1/GNSS2).

Vessel motion causes the INS solution to drop

- Check offsets have been entered as per the computed/measured offsets.

Appendix A – Equipment Required

Item		Description	P/N	Quantity
LD900	LD900 or LD900M	LD900 = L-band & GNSS LD900M = L-band, GNSS & MF	S80-9001 or S80-9002	1
	INS Auth Code	Authorises INS (includes Heading)		1
	Cabling	Standard cabling set	Multiple	1
Antenna	V560 Antenna	Antennas providing GNSS & Heading	S10-16000	2
	V86 Antenna	Optional dedicated L-band antenna (if required adjust mounting bracket and cabling quantity appropriately)	S10-11000	1
	Mounting Bracket	Antenna mounting bracket, c/w u-clamps	C110-1000	2
	RF Cable	2m Pigtail cable, NM-TNCM	CVI-CAB-0012	4
	RF Cable	30m LMR/SF400 cable, NF-NF	CVI-CAB-0010	2
IMU	IMU-ISA-100C or IMU-µIMU-IC	IMU with AC/DC PSU & M12 to DB9 IMU to LD900 cable	S50-1000 or S50-2000	1
	Mounting Plate	Plate for mounting IMU	-	1