C-Nav™

C-Mariner User Guide

Revision 6

Revision Date: April 20, 2017

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OCEANEERING®

Release Notice

This is the April 2017 release of the C-Mariner User Guide.

Revision History

Revision	Date	Description	Author
6	4/20/2017	Changed first page to C-Nav Logo	L. Cortes
5	1/17/2017	Added the Coast Guard Wheelmark Certificate	L. Cortes
4	9/06/2016	Added Performance & Testing Standards Added C-Mariner Side View – Labeling Updated OII Software Options	L. Cortes
3	6/20/2016	Updated for 60945 standards C-Mariner Pin Layout/ added UPS note	L. Cortes
2	5/31/2016	Acoustic release Updated for OII standards	L. Cortes
1	8/01/2014	Initial Release	L. Cortes

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Manual Organization

This section describes how the C-Mariner User Guide is laid out. It gives one or two sentence descriptions about each major section.

Manual Conventions

Arial font is used for plain text in this document.

Arial italic font is used for settings names.

“Arial quoted” font is used for settings values.

Arial Bold font is used for button names.

Arial Bold Italic font is used for menu items.

Arial Blue font is used for cross-references.

Arial Blue Underline font is used for hyperlinks.

Arial red italic is used for typed commands.

Arial Bold font size 10 is used for captions.

ARIAL BLACK ALL-CAPS font is used for port connection names.

This symbol means Reader Be Careful. It indicates a caution, care, and/or safety situation. The user might do something that could result in equipment damage or loss of data.

This symbol means Danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical and RF circuitry and be familiar with standard practices for preventing accidents.

Important notes are displayed in shaded text boxes.

> ***Please note***:
> Such note boxes display important information that should not be ignored.

Simple file content is displayed in Courier New Black font in a text box.

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#Sample File
Version 0.1
```

Section 1 - System Overview (Page 14) provides a brief overview of this document.

Section 2 - Getting Started (Page 16) provides a description of the equipment supplied and Quick Start Instructions.

Section 3 - Specification and Performance (Page 20) provides specification and performance information on the C-Mariner.

Section 4 - Principles of Operation (Page 25) provides information on how the C-Mariner system, along with the C-Mariner (CM300, CM400, and CM600) and the network interface, operates.

Section 5 - Installation and Removal (Page 34) describes mounting and removing the C-Mariner, orientation, and mounting tray instructions.

Section 6 - Configuration (Page 41) describes the C-Mariner configuration, initial power on check, lever arm terms, operation of the three different sensors, and serial output configuration.

Section 7 - Operation Modes (Page 65) describes the operation of the three devices that make up the C-Mariner family.

Appendix A – NMEA0183 Messages (Page 75) describes all the input and output NMEA formats.

Appendix B - Lever Arm Calibration (Page 95) instructs the user on how to perform a Self-Calibrating Lever Arm Function.

Appendix C – I/O Pin Description (Page 111) provides the I/O pin description of the Interface Cable.

Appendix D – Performance & Testing Standards (Page 112) list all of the test and performance standards.

Appendix E – United States Coast Guard Certificate (Page 113) US Coast Guard IEC 60945/Wheelmark Certificate.

Related Documents

CNAV-MAN-043.4 (CM145 Interface Manual)

The CM145 Interface Manual provides the user with information in the operation and configuration of the CM145 Interface. It is available from the C-Nav website at ftp://ftp.cctechnol.com/pub/C-Nav/CM145/CNAV-MAN-043.4 (CM145 Interface Manual).pdf

CNAV-MAN-034.4 (C-Mariner With CM145 Quick Start Guide)

The C-Mariner with CM145 Quick Start Guide provides instructions on how to quickly setup a C-Mariner using the CM145 Interface. It is available from the C-Nav website at ftp://ftp.cctechnol.com/pub/C-Nav/C-Mariner/CNAV-MAN-034.4 (C-Mariner with CM145 Quick Start Guide).pdf

Related Standards

NMEA-0183

National Marine Electronics Association Standard For Interfacing Marine Electronic Devices. NMEA National Office; 7 Riggs Avenue; Severna Park, Maryland 21146

License Free Export

The C-Mariner has an ECCN of 7A994 which identifies it as license free for all but a few countries on the US Department of Commerce list “AT” column1. The current prohibited countries can be found at https://www.bis.doc.gov/index.php/forms-documents/doc_view/14-commerce-country-chart.

The exporter must also follow the General Prohibitions 4-10 in the Export Administration Regulations see link for full information https://www.bis.doc.gov/index.php/forms-documents/doc_view/413-part-736-general-prohibitions.

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#Sample File
Version 0.1
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Section 1 - System Overview

Introduction

This section describes the C-Mariner family of systems. The C-Mariner sensor can be configured as a Stabilized Gyro - the CM300, an Attitude Heading Reference System (AHRS) - the CM400, and an Inertial Navigation System (INS) - the CM600; each of the configurations is normally supplied with a C-Mariner Interface. The CM300 outputs true heading, pitch, and roll. The CM400 outputs the same information as the Gyro and also produces a heave output. The CM600 outputs the same information as the CM400 and also produces position and velocity. Table 1 shows the outputs produced by the various C-Mariner sensor configurations. The hardware of all the C-Mariner models are identical, the difference in capabilities being a function of the loaded software.

Please note:

When the term C-Mariner is used, it applies to the common GYRO (CM300), AHRS (CM400), and INS (CM600) hardware.

Output	GYRO CM300	AHRS CM400	INS CM600
Heading	X	X	X
Pitch	X	X	X
Roll	X	X	X
Rate of Turn	X	X	X
Heave		X	X
Position			X
Velocity			X

Table 1: C-Mariner Outputs

Section 2 - Getting Started

This section provides a description of the equipment supplied. It also provides step by step instructions for a quick start-up of the C-Mariner system and the different options of the sensor that are available.
Confirm that all ordered equipment is delivered. Refer to the following below for the Equipment supplied:

C-Mariner:	Figure 1
CM145 Interface:	Figure 2
12’ Interface Cable:	Figure 3
C-Mariner Mounting Bracket:	Figure 4
Digital Media User Guide:	Figure 5

If any of the items are missing or damaged, please contact C-Nav Support immediately:

Telephone: +1 337.210.0000

E-mail: support@cnav.com

The C-Mariner has already been tested and configured by qualified C-Nav Technicians.

C-Mariner Supplied Equipment

Figure 1: C-Mariner

Figure 2: CM145

Figure 3: 12' Cable

Figure 4: C-Mariner Mounting Tray

Figure 5: Digital Media User Guide

Quick Start Instructions

1. Connect a GNSS input signal to the DB9 male connector labeled **COM7** at the rear panel of the interface, if using a second GNSS aiding input then connect to **COM8**. For acoustic aiding, connect to **COM6** at the rear panel of the CM145 interface.
2. Connect 1PPS (One Pulse Per Second) Signal from the GNSS to the BNC connector labeled **1PPS1** or **1PPS2** on the back of the CM145 interface (only for CM600).
3. Connect the interface cable 50 pin female connector to the C-Mariner. Connect the 23 pin male connector to the CM145 Interface connector labeled **POWER/DATA**.
4. Insert the 3 pin male XLR connector to the 3 pin female XLR connector in the Interface labeled **24VDC**.
5. Press the **ON/OFF** switch on the CM145 to turn on the C-Mariner. Check that the LED inside the switch is illuminated Green.
6. Ensure that the three LEDs, labeled “Input OK”, “28V OK”, and “12V OK” on the front of the CM145 interface are illuminated.
7. Check the front display on the CM145 interface for data.

Please note:

You will hear a low frequency buzzing sound from the C-Mariner. This is a normal function of the dithering mechanism for the Ring Laser Gyros (RLGs) inside.

The C-Mariner will go through a four minute calibration process. When the heading uncertainties are lower than 1.25°, it outputs valid heading values.

For the CM600 model, the C-Mariner achieves its optimum accuracy with current aiding devices within 40 minutes of startup.

C-Mariner Options

The C-Mariner hardware comes loaded with one of three initial software options.

C-Nav Part Number	Name	Description
CNVHG2172BD01-3-K	CM300 (Gyro)	Heading, Pitch, & Roll
CNVHG2171BD01-4-K	CM400 (AHRS)	Heading, Pitch, Roll, & Heave
CNVHG2170BD01-6-K	CM600 (INS)	Heading, Pitch, Roll, Heave, Position, & Velocity

Table 2: Software Options

Interface Options

C-Nav Part Number	Name	Description
CNVCM145-K	CM145	Basic Interface with display status monitor

Table 3: Interface Options

In the Box

- C-Mariner Hardware with CM300, CM400, or CM600 Option
- CM145 Interface
- 12’ Interface Cable
- C-Mariner Mounting Bracket
- C-Mariner User Guide on a digital media

Optional

C-Nav Part Number	Name	Description
CNVHON66020637-001	CM600 Dual GNSS	Dual GNSS Input License
CNVHON66020637-002	CM600 Lever Arm	Lever Arm Calibration
CNVHON66020637-003	Acoustic Input	Enable Acoustic Input
CNVCMINTPSU-K	Power Supply	24V Power Supply
CNVKEPHSF-24-1U	Dual Power Supply	Rack Mount 24V Dual Power Supply

Table 4: Optional Equipment

Section 3 - Specification and Performance

This section provides specification and performance information on the C-Mariner.

Physical

Height:	6.28 in (159.51 mm)
Width:	6.52 in (165.61 mm)
Length:	6.43 in (163.32 mm)
Weight:	9.3 lbs (4.22 kg)

Electrical

Voltage:	24 VDC nominal
	22-36 VDC startup
	18-36 VDC operating
Power Draw:	28 W max

Altitude / Pressure

Normal Operating:	-2000 to +80,000 ft. (-609.6 to 24,384 m)
Over Pressure Maximum:	-19,000 ft. (-5,791 m)
Shock, Operational:	20g maximum

Environmental

Normal Operating Temperature	-40 to +70 °C (-40 to +150°F)
Storage Temperature	-55 to +85 °C (-67 to +185°F)
Compass Safe Distance	>300 mm to magnetic compasses or flux gates

Performance

The following table shows the accuracies of the various C-Mariner options:

C-Mariner Sensor and Parameters	Units	INS (CM600) Accuracy (1σ)	AHRS (CM400) Accuracy (1σ)	GYRO (CM300) Accuracy (1σ)
Attitude / Heading				
Heading (GNSS or Acoustic Aided)	deg sec lat	0.05 1σ	0.05	0.3[1] 0.05
Rate of Turn	deg/min	0.4 1σ	0.4	0.4
Pitch / Roll	deg	0.01 1σ	0.01	0.1
Position				
Free Inertial	nm / hr	1 CEP	N/A	N/A
GNSS Aided without Differential	m	10 CEP	N/A	N/A
GNSS Aided with CCS	m	0.4 CEP	N/A	N/A
Acoustic Aided with USBL / SSBL	m	0.1%[2] depth	N/A	N/A
Acoustic Aided with LBL	m	0.5 CEP[(2)(3)]	NA	NA
Heave	cm	5 (or 5%)	5 (or 5%)	N/A

Table 5: C-Mariner Accuracies

Please note:

Note 1. Accuracy specified assumes velocity and latitude aiding versus full GNSS Aiding. It does not include errors induced by erroneous latitude and velocity

Note 2. Actual performance is dependent upon attitude installation/stability and environment conditions.

Note 3. Default performance for LBL. (Note that system will use error ellipse from acoustic system if available).

Certifications

The C-Mariner has received Wheelmark approval by the United States Coast Guard see Appendix E – United States Coast Guard Certificate (Page 113) for certificate.

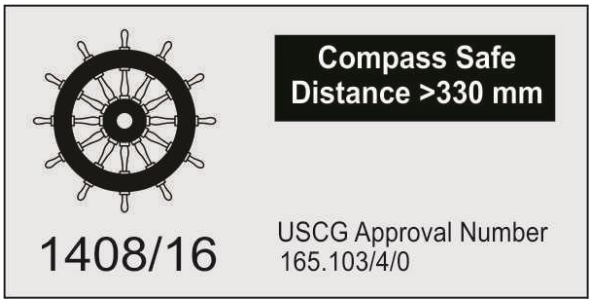


Figure 6: Wheelmark Label

The label is located on the right hand side of the C-Mariner enclosure.

Unit Labeling

The software loaded on the unit can be identified by a label in the front of the C-mariner with a mark on the white rectangle. The serial number of the unit is located in the front at the bottom right hand side of the securing screws. The part number is located in the front at the bottom on the left hand corner.

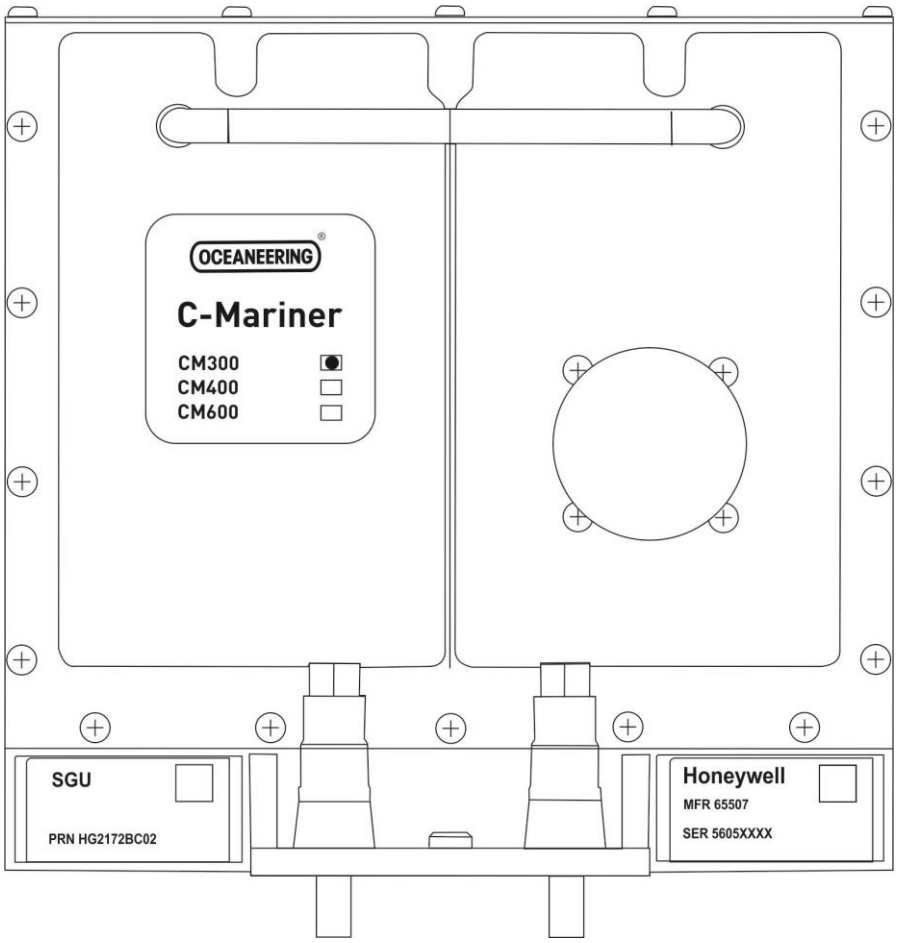


Figure 7: C-Mariner Front View Unit Labeling

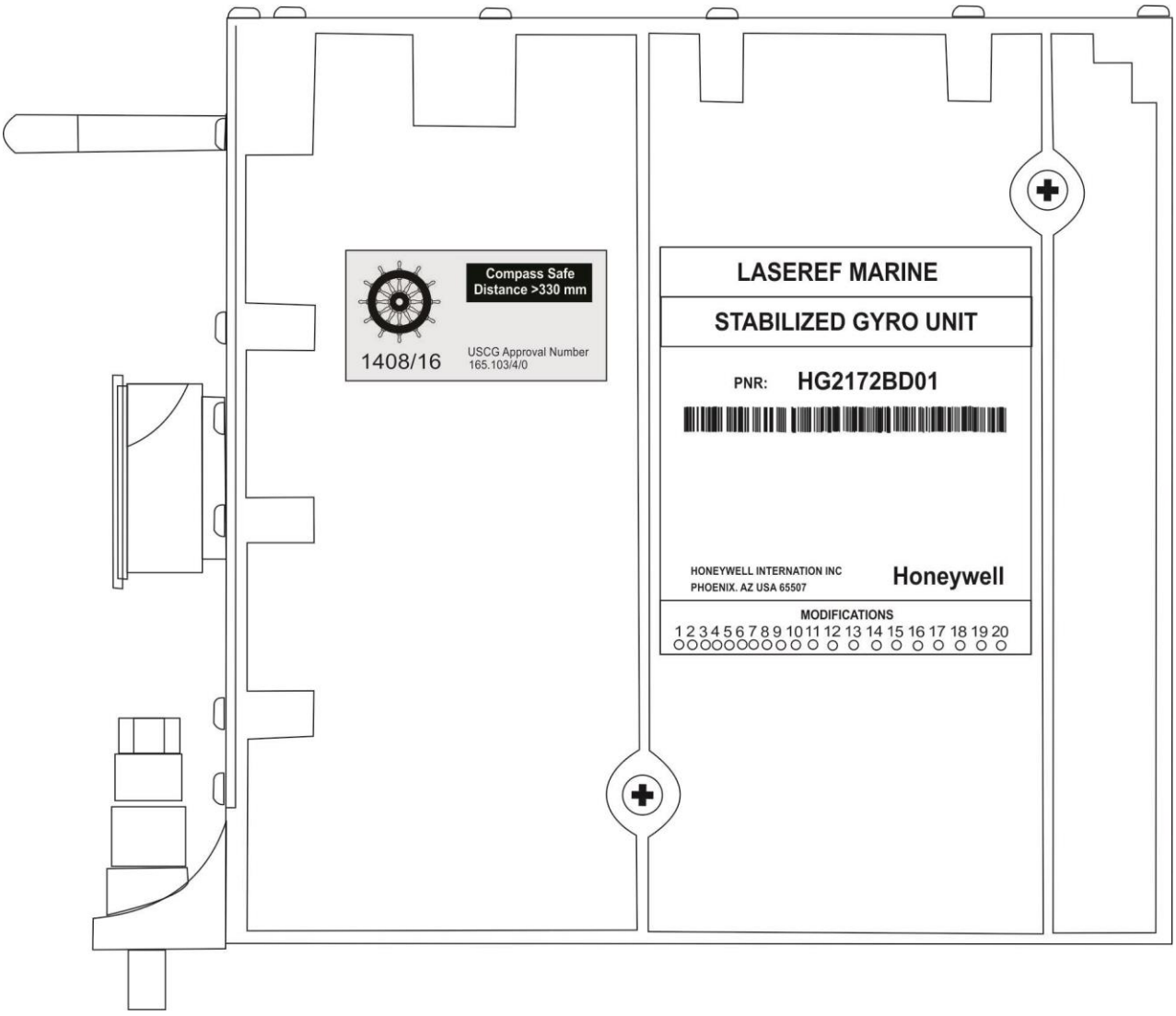


Figure 8: C-Mariner Side View Unit Labeling

Section 4 - Principles of Operation

Introduction

This section provides a description of the C-Mariner as a system and sensor. It includes network configuration instructions and provides a list of the default input and output ports. It also describes the physical description, input / output connector, and mounting tray.

C-Mariner System Description

The C-Mariner system consists of either a C-Mariner CM300 / CM400 / CM600, CM145 Interface, Mounting tray, 6 ft. Pig tail with power connector, and 12 ft. power / data cable. For the quoted accuracies, the CM300 and the CM400 require a GNSS input, the CM600 has optimal performance with a GNSS receiver receiving PPP corrections.

All C-Mariner model inputs are NMEA format messages received over Ethernet. Outputs are either NMEA or TSS1 format transmitted over Ethernet. The C-Mariner operates in one of two modes, Navigation Mode or Gyrocompass Mode (CM400 is considered an extension of Gyrocompass Mode for aiding requirements).

In Navigation Mode, the sensor accepts position and velocity data from the GNSS receiver or position data from an acoustic system that has been previously calibrated. A time mark signal from the receiver may be connected to the CM600 to improve position accuracy in dynamic conditions (recommended). If the Dual-GNSS option has been purchased, the C-Mariner will additionally accept inputs from a second GNSS.

In Gyrocompass Mode, the sensor requires knowledge of latitude and speed (as do even, spinning mass gyros). Errors in these parameters result in sub optimal performance. When used in restricted operating areas these parameters can be entered manually, however a low cost GNSS receiver input (GGA and VTG) will give best results.

C-Mariner Sensor Description

The C-Mariner contains an Inertial Reference (IR) and an aiding input. The sensor transmits its computed parameters on an Ethernet output bus. The IR components consist of three force rebalance accelerometers and three ring laser gyros (RLG) which together are used to measure inertial motion. The IR components require system initialization (entry of latitude and longitude). From these measurements and inputs the IR component continuously calculates attitude and heading information.

The aiding component works in two different modes depending on the aiding source. The sensor works in Navigation Mode or in Gyrocompass Mode. The sensor can default to Gyrocompass Mode when position aiding is lost for a period of time or if position is not provided upon a re-start.

When operating in Navigation Mode, the C-Mariner computes a hybrid solution by blending aiding inputs with inertial sensor data. The sensor also provides integrity monitoring of the hybrid solution. The Hybrid solution may be a combination of inertial/GNSS, inertial/acoustic, or inertial/GNSS/acoustic depending on the aiding sources provided. For GNSS aiding, the aiding component receives GNSS position from a GNSS sensor. For acoustic aiding, the aiding component receives position data from a calibrated acoustic system. GNSS inputs will be required to perform initial calibration of the acoustic system. After calibration is complete, subsequent power cycles will not require the GNSS inputs. For GNSS and acoustic aiding, the aiding component receives position data from both a GNSS and acoustic system. If any of the aiding inputs are lost, the system can “coast” for a period of time in Navigation Mode. If after startup in Navigation Mode, no aiding data is received, the system will degrade to Gyrocompass mode.

When operating in Gyrocompass Mode, the C-Mariner computes a hybrid attitude and heading solution. To accomplish this function, latitude information is inputted manually and velocity information is received from either a speed log or input manually. For a better performance, a low cost GNSS input is recommended (GGA & VTG). The aiding component computes and outputs a hybrid attitude solution by blending the aiding data with inertial sensor data. The Gyrocompass Mode of operation is a fallback mode for the C-Mariner should position aiding is lost for a period of time.

There are three forms to provide latitude and speed:

- Low cost GPS / GNSS input (GGA and VTG sentences only required). This is the most recommended solution.
- Manual Input via the web application. (This is possible but note the

accuracy of the gyro performance will go up to 0.3 degrees)

- A stored set from the last used value before power down. (This is done automatically but will required the operator to update latitude and speed when the vessel is transiting)

Input Power

The C-Mariner has two input power lines available for redundancy. A status message of the voltage at the C-Mariner is displayed on the web browser input power status page see Figure 26.

Please note:

The C-Mariner has primary and secondary DC inputs. It is suggested that these be fed from different uninterruptable power sources. The C-Mariner will normally operate on the primary voltage, switching automatically to the secondary in the event of primary failure.

Input and Outputs

The C-Mariner has digital inputs/outputs and time marks inputs. The digital inputs/outputs are via NMEA format messages over Ethernet see Appendix A – NMEA0183 Messages (Page 75) for all messages formats. Also, see Appendix C – I/O Pin Description for I/O pin description.

Discrete Outputs

The C-Mariner provides two open/ground discrete outputs. These can be used to trigger a relay or to switch a voltage output to ground.

Fault	Ground = Fault Open = No Fault
On secondary Power	Ground = On secondary power Open = Not on secondary power

Nominal output voltage is the low (ground) state is less than 1.5 VDC. Output impedance in the open state is greater than 100 K ohms and less than 15 ohms In the ground state. Each output can sink up to 100 ma of current.

Time Mark Inputs

The C-Mariner receives RS-422 time mark inputs from a GNSS receiver. The time mark can be connected to all three C-Mariner models, but it is especially critical that this input be wired in the CM600 configuration. The CM600 model will operate without the time mark inputs but position accuracy will be degraded, especially in dynamics conditions. If a Dual GNSS input option is enabled, a second time mark is available for the second GNSS. The time mark inputs are used to synchronize the GNSS time base to the INS, where the time mark pulses occur at a nominal rate of once per second and the resolution of this synchronization logic is 100 ms or less.

Time Mark Input signal from the Primary GNSS (if available) must be wired to the time mark pins associated with the GNSS Channel #1 Input Bus A and B. If Dual GNSS is enabled, then Time Mark Input signal from the Secondary GNSS (if available) must be wired to the time mark pins associated with GNSS Channel #2 Input Bus A and B.

Network Interface Information

The Ethernet interface on the C-Mariner is factory set to the following default fixed network parameters:

- IP Address = 192.168.1.10
- Subnet Mask = 255.255.255.0
- MAC Address = 00-40-84-00-00-01
- DHCP = Off
- Gateway IP Address = 192.168.1.1

However, the IP Address, subnet mask, MAC address and Gateway IP address are configurable by the user. Since these need to be static, DHCP is disabled and is not supported. The gateway address needs to the correct if client from another network wish to receive message from the C-Mariner device.

With the default settings, any Ethernet device on the same subnet which need to be connect to the C-Mariner device must configured with the same subnet mask and have an IP address of 192.168.1.xxx where xxx is any host address from 1 to 254 and be unique within the network (i.e something other than the host address 10 and 11 which is reserved for the BF-480 serial converter inside the CM145 interface).

The Ethernet interface supports up to 100 Mbit / second operation, and is set to

auto-negotiate to either 10 or 100 Mbit / second, depending on the network settings of the other devices in the system.

Input Channels

The C-Mariner receives NMEA messages over a defined input network port numbers using TCP/IP protocol. The default input channels are configured as follows:

- Input channel 1 = 4650 (GNSS #1)
- Input channel 2 = 4651 (GNSS #2 when enabled)
- Input channel 3 = 4652 Acoustic (when acoustic is enabled)
- Input channel 4 = 4653 EM Log

Depending on which license options are enabled will determine what input channels are displayed on the input configuration page as shown in Figure 27. The C-Mariner software is set up as TCP server for these ports.

At power-up initialization, the software initializes this port and waits for a single connection from the GNSS receiver. Once connected, the C-Mariner will begin processing input NMEA messages. If the connection is lost, the C-Mariner will reset the network server and wait for a new connection request. Note that only one connection is accepted. Additional simultaneous connection requests for the same port will be ignored. For inputs, the C-Mariner device does not currently support TCP client operations to other servers or UDP.

Output Channels

The C-Mariner is designed to transmit any user configured subset of the defined sentences simultaneously over eight output channel ports using TCP/IP or UDP protocol. For the TCP, the C-Mariner software is set up as a network server. The subset of sentences transmitted may be different for each port. The rates for each sentence may be different for each port and the rates for sentences on a particular port need not all be the same. The default 8 output ports are configured as the follows:

Port Numbers	Port Numbers
Port 1 = 4660	Port 5 = 4664
Port 2 = 4661	Port 6 = 4665

Port 3 = 4662	Port 7 = 4666
Port 4 = 4663	Port 8 = 4667

Table 6: Default Output Ports

When the unit is turned on it initializes all ports and waits for a single connection from any device connecting for each port. Once a port is connected, it will begin transmitting the output NMEA messages over that port. If a connection is lost on a port, the system will reset the network server (for just that port) and wait for a new connection request. Note that only one connection is accepted per port. Additional simultaneous connection requests for the same port will be ignored. Either TCP or UDP can be configured as the desired output protocol for each port, the C-Mariner does not currently support TCP client operations to other servers.

Please note:

Due to the complexity of TCP/IP in general, the network interface software and hardware, and processor throughput, attempts to transmit many output at high rates over multiple ports cannot be guaranteed. There may be loss of data and / or unacceptable latencies. Even at lower rates, the use of TCP/IP protocol allows combination of short messages before transmission, so latency cannot always be guaranteed.

TCP/IP Protocol Behavior

If any of the outputs on the C-Mariner are configured to use the TCP/IP protocol, then at power-up initialization the sensor initializes and enables the ports and waits for a single TCP/IP connection from any device listening on those ports. Once a port is connected (socket connection established), the C-Mariner will begin transmitting the NMEA output messages over that port (socket connection). If a connection is lost on a port, the C-Mariner will reset the network server (for just that channel) and wait for a new connection request. Note that only 1 connection is accepted per port. Additional simultaneous connection request for the same port will be ignored. However, with two ports, it is possible to have two client devices simultaneously connected.

UDP Protocol Behavior

The C-Mariner supports UDP protocol on output channels. When the UDP is configured and the channel is enabled, the C-Mariner will begin transmitting the NMEA output message over that port shortly after a power-on or reset. Unlike TCP, UDP is connectionless and can start outputting messages as soon as the

channel is configured and enabled. By default, NMEA output messages will broadcast using the configured UDP port# and destination IP address. If the configured address is the broadcast address for the subnet (for example, for the default settings, this would be 192.168.1.255) then multiple devices can receive the messages over the configured port. Windows Firewall must be turned off to receive UDP messages.

Physical Description

The C-Mariner, shown in Figure 9, is installed in a mounting tray that provides the physical interface between the sensor and the vessel. The C-Mariner sensor is a passively cooled device.

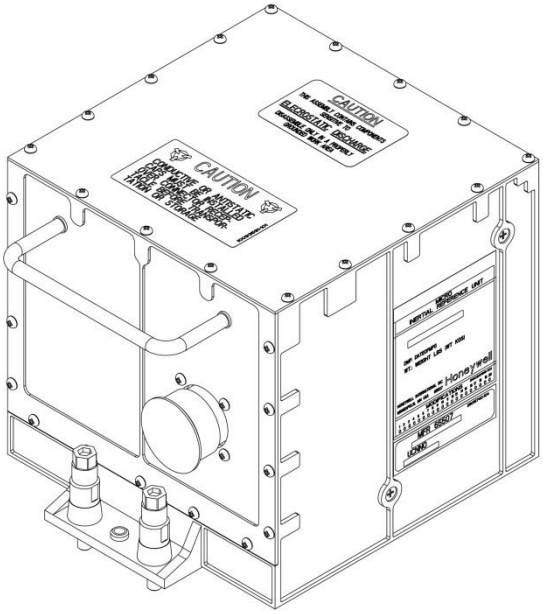


Figure 9: C-Mariner Illustration

Captive screws on the front of the chassis assembly permit mounting of the chassis to the mounting tray. A handle on the front of the chassis provides for ease of handling and installation.

The inertial sensor assembly consists of three gyroscopes and three accelerometer sensors mounted in a precisely machined metal base. Shock absorbing isolators attach the base to the chassis, protecting the sensors from disturbances due to temperature, vibration, and shock.

Please note:
Tampering with the sensor housing in any way will invalidate the warranty.

The C-Mariner connector is shown in Figure 10 and It is equivalent to a MS27656T17F35P, which is a circular bayonet mount 55 pin MIL-C-38999 Series I connector. This connector mates to a MS27467T17B35S or equivalent.

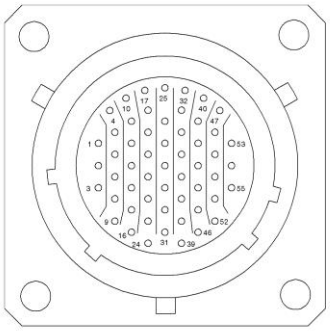


Figure 10: C-Mariner 55 Pin Connector

Mounting Tray Description

The Mounting Tray, in Figure 11, is a low-profile, lightweight tray that consists of machined aluminum and stainless steel bushings and fittings. The tray is designed to be mounted directly to the ship / vehicle. Two slotted round pins in the rear and one round pin in front keep the sensor in alignment with the tray. Two captive screws on the C-Mariner secure it to the tray.

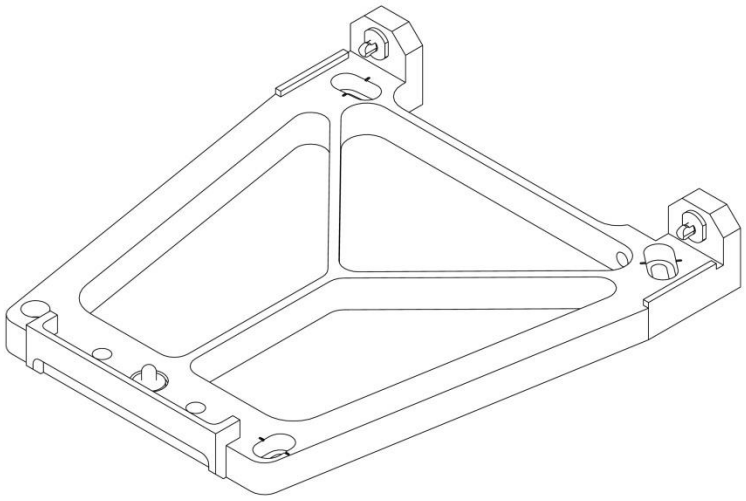


Figure 11: C-Mariner Mounting Tray

Section 5 - Installation and Removal

Introduction

This section describes mounting and removing the C-Mariner, orientation, and mounting tray instructions. The C-Mariner is installed on a tray and aligned such that the front (connector side) of the C-Mariner is within five degrees of facing either the bow or stern of the ship, or the port or starboard sides of the ship.

Please note:
Do not install the C-Mariner with the connector side against any obstruction that will prevent reaching the connector and tighten the two mounting Allen screws.

C-Mariner Orientation

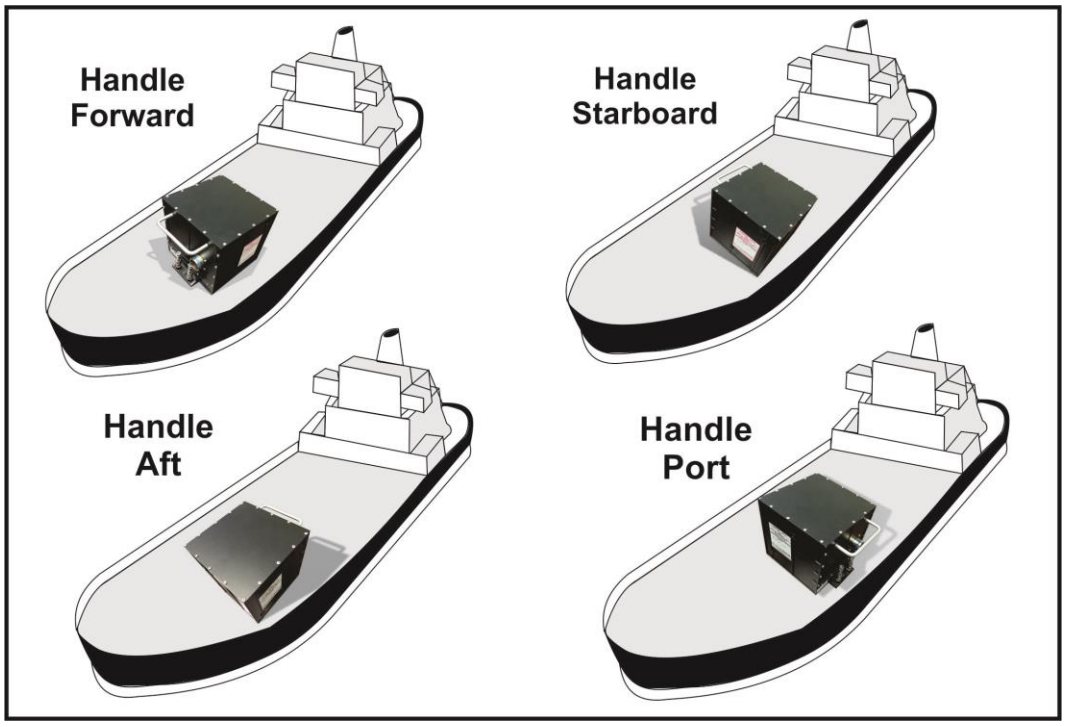


Figure 12: C-Mariner Orientation

Installation View

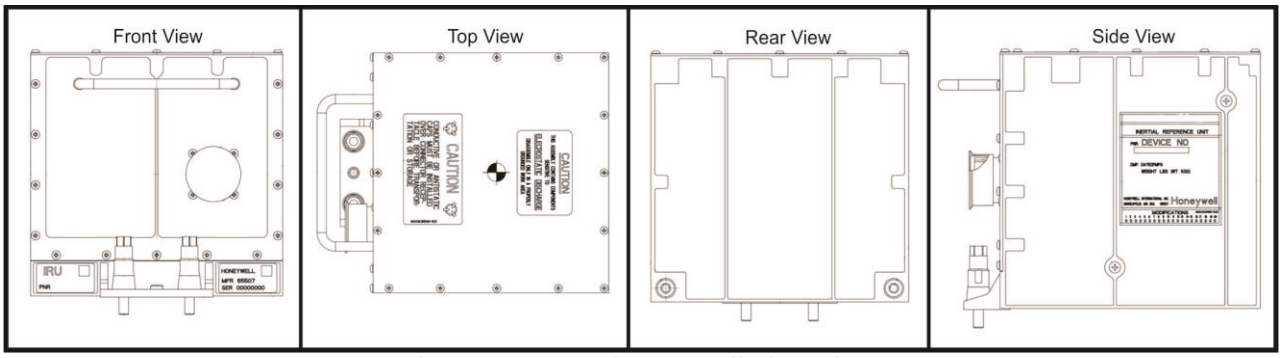


Figure 13: C-Mariner Installation View

Installation

The following steps are required to install the C-Mariner:

Mounting Tray Installation

The mounting tray must be aligned to one of the ship principle reference axes. The mounting tray must also be grounded and bonded to provide a wide frequency range, low impedance path to vehicle ground. A measured resistance of less than 0.0025 ohms from mounting tray to vehicle ground ensures that grounding and bonding requirements have been met.

The mounting tray is suitable for installations where the mounting surface provides the tray with the low impedance path to ground. The tray is provided with a #8-32 UNC-2B mounting bolt hole for a ground lug which can be used to further reduce impedance of the installation. The following is a procedure for installing and aligning the mounting tray.

1. Choose the orientation for the sensor in the ship. Refer to Figure 12 , which identifies the four cardinal orientations of the sensor in the ship. The mounting tray must be installed within ±5° of one of the orientations.
2. Determine the bolt hole locations
    a. Locate the bolt holes in the equipment shelf accurately with respect to the center line of the ship.
    b. Align the symmetric axis of the four mounting holes parallel to or perpendicular with the longitudinal axis, depending on which of the four cardinal orientations was chosen. Figure 14, gives dimensional references for mounting hole placement.

3. Drill (and tap, if desired) four holes for NAS1351C3-XX socket head or NAS1635-3-XX pan head screws. NOTE: Equivalent fasteners may be used.
4. Loosely secure the mounting tray to the ship's structure with four NAS1351C3-XX socket head or NAS1635-3-XX pan head screws and four NAS620C10L or MS15795-807 washers.
5. Using a 5/32 in. hex-driver, torque the mounting bolts to 28 ±1.5 in.-lb.

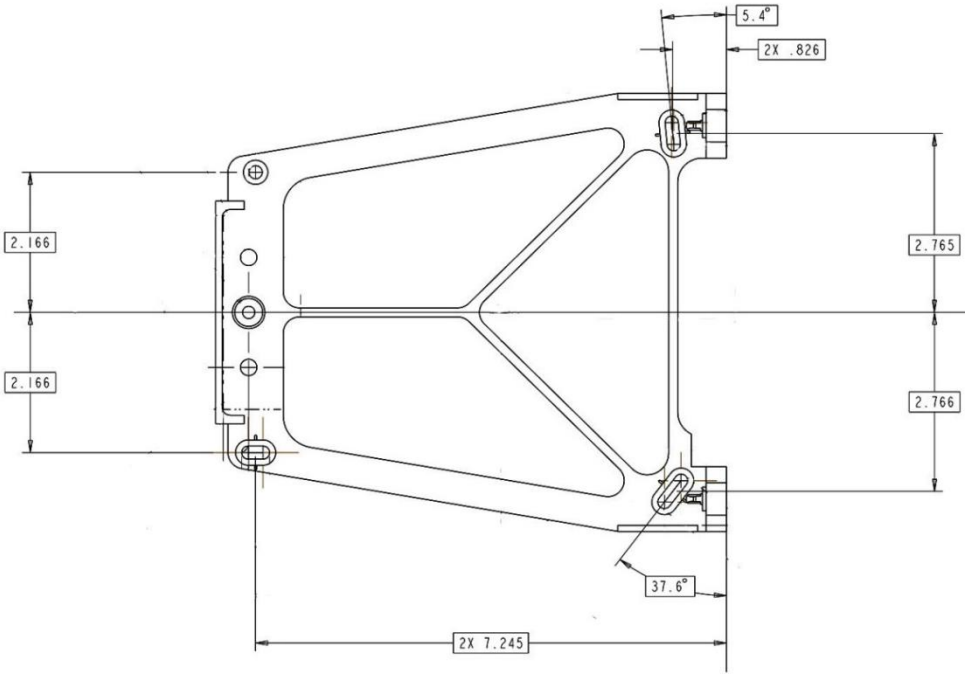


Figure 14: Tray Mounting Dimensions

Mounting Tray Description

The mounting tray is made out of machined aluminum and it has stainless steel bushings and fittings. The lightweight tray is designed to be mounted directly to the ship. Two slotted round pins in the rear and one round pin in front keep the sensor in alignment with the tray. Two captive screws on the C-Mariner secure it to the tray.

C-Mariner Installation

1. Set all circuit breakers to OFF.
2. Grasp the C-Mariner by the front handle and tilt it at a slight angle so that the sensor clears the front lip of the mounting tray.
3. Align the C-Mariner mounting holes with the two slotted round pins at

the rear of the tray. Slide the sensor at an angle until it fully mates with the slotted round pins.

4. Lower the front of the C-Mariner until it mates with the mounting tray round guide pin.

⚠ CAUTION: OVER TORQUING THE SENSOR MOUNTING SCREWS WILL CAUSE DAMAGE TO THE MOUNTING SCREW.

5. Using a 3/8 in. socket or 3/16 in. hex driver, torque 2 hex-head captive screws to 28 ± 1.5 in.-lb.
6. Remove the protective cap from the connector.
7. Attach and secure the power / data cable to the C-Mariner connector.

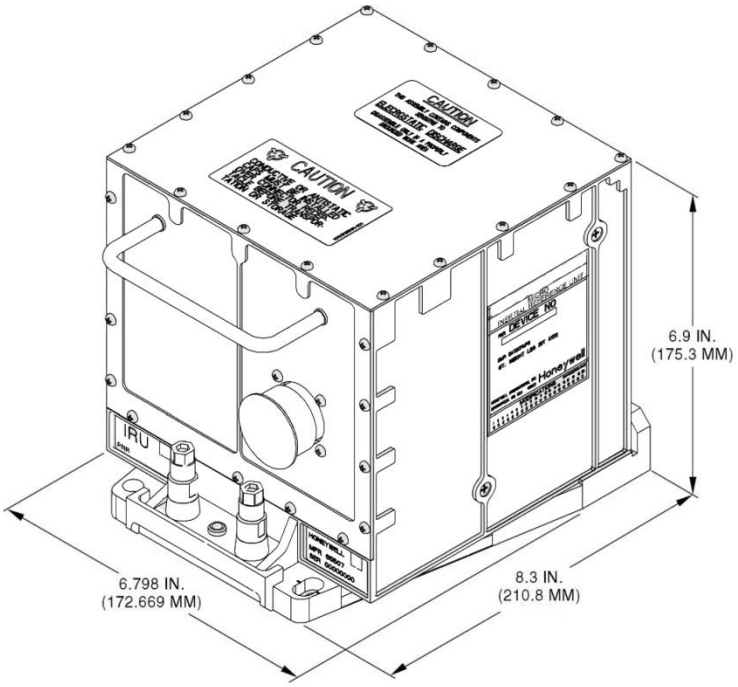


Figure 15: Overall Sensor & Tray Dimensions

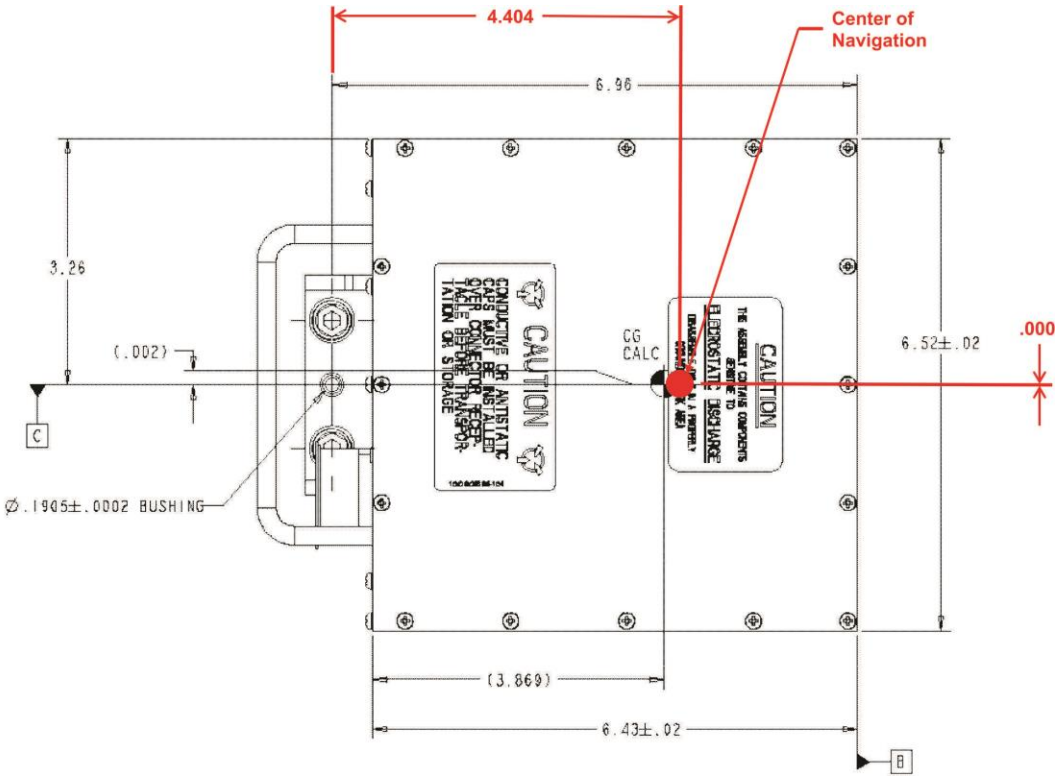


Figure 16: Center Of Navigation (Top View)

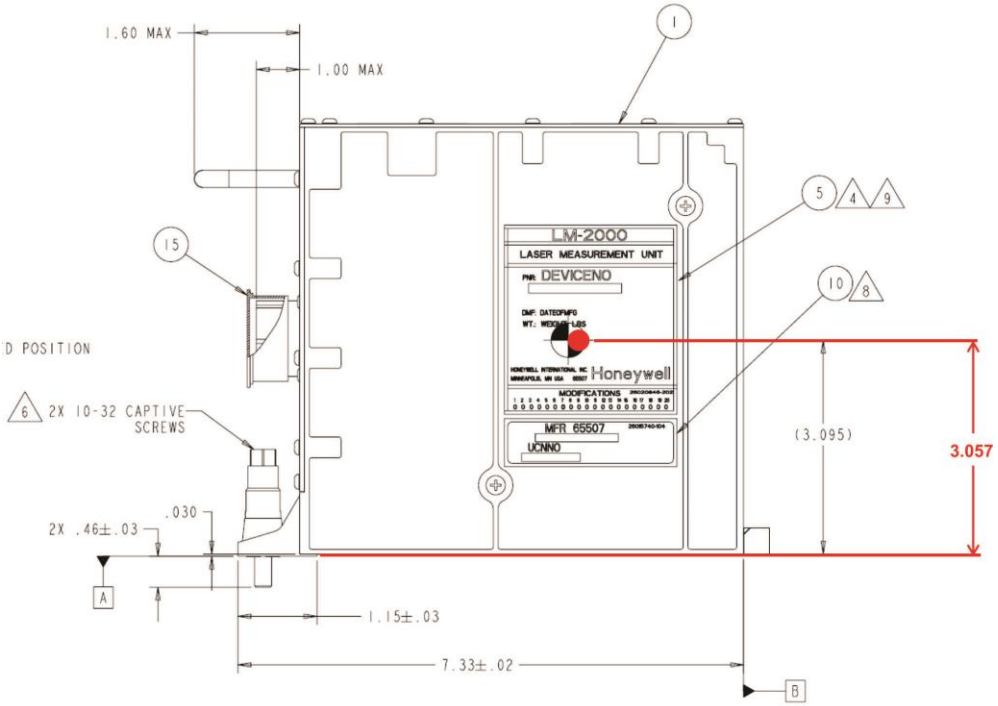


Figure 17: Center Of Navigation (Side View)

Receiver Installation

Refer to the **Oceaneering® C-Nav3050®** GNSS receiver installation instructions that were supplied with the unit. If the C-Mariner configuration is being installed, GNSS antenna to C-Mariner offset distances must be determined. Refer to Section 6 - Configuration (Page 41) for instructions on determining and entering these offsets.

Removal

If required, the C-Mariner and its equipment can also be removed. Please follow the instructions listed below.

C-Mariner Removal

1. Set all the C-Mariner circuit breakers to OFF.
2. Disconnect the power / data cable from sensor connector.
3. Install the protective cap on the sensor connector.
4. Loosen the 2 hex-head captive screws so that they are in the fully disengaged position. Do not loosen the captive screw retainer nut or sleeve insert.
5. Grasp the C-Mariner by the front handle and tilt it at a slight angle so that the sensor clears the front lip of the mounting tray and disengages from the round guide pin.
6. Remove the sensor from the mounting tray.

Mounting Tray Removal

CAUTION: REMOVAL OF THE MOUNTING TRAY WILL VOID THE EULER ANGLE AND ALIGNMENT DATA STORED IN THE SENSOR. WHEN MOUNTING TRAY IS REPLACED, THE TRAY SHOULD BE RE-ALIGNED.

1. Set all C-Mariner circuit breakers to OFF.
2. Remove the C-Mariner from the mounting tray.
3. Remove the four mounting screws.
4. If attached, remove the grounding strap from ship / vehicle ground.
5. Remove the mounting tray.

Receiver Removal

Refer to the **C-Nav3050®** GNSS receiver removal instructions that were supplied with the unit.

Section 6 - Configuration

Introduction

This section describes the PC network setup configuration, provides information of all of the C-Mariner web pages and helps verify operation, function, and status of the sensor.

The user interface is accessed via a web browser running on a standard PC. Before configuration and alignment, an initial power on check is performed to verify the sensor is wired properly and to check that the sensor and PC are communicating. For the initial power on check, the PC network connection port is wired directly by connecting a standard Cat5 jumper cable to either LAN #1 or #2 RJ45 Ethernet connectors on the interface. The BF-480 Ethernet to Serial (inside the CM145 interface unit) bridge is on the same local network as the C-Mariner unit and has a similar web browser interface for configuring the serial ports.

PC Network Setup to Configure C-Mariner

The PC used to configure C-Mariner on this local network must be set with a fixed IP address that lies in the C-Mariner's address field, other than that used by the BF-480 Ethernet to Serial Bridge.

1. Power on the sensor by pressing the **ON/OFF** switch on the CM145 Interface.
2. Set the PC network configuration:
    a. *IP Address* = 192.168.1.xxx where xxx is any value from 1 to 254 except for 10 and 11.
        i. Say "192.168.1.20"
    b. *Subnet Mask* = "255.255.255.0"
3. Open a web browser on the PC and type 192.168.1.10. The C-Mariner Home page should appear as shown in Figure 18.
4. Connect a GNSS unit to the **COM7** serial port with the required messages for the current operating mode. (GGA, VTG for Gyro and AHRS) and (GGA, GST, VTG, and ZDA for INS). Connect the **1PPS1** if available. For Dual-GNSS, connect the **COM8** and **1PPS2**. For acoustic aiding connect to **COM6**.

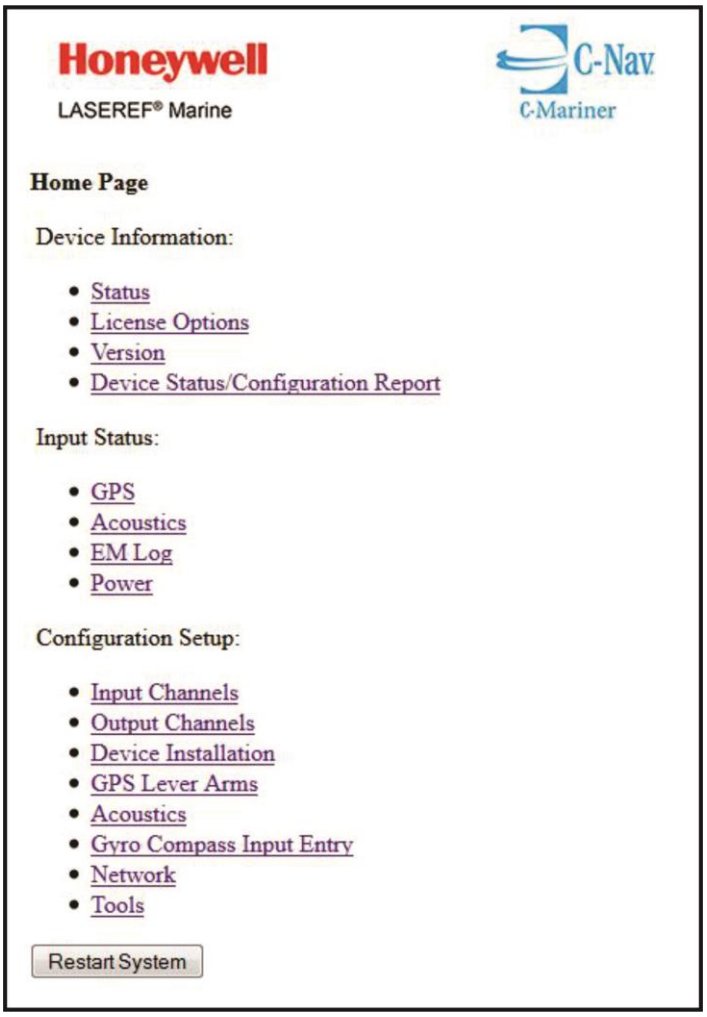


Figure 18: C-Mariner Home page

Device Information

The Device Information section provides Status of the system, License Options configuration page, displays the version of the unit, and provides a configuration report/status page.

Status Page

From the Home page, select the ***Status*** menu as shown in Figure 20. This page shows a list of status parameters and information of any faults within the unit. If the **Enable Auto-Refresh link** is selected, the values on the Device Status page will be updated periodically (about five second intervals).

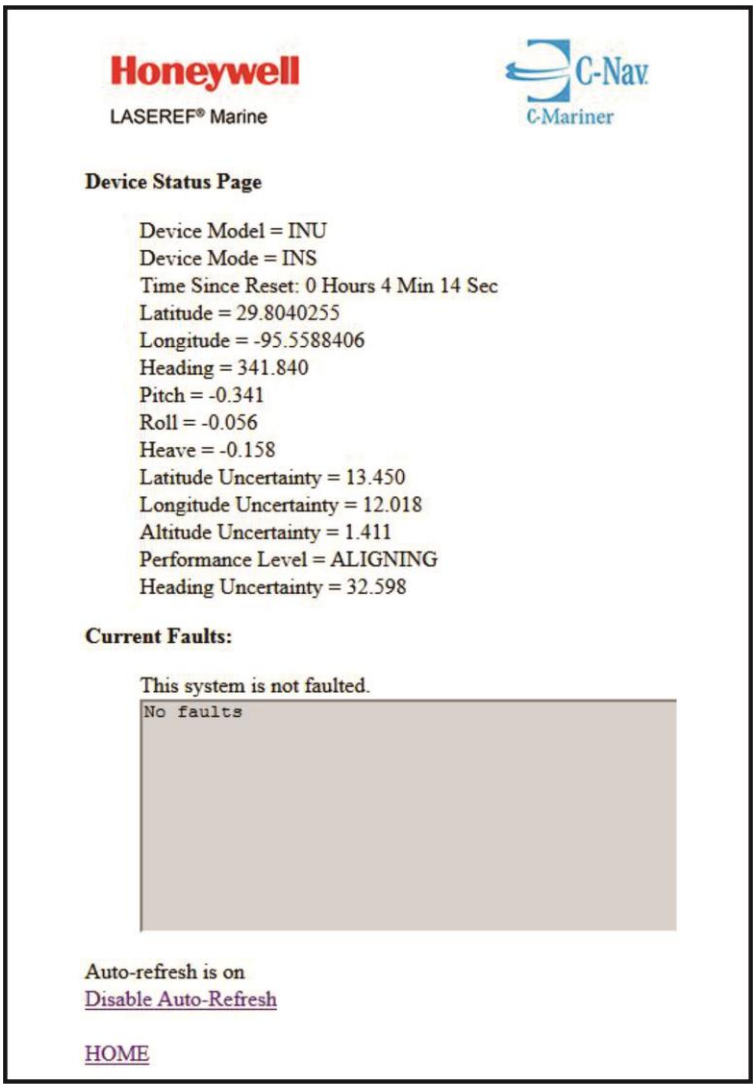


Figure 19: C-Mariner Device Status Page

License Options

From the Home page select the ***License Options*** **menu** as shown in Figure 20. It provides information of the options purchased, shows the license key and it allows to enter or delete a license key.

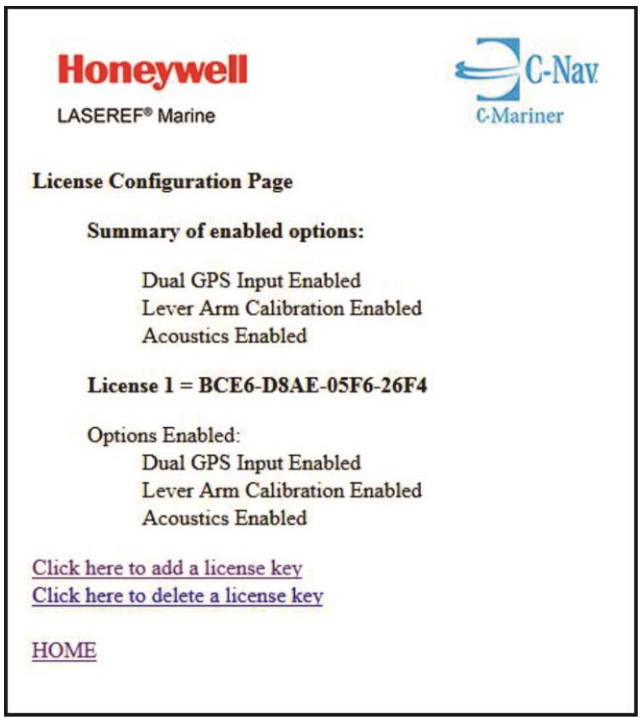


Figure 20: License Option Page

Version

From the Home page select the, ***Version*** menu as shown in Figure 21.

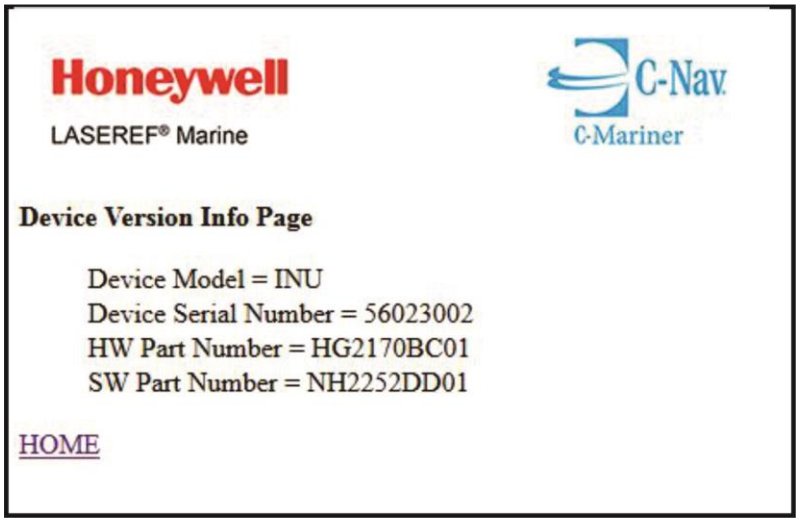
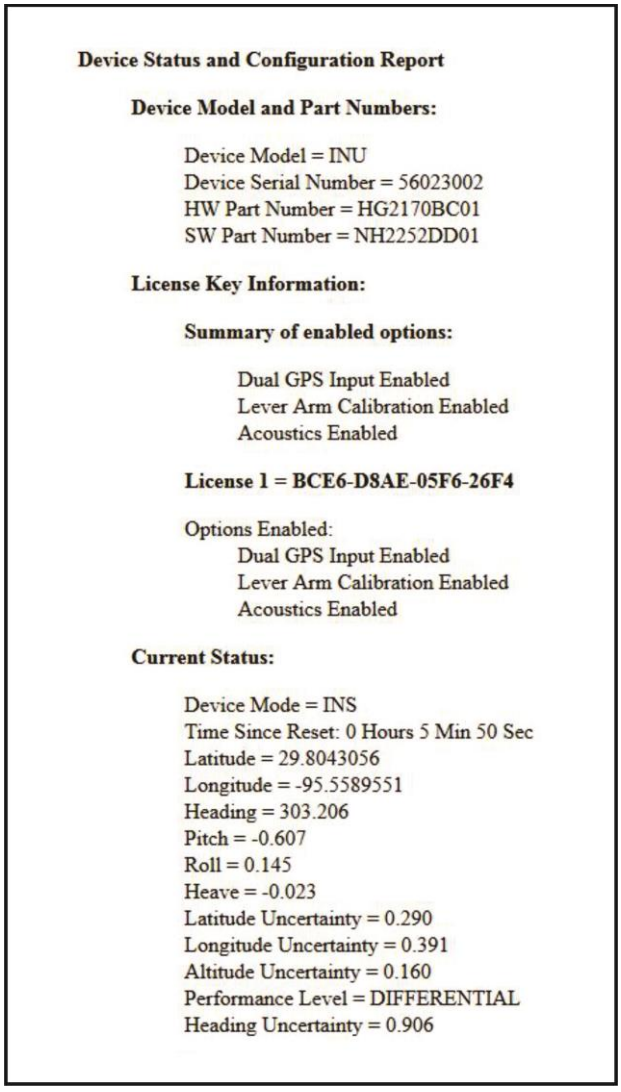


Figure 21: Device Version Info Page

This page provides the Model, Serial, Hardware & Software Part number.

Device Status / Configuration Report

From the Home page, select the ***Device Status/Configuration Report*** menu as shown in Figure 22. This page displays the status and configuration report.



Device Status and Configuration Report

Device Model and Part Numbers:

Device Model = INU
Device Serial Number = 56023002
HW Part Number = HG2170BC01
SW Part Number = NH2252DD01

License Key Information:

Summary of enabled options:

Dual GPS Input Enabled
Lever Arm Calibration Enabled
Acoustics Enabled

License 1 = BCE6-D8AE-05F6-26F4

Options Enabled:
Dual GPS Input Enabled
Lever Arm Calibration Enabled
Acoustics Enabled

Current Status:

Device Mode = INS
Time Since Reset: 0 Hours 5 Min 50 Sec
Latitude = 29.8043056
Longitude = -95.5589551
Heading = 303.206
Pitch = -0.607
Roll = 0.145
Heave = -0.023
Latitude Uncertainty = 0.290
Longitude Uncertainty = 0.391
Altitude Uncertainty = 0.160
Performance Level = DIFFERENTIAL
Heading Uncertainty = 0.906

Figure 22: Device Status & Configuration Report

Input Status

The Input Status section provides all the pages for all the aiding and power input information.

GNSS

From the Home page, select the ***GNSS*** menu as shown in Figure 23. This page shows the aiding input is being received by the sensor. Also indicates the time mark received from GNSS aiding. Click at the **Enable-Auto- Refresh**

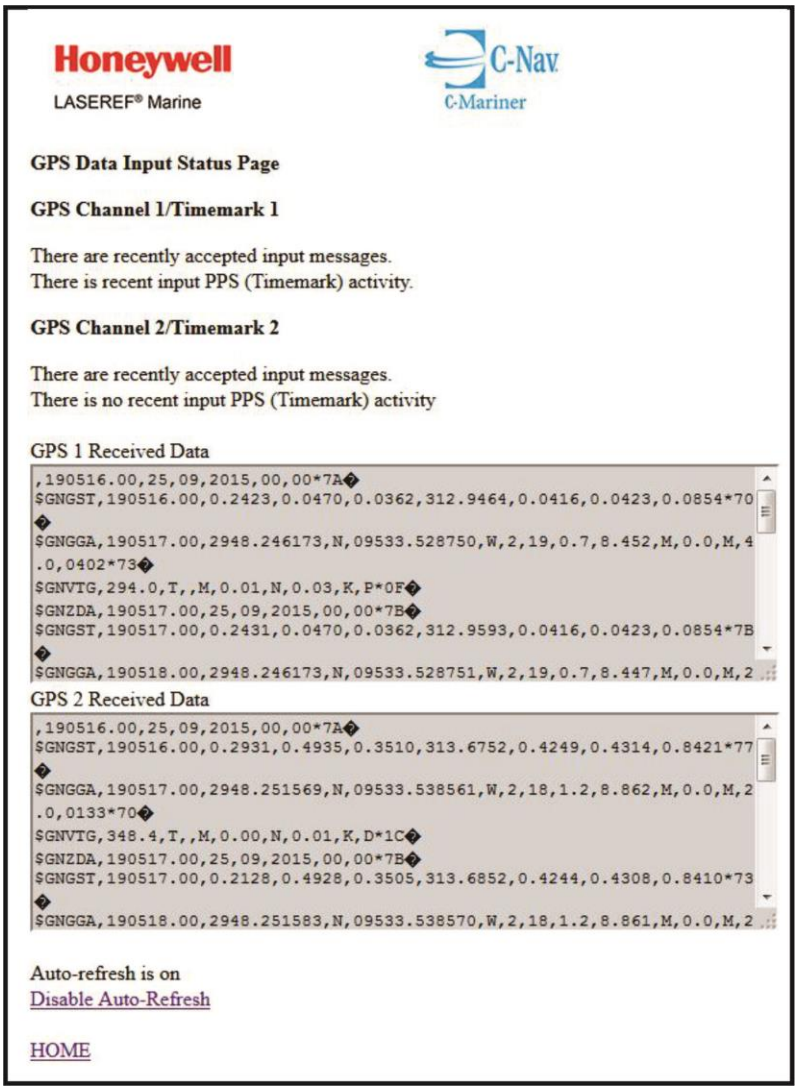


Figure 23: C-Mariner Data GNSS Input Status Page

Acoustics

From the Home page, select the ***Acoustics*** menu as shown in Figure 24. This page shows the acoustic aiding input messages and status of the configured transponder ID and the calibrated ones.

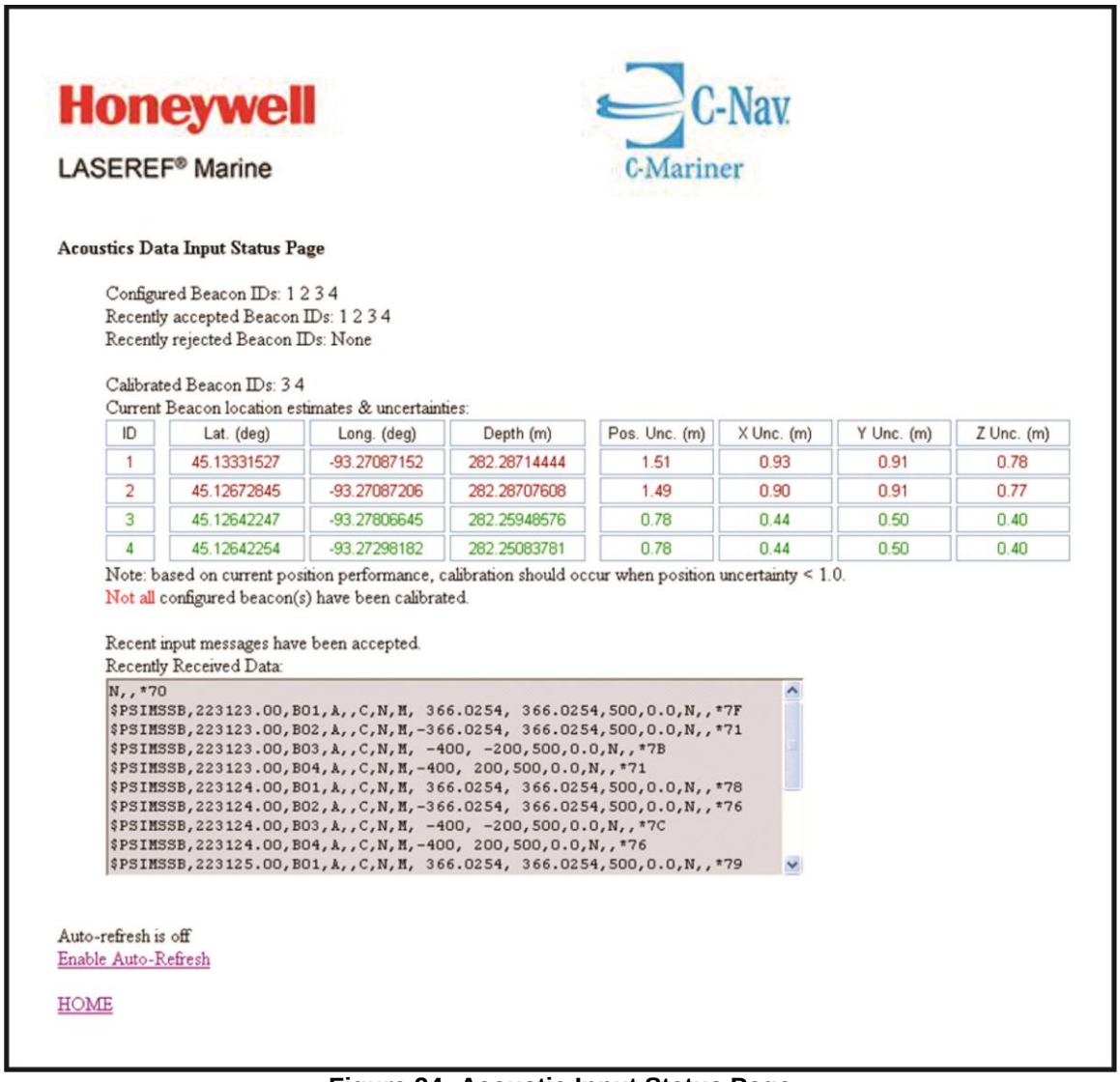


Figure 24: Acoustic Input Status Page

EM Log

From the Home page, select the ***EM Log*** menu as shown in Figure 25. This page

shows the input from an Electromagnetic Log.

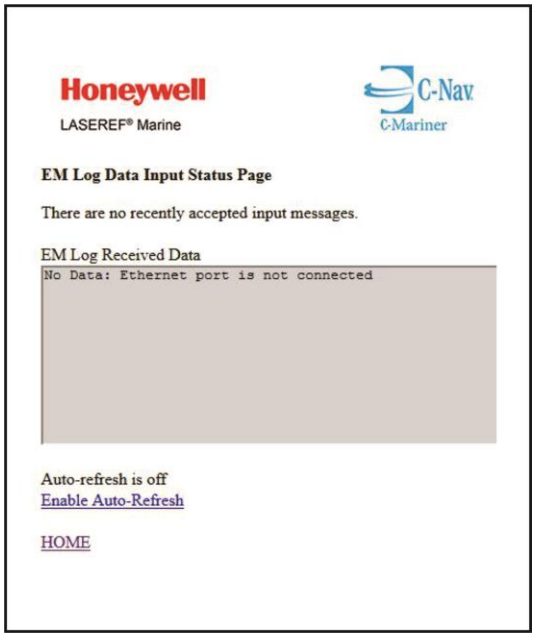


Figure 25: EM Log Status Page

Power

From the Home page, select the ***Power*** menu as shown in Figure 26. This page shows the primary 28 voltage status. Note: Secondary power is not connected.

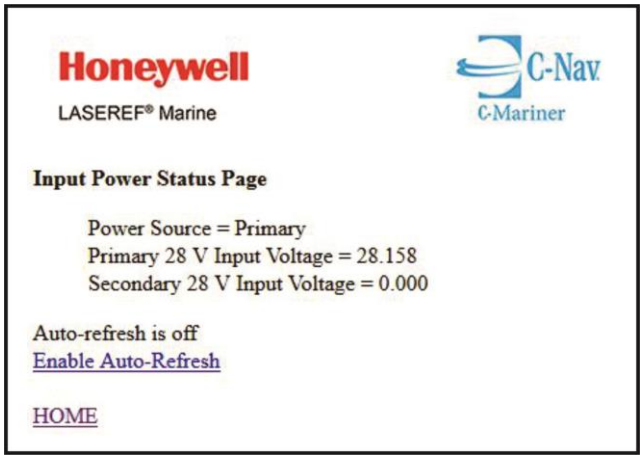


Figure 26: Power Status Page

Configuration Setup

The configuration setup is compose of Input & Output channels, Device Installation, GNSS Lever Arms, Acoustics, Gyro Compass Input Entry, Network, and Tools.

Input Channels

From the Home page, select the ***Input Channels*** menu as shown in Figure 27.

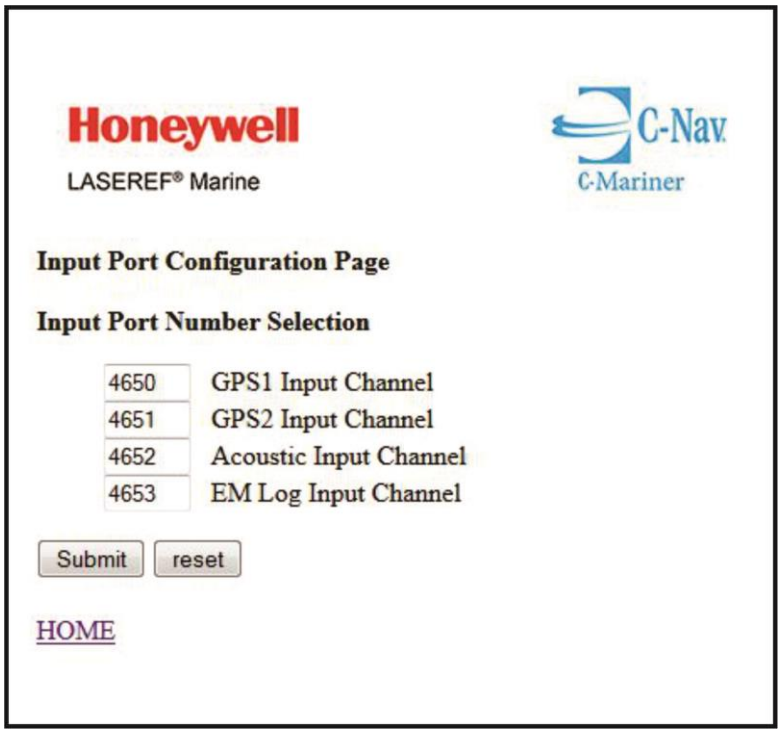


Figure 27: Input Channels Configuration Page

This page displays the default input channels available. If the default settings are not satisfactory, input settings may be modified.

1. Modify the Input Channel as required. Select Submit to save the changes to C-Mariner NVM.
2. Select **Restart System** from the Home page or cycle power for changes to take effect.

> ***Please note:***
> It is strongly suggested these default setting are not altered.

Output Channels

From the ***Home*** page, select the ***Output Channels*** menu as shown in Figure 28.

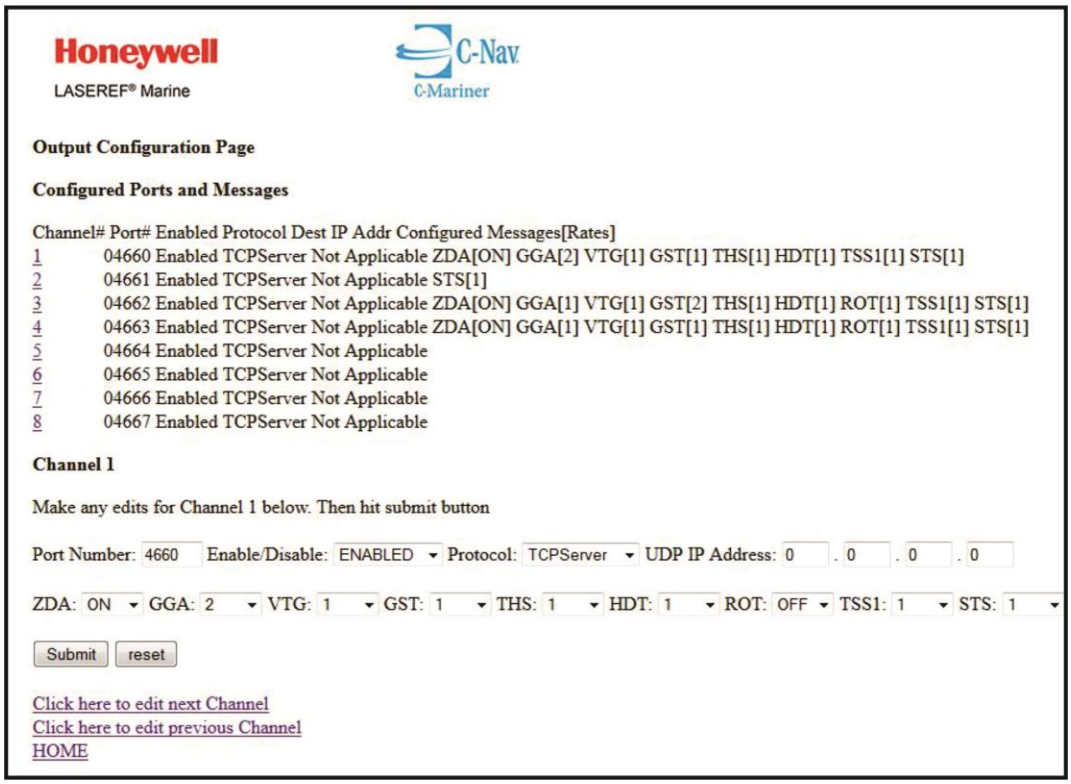


Figure 28: Output Channel Port Configuration Page

This page displays the 8 default output channels available. The following can be modified for each channel configured:

Output Channel Type: Output Port Numbers
Enabled Flag
Protocol type (TCP/UDP)
Output Message rates

Output Channels:

- Output Port Numbers: 4660, 4661, 4662, 4663, 4664, 4665, 4666, 4667 (for channels 1-8 respectively).
- Enabled Flag: Enables flag
- Protocol type (TCP/UDP)

Output Message rates

For CM300 and CM400 devices:

On enable ports = THS, HDT, TSS1, ROT at (1, 2, 5, 12.5, 50 Hz), STS at 1 Hz

For CM600 devices:

On enable ports = GGA, VTG, GST, THS, HDT, TSS1, ROT, ZDA (1, 2, 5, 12.5, 50 Hz), STS at 1 Hz

To modify the output settings:

1. The first channel will be available for modifications by default. Using drop down menu for each message select the desired output rate or turn it off if necessary.
2. Click **submit**, this allows the output the message on that channel immediately without having to re-start the unit. Changes should be observed above on the channel.
3. Should another channel needs to be changed then press the **Click here to edit next Channel** and performed steps 1-2 again.
4. To exit from this page, click **HOME**.

Output Sentence IDs

From the Home page, select the ***Output Sentence IDs*** menu as shown in Figure 29. In situations where a DP Console does not recognize the default output prefix identifier “IN”, the output sentences identifier can be modified. Enter two prefix letters from A-Z for each sentence message then press Submit.

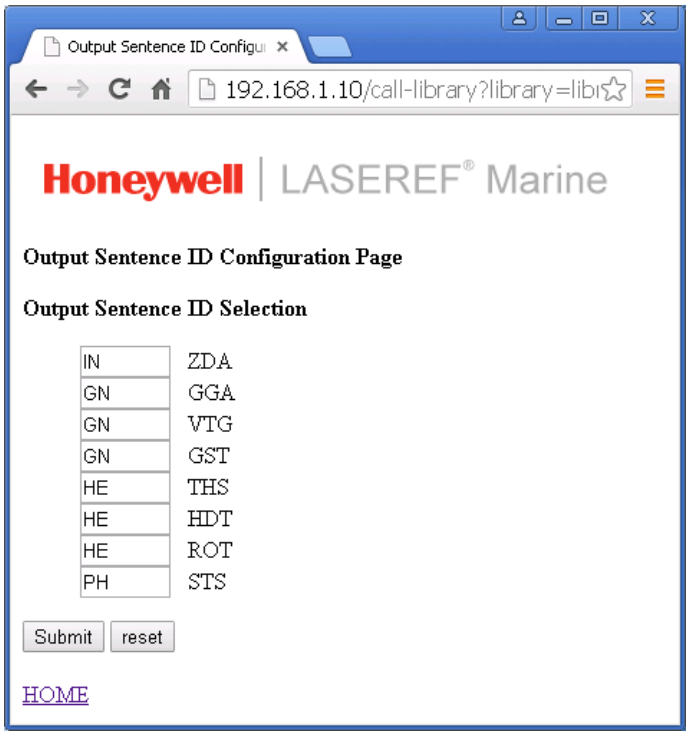


Figure 29: Output Sentence ID Configuration Page

Device Installation

From the Home page, select the ***Device Installation*** menu as shown in Figure 30. This page allows the user to configure the *Datum to Device Lever Arms*, *Datum to Output Lever Arms*, Mis-alignments for Pitch, Roll, Yaw (Heading), and to select the Handle orientation. Once data has been entered, click the **Submit Configuration Data** button to store the values to the C-Mariner NVM. A restart of the unit will be necessary for all the configured information to be implemented.

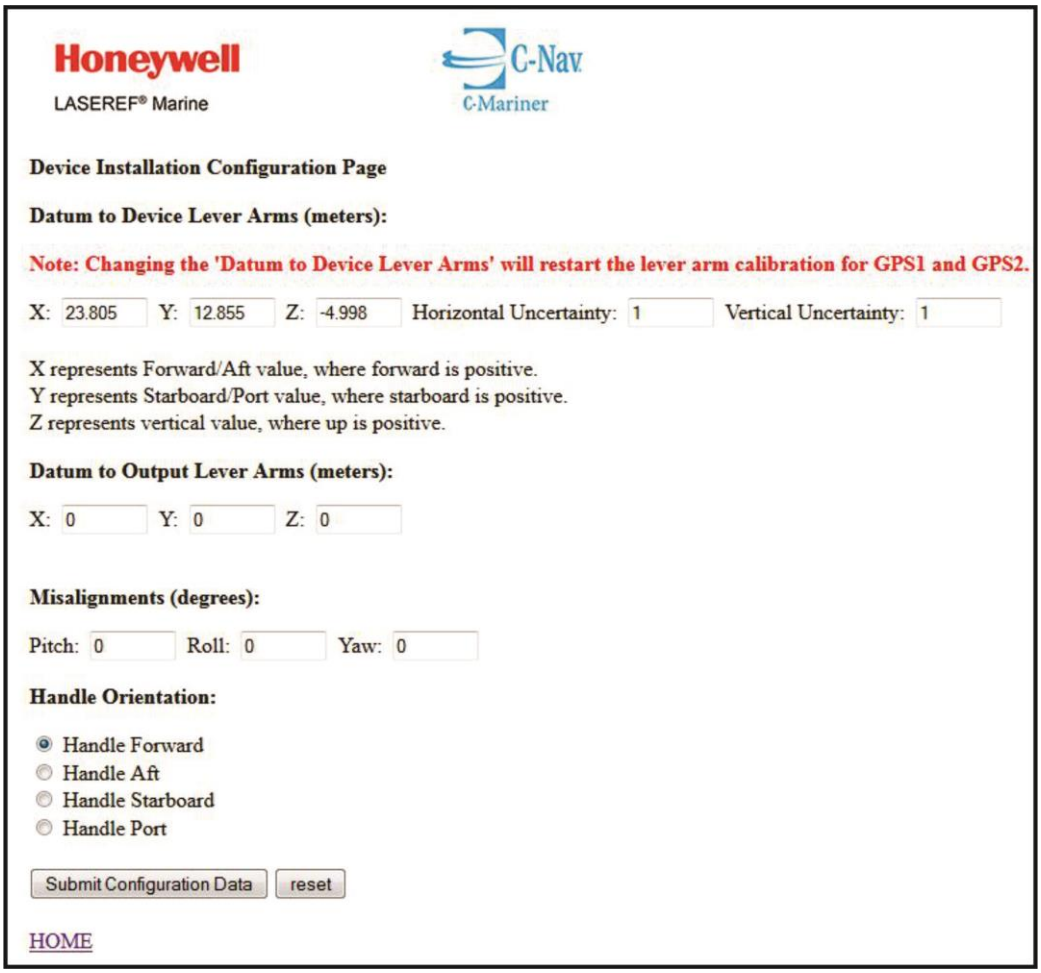


Figure 30: Device Installation Configuration Page

GNSS Lever Arms

Five sets of lever arms are supported: vessel's datum point to C-Mariner device, datum to output, datum to GNSS1 and GNSS2 antenna and datum to acoustic reference point. All C-Mariner lever arm terms are relative to the vessel's datum point. Measurements are inputted in meters.

The datum to sensor/output/GNSS antenna/acoustic lever arm terms describes the offset of these references from the vessel's datum point. The X value is the measurement from the datum to reference along the vessels fore - aft axis. Positive values are where the reference is forward of the datum. The Y value is the measurement from the datum to the reference along the vessels port – starboard axis. Positive values are where the reference is starboard of the datum. The Z value is the measurement from the datum to the reference along

the vessel's for samples of how to the lever arm calibration works see Appendix B - Lever Arm Calibration (Page 95).

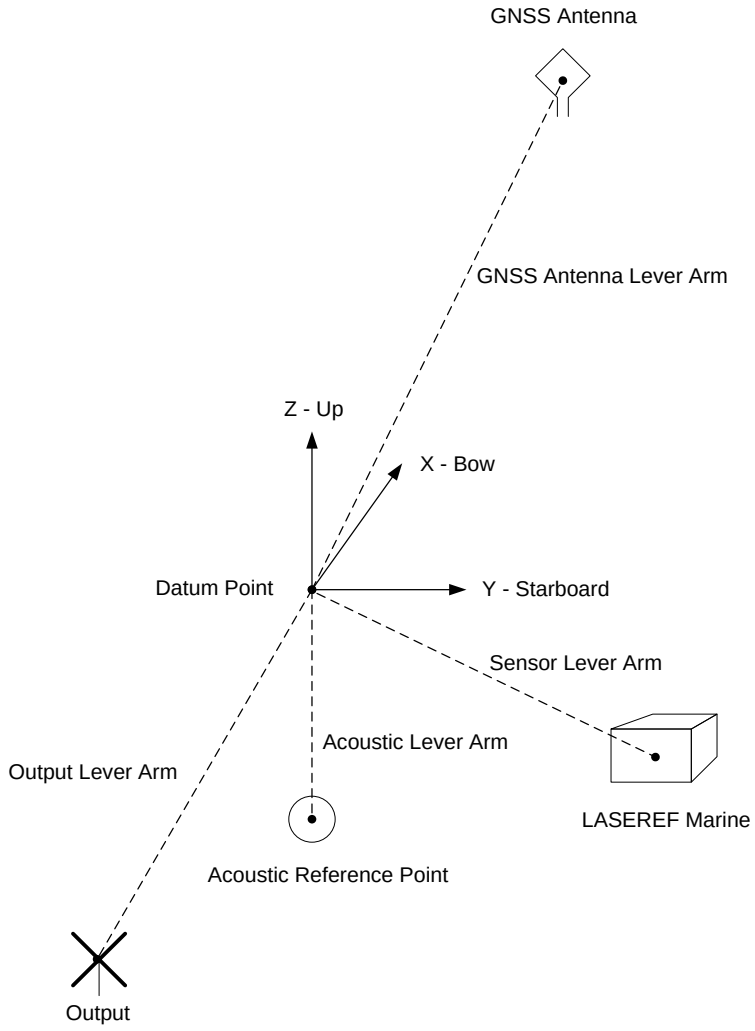


Figure 31: Lever Arms

From the Home page, select the ***GNSS Lever Arms*** menu as shown Figure 32. This page allows the user to configure the *Datum to GNSS Receiver#1 Lever Arms* and *Datum to GNSS Receiver #2 Lever Arms*. Also, it displays the calculated values from the C-Mariner Device to each GNSS receiver. Once data has been entered, click the **Submit Configuration Data** button to store the values to the C-Mariner NVM. A restart of the unit will be necessary for all the configured information to be implemented.

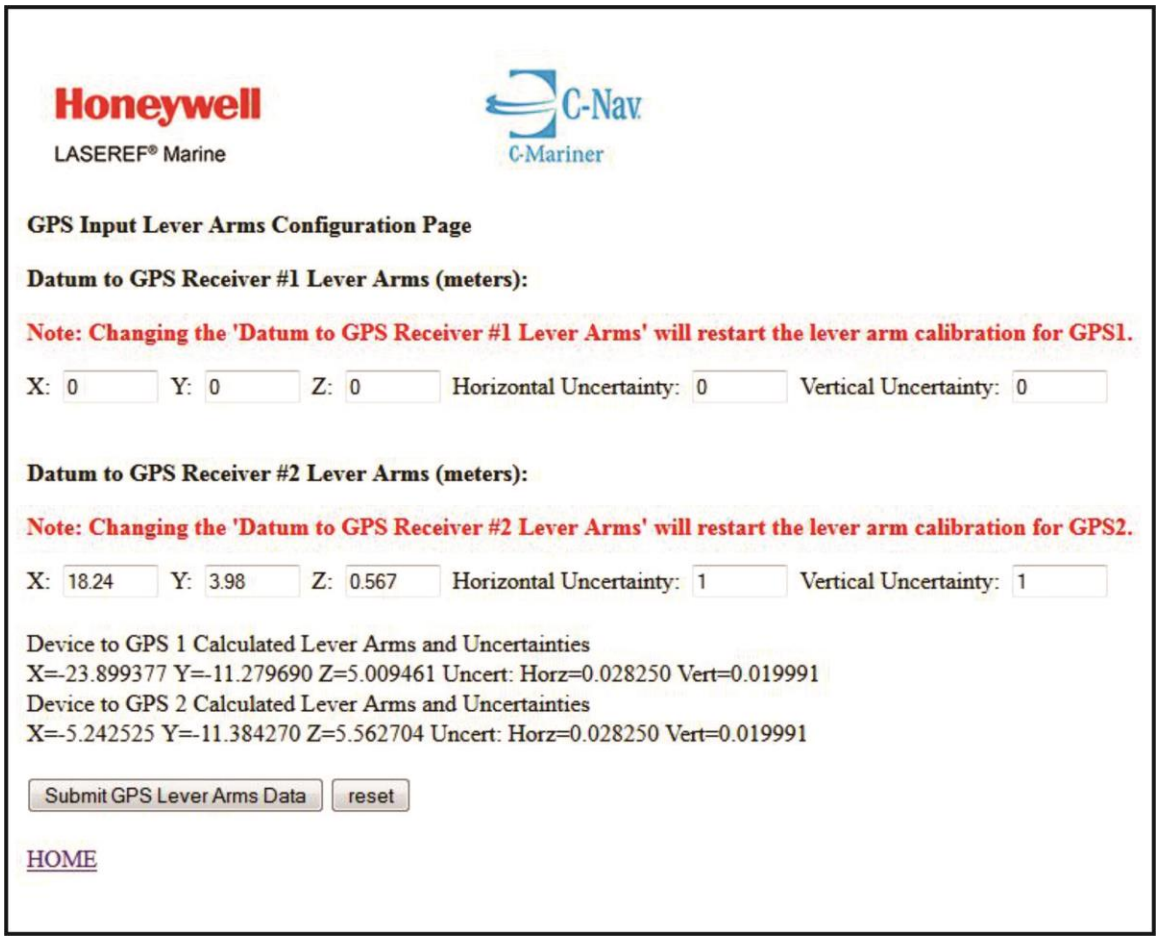


Figure 32: GNSS Lever Arms Configuration Page

Acoustics

From the Home page, select the ***Acoustics*** menu as shown Figure 33.

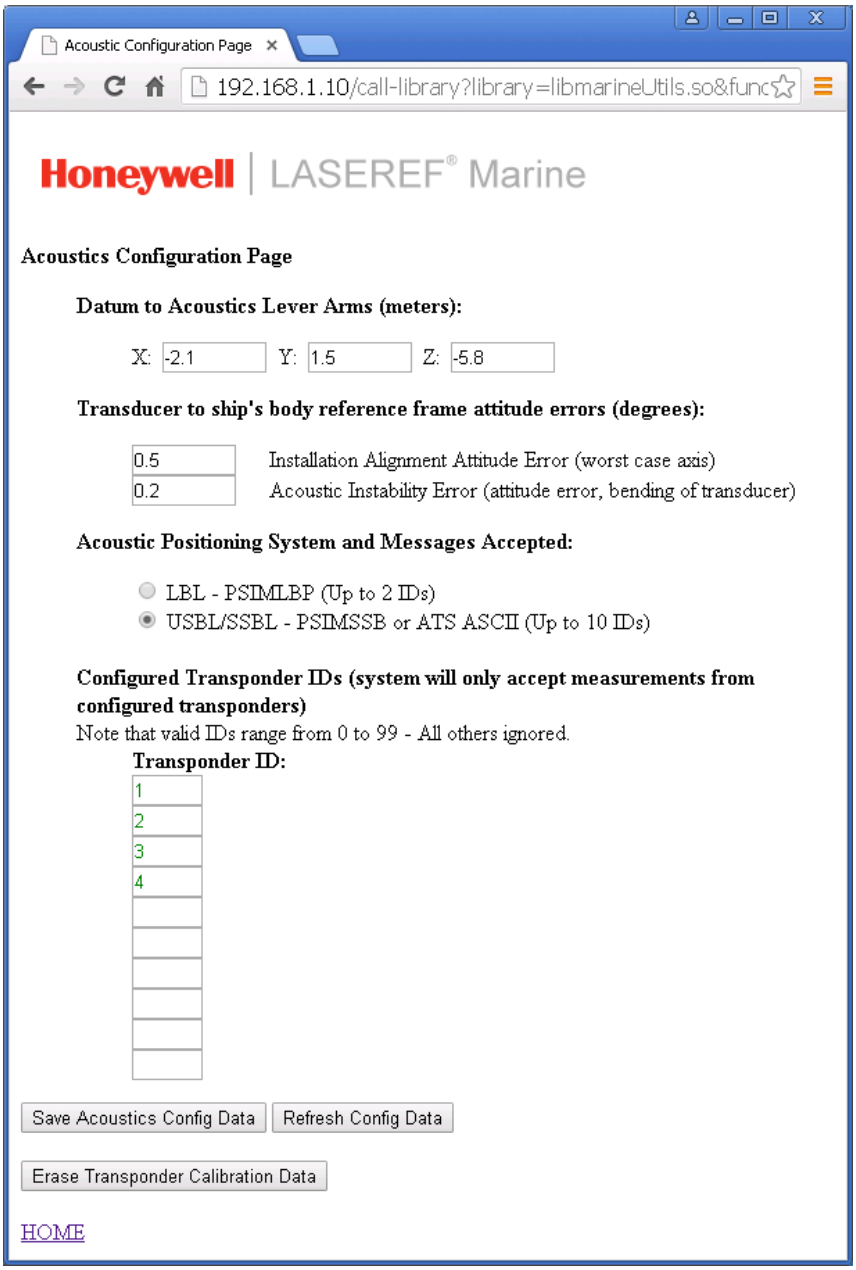


Figure 33: Acoustics Configuration Page

This page allows the user to configure the *Datum to Acoustics Lever Arms*, Enter transducer attitude errors, select between LBL and USB/SSBL aiding messages, and enter up to ten transponders ID for the USBL mode and two arrays for the LBL mode. It also allows the user to save or erase acoustic data.

Gyro Compass Input Entry

From the Home page, select the ***Gyro Compass Input Entry*** menu as shown Figure 34.

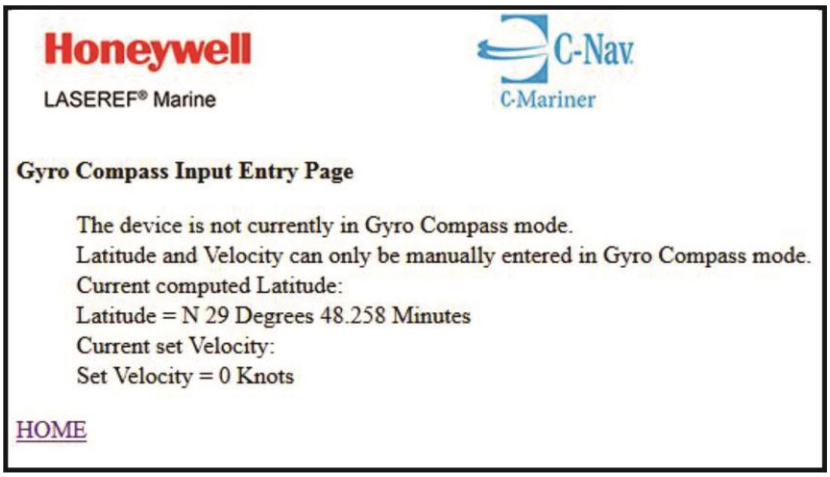


Figure 34: Gyro Compass Page with GNSS Aiding

This page displays the status of the current Latitude and Velocity used when using GNSS aiding. When not possible to have GNSS input, then a manual entry of Latitude and Velocity should be entered for the CM300 & 400 as shown in Figure 35.

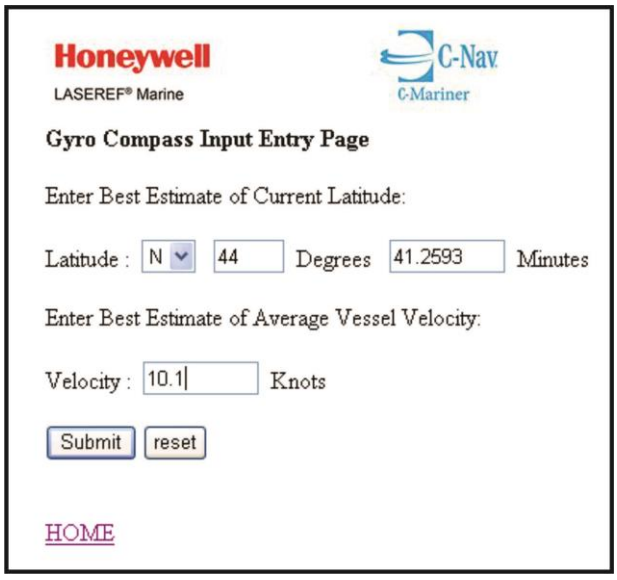


Figure 35: Gyro Compass Page with no GNSS aiding

Network

If the network default parameters are not satisfactory, network parameters may be modified. The sensor IP address, subnet mask and MAC address may be modified. Network default settings are as follows:

IP Address = 192.168.1.10 and Subnet Mask = 255.255.255.0

Please note:
It is strongly suggested these are not altered.

To modify the network parameters:

1. From the C-Mariner Home page, select the ***Network*** menu as shown in Figure 36.
2. Modify the *IP Address* and *Subnet Mask* as required. Select **Submit Network Setting** button to save the changes to C-Mariner NVM. Select **Restart System** from the Home page or cycle power for changes to take effect.

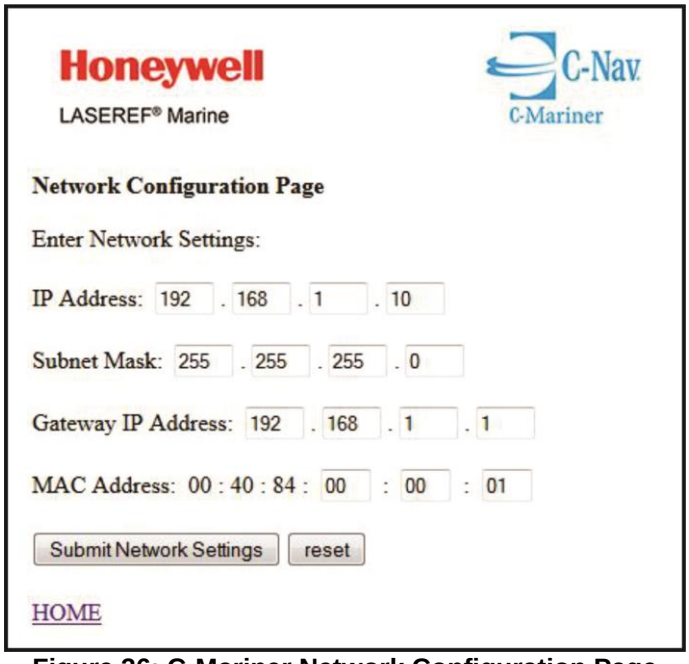


Figure 36: C-Mariner Network Configuration Page

From the C-Mariner Home page, select the ***Tools*** menu as shown in Figure 37.

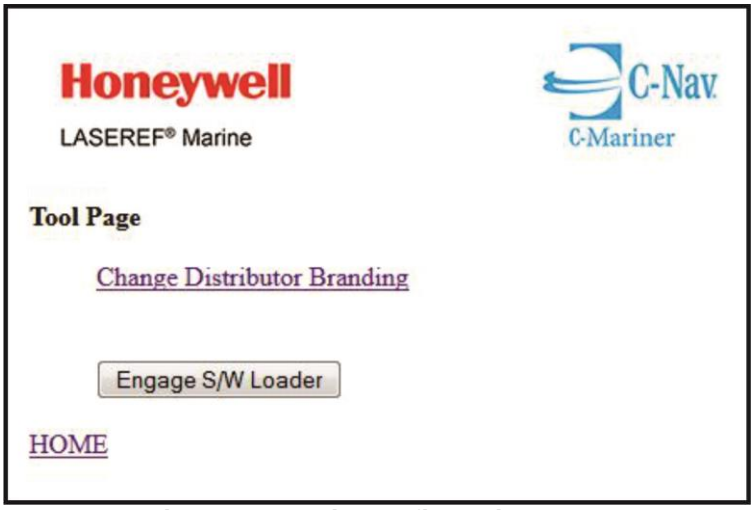


Figure 37: Tools Configuration Page

This page allows the user to update the C-Mariner with new firmware. Full instructions will be provided by the C-Nav support team when a new firmware is available.

Alignment and Calibration

Once the C-Mariner is installed and all aiding inputs and power has been verified, it is time to enter alignment and aiding offset values. The C-Mariner must be aligned to one the vessel axis see Figure 12.

1. From the home page, click at ***Device Installation*** menu and Enter measured values to *Datum to Device Lever Arms* and uncertainties see Appendix B - Lever Arm Calibration (Page 95) for a complete explanation of how the lever arm works and sample scenarios.

2. Select *Handle Orientation* and click **Submit Configuration Data** and then click **Home.**

3. From the home page, click at the ***GNSS Lever Arms*** menu and enter the measured *Datum to GNSS Receiver #1* offset values and uncertainties.

4. If a second receiver is used, enter the measured offsets and uncertainties. Click at **Submit GNSS Lever Arms Data** and check the fields populate with the numbers entered. Click **HOME**.

5. Cycle power by pressing on **Restart System** button on the main page.

6. Let the system run for 15-20 minutes until heading uncertainty is around 0.05 deg.

7. On the CM145 Beijer Display check the C-Mariner Heading value and compare it against other vessel calibrated Heading devices. Calculate the misalignment.

8. On the home page click at ***Device Installation*** menu enter a misalignment value on the *Yaw* block. (If an absolute dimensional survey was conducted with precision surveying equipment then enter the heading value provided for the C-Mariner). Also, enter any Pitch and Roll misalignments and click **Submit Configuration Data**.

9. Cycle power by pressing on **Restart System** on the main page.

10. Wait 15-20 minutes and look at the heading value displayed at the Beijer display and make sure that the alignments have been applied correctly. Otherwise, the values will need to be re-entered and cycle power again.

Misalignments can be up to five degrees only. If the misalignments are > than five degrees then it is necessary to re-position the C-Mariner mounting tray. Any misalignment errors are applied directly to output accuracy. Misalignment terms are relative to the vessel axis. A positive pitch misalignment is where the Sensor is pitched up relative to the vessel. A positive roll misalignment is where the Sensor is rolled further starboard relative to the vessel. A positive heading misalignment is where the Sensor heading is clockwise of the vessel heading.

Acoustic Transponder Configuration

The C-Mariner supports acoustic inputs, if enabled via license key. It accepts relative position from a USBL/SSBL or an LBL acoustic system. Acoustic messages supported are PSIMSSB or ATS for USBL/SSBL and PSIMLBP for LBLB.

Acoustic System Message Configuration:

1. Verify the acoustic and GNSS input message times are synced. This is critical for the C-Mariner performance in an acoustic environment.

2. If using PSIMSSB, setup the acoustic message as following:

   a) Coordinate System = Cartesian “C”
   b) SW Filter = Measured “ M”
   c) Orientation as either “H’ = Vessel heading up or “N” = North referenced
   d) Transponder ID = M00-M99, (note M-type transponders are preferred, but will accept any)

3. If using PSIMLBP, setup your acoustic message as follows.

   a) Type = Vessel “Ve”
   b) Coordinate System = Cartesian “C”
   c) Transponder ID = 0-99. (Note, up to two ID’s can be accepted)

To Setup Acoustic Transponder Configuration:

4. From the C-Mariner Home page in the configuration setup section, select Acoustics as shown in Figure 33.

5. Enter *Datum to Acoustic reference lever arm* terms.

6. Enter *Installation Alignment Attitude Error*. This error represents the worst case axis of the acoustic transducer relative to the ships body reference frame.

7. Enter Acoustic Instability Error. This error represents any attitude error variation overtime such as bending of the transducer mounting system.

8. Select the acoustic system, USBL/USSBL or LBL.

9. Enter transponder IDs in boxes provided.

   For USBL/SSBL mode: Up to ten transponder IDs can be configured
   For UBL mode: Up to two transponder arrays can be confirmed

10. Click **Save Acoustics Config Data** to save changes to device NVM.

11. Select **Restart System** from the C-Mariner ***Home*** page or cycle power for changes to take effect.

Acoustic Calibration

The C-Mariner will automatically store calibrated transponder/reference point positions in memory. GNSS is required during initial transponder calibration. If C-Mariner power is cycled during this time, the calibration routine will be automatically restarted.

Verify your acoustic and GNSS input message times are synced. This is critical for C-mariner performance in an acoustic environment.

To check status of acoustics calibration:

From the C-Mariner Home page in the Inputs Status section, select Acoustics.

This page shows all configured, accepted, Rejected and Calibrated transponder IDs. Once calibration is complete and updated status will be displayed on this page showing which transponder IDs are calibrated as well as removal of the STS on occurrence message, NOACAL. GNSS may then be removed and C-Mariner power cycled without losing its position.

Transponders added to the configuration after calibration will require GNSS aiding until added transponders show calibration is complete.

Erase Acoustic Calibration

When moving to a different acoustic environment, the acoustic calibration must be erased. This will remove all stored transponder positions from memory.

To erase acoustic calibration data:

1. From the C-Mariner Home page in the configuration section, select ***Acoustics*** as shown in Figure 33.
2. Select **Erase Transponder Calibration Data** button.
3. Press **Ok** to confirm recalibration.

Select **Restart System** from the C-Mariner Home page or cycle power for changes to take effect.

Section 7 - Operation Modes

Operation

The following sections describe the operation of the three devices that make up the C-Mariner family of products.

Normal Operation

Refer to Figure 38 for the C-Mariner mode control diagram.

Power-Up Mode

The C-Mariner enters Power-Up mode when it receives power. During the Power-Up mode, the C-Mariner does a configuration check to determine some of its functionality and the characteristics of its installation. The C-Mariner remains in Power-Up Mode for five seconds.

Leveling Mode

Following completion of the Power-Up mode, the C-Mariner establishes local level. No later than twenty seconds after entering Leveling Mode, the device mode indicator field of the STS message indicates GYC, AHS or INS and valid pitch and roll parameters are transmitted. The C-Mariner continues to refine pitch and roll after exiting Leveling Mode, but extreme dynamic maneuvers during Leveling Mode may degrade initial pitch and roll accuracy. Immediately following Leveling Mode, the C-Mariner transitions to one of two operating modes: Gyrocompass Mode or Navigation Mode.

Gyrocompass Mode

Gyrocompass Mode is a reversionary mode entered when there is no initial GNSS aiding, or if GNSS aiding is lost for some period of time and heading variance grows to greater than 0.3 degrees. When in Gyrocompass mode, the mode indicator field of the STS message indicates GYC.

In Gyrocompass Mode, the heading output is sensitive to latitude and velocity; for best performance the Gyrocompass Mode requires latitude and velocity inputs. Latitude may be entered through the user interface and velocity information may be provided using speed log aiding or entered through the user interface. If an incorrect latitude was entered, the device

must be restarted. Resubmitting the correct latitude after an incorrect one will not overwrite the previous latitude entry. If no latitude or velocity information is available, the C-Mariner uses the last stored latitude and assumes zero knot velocity.

When heading is resolved to 1.25 degrees or four minutes have elapsed since establishment of level, the C-Mariner is considered aligned and heading related outputs are set valid. Fifteen minutes after power-up, heading settles to full performance heading accuracy.

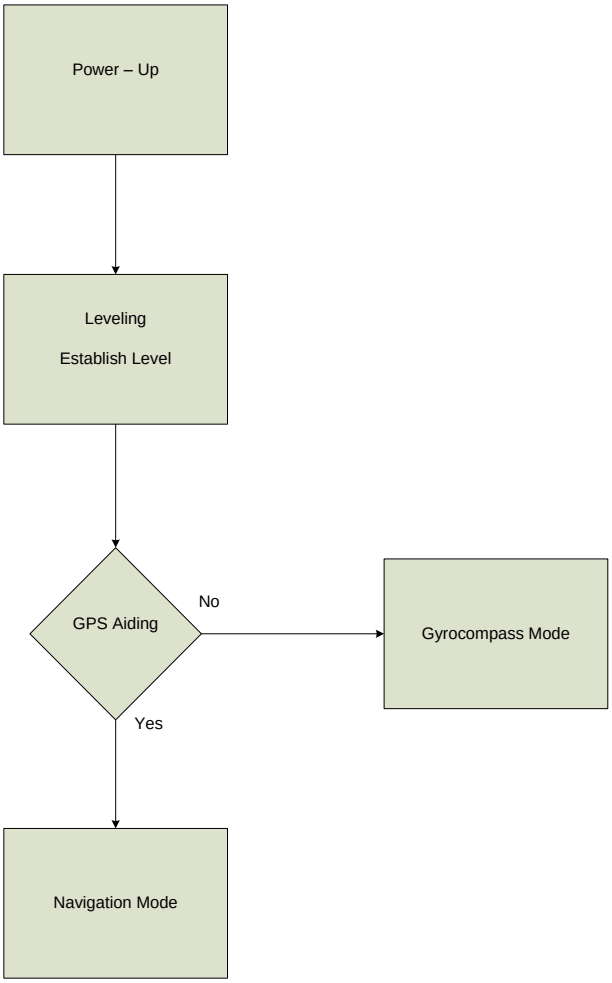


Figure 38: Operating Mode Control Diagram

Navigation Mode

With the INS option (CM600) the normal mode of operation is Navigation Mode. When the sensor is in Navigation Mode, the mode indicator field of the STS message indicates “GYC” if the sensor is in GYRO (CM300), “AHS” if the sensor is an AHRS (CM400) or “INS” if the sensor is an INS (CM600).

The Navigation Mode uses latitude, longitude, altitude, and velocity information from a GNSS receiver or position from an acoustic system to optimize performance. Using 1PPS and velocity information from a GNSS receiver provides the C-Mariner real world position epochs. Position accuracy of the INS mode output is directly related to the quality of the GNSS aiding input provided to the C-Mariner. If a GST message is supplied by the GNSS receiver, the C-Mariner uses the data to determine GNSS quality and tune the aiding filter. If a GST message is not received, the C-Mariner uses the GNSS Quality Indicator field from the GGA message to determine the quality of the GNSS position received. If a time mark is not received by the INS sensor, position accuracy will be degraded, especially in high dynamic conditions.

If the GNSS receiver changes modes as determined by the values contained in the GST message or mode indicated in the GGA message, the GNSS Quality Indicator field, the INS output GGA will show a corresponding change. For example, if the GNSS receiver mode changes from GNSS SPS mode to Differential GNSS, the INS sensor position and position uncertainty show a corresponding change.

When heading is resolved to 1.25 degrees, the C-Mariner is considered aligned and device outputs are set. Fifteen minutes after power-up, the sensor operates at full performance accuracy. Table 7 shows output data validity as a function of mode.

Output Word	Power -Up	Leveled	Aligned	Fault
ZDA	DS[1]	NORM[2]	NORM[2]	DS
GGA	DS	NORM[3]	NORM	DS
VTG	DS	INV	NORM	DS
GST	DS	NORM[3]	NORM	DS
THS	DS	INV	NORM	DS
HDT	DS	NULL	NORM	DS
TSS1	DS	NORM	NORM	DS
ROT	DS	INV	NORM	DS
STS	DS	NORM	NORM	NORM

Table 7: Output Message Validity

Please note:
Note 1. DS stands for don't send, INV stands for invalid, NULL stands for blank and NORM stands for normal operation
Note 2. ZDA transmitted only if ZDA and time mark are received from GNSS receiver.
Note 3. Outputs set to NORM if aiding information from GNSS received, otherwise NULL.

GNSS Input

The C-Mariner accepts up to two GNSS receivers. If a GST message is supplied by the GNSS receiver, the C-Mariner uses the data in the GST message to determine GNSS quality and tune the aiding filter. If a GST message is not received, the C-Mariner uses the GGA message GNSS Quality Indicator field to determine the quality of the GNSS position received. If a time mark (1PPS) is not received by the C-Mariner sensor, position accuracy will be degraded, especially in dynamic conditions.

If the GNSS receiver changes modes as determined by the values contained in the GST message or mode indicated in the GGA message GNSS quality indicator field, the INS (CM600) will show a corresponding change. For example, if the GNSS receiver mode changes from GNSS SPS mode to

Differential GNSS, the INU sensor position and position uncertainty show a corresponding change.

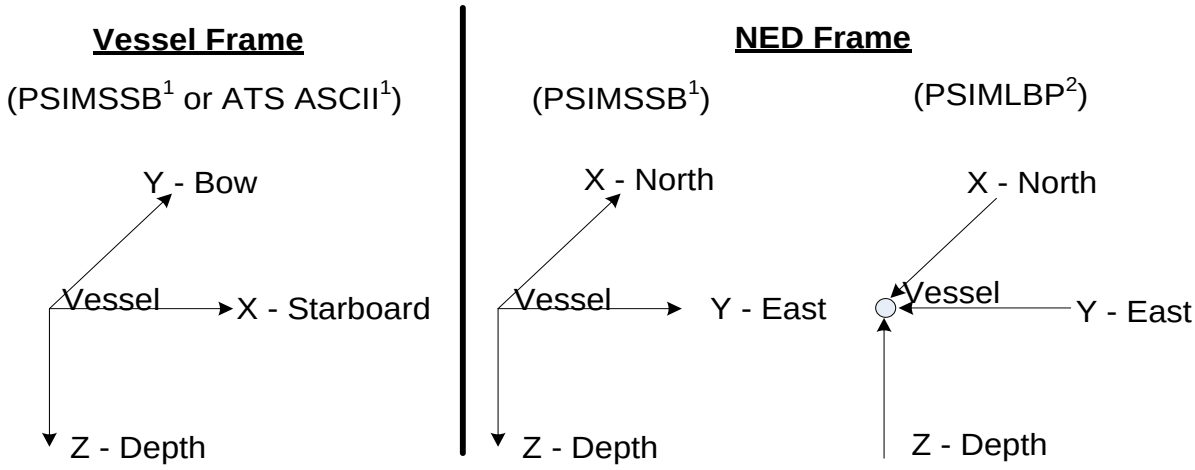
Acoustic Input

The C-Mariner accepts three types of acoustic message formats, PSIMSSB, ATS ASCII, and PSIMLBP. The maximum number of transponder IDs is dependent on the acoustic system selected. For USBL/SSBL, up to ten transponder ID positions can be accepted. For LBL, up to two reference points ID (arrays) positions can be accepted. Absolute acoustic positions are not supported at this time.

GNSS inputs will be required to perform initial calibration of the acoustic system. See Acoustic Calibration (Page 63) section for calibration details. After calibration is complete, subsequent power cycles will not require the GNSS inputs. Coordinate frames will either be in Vessel or North East Down (NED). ATS ASCII will only output in Vessel frame and PSIMLBP will only output in NED frame. PSIMSSB can output in either frame. Reference frames are defined in Figure 39.

If GNSS is removed from a calibrated acoustic system and the C-Mariner power is cycled, additional alignment time is required depending on the acoustic input messages received to enter Navigation mode. For NED input messages, the device will enter Navigation shortly after acoustic messages are received. For Vessel input messages, the device will enter Navigation after an extended gyro compass time of ~40 minutes to establish vessel heading. Once heading is established the device will enter Navigation mode.

The acoustic input messages need to have their time synced to the GNSS input message time. This is critical for C-Mariner performance in an acoustic environment.



Note 1: Measurements are distance from vessel to reference point
Note 2: Measurements are distance from reference point to vessel

Figure 39. Acoustic Input Coordinate Frames

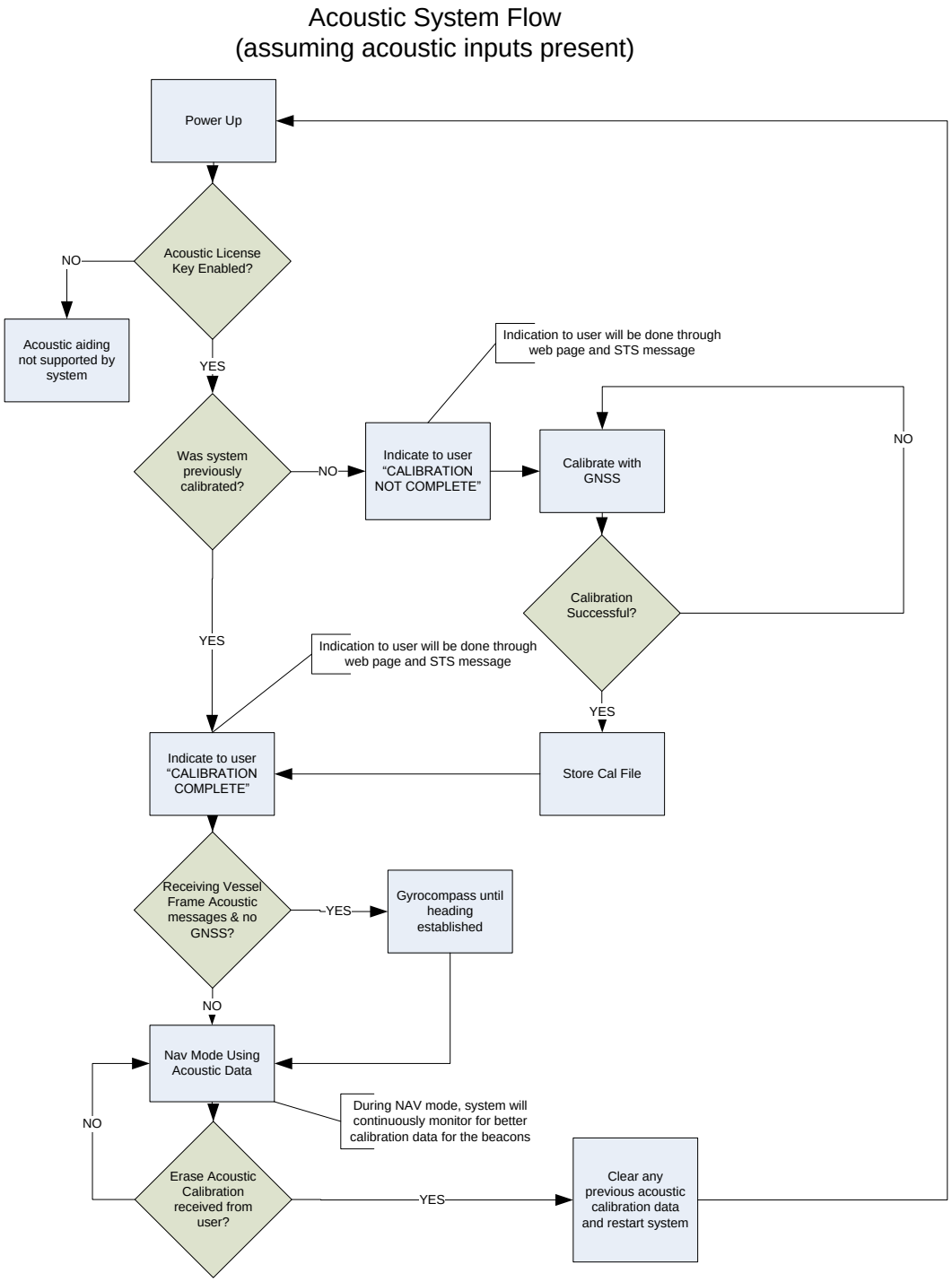


Figure 40: Acoustic System Flow Chart

Mode Transitions (CM600)

After Leveling Mode is completed, the C-Mariner will transition to Navigation Mode or Gyrocompass Mode as follows:

1. Navigation Mode is entered if GGA and VTG are received from GNSS receiver or an acoustic position is received. Note: For an acoustic system , this is assuming calibration has already been performed with GNSS inputs available to the C-Mariner.

2. Gyrocompass Mode is entered if VHW is received from a speed log.

3. If no aiding input is received for 30 seconds, the Gyrocompass Mode is entered and initialized assuming last stored latitude and velocity.

When in Navigation Mode, the sensor will transition to Gyrocompass Mode when both of the following conditions are met:

1. GGA and VTG or acoustic position is not received for 60 consecutive seconds.
2. Heading uncertainty is greater than 0.3 degrees.

When in Gyrocompass Mode, the sensor will transition to Navigation Mode within fifteen seconds of receiving GGA and VTG from the GNSS receiver or acoustic system, this is assuming calibration has already been performed with GNSS inputs available to the C-Mariner.

Shut Down / Loss of Power

When primary and secondary power is removed from the sensor, the sensor will shut down immediately. Position information is saved for use at the next power up.

Abnormal Operation

The following sections describe abnormal operation of the three devices that make up the C-Mariner family of products.

Loss of GNSS Aiding

GNSS aiding may be lost if the communication between the GNSS and the C-Mariner is disrupted or if the GNSS receiver output is rejected by the C-Mariner.

Please note:
If the entered lever arm values for GNSS to INS have large errors the GNSS data may be rejected.

Loss of communication between the GNSS receiver and the sensor is indicated by a “9” message in the GNSS 1 or 2 Aiding quality indicator field of the STS message. In the event that all GNSS communications is lost and the sensor is (CM600), the position output will drift. The accuracy of the position output may be determined from the GST message. If utilizing acoustic aiding and still available, the C-Mariner will at a minimum have position performance similar to the performance of the acoustic system.

Rejection (screening) of the GNSS receiver outputs is indicated by a “SCR#” (SCR1 if screening GNSS1, SCR2 if screening GNSS2) message in the On Occurrence Messages field of the STS message.

Further information on the state of the GNSS input is supplied on the ***GNSS Input Status*** page of the user interface, see Figure 23.

Loss of GNSS Time Mark

The time mark input may be used in any of the three C-Mariner configurations, but it is especially critical that this input be wired in the INS (CM600) configuration. Loss of time mark between the GNSS receiver and the C-Mariner is indicated by a “NOPPS#” (NOPPS1 if missing 1PPS from GNSS1, NOPPS2 if missing 1PPS from GNSS2) message in the On Occurrence Messages field of the STS message. Further information on the state of the 1PPS is supplied on the ***Data Input Status*** page of the user interface.

Loss of Acoustic Aiding

Acoustic aiding may be lost if the communication between the acoustic system and C-Mariner is disrupted or output is rejected by the C-Mariner.

When Acoustic aiding is lost, the position output will be dependent on the other aiding sources available. If GNSS is present, the C-Mariner will output position based on the hybrid (inertial / GNSS) solution and performance will be similar to the performance level of the GNSS. Without GNSS, the C-Mariner position output will drift to an uncertainty based on the inertial solution only. Similar to GNSS aiding, the C-Mariner will seamlessly switch in and out of acoustic aiding based on the input messages it receives. Acoustic aiding status can be found in the STS message defined in STS (Page 93).

Appendix A – NMEA0183 Messages

Input Messages

The C-Mariner accepts aiding inputs from a GNSS receiver, speed log, or acoustic system. If Dual GNSS is enabled via license key, then the C-Mariner can simultaneously accept two GNSS receiver inputs over two network ports and use both in its calculation. Each aiding source will have its own network port, configurable by the user, for communication with the sensor as shown in Figure 27.

The C-Mariner accepts several NMEA message inputs from a GNSS receiver The NMEA messages accepted are:

GGA	Global Positioning System Fix Data
VTG	Course Over Ground & Ground Speed
GST	GNSS Error Statistics
ZDA	Time and Date

Table 8: NMEA Input Messages

A minimum of GGA and VTG must be received from the GNSS receiver. If GST is received, these error estimates are used by the C-Mariner. If ZDA is received, the INS computes internal device time from ZDA and the time mark received from the GNSS receiver.

The C-Mariner accepts a single NMEA message input from a speed log. The message accepted is:

- Water Speed and Heading (VHW)

The C-Mariner accepts three types of NMEA message inputs from an acoustic system. The messages accepted are:

- USBL / SSBL Transponder Position Data (PSIMSSB)
- LBL Transponder Position Data (PSIMLBP)
- ATS ASCII

GNSS inputs will be required to perform initial calibration of acoustic system. After calibration is complete, subsequent power cycles will not require the GNSS inputs. Only the Cartesian coordinate system is supported.

GGA

```
          1            2            3   4              5 6 7 8  9      10 11    12 13 14   15
          |            |            |   |              | | | |  |      |  |     |  |  |    |
$--
GAA,hhmmss.sss,DDmm.mmmm,N,DDDmm.mmmm,W,x,xx,x.x,xx.xxx,M,xx.xxx,M,x.x,xxxx*hh
```

1	Time (UTC)
2	Latitude (Degrees, minutes decimal minutes)
3	N or S
4	Longitude (degrees, minutes decimal minutes)
5	E or W
6	GNSS Quality Indicator 0 = Fix not available or invalid 1 = GNSS SPS Mode, fix valid 2 = Differential GNSS, SPS Mode, fix valid 3 = GNSS PPS Mode, fix valid 4 = Real Time Kinematic. System used in RTK mode with fixed integers 5 = Float RTK. Satellite system used in RTK mode, floating integers 6 = Estimated (dead reckoning) Mode 7 = Manual Input Mode 8 = Simulator mode The GNSS Quality Indicator field shall not be a null field.
7	Number of satellites in use, 00-12
8	HDOP
9	Altitude MSL (geoid)
10	M: unit of measure for altitude is meters
11	Geoidal separation
12	M: unit of measure for geoidal separation is meters
13	Age of differential GNSS data record, Type 1 or Type 9. Null field when DGNSS not used.
14	Reference station ID, ranging from 0000 to 1023. A null field when any reference station ID is selected and no corrections are received.
15	Checksum

Table 9: GGA Message Input Format

Please note:

The C-Mariner uses fields 1 through 9. The other fields in GGA are not used.

.

VTG

```
                1  2 3   4 5  6 7 8 910
                |  | |   | |  | | | ||
$--VTG,x.x,T,x.x,M,x.x,N,x.x,K,a*hh
```

1	Course over ground
2	T: true
3	Course over ground
4	M: magnetic
5	Speed over ground
6	N: knots
7	Speed over ground
8	K: km/hr
9	Mode indicator: A = Autonomous D = Differential E = Estimated (dead reckoning) M = Manual input S = Simulator N = Data Not Valid
10	Checksum

Table 10: VTG Message Input Format

Please note:

The C-Mariner uses fields 1, 5, and 7. The other fields in VTG are not used.

GST

```
                1         2  3   4   5  6   7 8   9
                |         |  |   |   |  |   | |   |
$--GST, hhmmss.ss,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x*hh
```

1	Time (UTC)
2	RMS value of the standard deviation of the range inputs to the navigation process. Range inputs include pseudo ranges & DGNSS corrections.
3	Standard deviation of semi-major axis of error ellipse (meters)
4	Standard deviation of semi-minor axis of error ellipse (meters)
5	Orientation of semi-major axis of error ellipse (degrees from true north)
6	Standard deviation of latitude error (meters)
7	Standard deviation of longitude error (meters)
8	Standard deviation of altitude error (meters)
9	Checksum

Table 11: GST Message Input Format

Please note:

The C-Mariner uses fields 6 through 8. The other fields in GST are not used.

ZDA

```
          1            2 3  4    5  6 7
          |            | |  |    |  | |
$--ZDA,hhmmss.ss,xx,xx,xxxx,xx,xx*hh
```

1	Time (UTC)
2	Day, 01 to 31
3	Month, 01 to 12
4	Year
5	Local zone hours1, 00 to ± 13 hours
6	Local zone minutes, 00 to + 59
7	Checksum

Table 12: ZDA Message Input Format

Please note:

The C-Mariner uses fields 1 through 4. The other fields in ZDA are not used.

VHW

```
        1  23   4 5   67  89
        |  | |   | |   | |  | |
$--VHW,x.x,T,x.x,M,x.x,N,x.x,K*hh
```

1	Heading, degrees
2	T: true
3	Heading, degrees
4	M: magnetic
5	Speed through water
6	N: knots
7	Speed through water
8	K: km/hr
9	Checksum

Table 13: VHW Message Input Format

Please note:

The C-Mariner uses fields 5 and 6. The other fields in VHW are not used.

PSIMSSB

```
          1            2   3 4   5 6 7 8   9   10   11 12 13 14 15
          |            |   | |   | | | |   |   |   |   | |   |  |
$PSIMSSB,hhmmss.ss,aaa,a,aaa,a,a,a,x.x,x.x,x.x,x.x,a,x.x,x.x*hh
```

1	Time (Real time of measurement)
2	Transponder ID (e.g M00 to M99) Note: M-type Preferred, but will accept any.
3	Status (A = OK, V = not OK)
4	Error code (blank)
5	Coordinate system (C = Cartesian)
6	Orientation (H = Vessel heading up, N= North referenced)
7	SW Filter (M= Measured)
8	X Coordinate
9	Y Coordinate
10	Depth
11	Expected Accuracy
12	Additional Info (I = Inclinometer, N = Noe)
13	First add value (If “Additional Info = I”, this field is X inclination (roll) leaning starboard being positive, otherwise this field is empty)
14	Second add value (If “Additional Info = I”, this field is Y inclination (pitch) leaning forward being positive, otherwise this f Is empty)
15	Checksum

Table 14: PSIMSSB Acoustic Message Input

Please note:

The C-Mariner uses fields 1-3, 5, 6, 8-10.

PSIMLBP

```
          1            2   3   4 5 6   7   8   9 10  11  12   13
          |            |   |   | | |   |   |   |   |   |   |    |
$PSIMLBP,hhmmss.ss,nn,a_,a,a,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,*hh
```

1	Time (Real time of measurement)
2	Transponder ID (e.g 00 to 99) Only configured IDs will be accepted.
3	Type (Ve = Vessel)
4	Status (A = ok)
5	Coordinate system (C = Cartesian)
6	X Coordinate (Reference point to Vessel)
7	Y Coordinate (Reference point to Vessel)
8	Depth (+Z down Reference point to Vessel)
9	Major
10	Minor - Not used
11	Direction - Not used
12	Res_rms - Not used
13	Checksum

Table 15: PSIMLBP Acoustic Message Input

Please note:

The C-Mariner uses fields 1-9.

ATS ASCII

```
          1            2   3       4       5       6       7       8
```

| | | | | | | |
dd mmm yy hh:mm:ss B:d X:ddd.d Y:ddd.d D:ddd.d P:d.d R:d.d H:ddd.d

1	Date and time of receipt or the acoustic reply
2	Transponder Index (0 to 99)
3	X Coordinate in meters (Vessel Frame)
4	Y Coordinate in meters (Vessel Frame)
5	Depth in meters (Vessel Frame)
6	Ships pitch in degrees (Positive pitch is bow up ±9)
7	Ships roll in degrees (Positive roll is port up ± 9)
8	Ships heading relative to North in degrees (0-360)

Table 16: ATS ASCII Acoustic Message Input

Please note:

The C-Mariner uses fields 1-5.

Output Messages

The C-Mariner supports up to eight output channels. The output port numbers, messages, and message rates are configurable. Messages are NMEA-0183 compliant with the exception of the TSS1 message. C-Mariner default output messages and output rates are shown in Table 17.

Parameter	SG[3] (CM300)	AHRS[3] (CM400)	INS[3] (CM600)
Time & Date (**ZDA**)			1[2]
Positioning System Fix Data (**GGA**)			50
Course Over Ground & Ground Speed (**VTG**)			50
Error Statistics (**GST**)			50
True Heading and Status (**THS**)	50	50	50
Heading, True (**HDT**)	50	50	50
Pitch, Roll and Heave (**TSS1**)	50[1]	50	50
Rate of Turn (**ROT**)	50	50	50
Status (**STS**)	1	1	1

Table 17: Output NMEA Messages

Please note:

Note 1. No heave in CM300 TSS1 message.

Note 2. ZDA message not transmitted unless ZDA is received form GNSS receiver.

Note 3. Rate in Hz.

ZDA

```
          1              2 3 4    5 6  7
          |              | | |    | | |
$INZDA,hhmmss.sss,xx,xx,xxxx,xx,xx*hh
```

1	Time (UTC) *[See Note Below]*
2	Day, 01 to 31 *[See Note Below]*
3	Month, 01 to 12 *[See Note Below]*
4	Year *[See Note Below]*
5	Local zone description, 00 to +/- 13 hours (always 00)
6	Local zone minutes description, same sign as local hours (always 00)
7	Checksum

Table 18: ZDA Message Output Format

Please note:

Internal device time calculated from ZDA message and time mark received from GNSS receiver.

GGA

```
          1            2                  3 4                  5 6 7   8  9    10 11  12 13 14
          |            |                  | |                  | | |   |  |     |  |   |  |  |
$INGGA,hhmmss.sss,DDmm.mmmmmm,N,DDDmm.mmmmmm,W,x,xx,x.x,xxx.x,M,x.x,M,x.x,xxx

15
|
x*hh
```

1	Time (UTC)
2	Latitude (Degrees, minutes decimal minutes) [*Resolution set to 10e-6 minutes*]
3	N or S
4	Longitude (degrees, minutes decimal minutes) [*Resolution set to 10e-6 minutes*]
5	E or W
6	GNSS Quality Indicator 0 = No position calculation possible 1 = < 15m SD 2 = < 5 m SD 4 = < 0.5m SD 6 = Coasting SD of position > 15m
7	Number of satellites in use, echoed from GNSS GGA input
8	HDOP, echoed from GNSS GGA input
9	Altitude MSL (geoid) [*Resolution set to 10e-1 meters*]
10	M: unit of measure for altitude is meters
11	Geoidal separation, echoed from GNSS GGA input [*Resolution set 10e-1 meters*]
12	M: unit of measure for geoidal separation is meters
13	Age of differential GNSS data record, Type 1 or Type 9. echoed from GNSS GGA input
14	Reference station ID, ranging from 0000 to 1023. echoed from GNSS GGA input
15	checksum

Table 19: GGA Message Output Format

VTG

```
          1     2 3   4 5      6 7     8 9 10
          |     | |   | |      | |     |  | |
$INVTG,x.xxx,T,x.x,M,x.xxx,N,x.xxx,K,a*hh
```

1	Course over ground [*Resolution set to 10e-3 degrees*]
2	T: true
3	Course over ground, always null
4	M: magnetic
5	Speed over ground [*Resolution set to 10e-3 knots*]
6	N: knots
7	Speed over ground [*Resolution set to 10e-3 km/hr*]
8	K: km/hr
9	Mode indicator A = Valid; N = Data Not Valid
10	Checksum

Table 20: VTG Message Output Format

GST

```
          1            2 3  4  5  6  7  8 9
          |            | |  |  |  |  |  |  |
$INGST,hhmmss.sss,x.x,x.x,x.x,x.x,x.xx,x.xx,x.xx*hh
```

1	Time (UTC)
2	RMS value of the standard deviation of the range inputs to the navigation process. Range inputs include pseudo ranges & DGNSS corrections, always null.
3	Standard deviation of semi-major axis of error ellipse (meters), always null.
4	Standard deviation of semi-minor axis of error ellipse (meters), always null
5	Orientation of semi-major axis of error ellipse (degrees from true north), always null
6	Standard deviation of latitude error (meters) [*Resolution set to 0e-2 meters*]
7	Standard deviation of longitude error (meters) [*Resolution set to 10e-2 meters*]
8	Standard deviation of altitude error (meters) [*Resolution set to 10e-2 meters*]
9	Checksum

Table 21: GST Message Output Format

THS

Actual vessel heading in degrees true produced by any device or system producing true heading. This sentence includes a “Mode indicator” field providing critical safety related information about the heading data, and replaces the HDT sentence, which is found only in legacy systems.

```
        1    2 3
        |    | |
$HETHS,x.xxx,a*hh
```

1	Heading, degrees True [*Resolution set to 10e-3 degrees*]
2	Mode indicator: A = Valid V = Data not valid (including standby)
3	Checksum

Table 22: $THS Message Output Format

HDT

```
        1    2 3
        |    | |
$HEHDT,x.xxx,T*hh
```

1	True heading in degrees *[Resolution set to 10e-3 degrees]*
2	True
3	Checksum

Table 23: HDT Message Output Format

TSS1

```
1  2    345     678   9AB
|  |    |||     |||   |||
:XXAAAASMHHHHQMRRRRSMPPPP
```

1	Horizontal acceleration, always zero
2	Vertical acceleration, always zero
3	Space character.
4	Space if positive (up), minus if negative.
5	Heave, ASCII coded decimal, from -99.99 meters to +99.99 meters in units of centimeters. This field is zero if the LaserJet Marine is configured as an SG.
6	Status flag: ‘h’ = Data not valid; ‘H’ = Valid
7	Space if positive (port-side up), minus if negative.
8	Roll, ASCII coded decimal, from -90.99 degrees to +90.99 degrees.
9	Space character.
A	Space if positive (bow up), minus if negative
B	Pitch, ASCII coded decimal, from -90.99 degrees to +90.99 degrees.

Table 24: TSS1 Message Output Format

ROT

1 2 3

| | |

$HEROT,x.xx,A*hh

1	Rate of turn in degrees/minute. “-“ = bow turns to port *[Resolution set to 10e-2 degrees]*
2	Mode indicator: A = Valid; V = Data invalid
3	Checksum

Table 25: ROT Message Output Format

STS

1 2 3 4 5 6 7 8 9

| | | | | | | | | |

$PHSTS,xxx,x,xx.xx,x,x,x,x,xxxxxx*hh

1	Device Mode Indicator GYC = Gyrocompass Mode (CM300) AHS = Attitude Heading Reference System (CM400) INS = Inertial Navigation System (CM600) FLT = Fault.
2	Number of Aiding Sources received 0 = No Aiding Inputs 1 = 1 GNSS or EM Log, or Acoustics 2 =Two GNSS or one GNSS and Acoustics 3 = Two GNSS and Acoustics
3	Hearing Variance [Resolution set to 10e-2 degrees).
4	GNSS 1 Aiding Quality Indicator: 0 = No position calculation possible 1 = < 15m SD 2 = < 5 m SD 4 = < 0.5m SD 6 = Coasting SD of position > 15m 7 = Manual input Mode 8 = Simulator Mode 9 = No communication
5	GNSS 2 Aiding Quality Indicator: 0 = No position calculation possible 1 = < 15m SD 2 = < 5 m SD 4 = < 0.5m SD 6 = Coasting SD of position > 15m 7 = Manual input Mode 8 = Simulator Mode 9 = No communication Note: This field is blank if the Dual GNSS option is not enabled.
6	EM Log Aiding Quality Indicator 0 = no input 1 = Receiving speed through water
7	Acoustic Aiding quality indicator.

	0 = no acoustic data received 1 = Receiving configured acoustic data
8	On Occurrence Messages (if multiple, separated with a hyphen) ALG = Aligning SEC = On Secondary Power SCR1 = Screening measurements on GNSS1 or EM log SCR2 = Screening measurements on GNSS2 SCRA = Screening measurement on Acoustics NOPPS1 = No PPS (time mark) input for GNSS1 NOPPS2 = No PPS (time mark) input for GNSS2 NOINIT = for GYRO, no latitude; for AHRS or INS, no latitude and longitude NOACAL = Acoustics calibration not complete OK = No occurrence messages being reported Note: The GNSS2 related messages will be turned off if the Dual-GNSS feature is not enabled.
9	Checksum

Table 26: STS Message Output Format

Appendix B - Lever Arm Calibration

Introduction

One of the most important aspects of the installation is to get the lever arm values correct. Physically, the C-Mariner and the aiding GNSS antenna(s) cannot be located at the same position, therefore the distance between them must be accurately known. The lever arm is the distance between the datum and sensor, device, or output. The position that is calculated by the C-Mariner and the one that is calculated by the GNSS are different by the vector of the lever arm. The GNSS antenna is usually mounted on the highest point in the vessel such as the radar mast or the crown. This enables a clear view of the sky. The C-Mariner is located in the bridge or with existing attitude determination sensors.

All lever arms are entered relative to an arbitrary ***Datum*** point. The Datum point can be any point in the vessel which is convenient to measure to, both from the aiding inputs and the C-Mariner. It can be co-located with any of the aiding inputs, the C-Mariner, or the final output location.

For SG (CM300) and AHRS (CM400) configuration lever arm values are required if a GNSS sensor is connected for optimum accuracy.

The CM600 supports several sets of lever arms: (see Figure 31).

1. **Datum to Device (INS unit)**
2. **Datum to Output**
3. **Datum to GNSS Receiver #1**
4. **Datum to GNSS Receiver #2**
5. **Datum to Acoustics**

There are two methods to calculate the lever arms:

1. **Dimensional Survey:** This requires performing a survey with precision surveying equipment to all sensor's and datum position points to within 1-sigma of GNSS aiding inputs (better than 5 cm).

2. **Automatic Lever Arm Calibration Option:** This method calculates the lever arm between the C-Mariner and up to two GNSS antennas (if the Dual GNSS input is enabled). This calibration can only be done at sea. The vessel needs to be able to rotate 90, 180, or 360 degrees at 30-40 deg / min. This is the most common method used because the calibration

is embedded with the C-Mariner software and it constantly refines the lever arm values.

Please note:
Automatic lever arm only determine the distance between the device and the aiding sensors. It does not determine distances to any other point e.g. datum or output.

Sign Convention

It is very important to understand the C-Mariner sign convention before entering any parameters to the lever arm configuration pages.

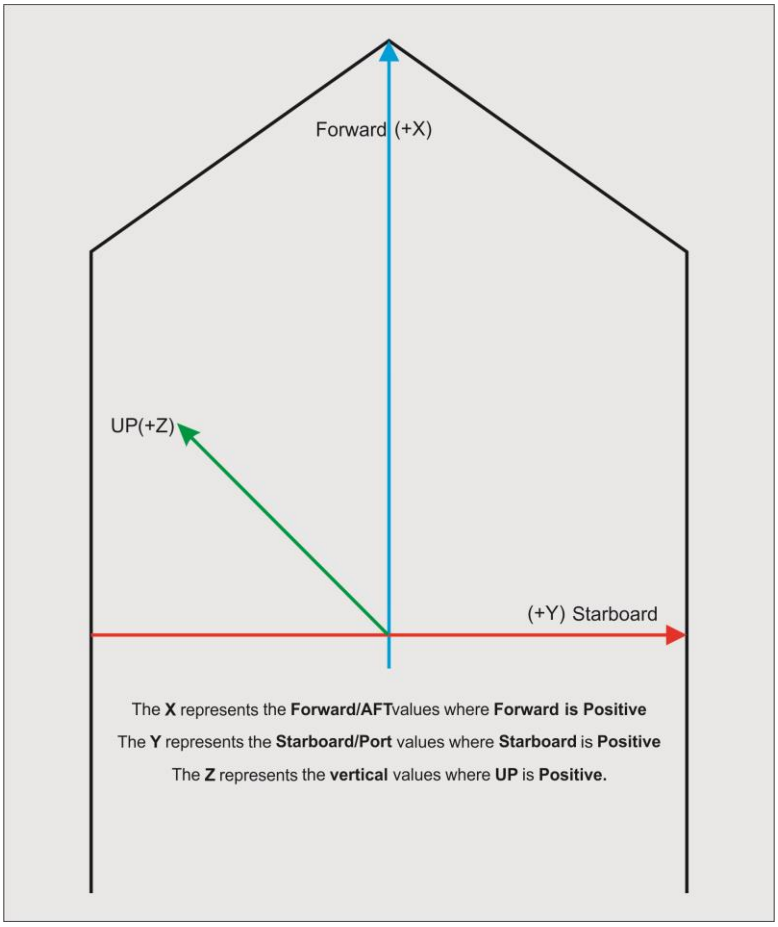


Figure 41: C-Mariner Sign Convention

Lever Arm Using Method 1

After a dimensional survey is performed and all the points are gathered it is important to enter the values correctly to the configuration page. The following practical example will guide the user on how to enter all parameters using a theoretical survey values as shown in Table 27. In this practical example a C-Mariner is using two aiding GNSS inputs. The datum is selected as the CoG (center of gravity) of the vessel and an output point was selected to demonstrate all possible lever arm scenarios. All measurements are from the Datum.

Location	Y = Across-ship	X = Along-ship	Z = Height
Datum	0m	0m	0m
GNSS 1	-15m	-10m	30m
GNSS 2	-5m	30m	20m
Device	10m	20m	5m
Output	15m	-5m	1m

Table 27: Example 1 lever arms

These figures represent the values that should be entered into the configuration page.

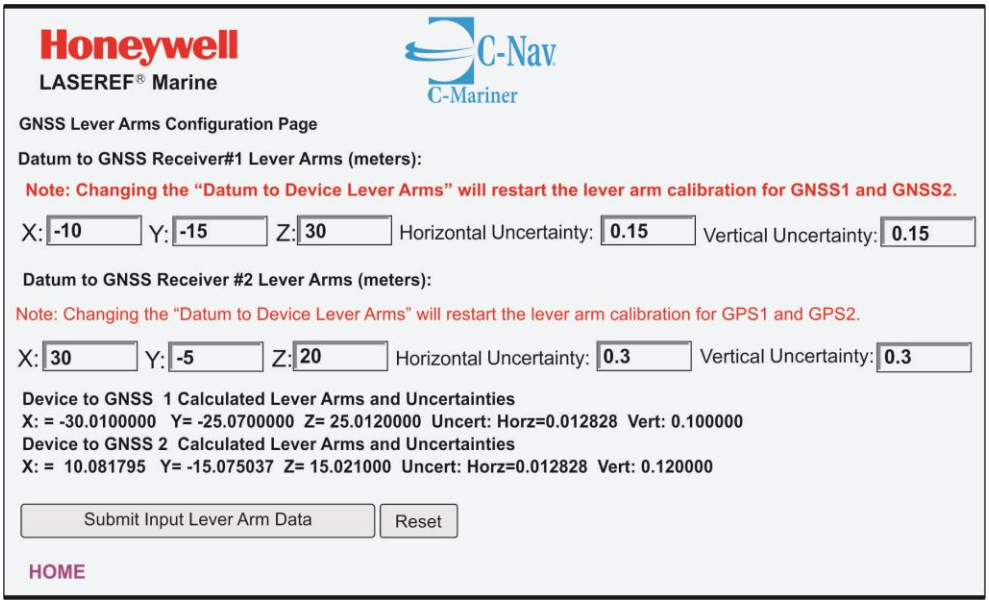


Figure 42: GNSS Lever Arm Configuration Page

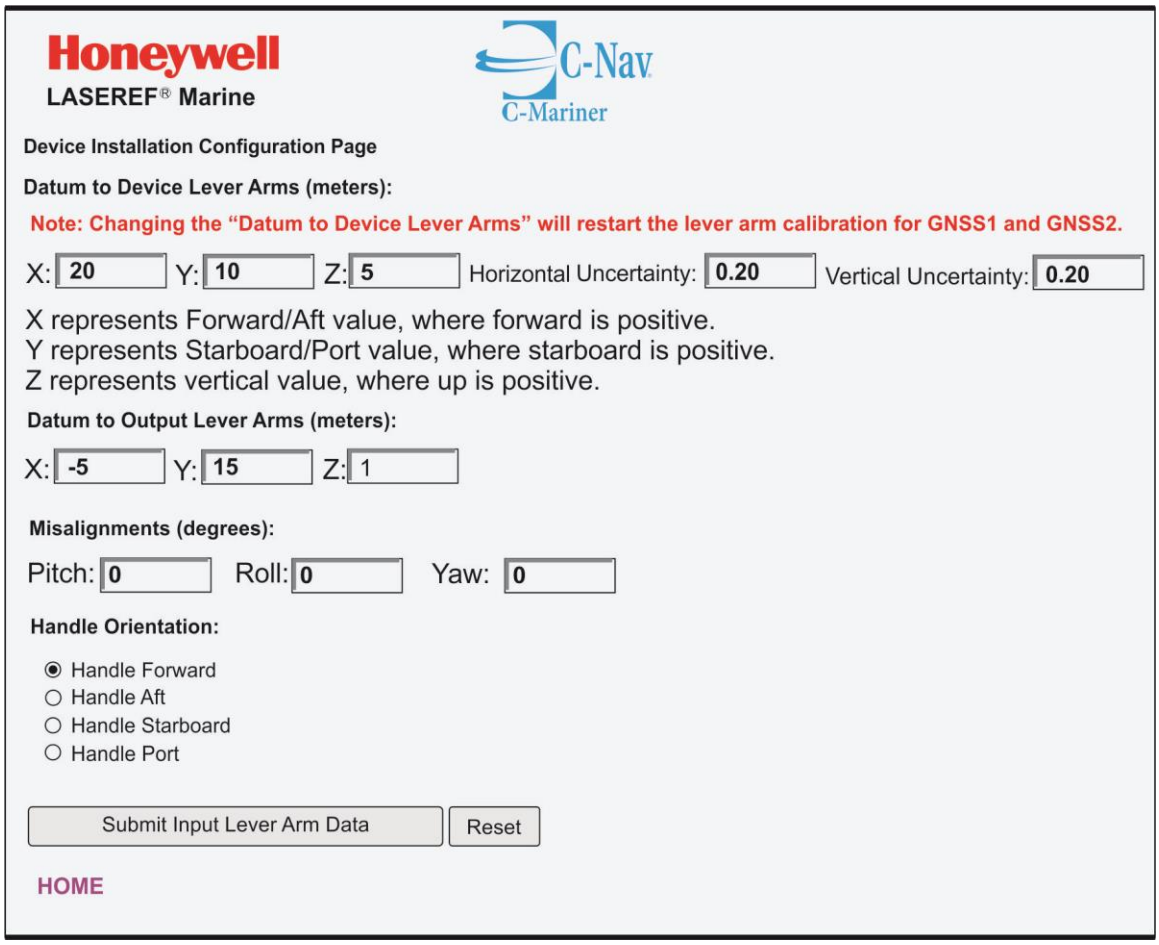


Figure 43: Device Installation Configuration Page

This introduces two new terms, the *Horizontal* and *Vertical Uncertainties*. Uncertainty here means the maximum expected error in the measurement. The Horizontal represents the highest uncertainty from the X and Y values entered. The Vertical represents the uncertainty value from the Z values entered. C-Mariner will use these uncertainty values when determining if a GNSS position will be used to aid the INS solution, or reject it i.e. *screened*. Should the uncertainty values been underestimated then GNSS screening will occur on a continuous or regular basis.

In this example the uncertainties are very small because the survey points used are very accurate, which results in a high confidence level in the lever arms.

The values entered into the ***GNSS Lever Arm Configuration*** page and

Device Installation Configuration page reflect the physical location of the antennas; the INS device itself and an output that signifies another point of interest where positional data is required - ROV launch table for example.

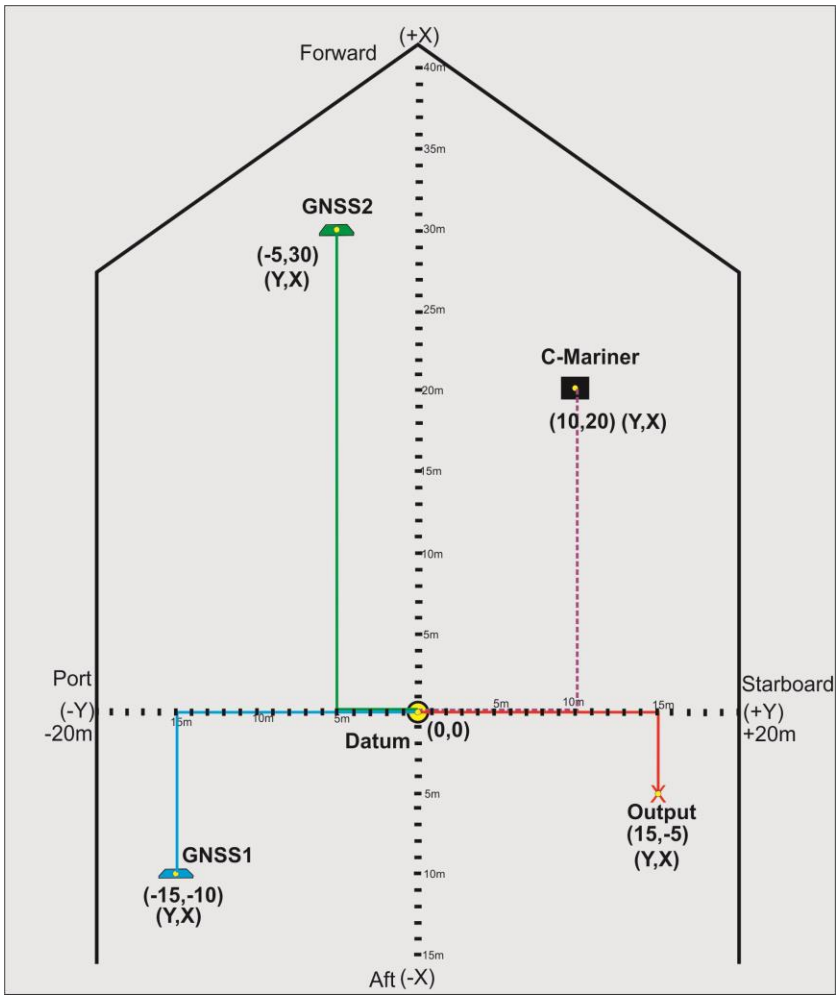


Figure 44: Representation of the GNSS, Device, Datum and Output location

After the lever arm values are submitted and the unit re-started the C-Mariner embedded software will internally calculate the distance from each GNSS antenna to the C-Mariner Figure 45.

Following the calculation of its own position the C-Mariner will adjust the position to the output (which it this example is at Y=15m, X=-5m). If the values entered at the“Datum to output” were all zeros, then the position will adjust to the Datum (CoG). The C-Mariner internally will calculate and utilized the lever arms vector distance between the Device and the GNSS receivers.

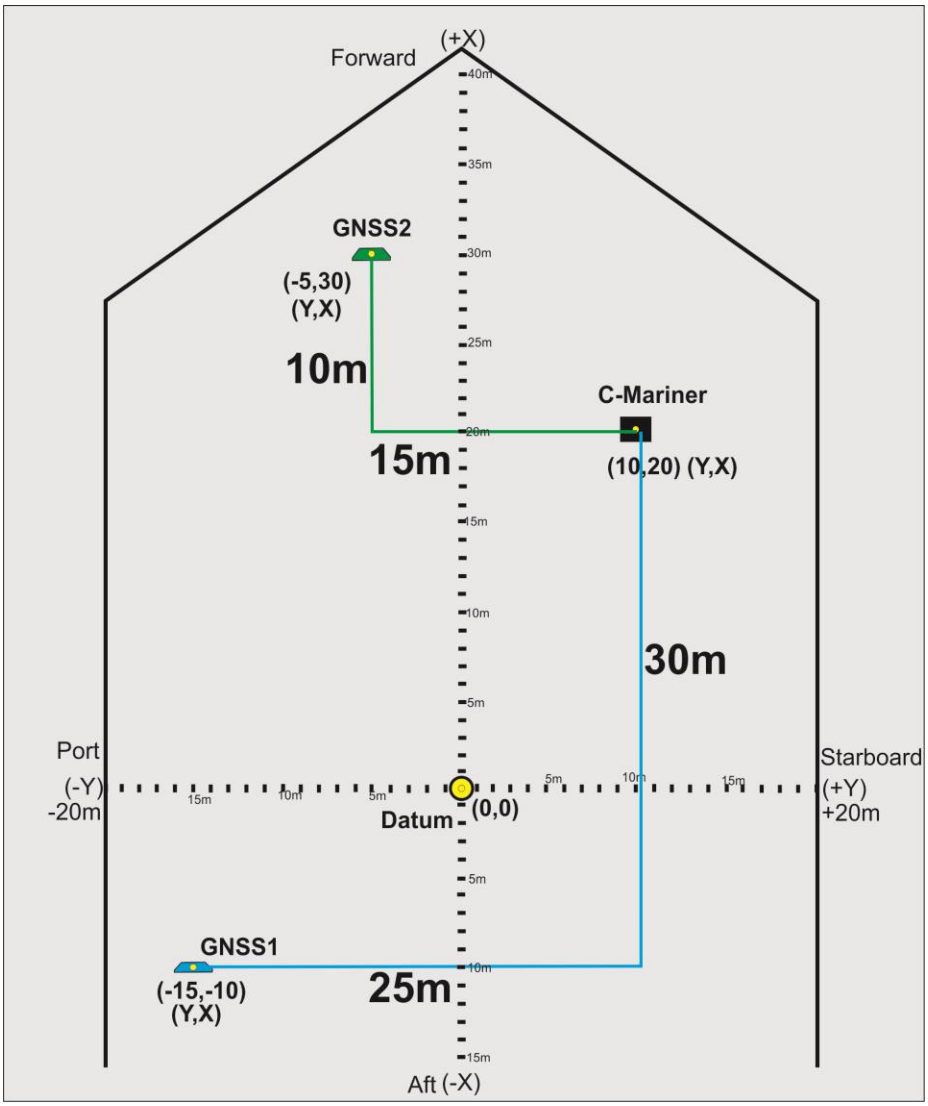


Figure 45: Internal Calculated Lever Arms Representation Diagram

If the measured values entered on the configuration pages are wrong, then when the vessel makes any heading changes the C-Mariner will screen the GNSS position values, providing “SCR1 or SCR2” flag on the occurrence message. If the values are entered correctly, then when the vessel makes any heading changes the C-Mariner will report an “OK” flag on the occurrence field message of the (PHSTS).

Lever Arm Using Method 2

The most practical method to use is the Automatic Lever Arm Calibration. This is an optional license that allows the CM600 to perform precise lever arm calibration between the C-Mariner and its aiding inputs. This is achieved by entering measured distances (in meters) between the aiding sensors and the device as well entering some uncertainties of the measured values. This calibration must be performed at sea because it requires some dynamics (heading changes) to allow the software to calculate the precise lever arm values between the GNSS and the C-Mariner.

This method is particularly useful where the INS is added to an existing DP system. Most DP systems have a calibration process for positioning sensors which is done at the time of system commissioning. This process minimizes the effect of any measurement errors in the positions of the original sensors. The best way to add a new sensor such as INS is to be able to relate the new sensor position accurately to an existing sensor position, which the existing DP system refers to. In practice we try and place one of our GNSS aiding antennas within a few meters of an existing “calibrated” antenna. In this way it’s easy to determine what to enter to the DP system for the INS sensor location.

The following example shows how the automatic lever arm works.

The Datum will be located at the same position as GNSS1, as this is closest to a known DP referenced antenna.

Location	X = Along-ship	Y = Across-ship	Z = Height
Datum	0m	0m	0m
GNSS1	0m	0m	0m
GNSS2	40m	10m	15m
Device	30m	25m	-68m

Table 28: Measured Lever Arms

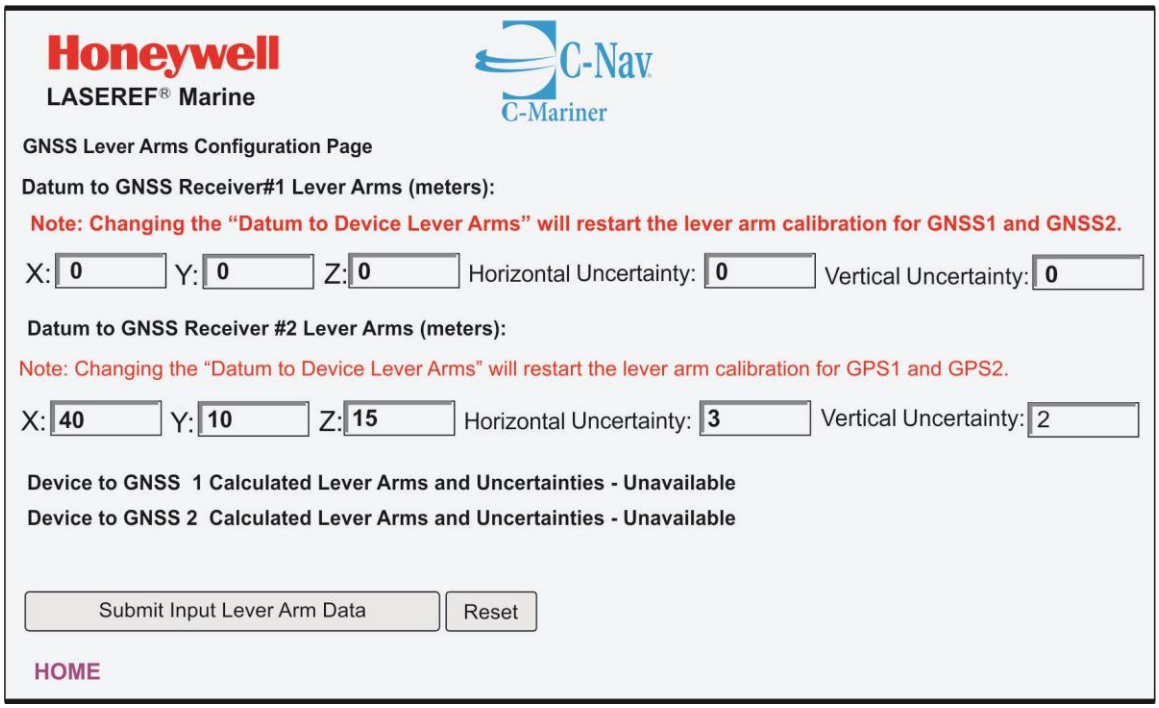


Figure 46: GNSS Lever Arm Configuration Page

The Datum location in this example was selected at the same point as of the GNSS1 antenna; therefore zeros were entered to the Datum to GNSS Receiver #1 Lever Arms. The Horizontal and vertical uncertainties were left at zero as well because no values were entered for X, Y, and Z therefore no uncertainties are needed.

Measured values were entered at ***Datum to GNSS Receiver #2 Lever Arms***. It is better to overestimate the uncertainties than underestimate because there is a risk if the uncertainties don't cover for the error, then the C-Mariner might screen the GNSS values.

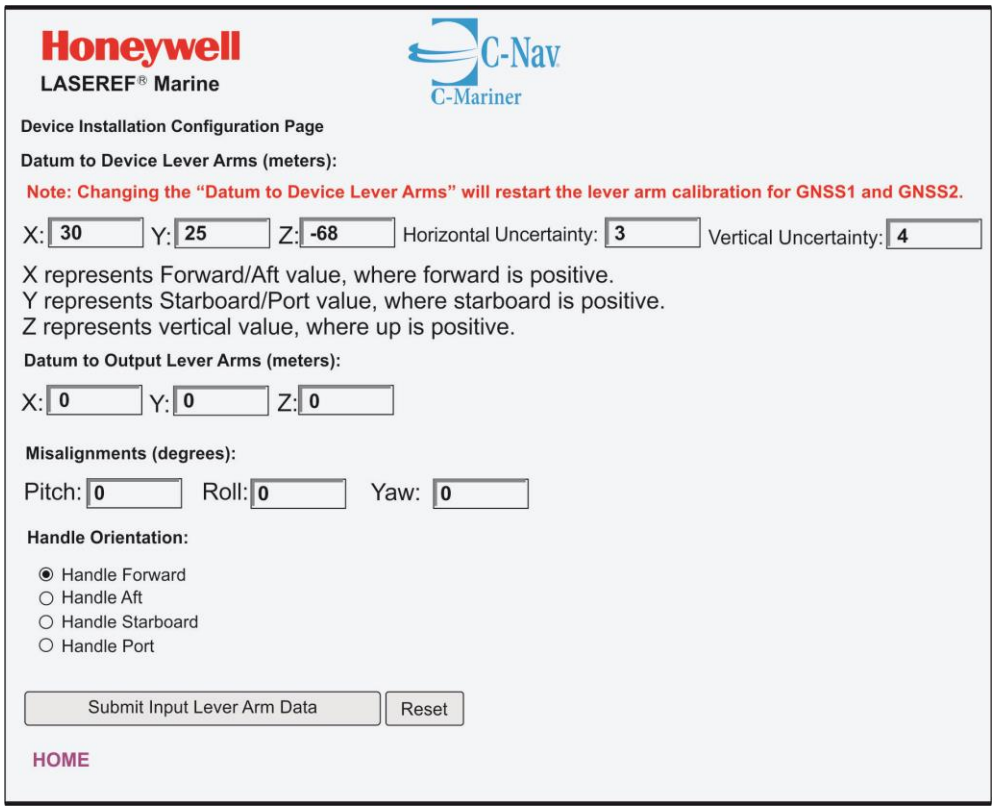


Figure 47: Device Installation Configuration Page

The values entered within Datum to Device Lever Arms are the measured distance between the device and the datum (GNSS#1 antenna). A horizontal uncertainty of 3 meters was entered to cover for the maximum expected error in the measurement of X and Y. A vertical uncertainty of 4 meters was entered to cover for the height error.

No additional output is being used in this example, therefore the fields are left as 0.

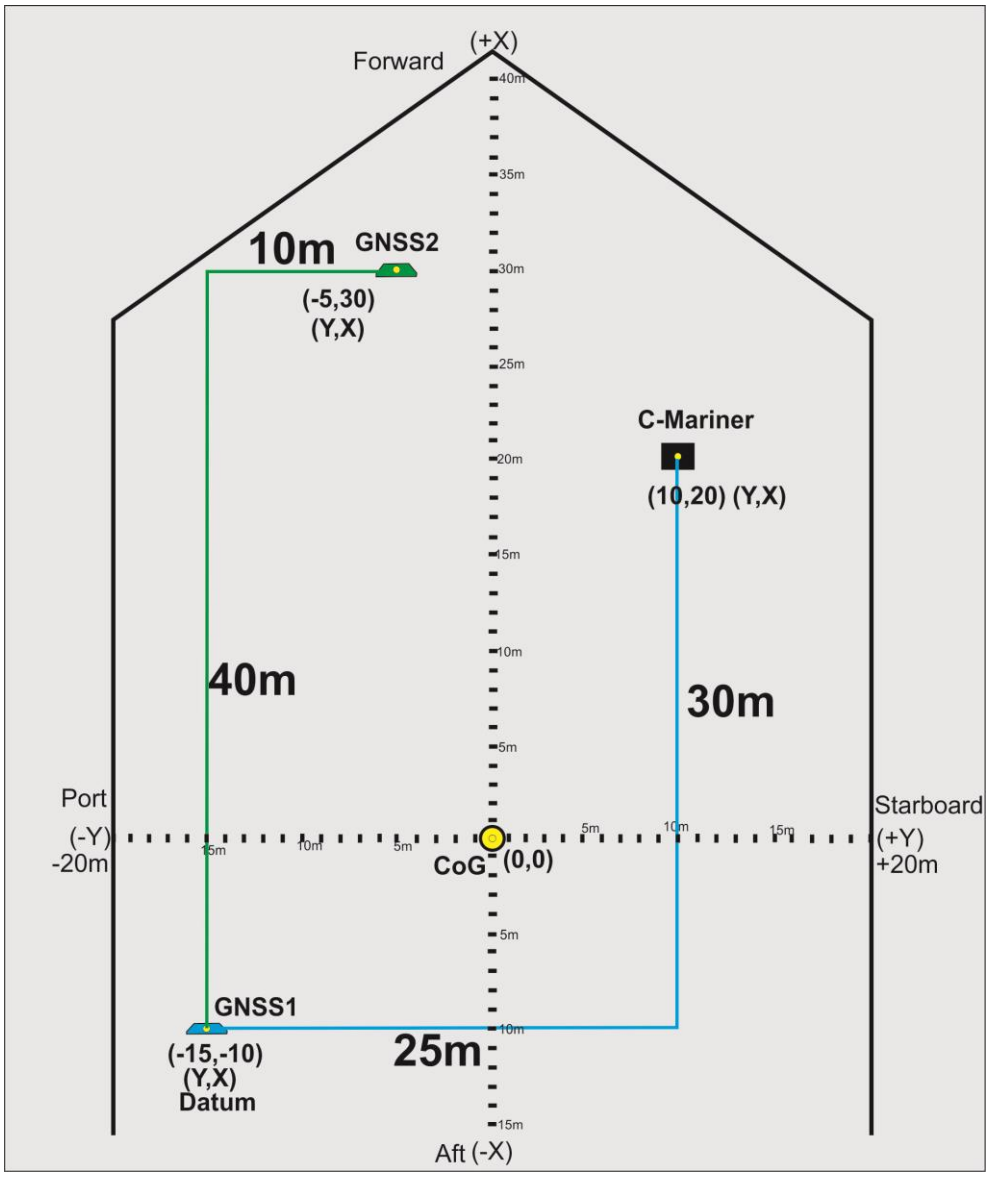


Figure 48: Representation of entered values

Find below step by step instructions of how the above values are entered during installation and Calibration of an INS system:

1. Select the aiding input antenna that is closest to a DP known point as the Datum. In this example GNSS1 antenna was selected as the Datum because is the closest to the CoG of the vessel.

2. On the ***Home*** page click at the ***GNSS Lever Arms***, enter zeros on

the *Datum to GNSS Receiver #1 Lever Arms because GNSS1 has been selected as the Datum.*

3. Enter measured values for GNSS#2 and uncertainties (see Figure 45)

4. Save values by pressing the **Submit GNSS Lever Arms Data**.

5. Exit page by clicking at ***Home***.

6. Clicking at the Device Installation page, enter measured values to the *Datum to Device Lever Arms* and uncertainties. No values need to be entered on the *Datum to Output Lever Arms* at this moment**.** Confirm that *Handle Orientation* is selected correctly. Press the **Submit Configuration Data** to save the values and exit the page by clicking ***Home***.

7. Click the **Restart System** button on the home page.

8. Monitor the heading variance on the CM145 interface until is below 0.1 deg. At this time the C-Mariner starts the automatic calibration internally.

9. Rotate the vessel at 35-40 degrees per minute. It could be a continuous 360° or ±90° or ±180° rotations. This process might take up to 1-3 hours, depending on the dynamics and the uncertainties entered. The calculated values and uncertainties can be observed by going to the GNSS Lever Arms page.

10. Observe the calculated values displayed at the bottom of the ***GNSS Lever Arms Configuration*** page (see Figure 49).

11. Press **F5** to your configuration PC to refresh the page.

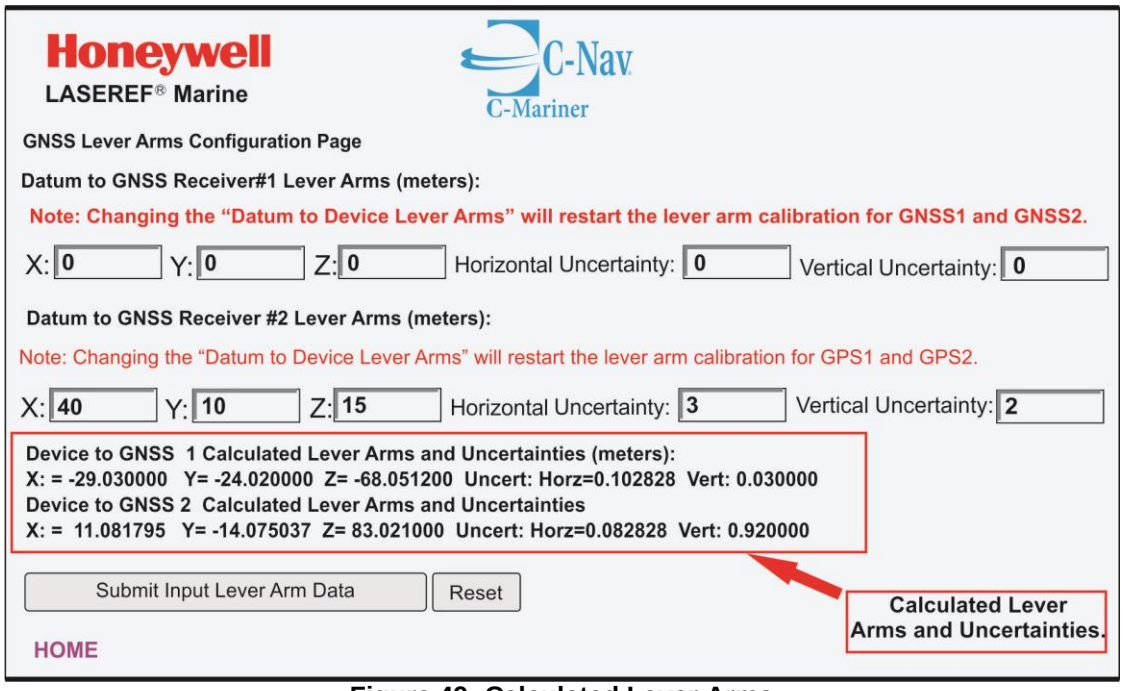


Figure 49: Calculated Lever Arms

When the uncertainties values are around 0.2m, the vessel can stop rotating. The automatic lever arm filter will continue to refine these values over the normal heading changes of the vessel.

Please note:

The measured lever arm values entered did not change. The result of the automatic calibration is displayed at the bottom of the ***GNSS Lever Arms*** page.

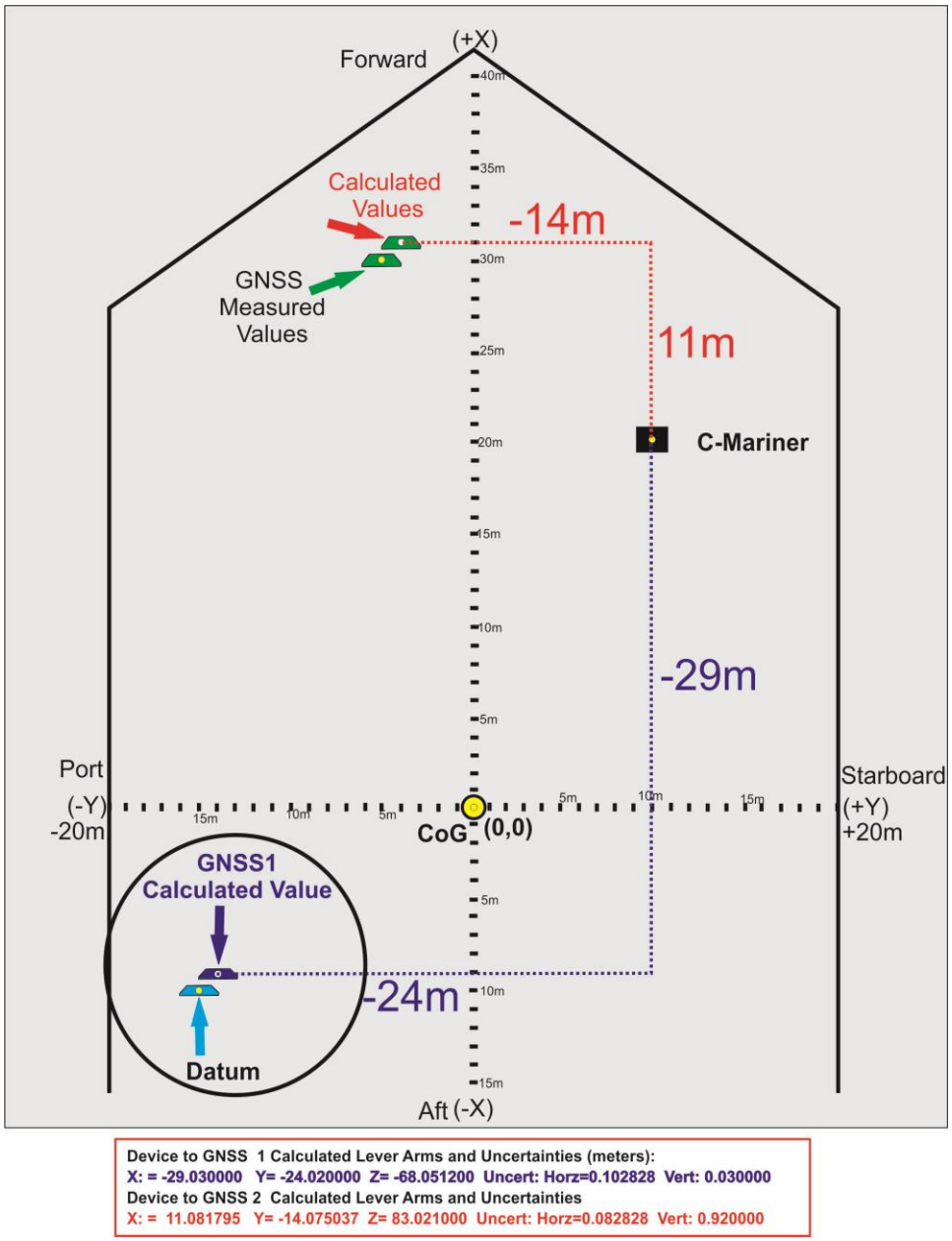


Figure 50: Calculated - Measured Lever Arms

Please note:

The final result of the automatic calibration returns the calculated distance (lever arm) between the Device (INS) and the GPS antenna locations see Figure 50. This information is used to translate the aiding position to the device location internally.

The result reveals the physical location of GNSS1 and GNSS2 antennas different

from the measured values. This puts the Datum off from the GNSS1 location. In order to correct this it is necessary to compensate the error and put back the Datum to the same location as GNSS1. No action has to be done with the GNSS2 as it is not associated with the datum.

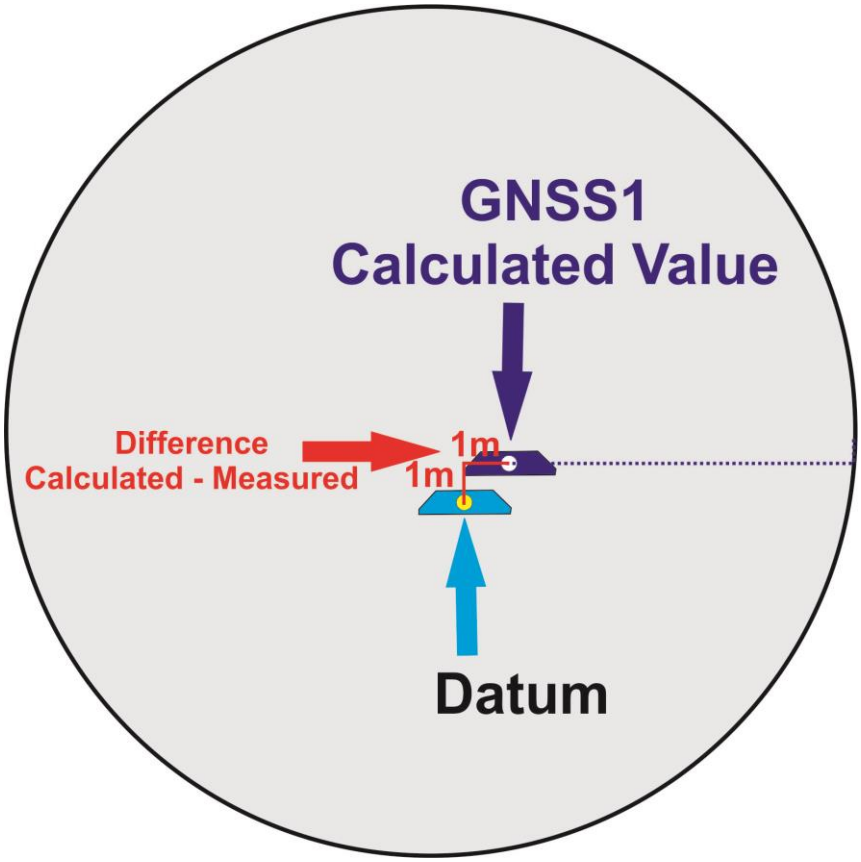


Figure 51: Zoomed to Calculated - Measured Difference

In order to move the Datum to the GNSS location it is necessary to obtain the difference between the Measured and Calculated values.

Measured Values for Datum to Device Lever Arms.

- X: 30m, Y: 25m, Z: -68m

Calculated values generated by Automatic Lever Arm for Device to GNSS1 Lever Arms:

- X: -29.0m, Y: -24m, Z: -68m

The difference is: X**:** 1m Y: 1m Z: 0m

The offset values need to be entered at the Device Installation Page at Datum to Output Lever arms fields. This will put back the Datum to the same physical location of the GNSS#1. Press Submit and re-start the unit.

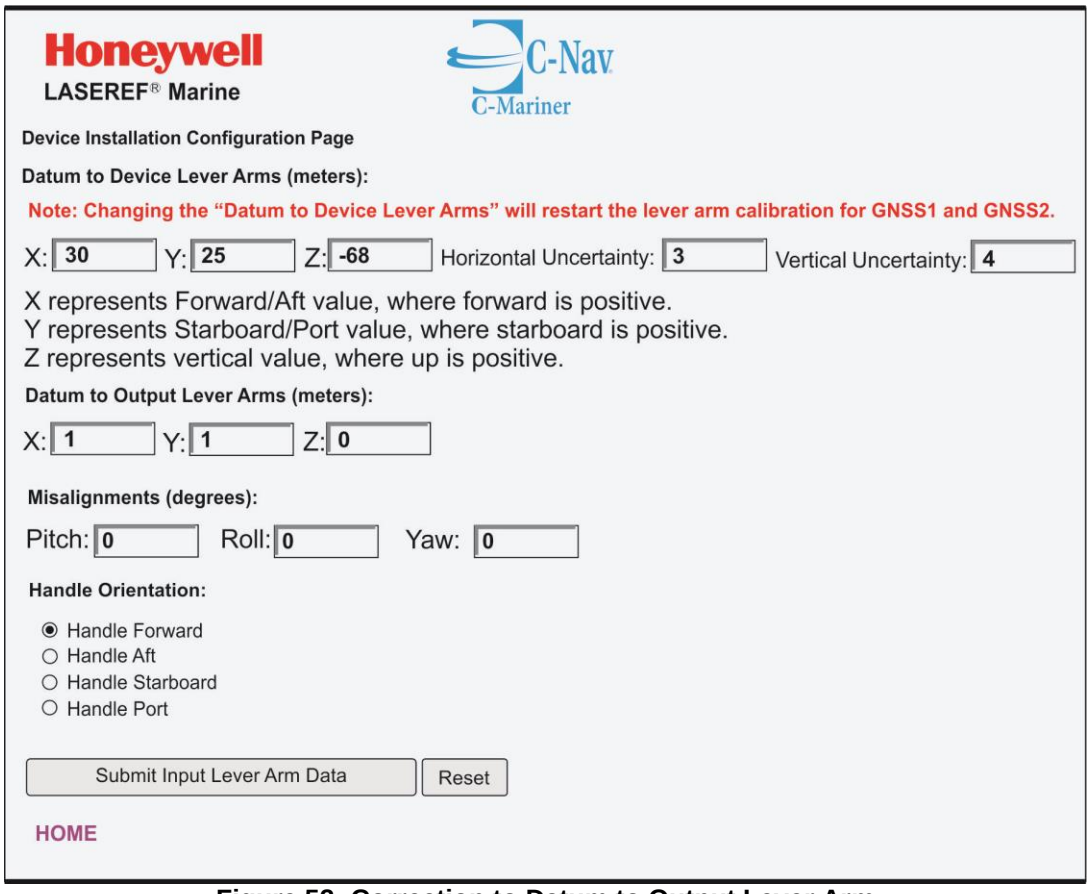


Figure 52: Correction to Datum to Output Lever Arm

Now the Datum is referenced back to the same position as the GNSS#1 and the C-Mariner can output the position at the correct location.

The next step is to measure an offset between the GNSS1 antenna and the reference (datum) location used by the DP Console. The easiest way is to measure an offset between the C-Nav GNSS1 antenna and a known antenna already calibrated and used by the DP system. Provide this offset to the DPO or the DP manufacture software engineer.

This concludes the automatic lever arm calibration process.

Appendix C – I/O Pin Description

Pin	Pin Name	Type	Pin	Pin Name	Type
1	Primary + 28 VDC	Power Input	29	Reserved	
2	Primary/Secondary Power Return	Common	30	Reserved	
3	Secondary + 28 VDC	Power Input	31	Reserved	
4	Common Ground	Ground	32	Reserved	
5	Ethernet RX+	Ethernet	33	Fault Discrete Output	Discrete Output Open/Ground
6	Ethernet TX+	Ethernet	34	Reserved	
7	Ethernet RX-	Ethernet	35	Reserved	
8	Ethernet TX-	Ethernet	36	Reserved	
9	Chassis Ground		37	Reserved	
10	Reserved		38	Reserved	
11	Reserved		39	Reserved	
12	On Secondary Discrete Output	Discrete Output open/Ground	40	Reserved	
13	Reserved		41	Ethernet Shield	Ground
14	Reserved		42	Reserved	
15	Reserved		43	Reserved	
16	Reserved		44	Reserved	
17	Reserved		45	Reserved	
18	Reserved		46	Reserved	
19	Reserved		47	Reserved	
20	Network Configuration Reset	Discrete Input	48	Not Used	N/A
21	Reserved		49	GNSS Channel 2 Time Mark Input Bus A	Digital RS422 Input Bus
22	Reserved		50	GNSS Channel 1 Time Mark Input Bus A	Digital RS422 Input Bus
23	Reserved		51	Reserved	
24	Reserved		52	Reserved	
25	Reserved		53	N/A	
26	Reserved		54	GNSS Channel 2 Time Mark Input Bus B	Digital RS422 Input Bus
27	Reserved		55	GNSS Channel 1 Time Mark Input Bus B	Digital RS422 Input Bus
28	Reserved				

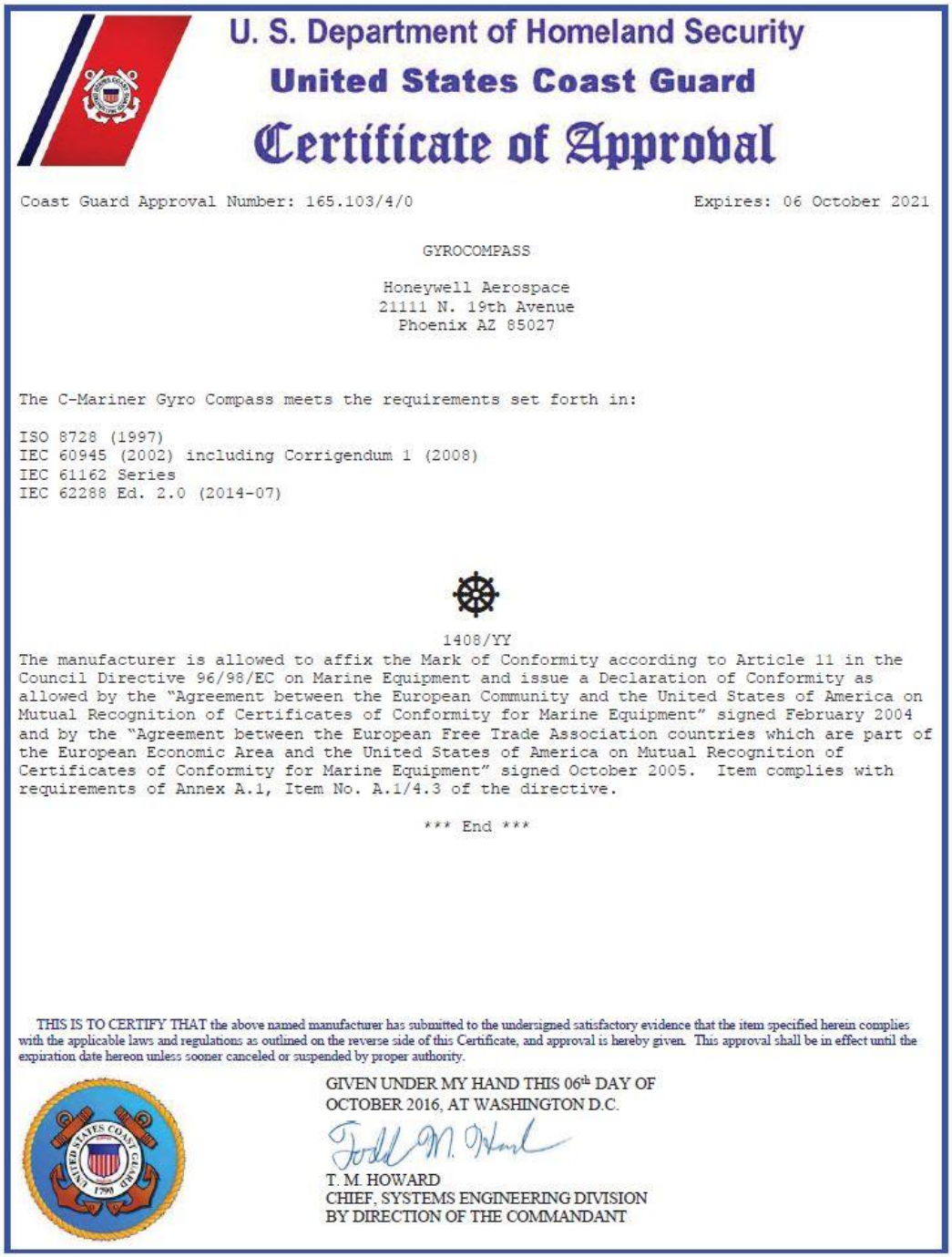
Table 29: C-Mariner Output/Input Pin Description

Appendix D – Performance & Testing Standards

Test Method	ISO 16328 (Para. Number)	ISO 8728 (Para. Number)	IEC 60945 (Para. Number)
Settling Time test	6.2	6.2	
Settle-point-error test	6.3	6.3	
Settle-point-heading repeatability test	6.4	6.4	
Settling time on a Scorsby table	6.5	6.5	
Scorsby test	6.6	6.6	
Intercardinal motion test	6.7	6.7	
Speed error correction test	6.9	6.9	
High Temperature Operation, Low Temperature Operation and Cold Start Temperature	6.10.5	6.10.4	8.2 and 8.4
Extreme Power Supply Variation (Retlif Testing Laboratories)			10.7
Vibration, Sinusoidal	6.10.4	6.10.3	8.7
Damp Heat	6.10.6	6.10.5	8.3
Acoustic Noise Measurements	6.10.7 (d)	6.10.6 (d)	11
Voltage Variation	6.10.2	6.10.1	
Conducted Emissions			9.2
Conducted Immunity			10.3
Voltage Dips & Interruptions (VDI)			10.8
Electrostatic Discharge (ESD)			10.9
Electrical Fast Transients and Bursts (EFT)			10.5
Radiated Emissions			9.3
Extreme Power Supply Variation (Northwest EMC)			10.7
Radiated Immunity			10.4
Corrosion (Salt Mist)			8.12

Table 30: C-Mariner Performance and Testing Standards

Appendix E – United States Coast Guard Certificate



U. S. Department of Homeland Security
United States Coast Guard

Certificate of Approval

Coast Guard Approval Number: 165.103/4/0 Expires: 06 October 2021

GYROCOMPASS

Honeywell Aerospace
21111 N. 19th Avenue
Phoenix AZ 85027

The C-Mariner Gyro Compass meets the requirements set forth in:

ISO 8728 (1997)
IEC 60945 (2002) including Corrigendum 1 (2008)
IEC 61162 Series
IEC 62288 Ed. 2.0 (2014-07)

1408/YY

The manufacturer is allowed to affix the Mark of Conformity according to Article 11 in the Council Directive 96/98/EC on Marine Equipment and issue a Declaration of Conformity as allowed by the "Agreement between the European Community and the United States of America on Mutual Recognition of Certificates of Conformity for Marine Equipment" signed February 2004 and by the "Agreement between the European Free Trade Association countries which are part of the European Economic Area and the United States of America on Mutual Recognition of Certificates of Conformity for Marine Equipment" signed October 2005. Item complies with requirements of Annex A.1, Item No. A.1/4.3 of the directive.

*** End ***

THIS IS TO CERTIFY THAT the above named manufacturer has submitted to the undersigned satisfactory evidence that the item specified herein complies with the applicable laws and regulations as outlined on the reverse side of this Certificate, and approval is hereby given. This approval shall be in effect until the expiration date hereon unless sooner canceled or suspended by proper authority.

GIVEN UNDER MY HAND THIS 06th DAY OF OCTOBER 2016, AT WASHINGTON D.C.

T. M. HOWARD
CHIEF, SYSTEMS ENGINEERING DIVISION
BY DIRECTION OF THE COMMANDANT