ComNav® marine ltd
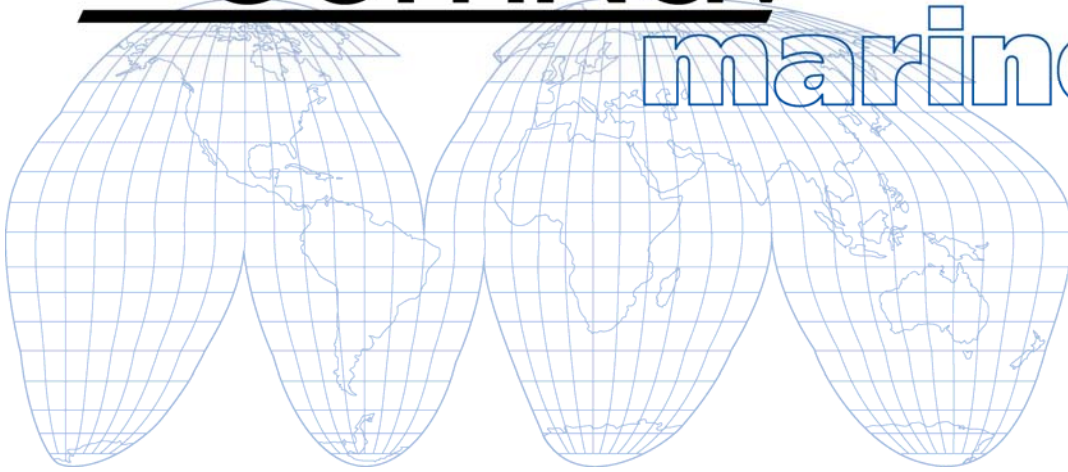
G2 & G2B

GPS Satellite Compasses

Installation & Operation Manual

ComNav

CE

COMPLIES WITH
CE REGULATIONS

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Copyright Notice

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Overview

Figure 1-1: G2 side view

Note: When referring to both the G2 GPS Satellite Compass and the G2B GPS Satellite Compass this manual uses the term G2/B. When referring to either product this manual uses either G2 or G2B, respectively.

The G2/B is a complete GPS Satellite Compass and positioning system in a single enclosure that requires only one power/data cable connection. With its NMEA 2000 support and ease of installation, the G2/B is the perfect solution for marine applications.

The G2/B is an integrated system that houses the following:

- Dual GPS antennas
- DGPS beacon module and H-field beacon antenna (G2B only)
- Power supply
- Single axis gyro
- Tilt sensor on each axis (X and Y axes)

The gyro and tilt sensors are present to improve system performance and to provide backup heading information in the event that a GPS heading is not available due to signal blockage.

Note: The G2 GPS Satellite Compass is identical to the G2B GPS Satellite Compass with the exception that it does not contain a DGPS beacon module and antenna. If you purchased the G2 GPS Satellite Compass, disregard the sections of this manual that discuss the beacon signal, receiver operation, and implications to installation relating to the beacon signal.

The G2 GPS Satellite Compass supports multiple RF front ends - enabling tighter coupling of measurements from separate antennas for use in heading-based products. Users will achieve excellent accuracy and stability due to the more accurate code phase measurements, improved multi path mitigation, and fewer components.

The G2/B's GPS antennas are separated by 50 cm between their phase centers, resulting in 0.5° rms heading performance. The G2/B provides heading and positioning updates of up to 20 Hz and delivers positioning accuracy of 1.0 m 95% of the time when using differential GPS corrections from beacon (G2B only) or from Space Based Augmentation Systems (SBAS).

The G2/B also features technology that enables ComNav GPS Satellite receivers to utilize old differential GPS correction data for 40 minutes or more without significantly affecting the positioning quality. The G2/B is less likely to be affected by differential signal outages due to signal blockages, weak signals, or interference.

Parts List

Note: The G2/B's parts comply with IEC 60945 Section 4.4: "exposed to the weather."

Table 1-1 lists the parts included in your G2/B kit.

Table 1-1: Parts list

Part Name	Qty	Part Number
G2 receiver or G2B receiver	1 1	21210002 or 21210005
Power/data cable, 15 m or Power/data cable, 30 m (Accessory item) Kit containing the following: • Clamp • Screw • Washer	 1 1 1 1	31110055 31110056 31210015

Vector G2 or G2B

Alarm System

Ship's Battery

Other Equipment

Autopilot System
(Commander P2 shown)

GPS Compass Display System
(Navigator G2 shown)

Signal Convertor
(NMEA<> PC)

PC System
(optional)

Navigation System
(Chartplotter, etc.)

A PC, with suitable software, can be used as an alternative to the Navigation System and/or the GPS Compass Display System

The arrows show the flow of the Navigation data (Position, Heading, Speed, etc.) and commands (Waypoints, G2 control, etc.), between the systems.

Chapter 2: Installation

Mounting Location

This section provides information on determining the best location for the G2/B.

GPS Reception

When considering where to mount the G2/B, consider the following GPS reception recommendations:

- Consider GPS reception, ensuring there is a clear view of the sky available to the G2/B so the GPS and SBAS satellites are not masked by obstructions that may reduce system performance

- Since the G2/B computes a position based on the internal primary GPS antenna element, mount the G2/B where you desire a position with respect to the primary GPS antenna (located on the end opposite the recessed arrow on the underside of the enclosure)

- Locate any transmitting antennas away from the G2/B by at least a few meters to ensure tracking performance is not compromised, giving you the best performance possible

- Make sure there is enough cable length to route into the vessel to reach a breakout box or terminal strip

- Do not locate the antenna where environmental conditions exceed those specified in Table B-5 on page 47

Beacon Reception

When using the G2B's internal beacon receiver as the correction source, consider the possible mounting locations from the perspective of ambient noise within the beacon band.

Keep the following in mind when deciding upon a location with respect to maximizing beacon performance:

- Ensure that the antenna is as far as possible from all other equipment that emits electromagnetic interference (EMI), including DC motors, alternators, solenoids, radios, power cables, display units, and other electronic devices.

- If you are installing the antenna on a vessel, mount the G2B as high as possible, considering maintenance and accessibility. In addition, ensure that the antenna is higher than the highest metal object on the vessel.

- If a radar system is present, mount the antenna outside the path of the radar beam.

The G2B's internal beacon receiver calculates a signal-to-noise ratio (SNR), measured in decibels (dB), that indicates the receiver's performance. The SNR is the height of the signal above the noise

floor: the higher the SNR, the better your beacon receiver demodulates the signal. The optimum antenna location will be a position where your average SNR is highest. You should turn on all accessories that you intend to use during normal operation when locating the best position for the antenna. By monitoring the SNR, you can determine the optimum location with respect to beacon reception.

Environmental Considerations

The G2/B is designed to withstand harsh environmental conditions; however, adhere to the following limits when storing and using the G2/B:

- Operating temperature: -30°C to +70°C (-22°F to +158°F)
- Storage temperature: -40°C to +85°C (-40°F to +185°F)
- Humidity: 95% non-condensing

VHF Interference

VHF interference from such devices as cellular phones and radio transmitters may interfere with GPS operation. For example, if installing the G2/B near marine radios consider the following:

- VHF marine radio working frequencies (Channels 1 to 28 and 84 to 88) range from 156.05 to 157.40 MHz. The L1 GPS working center frequency is 1575.42 MHz. The bandwidth is +/- 2MHz to +/- 10 MHz, which is dependent on the GPS antenna and receiver design.
- VHF marine radios emit strong harmonics. The 10th harmonic of VHF radio, in some channels, falls into the GPS working frequency band, which may cause the SNR of GPS to degrade significantly.
- The radiated harmonic signal strength of different brands/models varies.
- Follow VHF radio manufacturers' recommendations on how to mount their radios and what devices to keep a safe distance away.
- Handheld 5W VHF radios may not provide suitable filtering and may interfere with the G2/B's operation if too close.

Before installing the G2/B use the following diagram to ensure there are no nearby devices that may cause VHF interference.
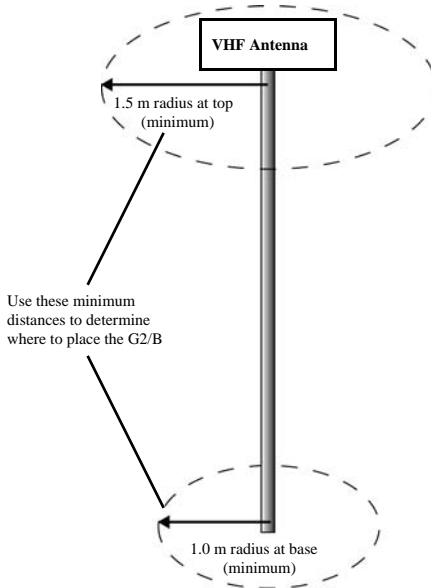
Figure 2-1: G2/B distance from nearby VHF radios

Mounting Orientation

The G2/B outputs heading, pitch, and roll readings regardless of the orientation of the antennas. However, the relation of the antennas to the boat's axis determines whether you will need to enter a heading, pitch, or roll bias. The primary antenna is used for positioning and the primary and secondary antennas, working in conjunction, output heading, pitch, and roll values.

Note: Regardless of which mounting orientation you use, the G2/B provides the ability to output the heave of the vessel. This output is available via the $GPHEV message.

Parallel Orientation: The most common installation is to orient the G2/B parallel to, and along the center line of, the axis of the boat. This provides a true heading. In this orientation:

- If you use a gyrocompass, you can enter a heading bias in the G2/B to calibrate the physical heading to the true heading of the vessel.

- You may need to adjust the pitch/roll output to calibrate the measurement if the Vector is not installed in a horizontal plane.

Perpendicular Orientation: You can also install the antennas so they are oriented perpendicular to the center line of the boat's axis. In this orientation:

- You will need to enter a heading bias of +90° if the primary antenna is on the starboard side of the boat and -90° if the primary antenna is on the port side of the boat.

- You will need to configure the receiver to specify the GPS antennas are measuring the roll axis using $JATT,ROLL,YES.

- You will need to enter a roll bias to properly output the pitch and roll values.

- You may need to adjust the pitch/roll output to calibrate the measurement if the Vector is not installed in a horizontal plane.

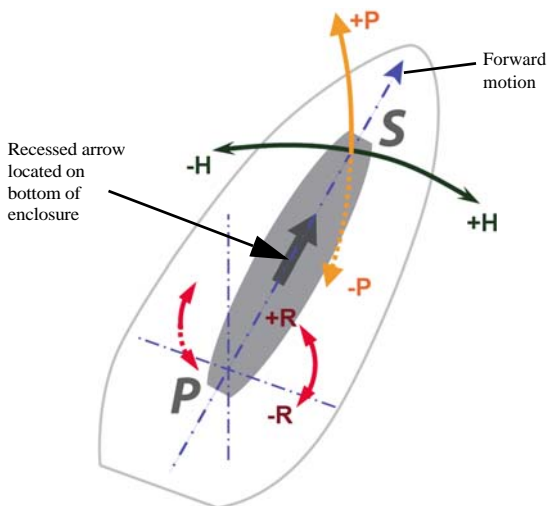Figure 2-2 and Figure 2-3 provide mounting orientation examples.

Figure 2-2: Recommended orientation and resulting signs of HPR values
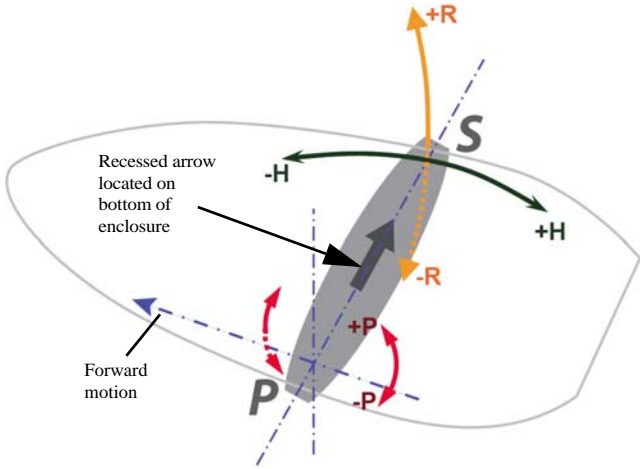
Figure 2-3: Alternate orientation and resulting signs of HPR values

G2/B Alignment

The top of the G2/B enclosure incorporates sight design features to help you align the enclosure with respect to an important feature on your vessel.

To use the sights, center the small post on the opposite side of the enclosure from you, within the channel made in the medallion located in the center of the enclosure top as shown in Figure 2-4 and Figure 2-5. Alignment accuracy when looking through the long site (Figure 2-4) is approximately +/- 1°, while alignment through the short site (Figure 2-5) is approximately +/- 2.5°.

Figure 2-4: Long site alignment

Figure 2-5: Short sight alignment

If you have another accurate source of heading data on your vessel, such as a gyrocompass, you may use its data to correct for a bias in G2/B alignment within the G2/B software configuration. Alternatively, you can physically adjust the heading of the G2/B so that it renders the correct heading measurement; however, adding a software offset is an easier process.

Mounting Options

The G2/B allows for two different mounting options: flush mount and pole mount.

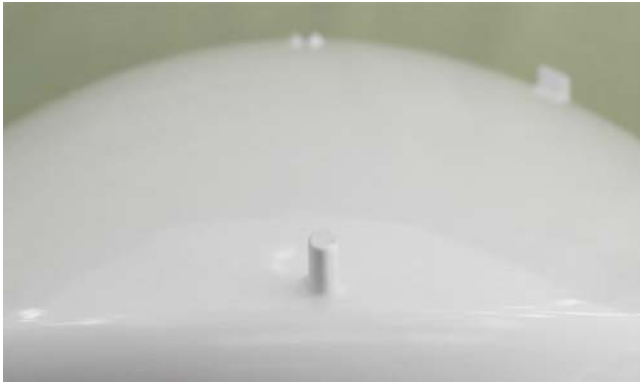- Flush mount - The bottom of the G2/B contains eight M8-1.25 holes for flush mounting the unit to a flat surface (see Figure 2-6). The eight holes comprise two sets of four holes. The inner four holes are in the same location as the MV102, allowing you to use the G2/B as a drop-in replacement. The outer four holes provide a wider mounting option.

- Pole mount - The bottom of the G2/B contains a mounting hole (1" thread, 0.9" depth) for easy pole mounting. Hand tighten until snug (do not overtighten). The set screws on the long sides of the base (see middle drawing in Figure 2-6) allow you to secure the G2/B in place (3/16" Allen wrench not included).

G2/B Dimensions

Figure 2-6 illustrates the physical dimensions of the G2/B.

209.16 mm (8.234 in)

122.32 mm (4.815 in)

668.54 mm (26.320 in)

SET SCREW
3/8-16 UNC THREAD SIZE
2 PLACES

31.75 mm (1.25")

101.60 mm (4.000 in)

63.50 mm (2.500 in)

50.80 mm (2.000 in)

MOUNTING HOLE
1-14 UNS THREAD SIZE

MOUNTING HOLE
M8-1.25 THREAD SIZE
8 PLACES

46.99 mm (1.850 in)

93.98 mm (3.700 in)

76.20 mm (3.000 in)

This drawing shows the NMEA 2000 adapter attached
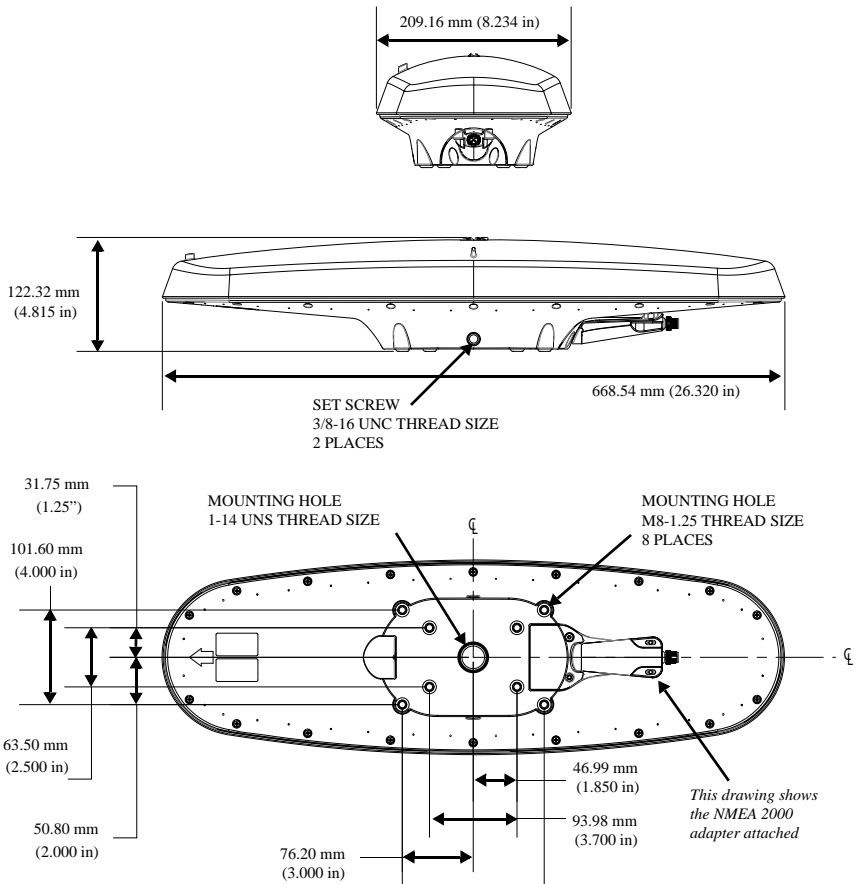
Figure 2-6: G2/B dimensions

Power/Data Cable Considerations

Before mounting the G2/B consider the following regarding power/data cable routing:

- Cable must reach an appropriate power source
- Cable may connect to a data storage device, computer, or other device that accepts GPS data
- Avoid running the cable in areas of excessive heat
- Keep cable away from corrosive chemicals
- Do not run the cable through door or window jams
- Keep cable away from rotating machinery
- Do not crimp or excessively bend the cable
- Avoid placing tension on the cable
- Remove unwanted slack from the cable at the G2/B end
- Secure along the cable route using plastic wraps

⚠WARNING: Improperly installed cable near machinery can be dangerous.

Mounting the G2/B

This section describes how to flush mount or pole mount the G2/B.

Keep the following in mind when planning your installation:

- ComNav GPS does not supply mounting surface hardware or a mounting pole. You must supply the appropriate hardware or mounting pole required to complete G2/B installation.

- You do not necessarily need to orient the antenna precisely as you can enter a software offset to accommodate for a heading measurement bias due to installation.

Flush Mounting the G2/B

The bottom of the G2/B contains eight holes (two sets of four holes) for flush mounting the unit to a flat surface (Figure 2-7). The flat surface may be something you fabricate per your installation, an off-the-shelf item (such as a radar mounting plate), or an existing surface on your vessel.
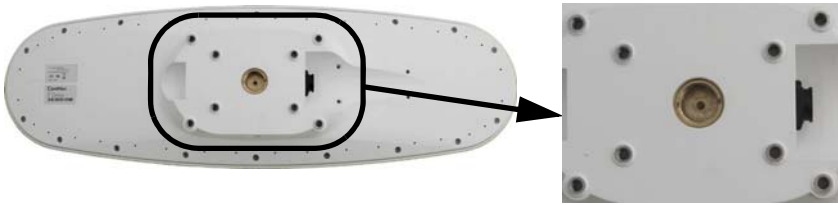

Figure 2-7: Flush mounting holes on bottom of G2/B

Complete the following steps to flush mount the G2/B:

1. Determine the desired location and proper orientation for the G2/B. See "Mounting Orientation" on page 9 for information on determining the desired orientation.
2. Use the supplied template or photocopy the section of the G2/B that contains the eight mounting holes (see Figure 2-7) for use as a template to plan the mounting hole locations. Use the inner four holes or the outer four holes per your installation.

   If using a photocopy make sure it is scaled one-to-one with the mounting holes on the bottom of the G2/B.

3. Mark the mounting hole centers on the mounting surface.
4. Place the G2/B over the marks to ensure the planned hole centers align with the true hole centers (adjusting as necessary).
5. Use a center punch to mark the hole centers.
6. Drill the mounting holes with a 9 mm bit appropriate for the surface.
7. Place the G2/B over the mounting holes and insert the mounting screws through the bottom of the mounting surface into the G2/B.

> **⚠WARNING:** When installing the G2/B, hand tighten only. Damage resulting from overtightening is not covered by the warranty.

Pole Mounting the G2/B

If you need the GPS-assisted roll measurement, install the G2/B perpendicular to the vessel's axis. If you do not need this measurement, install the G2/B parallel with the vessel's axis. For more information refer to Figure 2-2 and Figure 2-3 on page 10.

Complete the following steps to pole mount the G2/B:

1. Determine the desired location and proper orientation for the G2/B. See "Mounting Orientation" on page 9 for information on determining the desired orientation.

2. Hand tighten the G2/B on the pole until snug (unit is stable on pole) while ensuring correct orientation.

⚠️**WARNING:** Hand tighten only. Damage resulting from overtightening is not covered by the warranty.

3. Use the set screws on the long sides of the base (see Figure 2-6 on page 12) to secure the G2/B in place (3/16" Allen wrench not included).

Connecting Serial Cable / Serial-to-NMEA 2000 Adaptor to G2/B

After you mount the G2/B connect either the serial power/data cable or the serial-to-NMEA 2000 adapter to the G2/B.

Connecting the Serial Power/Data Cable

1. Align the cable connector keyway with the G2/B connector key.

2. Rotate the cable ring clockwise until it locks. The locking action is firm; you will feel a positive "click" when it has locked.

Steps 1&2:
Attach cable to unit

Connect cable here

Cable ring

Cable connector keyway

G2/B connector key
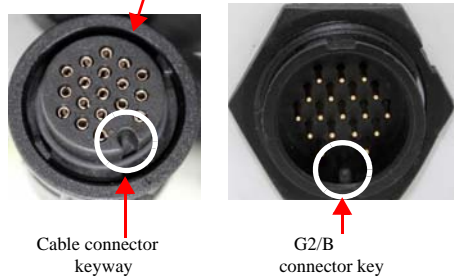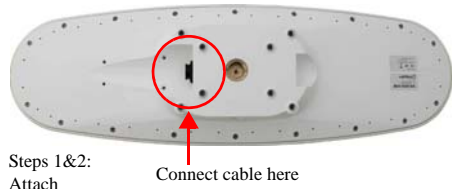
3. Attach the power/data cable to the cable clamp.

4. Fasten the clamp to the bottom of the G2/B using the screw and washer.

5. Attach the cable cover.

Steps 3&4:
Attach clamp and cable to unit

Step 5:
Attach cable cover
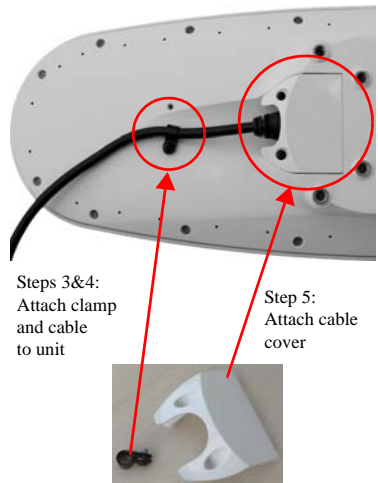
Connecting the Serial-to-NMEA 2000 Adapter

For more information on the serial-to-NMEA 2000 adapter see "NMEA 2000 Port" on page 19.

1. Align the adapter connector keyway with the G2/B connector key.

2. Rotate the cable ring clockwise until it locks. The locking action is firm; you will feel a positive "click" when it has locked.

Steps 1&2: Attach adapter to unit

Connect adapter here

Cable ring

Cable connector keyway

G2/B connector key
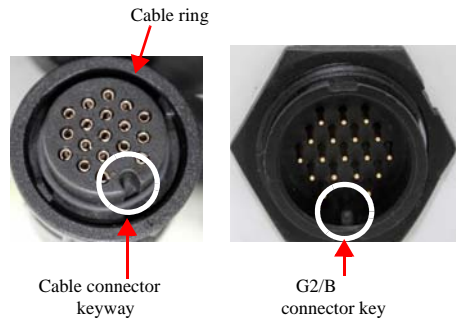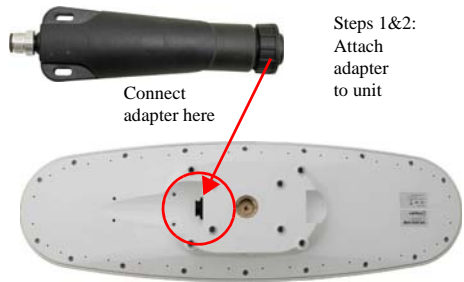
3. Fasten the adapter to the body of the G2/B using the provided screws and the two slots in the adapter.

4. Attach the cable cover.

Step 3: Fasten adapter to unit
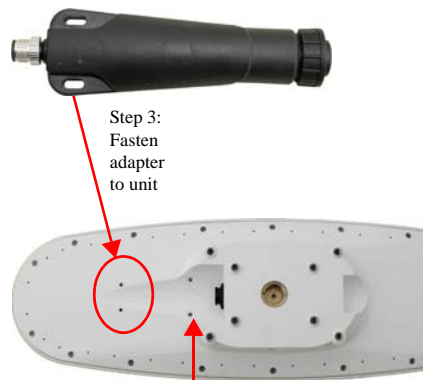
Step 4: Attach cable cover

Ports

The G2/B offers either serial port or NMEA 2000 port functionality.

Serial Ports

The G2/B has three ports (Port A, Port B, and Port C), where:

- Port A can be both full-duplex RS-232 and half-duplex RS-422 (transmit only)
- Port B is full-duplex RS-422
- Port C is for NMEA 2000 and only available via serial-to-NMEA 2000 adapter

You can receive external differential corrections via either Port A (full-duplex RS-232) or Port B (full-duplex RS-422). You can connect up to three devices at one time using two ports. One device can receive data via Port A (RS-422 transmit only) while two devices can transmit and receive data via Ports A and B (one connected to Port A RS-232 and one connected to Port B).

Note: Port A (RS-422) or Port B is required for communicating to an IMO-approved device.

You can update firmware via Port A (RS-232) or Port B.

Note: The G2B has maximum baud rate of 38400. Higher baud rates will impair beacon signal tracking.

Serial Port Configuration

You may configure Port A or Port B of the GPS receiver to output any combination of data. Port A can have a different configuration from Port B in terms of data message output, data rates, and the baud rate of the port. This allows you to configure the ports independently based upon your needs.

For example, if you want one generalized port and one heading-only port, you can configure the ports as follows:

- Port A to have GPGGA, GPVTG, GPGSV, GPZDA, and GPHDT all output at 1 Hz over a 9600 baud rate.
- Port B for GPHDT and GPROT message output at their maximum rate of 20 Hz over a 19200 baud rate.

The messages you configure each port to output and the rate of the port will be the same for both RS-232 and RS-422 interface levels. For example, the RS-232 Port A and RS-422 Port A output the same data messages at the same baud rate. If the baud rate or messages for the RS-422 port need to be changed, this needs to be commanded through the RS-232 port.

Both RS-232 and RS-422 output signals may be used simultaneously.

Note: For successful communications use the 8-N-1 protocol and set the baud rate of the G2/B's serial ports to match that of the devices to which they are connected. Flow control is not supported.

Selecting Baud Rates and Message Types

When selecting your baud rate and message types use the following formula to calculate the bits/sec for each message and then sum the results to determine the baud rate for your required data throughput.

Message output rate * Message length (bytes) * bits in byte = Bits/second
(1 character = 1 byte, 8 bits = 1 byte, use 10 bits/byte to account for overhead)

See "Common Commands and Messages" on page 36 for an example of this calculation.

Recommendations for Connecting to Other Devices

When interfacing to other devices, ensure the transmit data output from the G2/B is connected to the data input of the other device. The signal grounds must also be connected.

Since RS-422 is a balanced signal with positive and negative signals referenced to ground, ensure you maintain the correct polarity. For example, when connecting the transmit data output positive signal to the receive line of the other device, it should be connected to the receive positive terminal. The negative transmit data signal from the G2/B is then connected to the receive data negative input of the other device.

There is likely little reason to connect the receive data input of the G2/B to another device unless it is able to send configuration commands to the G2/B. Since the G2/B uses proprietary NMEA 0183 commands for control over its configuration, the vast majority of electronics will not be able to configure its settings unless the other device has a terminal setting where you can manually issue commands.

NMEA 2000 Port

To use G2/B with NMEA 2000 you have to connect the included serial-to-NMEA 2000 adapter (P/N 31210014, see Figure 2-8) to the unit. Insert the 18-pin connector of the adapter into the male end of the 18-pin connector on the G2/B by aligning the keys. You can then attach the adapter to the unit using the supplied screws (machine, 8-32, ½", PPHC, SS) and washer (washer, flat, #8, SS). The 5-pin male Micro-C connector connects to your NMEA 2000 drop cable.

Figure 2-8: Serial-to-NMEA 2000 adapter

Note: The serial-to-NMEA 2000 adapter is not an IMO requirement and may not be used in such an application.

Table 2-1 shows the requested PGNs with the G2/B in NMEA 2000 mode.

Table 2-1: Received messages based on a request

PG No. (PGN)	Description	Level	Default Update Rate (msec)	Freq (Hz)
059392	ISO Acknowledgement Used to acknowledge the status of certain requests addressed to a specific ECU.	B	On Request	On Request
059904	ISO Request Request the transmission of a specific PGN, addressed or broadcast.	B	On Request	On Request
060928	ISO Address Claim Used to identify to other ECUs the address claimed by an ECU.	B	On Request	On Request
126996	Product Information NMEA 2000 database version supported, manufacturer's product code, NMEA 2000 certification level, Load Equivalency number, and other product-specific information.	B	On Request	On Request
126464	Receive/Transmit PGNs group function The Transmit / Receive PGN List Group type of function is defined by first field. The message will be a Transmit or Receive PGN List group function.	B	On Request	On Request
129538	GNSS Control Status GNSS common satellite receiver parameter status.	B	On Request	On Request
129545	GNSS RAIM Output Used to provide the output from a GNSS receiver's Receiver Autonomous Integrity Monitoring (RAIM) process. The Integrity field value is based on the parameters set in PGN 129546 GNSS RAIM Settings.	B	On Request	On Request
129546	GNSS RAIM Settings Used to report the control parameters for a GNSS Receiver Autonomous Integrity Monitoring (RAIM) process.	B	On Request	On Request

Table 2-2 shows the transmitted PGNs with their default update rate with the G2/B in NMEA 2000 mode.

Table 2-2: Transmitted messages

PG No. (PGN)	Description	Level	Default Update Rate (msec)	Freq (Hz)
126992	System Time The purpose of this PGN is twofold: To provide a regular transmission of UTC time and date. To provide synchronism for measurement data.	B	1000	1
127250	Vessel Heading Heading sensor value with a flag for True or Magnetic. If the sensor value is Magnetic, the deviation field can be used to produce a Magnetic heading, and the variation field can be used to correct the Magnetic heading to produce a True heading.	B	100	10
127251	Rate of Turn Rate of change of the Heading.	B	100	10
127257	Attitude Provides a single transmission that describes the position of a vessel relative to both horizontal and vertical planes. This would typically be used for vessel stabilization, vessel control and onboard platform stabilization.	B	1000	1
127258	Magnetic Variation Message for transmitting variation. The message contains a sequence number to allow synchronization of other messages such as Heading or Course over Ground. The quality of service and age of service are provided to enable recipients to determine an appropriate level of service if multiple transmissions exist.		1000	1
129025	Position, Rapid Update Provides latitude and longitude referenced to WGS84. Being defined as single frame message, as opposed to other PGNs that include latitude and longitude and are defined as fast or multi-packet, this PGN lends itself to being transmitted more frequently without using up excessive bandwidth on the bus for the benefit of receiving equipment that may require rapid position updates.	B	100	10
129026	COG & SOG, Rapid Update Single frame PGN that provides Course Over Ground (COG) and Speed Over Ground (SOG).	B	250	4

Table 2-2: Transmitted messages (*continued*)

PG No. (PGN)	Description	Level	Default Update Rate (msec)	Freq (Hz)
129027	Position Delta, High Precision Rapid Update The "Position Delta, High Precision Rapid Update" Parameter Group is intended for applications where very high precision and very fast update rates are needed for position data. This PGN can provide delta position changes down to 1 mm with a delta time period accurate to 5 msec.	B	100	10
129028	Altitude Delta, High Precision Rapid Update The "Altitude Delta, High Precision Rapid Update" Parameter Group is intended for applications where very high precision and very fast update rates are needed for altitude and course over ground data. This PG can provide delta altitude changes down to 1 millimeter, a change in direction as small as 0.0057°, and with a delta time period accurate to 5 msec.	B	100	10
129029	GNSS Position Data Conveys a comprehensive set of Global Navigation Satellite System (GNSS) parameters, including position information.	B	1000	1
129033	Time & Date Single transmission that provides UTC time, UTC Date, and Local Offset.	B	1000	1
129539	GNSS DOPs Provides a single transmission containing GNSS status and dilution of precision components (DOP) that indicate the contribution of satellite geometry to the overall positioning error. There are three DOP parameters reported: horizontal (HDOP), Vertical (VDOP), and time (TDOP).	B	1000	1
129540	GNSS Sats in View GNSS information on current satellites in view tagged by sequence ID. Information includes PRN, elevation, azimuth, SNR, defines the number of satellites; defines the satellite number and the information.	B	1000	1

Powering the G2/B

Power Considerations

For best performance use a clean and continuous power supply. The G2/B power supply features reverse polarity protection but will not operate with reverse polarity.

See Table B-3 on page 47 for complete power specifications.

Connecting to a Power Source

Note: This section refers to powering the unit via serial connection. To power the unit via NMEA 2000 connection, follow the standard procedure for powering up via NMEA 2000.

Before you power up the G2/B you must terminate the wires of the power cable as required. There are a variety of power connectors and terminals on the market from which to choose, depending on your specific requirements.

⚠WARNING: Do not apply a voltage higher than 36 VDC. This will damage the receiver and void the warranty.

To interface the G2/B power cable to the power source:

- Connect the red wire of the cable's power input to DC positive (+)
- Connect the black wire of the cable's power input to DC negative (-)

The G2/B will start when an acceptable voltage is applied to the power leads of the extension cable.

Electrical Isolation

The G2/B's power supply is isolated from the communication lines and the PC-ABS plastic enclosure isolates the electronics mechanically from the vessel (addressing the issue of vessel hull electrolysis).

Connecting the G2/B to External Devices

Note: This section refers to a serial connection. For connecting external NMEA 2000 devices, plug the serial-to-NMEA 2000 adapter into the G2/B and then attach a standard NMEA 2000 drop line cable to the adapter.

Power/Data Cable Considerations

The G2/B uses a single 15 m (49 ft) or 30 m (98 ft) cable for power and data input/output.
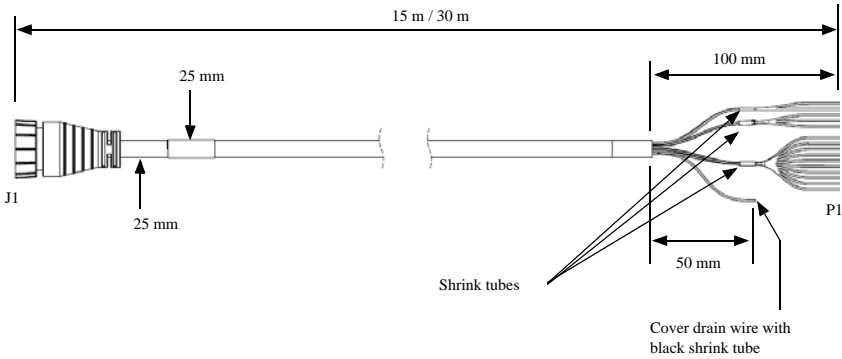
Figure 2-9: Power/data cable, 15 m or 30 m

The receiver end of the cable is terminated with an environmentally sealed 18-pin connection while the opposite end is un-terminated and requires field stripping and tinning.

Depending on the application and installation needs, you may need to shorten this cable. However, if you require a longer cable run than 30 m, you can bring the cable into a break-out box that incorporates terminal strips, within the vessel.

When lengthening the cable keep the following in mind:

- To lengthen the serial lines inside the vessel, use 20-gauge twisted pairs and minimize the additional wire length.
- When lengthening the power input leads to the G2/B, ensure the additional voltage drop is small enough that your power system can continue to power the system above the minimum voltage of the system. Wire of 18-gauge or larger should also be used.
- Minimize RS-232 cable length to ensure reliable communication

Power/Data Cable Pinout Specifications

Figure 2-10 shows the power/data cable pinout, while Table 2-3 shows the cable's pinout specifications.
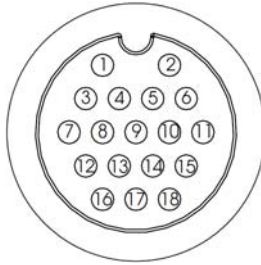
Figure 2-10: Power/data cable pin assignment

Table 2-3: Power/data cable pinout

Pin	Function	Wire Color
1	Power (+)	Red
2	Power (-)	Black
3	Port A Tx RS-232	Blue
4	Port A Rx RS-232	Black/blue stripe
5	Reserved	
6	Port A Tx RS-422(+)	Green
7	Port B Rx RS-422(+)	Brown
8	Port B Rx RS-422(-)	Black/brown stripe
9	Reserved	
10	Drain	Bare wire
11	Port A Tx RS-422(-)	Green/black stripe
12	Signal ground	Grey
13	Alarm	White
14	Alarm	White/red stripe
15	1 PPS(+)	Orange
16	Port B Tx RS-422(+)	Yellow
17	Port B Tx RS-422(-)	Yellow/black stripe
18	1 PPS(-)	Orange/black stripe

Default Parameters

Table 2-4 provides details on certain default parameters. Contact your dealer for default port settings for your unit.

Note: Use the $JSAVE command to save changes you make to the G2/B's configuration for the changes to be present in subsequent power cycles.

Table 2-4: Default parameters

| Unit	Parameter	Specification
G2 and G2B	Max DGPS age (correction age)	2700 seconds
	Elevation mask	5°
	Differential mode	G2: SBAS G2B: Beacon
G2B (internal beacon parameters)	Frequency selection	Automatic
	MSK rate selection	Automatic

Sentence	Description	Enabled Port A default	Port A User	Port B default	Port B User	Max Rate
GPGGA	Global Positioning System Fix Data	X		X		10
GPGLL	*Geographic Position (Latitude & Longitude)*	*1*		X		10
GPGSA	GNSS DOP & Active Satellites	X		X		1
GPGST	GNSS Pseudorange Error Statistics	X		X		1
GPGSV	GNSS Satellites in View	X		X		1
GPRMC	Recommended Minimum Specific GNSS Data	X		X		10
GPRRE	Range Residual	X		X		1
HEHDT	*True Heading*	*1*		*10*		10
HEHDG	True Heading, Variation & Deviation	X		X		10
HCHDM	*Magnetic Heading*	*1*		*10*		10
GPROT	*Rate of Turn*	*1*		*10*		10
GPVTG	*Course and Speed Over Ground*	*1*		1		10
GPZDA	*Time and Date*	*1*		X		10
HPR	Time, True Heading, and Pitch (or Roll) *(proprietary sentence)*	X		X		1
PCSI	Beacon Status Information *(G2B only)* *(proprietary sentence)*	X		X		1
RDI	SBAS Diagnostic Information *(proprietary sentence)*	X		X		1
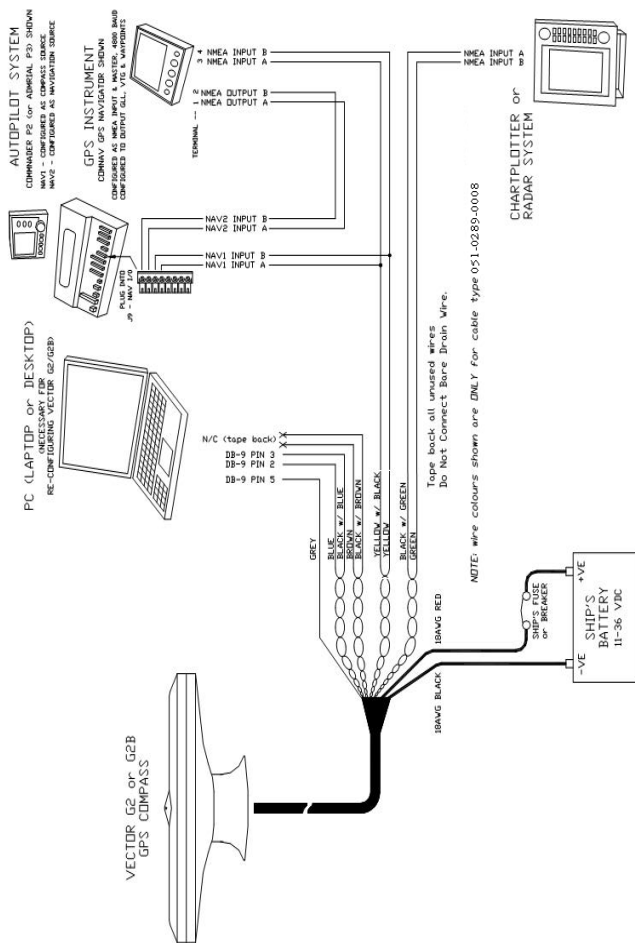
Chapter 3: Operation

GPS Overview

G2/B Overview

Common Commands and Messages

GPS Overview

For your convenience, both the GPS and SBAS operation of the G2/B features automatic operational algorithms. When powered for the first time, the G2/B performs a 'cold start' that involves acquiring the available GPS satellites in view and the SBAS differential service.

If SBAS is not available in your area, an external source of RTCM SC-104 differential corrections may be used. If you use an external source of correction data, it must support an eight data bit, no parity, one stop bit configuration (8-N-1).

GPS Operation

The GPS receiver is always operating, regardless of the DGPS operation mode. The following sections describe general operation of the G2/B's internal GPS receiver.

Note: Differential source and status have no impact on heading, pitch, or roll. They only have an impact on positioning and heave.

Automatic Tracking

The G2/B's internal GPS receiver automatically searches for GPS satellites, acquires the signals, and manages the navigation information required for positioning and tracking.

Receiver Performance

The G2/B works by finding four or more GPS satellites in the visible sky. It uses information from these satellites to compute a position within 4.0 m. Since there is some error in the GPS data calculations, the G2/B also tracks a differential correction. The G2/B uses these corrections to improve its position accuracy to better than 1.0 m.

The two main aspects of GPS receiver performance are 1) satellite acquisition, and 2) positioning and heading calculation.

When the G2/B is properly positioned, the satellites transmit coded information to the antennas on a specific frequency. This allows the receiver to calculate a range to each satellite from both antennas. GPS is essentially a timing system. The ranges are calculated by timing how long it takes for the signal to reach the GPS antenna. The GPS receiver uses a complex algorithm incorporating satellite locations and ranges to each satellite to calculate the geographic location and heading. Reception of any four or more GPS signals allows the receiver to compute three-dimensional coordinates and a valid heading.

Differential Operation

The purpose of differential GPS (DGPS) is to remove the effects of selective availability (SA), atmospheric errors, timing errors, and satellite orbit errors, while enhancing system integrity. Autonomous positioning capabilities of the G2/B will result in positioning accuracies of 4.0 m 95% of the time. In order to improve positioning quality to better than 1.0 m 95%, the G2/B is able to use differential corrections received through the internal SBAS demodulator or beacon receiver, or through externally-supplied RTCM corrections.

Automatic SBAS Tracking

The G2/B automatically scans and tracks SBAS signals without the need to tune the receiver. The G2/B features two-channel tracking that provides an enhanced ability to maintain a lock on an SBAS

satellite when more than one satellite is in view. This redundant tracking approach results in more consistent tracking of an SBAS signal in areas where signal blockage of a satellite is possible.

Beacon Operation

Many marine authorities, such as coast guards, have installed networks of radio beacons that broadcast DGPS corrections to users of this system. With the increasing utility of these networks for terrestrial applications, there is an increasing trend toward densification of these networks inland. The dual channel beacon receiver in the G2B can operate in manual or automatic tuning mode, or, using database mode, will select the closest station in compliance with IEC 61108-4 standards.

G2/B Overview

The G2/B provides accurate and reliable heading and position information at high update rates. To accomplish this task, the G2/B uses a high performance GPS receiver and two antennas for GPS signal processing. One antenna is designated as the primary GPS antenna and the other is the secondary GPS antenna. Positions computed by the G2/B are referenced to the phase center of the primary GPS antenna. Heading data references the vector formed from the primary GPS antenna phase center to the secondary GPS antenna phase center.

The heading arrow located on the bottom of the G2/B enclosure defines system orientation. The arrow points in the direction the heading measurement is computed (when the antenna is installed parallel to the fore-aft line of the vessel). The secondary antenna is directly above the arrow.

Fixed Baseline Moving Base Station RTK

The G2/B's internal GPS receiver uses both the L1 GPS C/A code and carrier phase data to compute the location of the secondary GPS antenna in relation to the primary GPS antenna with a very high sub-centimeter level of precision. The technique of computing the location of the secondary GPS antenna with respect to the primary antenna, when the primary antenna is moving, is often referred to as moving base station Real Time Kinematic (or moving base station RTK).

Generally, RTK technology is very sophisticated and requires a significant number of possible solutions to be analyzed where various combinations of integer numbers of L1 wavelengths to each satellite intersect within a certain search volume. The integer number of wavelengths is often referred to as the "ambiguity" as they are initially ambiguous at the start of the RTK solution.

The G2/B restricts the RTK solution. It does this knowing that the secondary GPS antenna is 50 cm from the primary GPS antenna. This is called a fixed baseline and it defines the search volume of the secondary antenna as the surface of a sphere with radius 50 cm centered on the location of the primary antenna (see Figure 3-1).
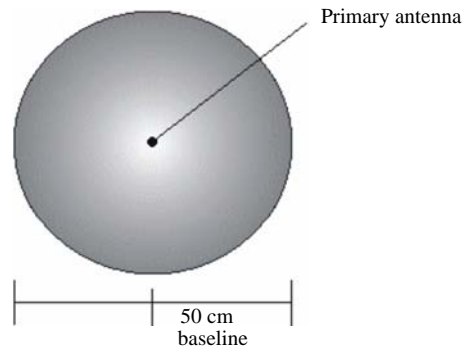
Primary antenna

50 cm
baseline

Figure 3-1: Secondary antenna's search volume

Note: The G2/B moving base station algorithm only uses GPS to calculate heading. Differential corrections are not used in this calculation and will not affect heading accuracy.

Supplemental Sensors

The G2/B has three supplemental sensors (gyro and two tilt sensors) that are integrated into the unit's carrier board. The supplemental sensors are enabled by default. You can enable/disable the gyro and both tilt sensors (you cannot enable/disable each tilt sensor separately).

The sensors act to reduce the RTK search volume, which improves heading startup and reacquisition times. This improves the reliability and accuracy of selecting the correct heading solution by eliminating other possible, erroneous solutions. Table 3-1 provides a sensor operation summary.

Table 3-1: Sensor operation summary

Feature	Normal Operation	Coasting (no GPS)
Heading	GPS	Gyro
Heave	GPS	None
Pitch	GPS	Inertial sensor
Roll	Inertial sensor	Inertial sensor

Contact ComNav for the commands and methodology required to recalibrate, query, or change a sensor's status.

Tilt Aiding

The G2/B's accelerometers (internal tilt sensors) are factory calibrated and enabled by default. This constrains the RTK heading solution beyond the volume associated with just a fixed antenna separation. This is because the G2/B knows the approximate inclination of the secondary antenna with respect to the primary antenna. The search space defined by the tilt sensor will be reduced to a

horizontal ring on the sphere's surface by reducing the search volume. This considerably decreases instances of incorrect headings as well as startup and reacquisition times (see Figure 3-2).
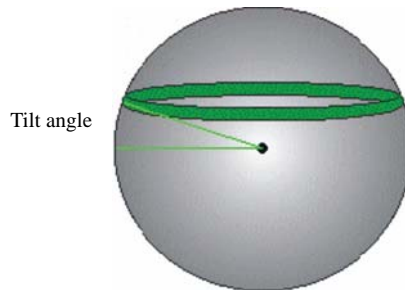

Figure 3-2: G2/B's tilt aiding

Gyro Aiding

The G2/B's internal gyro offers several benefits. It reduces the sensor volume for an RTK solution. This shortens reacquisition times when a GPS heading is lost because the satellite signals were blocked. The gyro provides a relative change in angle since the last computed heading, and, when used in conjunction with the tilt sensor, defines the search space as a wedge-shaped location (see Figure 3-3).
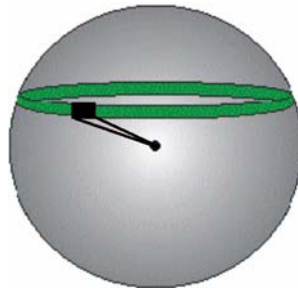

Figure 3-3: G2/B's gyro aiding

The gyro aiding accurately smooths the heading output and the rate of turn. It provides a substitute heading for a short period, accurate to within 1° per minute for up to three minutes, in times of GPS loss for either antenna. If the outage lasts longer than three minutes, the gyro will have drifted too far and the G2/B begins outputting null fields in the heading output messages. There is no user control over the time out period of the gyro.

Calibration, which is set at the factory, is required for the gyro to remove latency from the heading solution as well as provide backup heading when GPS is blocked. The receiver will calibrate itself after running for a while but it may be important to follow the manual calibration instructions if you want to guarantee performance quickly after powering up the receiver.

The gyro initializes itself at power up and during initialization, or can be calibrated. When the gyro is first initializing, it is important that the dynamics that the gyro experiences during this warm up period are similar to the regular operating dynamics. For example, if you use the G2/B on a high speed, maneuverable craft, it is recommended that when gyro aiding in the G2/B is first turned on, use it in an environment that has high dynamics for the first five to ten minutes instead of sitting stationary.

With the gyro enabled, the gyro is also used to update the post HTAU smoothed heading output from the moving base station RTK GPS heading computation. This means that if the HTAU value is increased while gyro aiding is enabled, there will be little to no lag in heading output due to vehicle maneuvers.

Time Constants

The G2/B incorporates user-configurable time constants that can provide a degree of smoothing to the heading, pitch, rate of turn (ROT), course over ground (COG), and speed measurements. You can adjust these parameters depending on the expected dynamics of the vessel. For example, increasing the time is reasonable if the vessel is very large and is not able to turn quickly or would not pitch quickly. The resulting values would have reduced 'noise,' resulting in consistent values with time. However, if the vessel is quick and nimble, increasing this value can create a lag in measurements. If you are unsure on how to set this value, it is best to be conservative and leave it at the default setting.

Note: For heading and rate of turn there is no lag once the gyro is calibrated and enabled.

Heading time constant: Use the $JATT,HTAU command to adjust the level of responsiveness of the true heading measurement provided in the $GPHDT message. The default value of this constant is 10.0 seconds of smoothing when the gyro is enabled. The gyro is enabled by default, but can be turned off. By turning the gyro off, the equivalent default value of the heading time constant would be 0.5 seconds of smoothing. This is not automatically done and therefore you must manually enter it. Increasing the time constant increases the level of heading smoothing and increases lag only if the gyro is disabled.

Pitch time constant: Use the $JATT,PTAU command to adjust the level of responsiveness of the pitch measurement provided in the $PSAT,HPR message. The default value of this constant is 0.5 seconds of smoothing. Increasing the time constant increases the level of pitch smoothing and increases lag.

Rate of Turn (ROT) time constant: Use the $JATT,HRTAU command to adjust the level of responsiveness of the ROT measurement provided in the $GPROT message. The default value of this constant is 2.0 seconds of smoothing. Increasing the time constant increases the level of ROT smoothing.

Course Over Ground (COG) time constant: Use the $JATT,COGTAU command to adjust the level of responsiveness of the COG measurement provided in the $GPVTG message. The default value of this constant is 0.0 seconds of smoothing. Increasing the time constant increases the level of COG smoothing. COG is computed using only the primary GPS antenna and its accuracy depends upon the speed of the vessel (noise is proportional to 1/speed). This value is invalid when the vessel is stationary, as tiny movements due to calculation inaccuracies are not representative of a vessel's movement.

Speed time constant: Use the $JATT,SPDTAU command to adjust the level of responsiveness of the speed measurement provided in the $GPVTG message. The default value of this constant is 0.0 seconds of smoothing. Increasing the time constant increases the level of speed measurement smoothing.

Alarm Functionality

Note: Alarm functionality is only valid for serial communication.

A relay is located on the Transmit Heading Device (THD) circuit board. The relay contacts are isolated from all circuitry in the THD. The THD is connected to the coil side of the relay, but not to the contacts that are connected to the external pins through the main IO connector. If the THD loses power or heading, the coil voltage is lost and the relay opens and activates the notification method employed by the user. When the heading is output, the relay contacts remain closed, completing the circuit as an indication that the G2/B is operational.

Note: Alarm pins must be connected to an IMO-approved device.

Alarm Signal

There are two wires (24 AWG multi strands) on the output cable that are used for the external alarm function. The color codes for the two wires are white and white/red stripe and are the output of a relay. When this relay closes, the connection is complete on the user-defined external notification device.

Watchdog

The watchdog is a timer that is controlled by the software that monitors if the heading is lost. The watchdog software is compliant with IEC 60495.

Common Commands and Messages

Note: When selecting your baud rate and message types use the following formula and example to calculate the bits/sec for each message and then sum the results to determine the baud rate for your required data throughput.

Message output rate * Message length (bytes) * bits in byte = Bits/second
(1 character = 1 byte, 8 bits = 1 byte, use 10 bits/byte to account for overhead)

Example:

Message	Rate	Bytes	Bits in byte	Bits/sec
GPHDT	10	20	10	2000
GPROT	5	18	10	900
GPHDG	1	33	10	330
GPGGA	1	83	10	830
GPZDA	1	38	10	380
			Total	4440

Table 3-2 below through Table 3-5 provide brief descriptions of common commands and messages for the G2/B.

Table 3-2: Commands

Command	Description
$GPMSK	Tune beacon to specific frequency
$JAGE	Specify maximum DGPS correction age (6 to 8100 seconds)
$JAPP	Query or specify receiver application firmware
$JASC	Specify ASCII messages to output to specific ports (see ASCII messages in Table 3-3)
$JBAUD	Specify RS-232, RS-422 (output) communication rate
$JBIN	Specify binary messages to output to specific ports (see Table 3-4)
$JDIFF	Query or specify differential correction mode
$JGEO	Query or specify SBAS for current location and SBAS satellites
$JI	Query unit's serial number and firmware versions
$JOFF	Turn off all data messages
$JQUERY,GUIDE	Query accuracy suitability for navigation

Table 3-2: Commands (*continued*)

Command	Description
$JRESET	Reset unit's configuration to firmware defaults
	Note: $JRESET clears all parameters. For the G2/B you will have to issue the $JATT, FLIPBRD,YES command to properly redefine the circuitry orientation inside the product once the receiver has reset. Failure to do so will cause radical heading behavior.
	You can also issue the $JRESET command with an optional field as follows:
	• $JRESET,ALL does everything $JRESET does, plus it clears almanacs
	• $JRESET,BOOT does everything $JRESET,ALL does, plus clears use of the real-time clock at startup, clears use of backed-up ephemeris and almanacs, and reboots the receiver when done
$JSAVE	Save session's configuration changes

In Table 3-3 the Info Type value is one of the following:

- P = Position
- V = Velocity, Time
- H = Heading, Attitude
- S = Sats, Stats, Quality

Table 3-3: NMEA 0183 and other messages

Message	Info Type	Max Output Rate	Description	IEC Approved Message
$GPDTM	P	1 Hz	Datum reference	Yes
$GPGGA	P	20 Hz	GPS position and fix data	Yes
$GPGLL	P	20 Hz	Geographic position - lat/long	Yes
$GPGNS	P	20 Hz	GNSS position and fix data	Yes
$GPGRS	S	1 Hz	GNSS range residual (RAIM)	Yes
$GPGSA	S	1 Hz	GNSS DOP and active satellites	Yes
$GPGST	S	1 Hz	GNSS pseudo range error statistics and position accuracy	Yes
$GPGSV	S	1 Hz	GNSS satellites in view	Yes
*$GPHDG	H	20 Hz	Provides magnetic deviation and variation for calculating magnetic or true heading *see last bullet in Note at end of this table	Yes
*$GPHDM	H	20 Hz	Magnetic heading (based on GPS-derived heading and magnetic declination) *see last bullet in Note at end of this table	No
*$GPHDT	H	20 Hz	GPS-derived true heading *see last bullet in Note at end of this table	Yes

Table 3-3: NMEA 0183 and other messages (*continued*)

Message	Info Type	Max Output Rate	Description	IEC Approved Message
$GPHEV	H	20 Hz	Heave value (in meters)	Yes
$GPRMC	P	20 Hz	Recommended minimum specific GNSS data	Yes
*$GPROT	H	20 Hz	GPS-derived rate of turn (ROT) *see last bullet in Note at end of this table	Yes
$GPRRE	S	1 Hz	Range residual and estimated position error	Yes
$GPVTG	V	20 Hz	COG and ground speed	Yes
$GPZDA	V	20 Hz	Time and date	Yes
$PASHR	H	20 Hz	Time, heading, roll, and pitch data in one message	No
$PSAT,GBS	S	1 Hz	Satellite fault detection (RAIM)	Yes
$PSAT,HPR	H	20 Hz	Proprietary NMEA message that provides heading, pitch, roll, and time in single message	No
$PSAT,INTLT	H	1 Hz	Proprietary NMEA message that provides the pitch and roll measurements from the internal inclinometers (in degrees)	Yes
$RD1	S	1 Hz	SBAS diagnostic information	Yes
$TSS1	H	20 Hz	Heading, pitch, roll, and heave message in the commonly used TSS1 message format	No

Notes:

- The GP of the message is the talker ID.
- GPGRS, GPGSA, GPGST, and GPGSV support external integrity checking. They are to be synchronized with corresponding fix data (GPGGA or GPGNS).
- *You can change the message header for the HDG, HDM, HDT, and ROT messages to either GP or HE using the $JATT,NMEAHE command.
    - To preface these messages with GP, issue the following command: $JATT,NMEAHE,0<CR><LF>
    - To preface these messages with HE, issue the following command:

Table 3-4: Binary messages

$JBIN Message	Description
1	GPS position
2	GPS DOPs
80	SBAS
93	SBAS ephemeris data
94	Ionosphere and UTC conversion parameters
95	Satellite ephemeris data
96	Code and carrier phase
97	Processor statistics

Table 3-4: Binary messages (*continued*)

$JBIN Message	Description
98	Satellites and almanac
99	GPS diagnostics

Table 3-5: Parameters specific to $JATT command

Parameter	Description	Query	Specify
COGTAU	Set/query COG time constant (0.0 to 3600.0 sec)	X	X
CSEP	Query antenna separation	X	
EXACT	Enable/disable internal filter reliance on the entered antenna separation	X	X
FLIPBRD	Turn the flip feature on/off. Default is Yes (On). If performing a factory reset verify this is on.	X	X
GYROAID	Enable/disable gyro	X	X
HBIAS	Set/query heading bias (-180.0º to 180.0º)	X	X
HELP	Show the available commands for GPS heading operation and status	X	
HIGHMP	Set/query the high multi path setting for use in poor GPS environments	X	X
HRTAU	Set/query ROT time constant (0.0 to 3600.0 sec)	X	X
HTAU	Set/query heading time constant (0.0 to 3600.0 sec)	X	X
LEVEL	Enable/disable level operation	X	X
MSEP	Manually set or query antenna separation	X	X
NEGTILT	Enable/disable negative tilt	X	X
NMEAHE	Change the HDG, HDM, HDT, and ROT message headers between GP and HE	X	X
PBIAS	Set/query pitch/roll bias (-15.0º to 15.0º)	X	X
PTAU	Set/query pitch time constant (0.0 to 3600.0 sec)	X	X
ROLL	Configure for roll or pitch GPS orientation	X	X
SEARCH	Force a new GPS heading search		X
SPDTAU	Set/query speed time constant (0.0 to 3600.0 sec)	X	X
SUMMARY	Display current settings summary	X	
TILTAID	Enable/disable accelerometer, pre-calibrated	X	X
TILTCAL	Calibrate accelerometers		X

Appendix A: Troubleshooting

Table A-1 provides troubleshooting for common problems.

Table A-1: Troubleshooting

Symptom	Possible Solution
Receiver fails to power	• Verify polarity of power leads • Check integrity of power cable connectors • Check power input voltage (6 to 36 VDC) • Check current restrictions imposed by power source (minimum available should be > 1.0 A)
No data from G2/B	• Check receiver power status to ensure the receiver is powered (an ammeter can be used for this) • Verify desired messages are activated (using ComNav ToolKit or $JSHOW command in any terminal program) • Ensure the baud rate of the G2/B matches that of the receiving device • Check integrity and connectivity of power and data cable connections
Random data from G2/B	• Verify the RTCM or binary messages are not being output accidentally (send a $JSHOW command) • Ensure the baud rate of the G2/B matches that of the remote device • Potentially, the volume of data requested to be output by the G2/B could be higher than the current baud rate supports (try using 19200 as the baud rate for all devices or reduce the amount of data being output)
No GPS lock	• Verify the G2/B has a clear view of the sky • Verify the lock status of GPS satellites (this can be done with ComNav ToolKit)
No SBAS lock	• Verify the G2/B has a clear view of the sky • Verify the lock status of SBAS satellites (this can be done with ComNav ToolKit - monitor BER value) • Set SBAS mode to automatic with the $JWAASPRN,AUTO command **Note:** SBAS lock is only possible if you are in an appropriate SBAS region; currently, there is limited SBAS availability in the southern hemisphere.

Table A-1: Troubleshooting (*continued*)

Symptom	Possible Solution
No heading or incorrect heading value	• Check CSEP value is fairly constant without varying more than 1 cm (0.39 in)—larger variations may indicate a high multipath environment and require moving the receiver location • Heading is from primary GPS antenna to secondary GPS antenna, so the arrow on the underside of the G2/B should be directed to the bow side • $JATT,SEARCH command forces the G2/B to acquire a new heading solution (unless gyro is enabled) • Enable GYROAID to provide heading for up to three minutes during GPS signal loss • Enable TILTAID to reduce heading search times • Monitor the number of satellites and SNR values for both antennas within ComNav ToolKit—at least four satellites should have strong SNR values • Potentially, the volume of data requested to be output by the G2/B could be higher than the current baud rate supports (try using 19200 as the baud rate for all devices or reduce the amount of data being output)
No DGPS position in external RTCM mode	• Verify the baud rate of the RTCM input port matches the baud rate of the external source • Verify the pinout between the RTCM source and the RTCM input port (transmit from the source must go to receive of the RTCM input port and grounds must be connected) • Ensure corrections are being transmitted to the correct port—using the $JDIFF,PORTB command on Port A will cause the receiver to expect the corrections to be input through Port B

Appendix B: Technical Specifications

Table B-1 through Table B-5 provide the G2/B's GPS sensor, communication, power, mechanical, and environmental specifications.

Table B-1: GPS sensor specifications

Item	Specification
Receiver type	L1, C/A code with carrier phase smoothing
Channels	Two 12-channel, parallel tracking (Two 10-channel when tracking SBAS)
SBAS tracking	2-channel, parallel tracking
Update rate	20 Hz (position and heading)
Horizontal accuracy	< 1.0 m 95% confidence (DGPS[1]) < 4.0 m 95% confidence (autonomous, no SA[2])
Heading accuracy	< 0.5° rms Normal operation: GPS Coasting (no GPS): Gyro
Heave accuracy	< 30 cm rms[5] Normal operation: GPS Coasting (no GPS): None
Pitch accuracy	< 1° rms Normal operation: GPS Coasting (no GPS): Inertial sensor
Roll accuracy	< 1° rms using accelerometer Normal operation: Inertial sensor Coasting (no GPS): Inertial sensor
Rate of turn	90°/s maximum
Cold start	< 60 s typical (no almanac or RTC)
Warm start	< 20 s typical (almanac and RTC)
Hot start	< 10 s typical (almanac, RTC, and position)
Heading fix	< 10 s typical (valid position)
Compass safe distance	75 cm (29.5 in)[4]
Maximum speed	1,850 kph (999 kts)
Maximum altitude	18,288 m (60,000 ft)

Table B-2: Communication specifications

Item	Specification
Serial ports	1 RS-232 (full-duplex) 2 RS-422 (1 full duplex, 1 half duplex)
Baud rates	G2: 4800, 9600, 19200, 38400 G2B: 4800, 9600, 19200, 38400
Correction I/O protocol	RTCM SC-104
Data I/O protocol	NMEA 0183, NMEA 2000

Table B-3: Power specifications

Item	Specification	
Input voltage	6 to 36 VDC	
Power consumption	3 W nominal	
Current consumption	G2	G2B
	320 mA @ 9 VDC 240 mA @ 12 VDC 180 mA @ 16 VDC	350 mA @ 9 VDC 265 mA @ 12 VDC 200 mA @ 16 VDC
Power isolation	Isolated to enclosure	
Reverse polarity protection	Yes	

Table B-4: Mechanical specifications

Item	Specification	
Enclosure	UV resistant, white plastic, AES HW 600G, non-corrosive, self extinguishing	
Dimensions	209.16 L x 668.54 W x 122.32 H (mm)	
	8.234 L x 26.320 W x 4.815 H (in)	
Weight	G2	G2B
	2.131 kg (4.70 lb)	2.44 kg (5.38 lb)

Table B-5: Environmental specifications

Item	Specification
Operating temperature	-30°C to +70°C (-22°F to +158°F)
Storage temperature	-40°C to +85°C (-40°F to +185°F)
Humidity	95% non-condensing
Vibration	IEC 60945
EMC	FCC Part 15, Subpart B; CISPR22; IEC 60945 (CE)

Table B-6: Certifications

IMO Resolution MSC.116(73)	ISO 22090-3 Ed.1.0, 2004 incl. Corr. 1,2005
IMO Resolution A.694(17)	IEC 60945 Ed.4.0, 2002 incl. Corr.1, 2008
IMO Resolution MSC.191(79)	IEC 61162-1 Ed.4.0 2010
	IEC 61162-2 Ed.1.0, 1998
	IEC 62288 Ed.1.0, 2008

IMO wheelmarked for Annex A.1 item 4.41 Transmitting heading device THD (GNSS method. Based on the Directive 2009/26/EC.

[1]Depends on multipath environment, number of satellites in view, satellite geometry, ionospheric activity, and use of SBAS

[2]Depends on multipath environment, number of satellites in view, satellite geometry, and ionospheric activity

[4]IEC 60945 Standard

[5]Based on a 40 second time constant

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21. **TERMINATION**. Licensee may terminate this Agreement at any time without cause. ComNav may terminate this Agreement on 30 days notice to Licensee if Licensee fails to materially comply with each provision of this Agreement unless such default is cured within the 30 days. Any such termination by a party shall be in addition to and without prejudice to such rights and remedies as may be available, including injunction and other equitable remedies. Upon receipt by Licensee of written notice of termination from ComNav or termination by Licensee, Licensee shall at the end of any notice period (a) cease using the Software; and (b) return to ComNav (or destroy and provide a certificate of a Senior Officer attesting to such destruction) the Software and all related material and any magnetic or optical media provided to Licensee. The provisions of Sections 6), 7), 8), 9), 10), 15), 21), 26) and 27) herein shall survive the expiration or termination of this Agreement for any reason.

22. **EXPORT RESTRICTIONS**. Licensee agrees that Licensee will comply with all export control legislation of Canada, the United States, Australia and any other applicable country's laws and regulations, whether under the Arms Export Control Act, the International Traffic in Arms Regulations, the Export Administration Regulations, the regulations of the United States Departments of Commerce, State, and Treasury, or otherwise as well as the export control legislation of all other countries.

23. **PRODUCT COMPONENTS.** The Product may contain third party components. Those third party components may be subject to additional terms and conditions. Licensee is required to agree to those terms and conditions in order to use the Product.

24. **FORCE MAJEURE EVENT.** Neither party will have the right to claim damages as a result of the other's inability to perform or any delay in performance due to unforeseeable circumstances beyond its reasonable control, such as labor disputes, strikes, lockouts, war, riot, insurrection, epidemic, Internet virus attack, Internet failure, supplier failure, act of God, or governmental action not the fault of the non-performing party.

25. **FORUM FOR DISPUTES**. The parties agree that the courts located in Vancouver, BC, Canada and the courts of appeal there from will have exclusive jurisdiction to resolve any disputes between Licensee and ComNav concerning this Agreement or Licensee's use or inability to use the Software and the parties hereby irrevocably agree to attorn to the jurisdiction of those courts. Notwithstanding the foregoing, either party may apply to any court of competent jurisdiction for injunctive relief.

26. **APPLICABLE LAW**. This Agreement shall be governed by the laws of the Province of British Columbia, Canada, exclusive of any of its choice of law and conflicts of law jurisprudence.

27. **CISG.** The United Nations Convention on Contracts for the International Sale of Goods will not apply to this Agreement or any transaction hereunder.

28. **GENERAL.** This is the entire agreement between Licensee and ComNav relating to the Product and Licensee's use of the same, and supersedes all prior, collateral or contemporaneous oral or written representations, warranties or agreements regarding the same. No amendment to or modification of this Agreement will be binding unless in writing and signed by duly authorized representatives of the parties. Any and all terms and conditions set out in any correspondence between the parties or set out in a purchase order which are different from or in addition to the terms and conditions set forth herein, shall have no application and no written notice of same shall be required. In the event that one or more of the provisions of this Agreement is found to be illegal or unenforceable, this Agreement shall not be rendered inoperative but the remaining provisions shall continue in full force and effect.

Warranty Information

Limited Warranty

This Limited Warranty (the "Warranty") covers all Vector and Navigator GPS Compass products & accessories (the "Equipment") sold by ComNav Marine Ltd. ("ComNav").

LIMITED ONE YEAR WARRANTY

ComNav warrants to the Purchaser, provided that the recommended installation and maintenance procedures set forth in the manual (the "Manual") provided with the Equipment have been followed, and subject always to the other provisions of this Warranty, that the Equipment is free from defects in workmanship and materials under normal use and service for a period of one (1) year from the date of purchase of the Equipment by the Purchaser.

EXCLUSIONS

This Limited Warranty is null and void if:

1. The serial number of the Equipment has been removed, altered or mutilated;

2. Any of the anti-tamper seals covering case-screw holes, or other mechanisms for opening the Equipment's case, have been removed, broken or otherwise tampered with;

3. There are any defects in it, or damages to it, caused by:

a. Faulty installation or hook-up of the Equipment;

b. Abuse, misuse, or any use of the Equipment in violation of the instructions set forth in the Manual;

c. Shipping, alterations, or incorrect and/or unauthorized service;

d. Accident, exposure of the Equipment to excessive heat, fire, lightning or other electrical discharge, or water immersion;

e. Water damage due to failure to fully fasten the plug connected into the equipment's power/signal receptacle;

f. Improper or inadequate ancillary or connected equipment.

OTHER LIMITATIONS AND EXCLUSIONS

1. ComNav does not warrant or guarantee the precision or accuracy of positions, heading, or other GPS-based navigation data obtained when using the Equipment. The potential accuracy of the Equipment, as stated in the Manual, associated ComNav literature and/or Product specifications, provides only an estimate of the highest achievable accuracy based on:

a. Specifications provided by the US Department of Defence for GPS Positioning;

b. GPS Receiver specifications provided by the OEM manufacturer;

c. DGPS service provider performance specifications.

2. The Equipment is not intended for primary navigation or for use in safety of life applications; ComNav does not warrant or guarantee that the Equipment will perform in accordance with the requirements of such usage;

3. ComNav reserves the right to modify the Equipment without any obligation to notify, supply or install any improvements or alterations to existing Equipment.

NO OTHER WARRANTIES

THE FOREGOING WARRANTY IS EXCLUSIVE OF ALL OTHER WARRANTIES AND CONDITIONS, WHETHER WRITTEN, ORAL OR IMPLIED, ARISING BY STATUTE OR OTHERWISE, WITH RESPECT TO THE DESIGN, SALE, INSTALLATION OR USE OF THE EQUIPMENT, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OR CONDITIONS OF MERCHANTABILITY AND FITNESS FOR THE ORDINARY PURPOSES FOR WHICH THE EQUIPMENT IS USED OR FITNESS FOR A PARTICULAR PURPOSE, AND ANY OTHER OBLIGATIONS ON THE PART OF COMNAV, ITS EMPLOYEES, SUPPLIERS, AGENTS, OR REPRESENTATIVES.

LIMITATION OF LIABILITY

The extent of ComNav's liability for damages of any nature to the end purchaser or any other person or entity whether in contract or tort, and whether to persons or property, shall in no case exceed, in the aggregate, the cost of correcting the defect in the equipment or, at ComNav's option, the cost of replacing the defective item. In no event will ComNav be liable for any loss of production, loss of profits, loss of use or for any special, indirect, incidental, consequential or contingent damages, even if ComNav has been advised of the possibility of such damages. Without limiting the foregoing, ComNav shall not be liable for any damages of any kind resulting from installation, use, quality, performance or accuracy of the equipment.

NOTICE OF DEFECT

The Limited Warranty will not apply with respect to any defective Equipment unless written notice of such defect is given to ComNav, by mail to the address for ComNav set forth below, or by facsimile to ComNav at 604-207-8008, and unless that written notice is received by ComNav within ten (10) days of the date upon which the defect first became known to the Purchaser.

Notices sent by mail from within North America will be deemed to be received by ComNav on the seventh (7th) day first following the date of posting. Notices sent by mail from anywhere else in the world will be deemed to be received by ComNav on the tenth (10th) day next following the date of posting. Notices sent by facsimile will be deemed to be received by ComNav on the date of transmission with appropriate answerback confirmation.

REMEDIES NOT TRANSFERABLE

The Purchaser's remedies under this Warranty apply only to the original end-user of the ComNav Equipment, being the Purchaser, and apply only to the original installation of the Equipment. The Purchaser's remedies under this Warranty are not transferable or assignable by the Purchaser to others in whole or in part.

CUSTOMER REMEDIES

1. If the Equipment, or any part thereof, proves to be defective within the warranty period, the Purchaser shall do the following:

a. contact ComNav, by phoning 604-207-1600, to discuss the nature of the problem and to obtain return shipping instructions for the defective Equipment;and,

b. prepare a detailed written statement of the nature and circumstances of the defect, to the best of the Purchaser's knowledge, and including the date of purchase of the Equipment, the place of purchase, the name and address of the installer, and the Purchaser's name, address and telephone

number, all to be sent, along with proof of purchase, to ComNav at the address set out below, and within the time limits set out above for Notice of Defect.

2. If, upon examination by ComNav, the defect is determined to result from defective workmanship or material and if the defect has occurred within the warranty period set forth above, the Equipment or the defective parts thereof shall be repaired or replaced, at ComNav's sole option, without charge, and shall be returned to the Purchaser at ComNav's expense. Return delivery will be by the most economical means. Should the Purchaser require that the Equipment be returned by a faster method, the costs incurred by the faster delivery will be pre-paid by the Purchaser.

3. No refund of the purchase price for the Equipment will be made to the Purchaser unless ComNav is unable to remedy the defect after having a reasonable number of opportunities to do so.

4. Warranty service shall be performed only by ComNav. Any attempts to remedy the defect by anyone else shall render the warranties set forth in this Warranty null and void.

CHOICE OF LAW AND JURISDICTION

This Warranty is governed by the laws of the Province of British Columbia, Canada. If the Purchaser acquired the Equipment outside of Canada, each of the parties hereto irrevocably attorn to the jurisdiction of the courts of the Province of British Columbia, Canada, and further agree to settle any dispute, controversy or claim arising out of or relating to this Limited Warranty, or the breach, termination, or invalidity of it, by arbitration under the rules of the British Columbia International Commercial Arbitration Centre ("BCICAC"). The appointing authority shall be BCICAC [or, if the BCICAC shall cease to exist, the Chief Justice of the Supreme Court of British Columbia]. BCICAC shall administer the case in accordance with BCICAC Rules. There shall be one arbitrator and the place of arbitration shall be Vancouver, British Columbia, Canada.

The United Nations Convention on Contracts for the International Sale of Goods Act, S.B.C 1990, c. 20, and any other statutory enactments of the United Nations Convention on Contracts for the International Sale of Goods do not apply to this Warranty.

ComNav Maine Ltd.
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Richmond, British Columbia
V6V 2G1
Canada
www.comnav.com

WARNING

The Equipment is an aid to navigation only. It is not intended or designed to replace the person on watch. A qualified person should always be in a position to monitor the vessel's heading, and to watch for navigational hazards, and should be prepared to revert to manual steering immediately if an undesired change of heading occurs, if the heading is not maintained within reasonable limits, or when navigating in a hazardous situation.

ALWAYS REMEMBER:
WHENEVER UNDER WAY, A QUALIFIED PERSON ON WATCH IS REQUIRED BY LAW.

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