C-NavX1 GNSS Receiver User Manual

CNAV-MAN-061

Revision B

C-Nav® Positioning Solutions

oceaneering.com/cnav

Document Owner

C-Nav

Revision History

Revision	Prepared by	Checked by	Approved by	Date Approved
B	Surbhi Dogra	Jamie Hall	Ben Dean	26-Apr-24
A	Jamie Hall Ben Dean Zac Watson Russell Moton	Jamie Hall Ben Dean Zac Watson Russell Moton	Ben Dean	1-Aug-2023

Revision Details

Revision	Change Details
B	Changed document to global format
A	Initial Release

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LIST OF TABLES

1 MANUAL ORGANIZATION

This section describes how the manual is laid out. It gives one or two sentence descriptions about each major section.

Section 5- Getting Started provides instructions to enable the robust functionality of the Oceaneering C-NavX1 GNSS receiver.

Section 6- Introduction introduces the user to the system overview of the C-NavX1 GNSS receiver.

Section 7- Interfacing instructs the user on how to interface with the C-NavX1 GNSS receiver.

Section 8- Installation provides installation instructions.

Section 9- Configuration provides instructions on four ways to configure a C-NavX1 GNSS receiver.

Section 10- Safety Instructions provides the safety information for the user.

Appendix A- GNSS Sensor Specifications provides the user with specifications on the C-NavX1 GNSS receiver.

Appendix C- C-Nav LEO Correction Services (CCS) provides information on the C-Nav LEO correction service.

Appendix D- NMEA Data Output Messages describes the many different NMEA messages that the C-NavX1 GNSS receiver can output.

Appendix E- Software License Agreement provides legal information in regard to the software used with the C-NavX1 GNSS receiver.

Glossary provides the user with abbreviations and definitions relative to the C-NavX1 GNSS receiver.

2 NOTICES

2.1 FCC Notice

This device complies with Part 15 Subpart B Class B 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.

The GNSS sensor has been tested in accordance with FCC regulations for electromagnetic interference. This does not guarantee non-interference with other equipment. Additionally, the GNSS sensor may be adversely affected by nearby sources of electromagnetic radiation.

2.2 C-Nav Licensing

Access to the C-Nav Correction Service (CCS) requires a license that must be purchased. Licenses are non-transferable and are subject to the terms of the C-Nav License Agreement. Activations can be requested online by completing the webform at https://cnavauthcode.oceaneering.com or alternatively via your portal account at https://cnavportal.oceaneering.com.

For further details on the C-Nav Corrections Service, subscriptions, deactivations, terms, conditions, and its capabilities, refer to

Appendix C - C-Nav LEO Correction Service (CCS), of this manual or send an email inquiry to C-Nav Support (cnavsupport@oceaneering.com).

2.3 Software License Agreement

By powering on and using this GNSS C-Nav Correction Service receiver, you agree to the terms and conditions of the C-Nav Receiver Software License. The complete terms and conditions of these software licenses may be found in the C-NavX1 User Guide, Appendix E- Software License.

2.4 USG FAR

Technical Data Declaration (Jan 1997)

The Contractor, Oceaneering International, Inc., and associates / affiliates hereby declares that, to the best of its knowledge and belief, the technical data delivered herewith under Government contract (and subcontracts, if appropriate) are complete, accurate, and comply with the requirements of the contract concerning such technical data.

2.5 Global Navigation Satellite Systems

Global Navigation Satellite Systems (i.e., GPS, GLONASS, Galileo and BeiDou) are under the control of the respective Governmental agency and the operation of these satellites may be changed at any time without warning.

GPS Selective availability (S/A code) was disabled on 02 May 2000 at 04:05 UTC. The United States government has stated that present GPS users use the available signals at their own risk.

The U.S. State Department International Traffic in Arms Regulations (ITAR) limits the performance of commercial GNSS products. As a result, access to satellite measurements and navigation results will be limited from display and recordable output when predetermined values of velocity and altitude are exceeded. These threshold values are far in excess of the normal and expected operational parameters of the C-NavX1 GNSS receiver.

Revisions to this User Guide can be obtained in a digital format from the C-Nav Resources Web Page.

3 DOCUMENT CONVENTIONS

Font Type	Used for
Arial	Plain Text
Arial Italic	Setting Names
‘Arial Quoted ‘	Setting Values
Arial Bold	Button Names
Arial Bold Italic	Menu Items
Arial Blue	Cross Reference
Arial Blue Underline	Hyperlinks
Arial Red Italic	Typed Commands
Arial Bold Size 10	Captions
ARIAL BLACK ALL-CAPS	Port Connection Names

4 REFERENCES

4.1 Related Documents

Document Title	Document Detail
C-NavX1 Quick Start Guide	Provides instructions to quickly set up the standard configuration of the C-NavX1 GNSS receiver, and how to obtain a C-Nav LEO license.

4.2 Related Standards

Standard Title	Standard Detail
ICD-GPS-200	NAVSTAR GPS Space Segment / Navigation User Interfaces Standard. ARINC Research Corporation; 2250 E. Imperial Highway; El Segundo, California 90245 IEC 60945, IEC 61108-1, IEC 61162-1 Ed 4, IEC 61162-2
GLONASS ICD, Version 5.0, 2002	Russian Space Agency, Information Analytical Centre Internet: http://glonass-iac.ru/en/
Beidou	Beidou Navigation Satellite System Internet: http://en.beidou.gov.cn/ Tel: +86 10 62567566 Email: webeditor@beidou.gov.cn
Galileo	Galileo ICD Issue 1, Revision 2, November 2015 Internet: https://ww.gsa.europa.eu/ ICD: https://www.gsc-europa.eu/system/files/galileo_documents/Galileo_OS_SIS_ICD.pdf European GNSS Agency Janovského 438/2 170 00 Prague 7 – Holesovice Czech Republic Tel: +420 234 766 000
RTCM-SC-104	Recommended Standards For Differential GNSS Service. Radio Technical Commission For Maritime Services; 1611 N. Kent St, Suite 605; Arlington, Virginia 22209
NTRIP	Radio Technical Commission for Maritime Services (RTCM) Standard 10410.0 (RTCM Paper 200-2004/SC104-STD, Version 1.0 for Networked Transport of RTCM via Internet Protocol (NTRIP) Radio Technical Commission for Maritime Services (RTCM) Standard 10410.1 (RTCM Paper 111-2009-SC104-STD, Version 2.0 for Networked Transport of RTCM via Internet Protocol (NTRIP)
RINEX	Receiver Independent Exchange Format; Astronomical Institute of the University of Bern
QZSS	Quasi Zenith Satellite System. Japan Aerospace Exploration Agency (JAXA). 7-44-1 Jindaiji Higashi-machi, Chofu-shi, Tokyo 182-8522.
NMEA-0183	National Marine Electronics Association Standard for Interfacing Marine Electronic Devices. NMEA National Office; 7 Riggs Avenue; Severna Park, Maryland 21146

4.3 Publicly-Operated SBAS Signals

Signal	Detail
RTCA/DO-229D	The Radio Technical Commission for Aeronautics (RTCA) develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management (CNS/ATM) system issues. RTCA. 1828 L Street, NW, Suite 805, Washington, DC 20036. These organizations implement the RTCA/DO-229D standard set by RTCA:
WAAS (Wide Area Augmentation System)	U.S. Department of Transportation. Federal Aviation Administration. 800 Independence Ave, SW, Washington, DC 20591
EGNOS (European Geostationary Navigation Overlay Service)	European Space Agency. 8, 10 rue Mario-Nikis, F-75738 Paris Cedex 15, France.
MSAS (MTSAT Satellite-based Augmentation System)	Japan Civil Aviation Bureau. Ministry of Transport. Kasumigaseki 2-1-3, Chiyoda-ku, Tokyo 100, Japan.
GAGAN (GPS Aided Geo Augmented Navigation)	Indian Space Research Organization. Antariksh Bhavan, New Bel Road, Bangalore - 560 094, India.

4.4 Symbols

The following words and symbols found throughout this document, highlights special messages to alert the operator of specific information concerning **personnel**, **equipment**, **process** or **environmental impact**.

Symbol	Description
	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.
	CAUTION: Failure to follow these directions can result in damage to equipment.
	CAUTION: Failure to follow these directions can result in environmental hazard.
IMPORTANT NOTES: Such note boxes display important information that should not be ignored.	
	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

5 GETTING STARTED

5.1 Hardware Setup

This chapter provides instructions to enable the robust functionality of the

C-NavX1 GNSS receiver.

Confirm that all ordered equipment is delivered. Refer below for the following tables:

- Table 1: C-NavX1 Supplied Equipment Description and Part Numbers
- Table 3: Antenna Part Numbers
- Table 4: AC Power Supply Kit - Part Numbers
- Table 5: Optional Antenna Cable - Part Numbers
- Table 7: C-NaviGator III Bundle - Part Numbers
- Table 8: Optional Ruggedized Transportation Cases - Part Numbers

If any items are missing or damaged immediately contact C-Nav Support:

Phone : Regional Office Contact Details
E-mail: cnavsupport@oceaneering.com
Join the C-Nav alert mailing list: C-Nav Alerts Signup to receive important announcements from C-Nav Support.

Please note:
Your C-NavX1 GNSS receiver has already been tested prior to shipment by qualified C-Nav service technicians. Refer to the following steps to connect equipment and operate the receiver.

5.2 Connect Equipment

Figure 1: C-NavX1 GNSS Receiver Rear View

Please note:

• Never open or otherwise tamper with the device enclosure screws or connectors or you will void the warranty.
• Ensure that the device is installed securely.
• Do not install or use your device in damp or wet conditions and always avoid installing the device where it may be dripped on or splashed by any substance.
• Do not install your device in a location that is subject to excessive heat, humidity, dust, or vibration.
• Always connect the device to a suitable power supply

Refer to Figure 1 for the steps below.

1. Use one of the three supplied interface cables for communications:

   - Ethernet (CNV-C-ETH-X1-2-1): Connect the Ethernet connector of the cable to ETHERNET at the rear of C-NavX1 GNSS receiver. Connect the RJ45 end to the computer or C-NaviGator III CDU.

   Or

   - 4-way spider Cable (CNV-C-MAIN-X1-2-1): Connect the M16 connector of the cable to MAIN connector at the rear of C-NavX1 GNSS receiver. Connect the Port 1 DB9S end to the computer or C-NaviGator III CDU. C-Nav Controller software uses a Baud Rate of 115200.

   Or

   - 4-way spider Cable (CNV-C-MAIN-X1-2-1): Connect the M16 connector of the cable to MAIN connector at the rear of C-NavX1 GNSS receiver. Connect the USB V2.0 connector to a PC or C-Navigator. The PC will treat it as an additional serial port, no new driver software is required to be loaded.

   Or

   - 3-way spider Cable (CNV-C-AUX-X1-2-1): Connect the M16 connector of the cable to AUX connector at the rear of C-NavX1 GNSS receiver. These RS422 connection can be used for output to DP systems.

Please note:

Only two concurrent devices can be used to control the C-NavX1: one serial (including the USB virtual serial port and one Ethernet local port

2. Mount the supplied GNSS antenna. Locate the antenna in an area with a 360° clear view of the sky.

3. Connect the TNC connector on one end of a C-Nav approved GNSS antenna cable to the GNSS antenna. Connect the other end of the cable to the TNC connector, labeled **GNSS**, at the rear of the C-NavX1 GNSS receiver.

4. Mount the supplied Iridium Edge antenna using the supplied mounting bracket.

5. Connect the M12 connector of the Iridium Edge antenna cable to the 20cm pigtail of the Edge antenna.

Connect the other end of the cable to the M12 connector, labelled **IRIDIUM**, at the rear of the C-NavX1 GNSS receiver.

6. Perform these steps to setup power:

   - If you are connecting using the AC Power Supply Kit (CNV-C-PSU-X1-2-2), connect the connector of the Power Supply Unit to the power tail from the 4-way spider MAIN interface cable connector labeled MAIN, at the rear of the C-NavX1 GNSS receiver. Insert an AC Power Cord into the 3-prong receptacle on the PSU, based on regional AC power availability (110, 220 or 240 VAC power cords provided) and plug into an appropriately rated wall receptacle.

   - Alternatively, if a suitable DC source is available, it can be directly connected to the DC unterminated cable (CNV-C-PWR-UT-2-1) and connected to the MAIN cable assembly.

7. Once power is applied, the C-NavX1 receiver will automatically power on. Refer to Page 39 for LED status descriptions.

Figure 2: C-NavX1 LED Indicator Panel

8. Your C-NavX1 GNSS receiver hardware is now properly connected.

9. At this point you may connect to C-Setup or other C-Nav controller software via PC, or to a C-NaviGator III/C-NaviGator IV Control & Display Unit to view real-time positioning data and control the C-NavX1 GNSS receiver.

10. C-Nav control devices can be connected either via Ethernet, or serial, but only one serial device and/or one Ethernet controller is allowed. Contact C-Nav Support (cnavsupport@oceaneering.com) for more information.

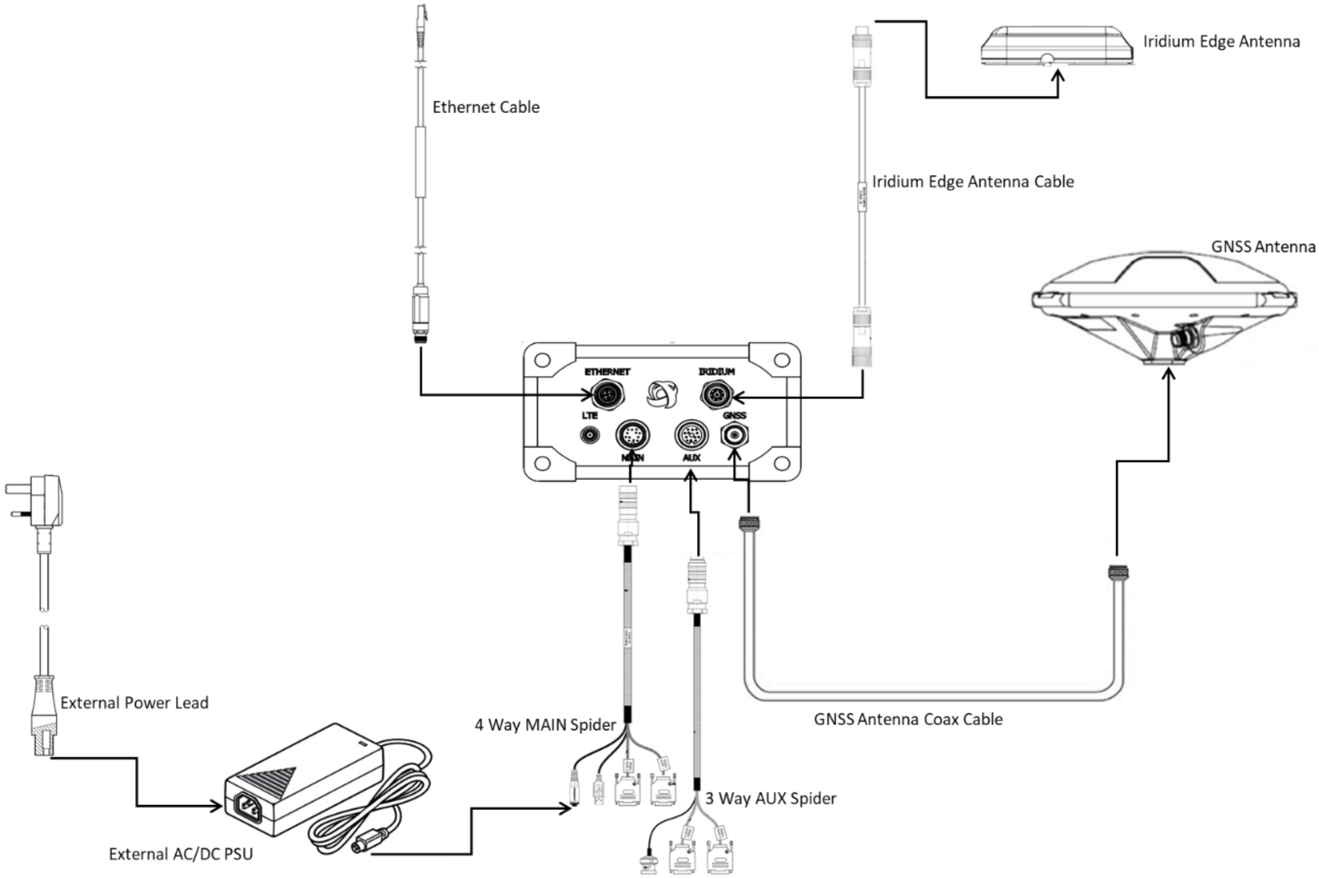


Figure 3: C-NavX1 Typical Installation Drawing

Please note:

- Refer to Section 5- Configuration, for instructions on I/O data port configuration.
- If the C-NavX1 GNSS receiver does not function properly, contact C-Nav Support (cnavsupport@oceaneering.com) immediately.

5.3 Supplied Equipment

Table 1: C-NavX1 Supplied Equipment Description and Part Numbers

Description	Part Number
C-NavX1 Receiver Kit	CNV-CX1- MAX-1-1
Includes the following items:	
C-NavX1 (LEO) GNSS Sensor	CNV-X1- MAX-1-1
4-Way MAIN Spider Cable Power/USB/RS232(x2)	CNV-C-MAIN-X1-2-1
3-Way AUX Spider Cable 1PPS(BNC)/RS422(x2)	CNV-C-AUX-X1-2-1
Ethernet Cable RJ45 connector(x1)	CNV-C-ETH-X1-2-1
AC/DC Power Supply Unit (Locking)	CNV-C-PSU-X1-2-2
UK plug to PSU's IEC C13 plug, 2m	CNV-C-PWR-UK-2-1
US plug to PSU's IEC C13 plug, 2m	CNV-C-PWR-US-2-1
EU plug to PSU's IEC C13 plug, 2m	CNV-C-PWR-EU-2-1
Unterminated DC Power Cable	CNV-C-PWR-UT-2-1
C-NavX1 Mounting Brackets	CNV-R-MTGBKT-KIT
LTE Paddle Antenna	CNV-A-LTE-PAD-1
USB Flash Drive	CNV-USB-CUS-1

5.4 Iridium Edge Cable

Table 2: Iridium Edge Cable Description and Part Numbers

Description	Part Number
C-Nav 25m Edge Cable (Abrasion Resistant)	CNV-C-EDGE-25-2
C-Nav 50m Edge Cable (Abrasion Resistant)	CNV-C-EDGE-50-2
C-Nav 75m Edge Cable (Abrasion Resistant)	CNV-C-EDGE-75-2
C-Nav 100m Edge Cable (Abrasion Resistant)	CNV-C-EDGE-100-2

Figure 4: Iridium Edge Cable

5.5 Antennas

Table 3: Antenna Part Numbers

Description	Part Number
Iridium Edge Antenna inc. Mounting Bracket & mounting hardware	CNV-A-IRDM-EDGE-B
C-Nav289 GNSS Antenna Kit	CNVAT1675-289B

Table 4: Edge Supplied Equipment Description and Part Numbers

Description	Part Number
Iridium Edge Antenna Bundle	CNV-A-IRDM-EDGE-B
Includes the following items:	
Iridium Edge Antenna	CNV-A-IRDM-EDGE-1
Iridium Edge Mounting Bracket Kit	CNV-A-MTGBKT-KIT-1
Washer, Split Lock, M4	0511513
Screw, Round Button Head, M4	0521420
Washer, Plain, M4	0528330
Nut, Hex, Nyloc M4	0528344

Please note:

The X1 receiver requires a GNSS antenna and an Iridium Edge antenna to function correctly. The LTE antenna adds additional diagnostic capabilities, but is not a system requirement

5.6 Electrical Power

5.6.1 AC Power Supply Kit

An AC Power Supply Kit is included for those with a requirement to connect via AC power.

Table 5: AC Power Supply Kit - Part Numbers

Description	Part Number
AC/DC Power Supply Unit (w/locking connector)	CNV-C-PSU-X1-2-2
UK plug to PSU's IEC C13 plug, 2m	CNV-C-PWR-UK-2-1
US plug to PSU's IEC C13 plug, 2m	CNV-C-PWR-US-2-1
EU plug to PSU's IEC C13 plug, 2m	CNV-C-PWR-EU-2-1

5.7 Optional GNSS Antenna Cables

5.7.1 LMR400 Antenna Cable

Figure 5: Optional LMR400 Antenna Cable

Table 6: Optional LMR400 Antenna Cable

Description	Part Number
Cable, Antenna, TNC-m to TNC-m, LMR400, 45m	CNVLMR400-150-K
Cable, Antenna, TNC-m to TNC-m, LMR400, 30m	CNVLMR400-100-K
Cable, Antenna, TNC-m to TNC-m, LMR400, 15m	CNVLMR400-50-K

5.7.2 LMR600 Cable

For those applications that require longer antenna cable runs, the LMR600 cable is recommended to be used.

Figure 6: Optional LMR400 Antenna Cable

Table 7: LMR600 Cable – Part Numbers

Description	Part Number
Cable, Antenna, TNCF-TNCF, 60m LMR600	LMR600-TNC-60000-TNC
Cable, Antenna, TNCF-TNCF, 70m LMR600	LMR600-TNC-70000-TNC
Cable, Antenna, NF-NF, 60m LMR600	LMR600-NF-60000-NF
Cable, Antenna, NF-NF, 70m LMR600	LMR600-NF-70000-NF

5.8 C-Nav Display Unit Controller

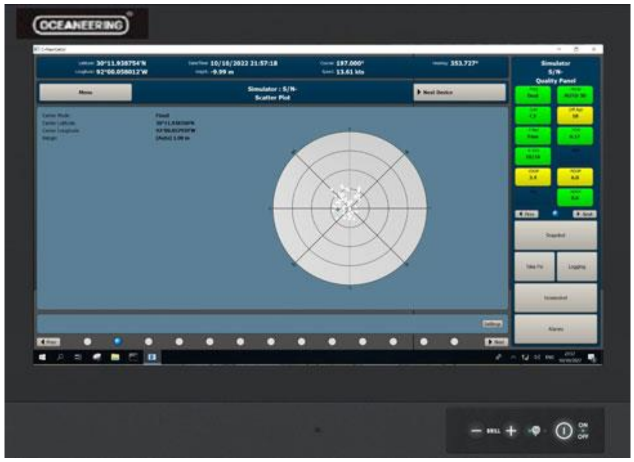


Figure 7: C-NaviGator IV Control & Display Unit

Table 8: C-NaviGator IV Bundle - Part Numbers

Description	Part Number
C-NaviGator IV Bundle	BUNDLE-C-NAVIG_IV
Includes the following items:	
C-NaviGator III Control & Display Unit, Touchscreen	CNVC-Navigator-IV
AC Power Cord, IEC320-C13, Computer Type, US	CNV4000001-110
AC Power Cord, IEC320-C13, Computer Type, Euro	CNV4000002-220
AC Power Cord, IEC320-C13, Computer Type, UK	CNV4000003-240

5.9 Optional Transportation Case

Figure 8: Ruggedized Transportation Case

Table 9: Optional Ruggedized Transportation Cases - Part Numbers

Description	Part Number
Ruggedized Case, C-NavX1, Black	CNV-TCL-540H245

6 INTRODUCTION

6.1 System Overview

Figure 9: C-NavX1 GNSS Receiver

6.1.1 GNSS Sensor System

The C-NavX1 is an IP67 rated rugged mobile device designed for a wide range of uses in the marine sectors.

The C-NavX1 is an integrated multi constellation GNSS and PPP augmentation receiver that tracks GPS, GLONASS, BeiDou, Galileo and QZSS constellations. In addition, the device tracks single frequency SBAS WAAS, EGNOS, MSAS and GAGAN.

The C-NavX1 device receives C-Nav LEO correction data exclusively via Iridium's satellite network.

The C-NavX1 has positioning accuracies of < 10cm (@ 2σ) anywhere in the world, including polar regions when using C-Nav LEO correction.

The C-NavX1 GNSS receiver is suited to real-time applications in areas such as surveying and dynamic positioning, with all output strings for common auxiliary equipment feeds. The sensor delivers the required measurement precision and fast update rates at low data latency.

The C-NavX1 can be configured to log data via a C-Controller device, storing to the Personal Computers storage, or a USB thumb drive if using the C-NaviGator.

The C-NavX1 is an easy-to-use simple plug and play unit that can be delivered pre-configured for the use case, it has the ability to be interrogated remotely to provide technical support, if an LTE signal is available, this feature is off by default.

The C-NavX1 GNSS receiver provides, but is not limited to:

- **C-Nav LEO Corrections Service (CCS)**: A Precise Point Positioning (PPP) solution providing worldwide corrections for decimeter level position accuracy.

  For more information on the C-Nav Corrections Service and obtaining a license, refer to **Error! Reference source not found.** (Page **Error! Bookmark not defined.**).

Please note: C-Nav LEO Correction Subscription Required

- **Signal Reception:** The C-NavX1 GNSS receiver provides signal tracking incorporating the use of GPS (L1, L2, L2C, L5), GLONASS (G1, G2), QZSS (L1 C/A, L1C, L1-SAIF, L2C, L5) and SBAS (WAAS, EGNOS, MSAS, GAGAN, and SBAS). The receiver tracks and provides raw measurements data for Beidou (B1 and B2) and Galileo (E1, E5a, and E5b) satellite signals. Currently only GPS, Galileo, and GLONASS data are used in the positioning calculations

- **226 Signal Channels:** Provides the ability to track multiple frequencies of satellites in several constellations simultaneously. This allows for extended navigation in otherwise adverse conditions for a single constellation. With further tracking channels for Iridium Burst and Short Burst Data (SBD) service channels.

- **1PPS:** A pulse is available from the C-NavX1 GNSS receiver at an output rate of once per second. This pulse can be used for a variety of Time / Mark applications where relative timing is required.

- PVT and Raw Data Output Rates at 1 Hz

6.2 Applications

The C-NavX1 GNSS receiver meets the needs of a large number of applications. The applications include, but are not limited to:

6.2.1 Offshore

- Nautical Station keeping
- Dynamic Positioning
- Dredging and Offshore Construction
- Deep Water Survey

6.2.2 Machine Control and Vehicle Navigation

- Towed Implement Guidance
- Construction Machine Control - Blade Control and Grading
- Railway, Ship, and Aircraft Precision Tracking
- Port Operations and Container Tracking

6.2.3 Survey and GIS

- Boundary Survey
- Topographical Surveys in Rough Terrain
- Construction Site Stake-out
- High-Accuracy Data Collection for Post-Processing
- Hydrographic Survey

6.2.4 Military Applications

- Non-Weaponized Military Positioning Applications
- Unmanned Systems

- Oceanographic Survey and Research

6.2.5 Specialty Applications

- Aerial - Photogrammetric Survey
- High-Value Asset Location and Tracking
- Positioning for Mining Applications
- Continuously Operating Reference Stations
- Structural Monitoring
- Real-time Positioning Applications
- OEM Integration

6.3 Accuracy

6.3.1 C-Nav Correction Service (CCS)

The system provides < 10 cm (@ 2σ) horizontal position accuracy when CCS Dual Frequency signals are used.

> **Please note:**
>
> Multi Constellation and multi frequency operation is only available when using C-Nav LEO correction. SBAS and Autonomous operation will be GPS single frequency.

6.3.2 SBAS

When WAAS, EGNOS, MSAS, QZSS, or GAGAN, SBAS correction signals are used, the system provides < 1.5m 2D position accuracy (1σ). System accuracy with WAAS, EGNOS, MSAS, QZSS or GAGAN signals is subject to the quality and update rate of these publicly operated signals.

6.4 Receiver Features

Output Data Rate

The C-NavX1 GNSS receiver can output proprietary raw data and NMEA data at a 1Hz rate.

> **Please note:**
>
> The throughput capacity of the ports is limited by the baud rate and the byte size and number of messages output.
>
> Note 1: Port dependent, refer to Communications Ports for details.

6.5 NMEA-0183 Data

The C-NavX1 GNSS receiver is capable of outputting several standard NMEA-0183 data strings (see Appendix D- NMEA Data Output Messages) and several proprietary data strings. Proprietary data strings are denoted with a $PNCT prefix.

6.5.1 Standard

- DTM: Datum Reference
- GBS: GPS Satellite Fault Detection
- GGA: GPS Fix Data
- GLL: Geographic Position – Lat/Lon
- GNS: GNSS Fix Data
- GRS: GPS Range Residuals
- GSA: GNSS DOP & Active Satellites
- GST: GNSS Pseudo-range Error Statistics
- GSV: GNSS Satellites In View
- RMC: Recommended Min. Specific GNSS Data
- VTG: Course Over Ground & Ground Speed
- ZDA: Time & Date

6.5.2 Proprietary (prefix $PNCT)

- GGA: GPS Fix Data with Field 14, which shows Navigation Mode.
- GST: GNSS Pseudo-range Error Statistics
- MDE: Marginally Detectable Error
- SET: Solid Earth Tide

6.6 Extended Features

The C-NavX1 GNSS receiver has feature set that includes (but is not limited to):

6.6.1 C-Nav LEO Correction Service (CCS)

The ability to receive C-Nav LEO Correction Service (CCS) signals is fully integrated within each unit. A single set of correction can be used globally enabling a user to achieve decimeter level positioning accuracy without the need to deploy a separate base station, thus saving time and capital expenditure.

C-NavX1 position outputs are referenced to the ITRF-2014 datum (default). Refer to Appendix C - C-Nav LEO Correction Service (CCS) for more information.

6.6.2 Over-The-Air C-Nav Licensing

Over-the-Air C-Nav Licensing is the easiest way to install a C-Nav license. The installation of a purchased license is accomplished via IRIDIUM broadcast.

Over-the-Air C-Nav Licensing is especially convenient for receivers in remote locations in the field.

6.6.3 GNSS Performance

The C-NavX1 GNSS receiver utilizes the Topcon B125 GNSS engine, which incorporates several patented innovations. This results in improved real time positioning, proven through independent tests, when facing various multipath environments.

6.6.4 Rugged Design

Units have been tested to conform to MIL-STD-810G for low pressure, solar radiation, rain, humidity, salt-fog, sand, and dust. In addition, the unit is IP certified to the IP67 level (compliant only when cables are connected).

The C-NavX1 is also designed to comply with the relevant type approval procedure, EN 60945.

6.7 Antennas

6.7.1 C-Nav289

Figure 10: C-Nav289 Antenna

The C-Nav289 is a GNSS antenna (CNVAT1675-289B / AT1675-289) housed in an All-polymer enclosure, non-corrosive design to improve corrosion resistance. It has an excellent tracking performance and a stable phase center. It contains a 90 dB out of ban rejection filter of the INMARSAT uplink frequencies and has a steeper high end roll-off which significantly reduces interference for Iridium uplink transmission. It tracks GPS (L1, L2,), GLONASS (G1, G2), Galileo (E1/E5a/E5b), BeiDou (B1,B2),C-Nav Correction (CCS) Service (L-Band differential correction), and SBAS (WAAS / EGNOS / MSAS / GAGAN) signals. See Table 33: C-Nav289 Specification Sheet for more information.

6.7.2 Iridium Edge

Figure 11: Iridium Edge Antenna

The Iridium Edge antenna (CNV-A-IRDM-EDGE-1) is a finished satellite device with a power supply and antenna in a sealed enclosure. It is able to receive Iridium Burst data and also receive / transmit Iridium Short Burst Data (SBD). See Table 35: Iridium Edge Specification Sheet for more information. It is actually a smart antenna and the connection to it is power and RS232, not an RF signal.

6.7.3 Poynting LTE Antenna

Figure 12: Poynting LTE Antenna

The LTE antenna (CNV-A-LTE-PYG-1) is a high gain omni-directional antenna that covers all cellular frequencies bands needed for LTE, but also covers the bands for HSDPA, 3G, EDGE, GPRS, voice and 2.4 GHz LTE and Wi-Fi bands. See Table 36: Poynting LTE Antenna Specification Sheet for more information.

6.7.4 Paddle LTE Antenna

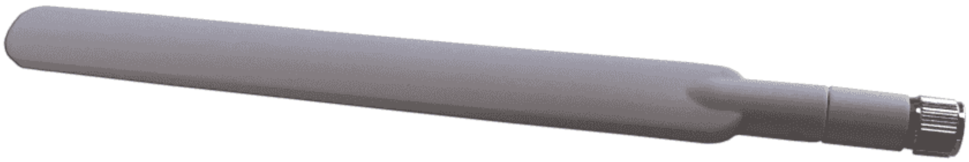


Figure 13: Paddle LTE Antenna

The LTE antenna (CNV-A-LTE-PAD-1) is a high gain omni-directional antenna that covers all cellular frequencies bands needed for LTE, but also covers the bands for HSDPA, 3G, EDGE, GPRS, voice and 2.4 GHz LTE and Wi-Fi bands. See Table 34: Paddle LTE Antenna Specification Sheet for more information.

7 INTERFACING

This chapter details the C-NavX1 GNSS sensor connectors, cables, LED displays, appropriate sources of electrical power, and how to interface the communication ports.

Please note:

To maintain IP67 capability the cable connectors must be fully seated in the mating connector. In addition, blanking plugs must be used on connections not in use.

7.1 Electrical Power

There are two ways to power the C-NavX1. Both cable options are provided with the system.

- Universal AC/DC power supply
- Direct DC connection to the MAIN cable assembly

⚠ Voltages less than approximately 6 VDC will turn the unit off. Voltages from approximately 5 VDC to < 7 VDC will create a brown-out. In such a case, power the unit on as follows:

⚠ Voltages in excess of 36 VDC will damage the unit. The power supply must be well conditioned with surge protection. Vehicular electrical systems, which create voltage spikes in excess of 36 VDC, will benefit from providing power protection during vehicle engine power-up. This can be accomplished through a relay power-on sequence and / or power conditioning (such as a DC-to-DC converter). Do not connect equipment directly to the vehicle's battery without in-line protection.

7.2 AC/DC Power Supply

An AC/DC Power Supply Kit (CNV-C-PSU-X1-2-2), complete with AC power cords for 110, 220, and 240 VAC regions is included for those with a requirement to connect via AC power. Replacement 110, 220, and 240 VAC power cords can be purchased from any authorized C-Nav dealer.

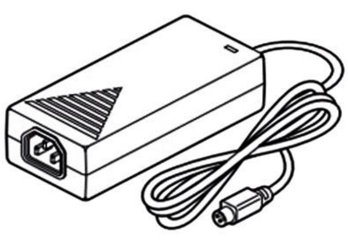


Figure 14: C-NavX1 Universal Power Supply

7.3 Communication Ports

The C-NavX1 GNSS receiver provides one 12-pin male Binder M16 connector communication ports labeled MAIN, one 12-pin female Binder M16 connector labeled as AUX and one 8-pin female X-Code M12 connector labeled **ETHERNET** at the rear of the receiver, as shown in below.

Figure 15: C-NavX1 Communications Ports

Table 10: C-NavX1 GNSS Receiver Rear View

Item	Connector / Type	Connector Function
1	ETHERNET / Female M12 8-WAY CODE-X	RJ45 I/O Port
2	IRIDIUM / Female M12 8-WAY CODE-A	Iridium Edge Connector
3	LTE / Female SMA	LTE Antenna Connector
4	MAIN / Male Panel Mount 12-WAY	4-way spider [or multi-cable] MAIN connector for • Power supply to the unit. • I/O: 2x DB9 female RS232 ports. • I/O: 1x USB A 2.0 male connector.
5	AUX / Female Panel Mount 12-WAY	3-way spider [or multi-cable] AUX connector for • 1PPS: 1x BNC male connector. • I/O: 2x DB9 female RS422 ports.
6	GNSS / Female TNC	GNSS Antenna Connector

The MAIN connector pin-outs and AUX connector pin-outs are described in Table 11: AUX 3-Way Spider Cable Pin Assignment.

7.4 Supplied Data Cables

There are three supplied interface data cables:

1. **MAIN** – 2 x DB9S female RS232 ports, 1x USB port, 1 x DC Jack (CNV-C-MAIN-X1-2-1)
2. **AUX** – 2 x DB9S female RS422 ports, 1 x BNC male 1PPS connector (CNV-C-AUX-X1-2-1)
3. **ETHERNET** - 1 x RJ45 (CNV-C-ETH-X1-2-1)

7.5 4-Way MAIN Spider Cable

The MAIN connector pin-outs, 2x DB9S female RS232 ports, 1x USB port, 1 x DC Jack (CNV-C-MAIN-X1-2-1) is described below:

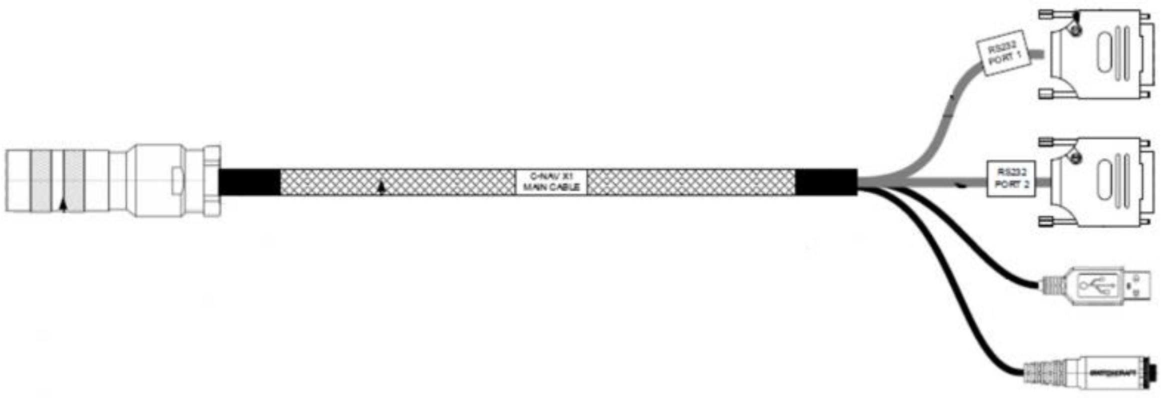


Figure 16: C-NavX1 4-Way MAIN Spider Cable

Table 11: MAIN 4-Way Spider Cable Pin Assignment

Binder M16 12-Way Male Pin	Signal	D-SUB9 RS232 Port-1 Pins	D-SUB9 RS232 Port-2 Pins	USB-A	2.5mm DC Power Jack
A	GND	-	-	-	2
B	Vin	-	-	-	1
SHELL		-	-	SHELL	-
C	GND (BLACK)	-	-	4	-
D	Vcc (RED)	-	-	1	-
E	DATA+ (GREEN)	-	-	3	-
F	DATA- (WHITE)	-	-	2	-
G	Tx	-	2	-	-
H	Rx	-	3	-	-
J	Tx	2	-	-	-
K	Rx	3	-	-	-
L	GND	-	5 & SHELL	-	-
M	GNS	5 & SHELL	-	-	-

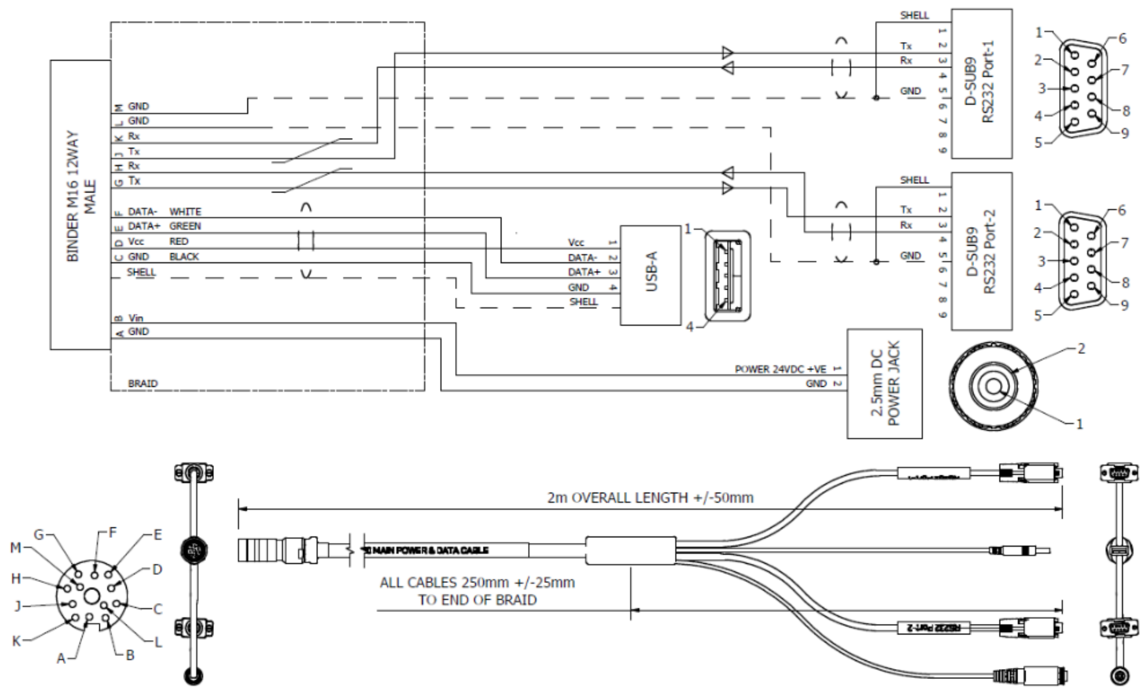


Figure 17: MAIN 4-Way Spider Cable Pin Assignment

7.6 3-Way AUX Spider Cable

The AUX connector pin-outs, 2x DB9S female RS422 connectors, 1 x BNC male 1PPS connector (CNV-C-AUX-X1-2-1) is described below:

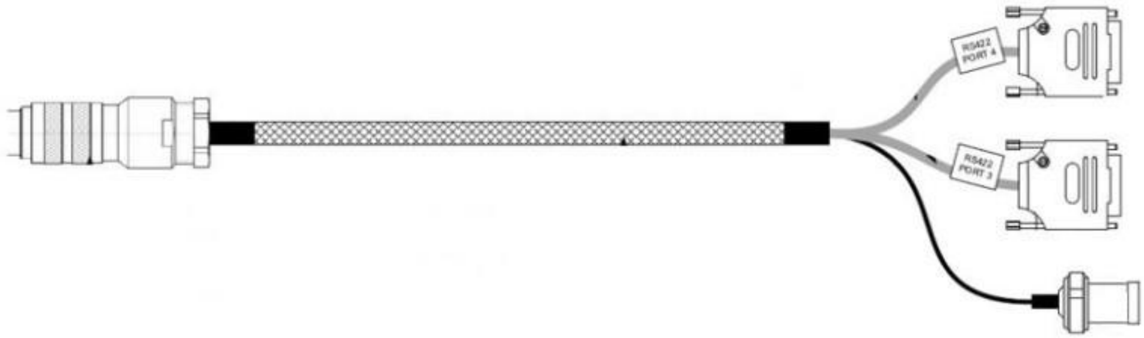


Figure 18: C-NavX1 3-Way AUX Spider Cable

Table 12: AUX 3-Way Spider Cable Pin Assignment

Binder M16 12-Way Male Pin	Signal	D-SUB9 RS422 Port-3 Pins	D-SUB9 RS422 Port-4 Pins	BNC
A	OUTER (GND)	-	-	2
B	INNER (1PPS)	-	-	1
C	TxD-	2	-	-
D	TxD+	7	-	-
E	RxD-	3	-	-
F	RxD+	8	-	-
G	TxD-	-	2	-
H	TxD+	-	7	-
J	RxD-	-	3	-
K	RxD+	-	8	-
L	GND	5	-	-
M	GND	-	5	-

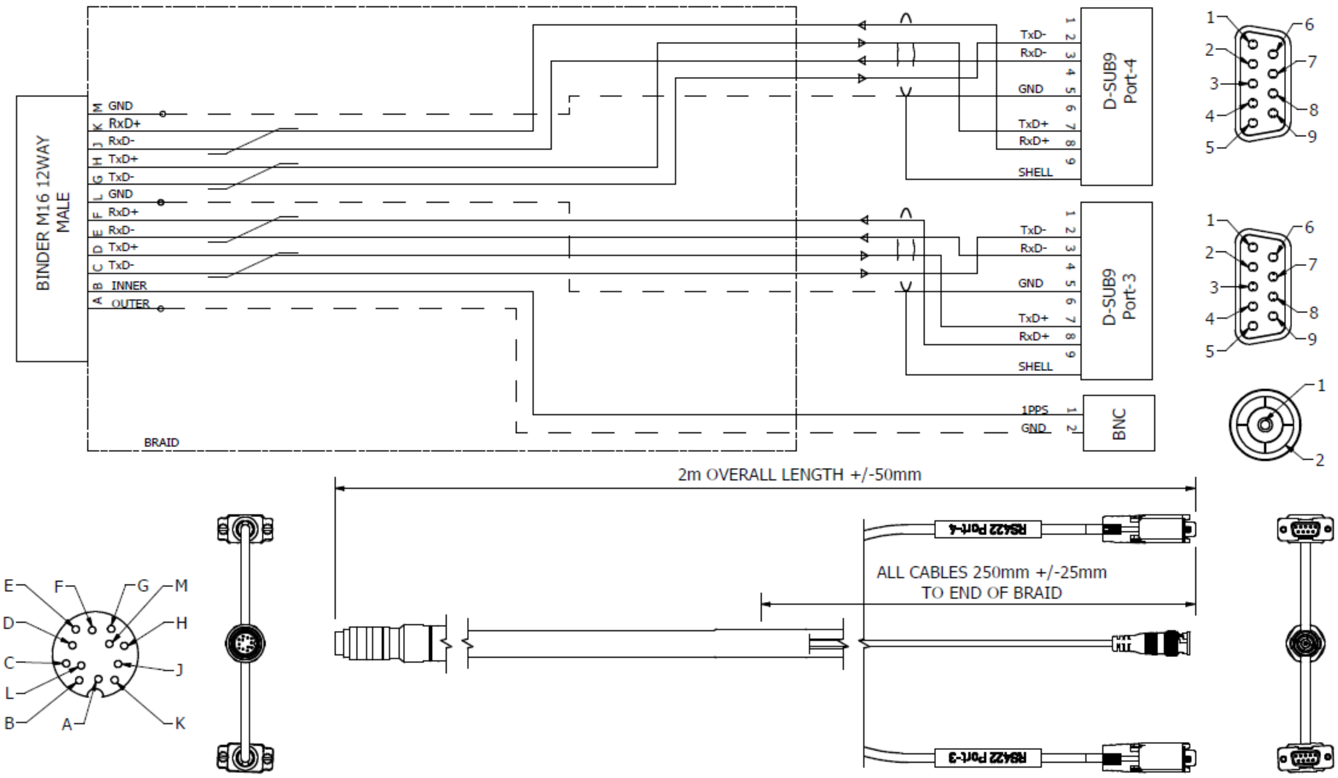


Figure 19: AUX 3-Way Spider Cable Pin Assignment

7.7 ETHERNET Cable

The ETHERNET connector pinouts, 1 x RJ45 (CNV-C-ETH-X1-2-1) is described below:

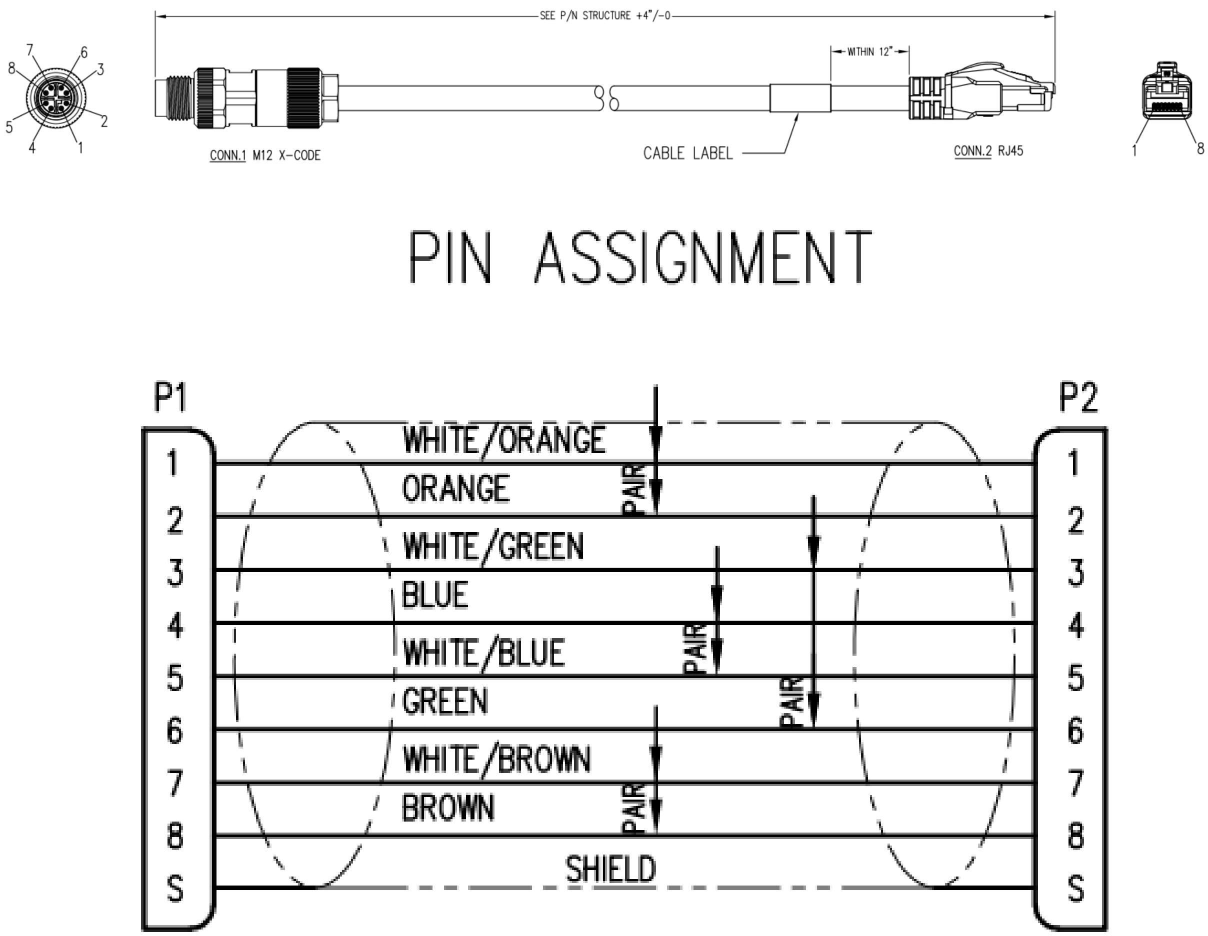


Figure 20: ETHERNET Cable

7.8 IRIDIUM Cable

The IRIDIUM connector pinouts, (CNV-C-EDGE-50-2 or similar) is described below:

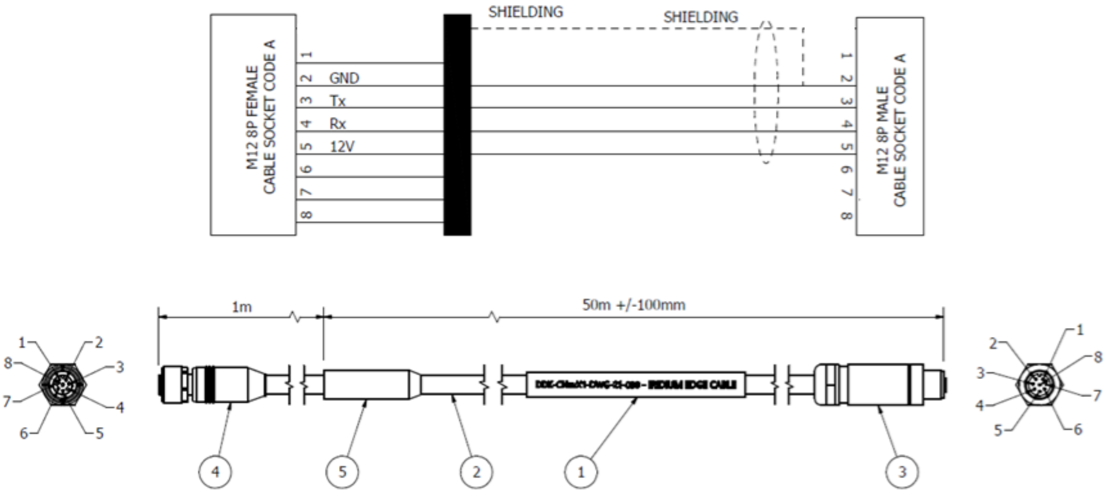


Figure 21: Iridium Edge Interface Cable

7.9 1PPS

A pulse is available from the C-NavX1 GNSS receiver via the 3-Way AUX Spider Cable BNC male connector at an output rate of once per second. This pulse can be used for a variety of Time / Mark applications where relative timing is required.

Specifications:

- 30 ns relative accuracy
- 10 mS wide positive going
- 3.3 V LVTTL
- 50 ohm impedance

7.10 Front Indicator Panel LEDs

Figure 22: C-NavX1 GNSS Receiver Front Indicator Panel LED's

The indicator panel provides a quick status view of the GNSS navigation / operating mode, C-Nav signal strength.

7.10.1 GNSS LEDs

Table 13: GNSS LED Indication

Icon	Indicator	Status	Description
	GNSS Status	**Red**	GNSS Antenna Not Connected / No or ≤3 SVs in View
		Amber	Signal Strength ≤40% / ≤4 SVs In View
		Green	Signal Strength ≥40% / ≥4 SVs in View / GNSS Position Solution Computed

7.10.2 Correction Age LEDs

Table 14: Correction Age LED Indication

Icon	Indicator	Status	Description
	Correction Age Status	**Red**	Iridium Antenna Not Connected / No signal
		Amber	Correction Age Latency >10 mins
		Green	Correction Age Latency ≤10 mins

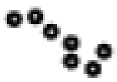
7.10.3 Status LEDs

Table 15: Status LED Indication

Icon	Indicator	Status	Description
STATUS	**C-NavX1 Device Status**	**Amber**	Device Not Booted / No Position Solution / No signal from GNSS antenna and/or Iridium antenna and or LTE antenna Augmentation Latency >10 mins
		Green	PPP Solution Computed

7.10.4 Iridium Status LEDs

Table 16: Iridium Status LED indication

Icon	Indicator	Status	Description
	**Iridium Status**	**Red**	Iridium Antenna Not Connected / No Signal
		Amber	Iridium Augmentation Received but Signal Strength is Low
		Green	Iridium Connection Made and Steady

7.10.5 LTE Status LEDs

Table 17: LTE Status LED Indication

Icon	Indicator	LED	Description
	**LTE Status**	**Off**	LTE Disabled (default)
		Red	LTE Antenna Not Connected / No Signal
		Amber	Connection Made but Signal Strength is Low
		Green	LTE Connection Made and Steady

8 INSTALLATION

This chapter provides guidance on hardware installation for optimum performance.

Prior to commencing any installation, discuss proposed mounting locations / methods and cable routes with those involved to ensure all parties are aware and approving of the work to be done and the risks involved.

Always wear appropriate protective equipment, including a certified fall arrestor harness and hard hat when working at heights to prevent injury to personnel, or death. Prior to commencing any work on the mast, ensure that all radar systems are switched off and isolated and that anyone on the job is trained and certified to perform the task(s).

8.1 GNSS Antenna

The 5/8-inch BSW threaded antenna mount has a depth of 16 mm (0.63 inch).

Antenna placement is critical to good system performance. It is necessary to mount the antenna as high on the mast as possible, ideally at the highest point, in order to avoid shading or multi-path by surrounding structures.

Figure 23: C-Nav289 GNSS Antenna

8.2 Antenna Location

- Locate the antenna where it has a clear view of the sky, to an elevation angle of 7º if possible.
- Avoid placing the antenna where more than 90º azimuth of the sky is obstructed. When more than 90º of azimuth is shaded, the receiver will still try to navigate; however, poor satellite geometry (due to satellite shading) will provide poor positioning results. Even minor shading can have a negative effect on performance.
- Avoid placing the antenna on or near metal or other electrically reflective surfaces.
- Do not paint the antenna enclosure.
- Do not install any metallic stickers on top of the antenna.
- Secure the antenna to the mast firmly to avoid wind and vibration which can affect the performance of the C-NavX1 GNSS receiver system.

- Avoid placing the antenna near electrical motors (elevator, air conditioner, compressor, etc.) or other sources of of interference such as radar systems, satcom domes, HF antennas or whip antennas.

- Do not place the antenna too close to other active antennas. The wavelength of L5 is 0.255 m and G1 is 0.187 m. The minimum acceptable separation between antennas is 1 m (39 in), which provides 5.9 dB of isolation. For 10 dB of isolation, separate the GNSS antennas by 2.55 m, and for 13 dB of isolation (recommended) separate the antennas by 5.1 m.

- Active antennas (those with LNAs or amplifiers) create an electrical field around the antenna. These radiated emissions can interfere with other nearby antennas. Multiple GNSS antennas in close proximity to each other can create multipath and oscillations between the antennas. These add to position error or the inability to process the satellite signals.

- Most antennas have better gain when the satellite is high in elevation. Expect tracking performance to fade as the satellite lowers in elevation. It is not unusual to see 10 dB difference in antenna gain (which translates into signal strength) throughout the entire elevation tracking path.

There are also additional errors that may cause your GNSS PPP positioning solution to not perform at its optimum level. These additional errors are largely due to the antenna installation location, and are characterized as follows:

- **Interference –** this is when the correction and or satellite signals are intentionally or unintentionally swamped by transmitting signals.

- **Multi-path –** this is when the GNSS signals reflect or bounce off of another surface prior to reception at the antenna.

- **Masking –** this is when the GNSS or correction signal is blocked or masked by a manmade or natural feature.

Marine band Channel 20 is an exact harmonic of GPS L1 and should not be used

8.3 Antenna Mounting Pole

Included with the C-Nav289 Antenna is a 1 ft Antenna Mounting Pole (P/N CNVWES534610). See Figure 24 below.

Figure 24: Antenna Mounting Poles

8.4 Antenna Mounting Pole Adaptor

The antenna is fitted with a 5/8” BSW threaded mount with a depth of 16 mm (0.63”).

Figure 25: Antenna Mounting Pole Adapter

The antenna mounting pole adaptor converts:

- From: 5/8” BSW (depth of 14 mm [0.55”])
- To: 1 ¼” UNS-2B (depth of 32 mm [1 ¼”])

C-Nav recommends that the supplied mounting adaptor hardware (P/N CNV3250005-0) be used in conjunction with the supplied antenna-mounting pole (P/N CNVWES534610) as the primary means of mounting.

Figure 26: Antenna, Adaptor and Mounting Pole

8.5 Antenna Installation

1. Once the antenna location has been determined based on the aforementioned criteria, mount the antenna onto an antenna-mounting pole via the antenna mounting pole adaptor. This should be done on deck prior to climbing the mast as mounting the antenna aloft poses potential risks to personnel and equipment due to possible dropped object hazards.

2. Install the antenna with an antenna-mounting pole in the predetermined location. The pipe can either be welded to the mast for a more permanent installation or secured using stainless steel hose clamps.

3. Use a level to ensure that the antenna is mounted vertically.

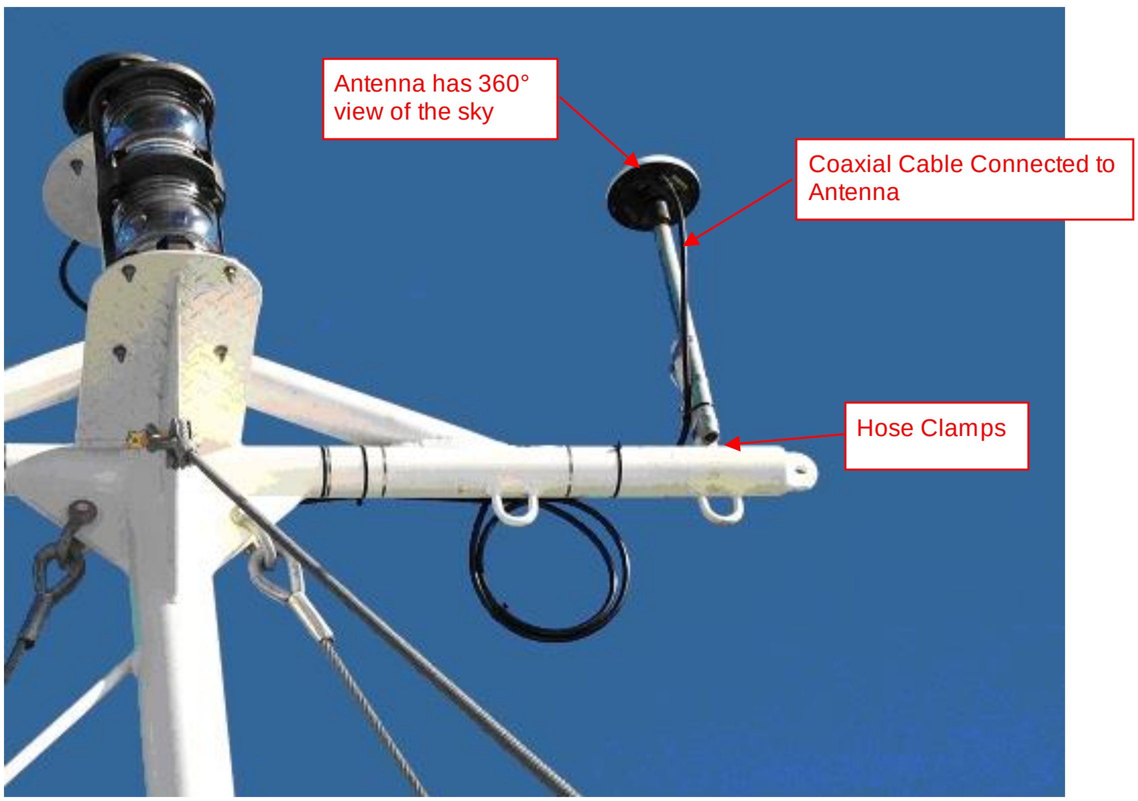


Figure 27: C-NavX1 GNSS Receiver Antenna Mast Installation

8.6 Coaxial Cable

Proper installation of coaxial cables is important to ensure successful communication between the antenna and the GNSS sensor.

The connector used on the C-NavX1 GNSS receiver is a TNC female, labeled GNSS on the rear panel of the X1

The GNSS antenna connector provides +5 V ± 0.5 V at 100 mA. Do not disconnect the antenna when the GNSS unit is powered on.

8.7 Cable Route

When choosing a cable route for coaxial cable, consider the following:

- Avoid running coaxial cable across, or parallel to power cables and high-power RF cables.
- Ensure that the cable route is free of sharp edges or places where the cable could become pinched, kinked, sliced, or damaged in any way.
- Determine the manufacturer's specifications for the coaxial cable in use. This should include impedance, diameter, attenuation in dB / 100 ft and dB / 100 m at 1.575 GHz, velocity of propagation and the minimum bend radius of the cable.
- Ensure the cable does not exceed the recommended minimum bend radius suggested by the manufacturer.
- Ensure there is sufficient space at the cable entry point to the bulkhead as to not damage the connector during installation.
- Measure the length of the cable route and refer to Table 17 for acceptable cable lengths in relation to attenuation loss at the frequencies in use. The cable length between the antenna and C-NavX1 GNSS receiver should not exceed 7 dB loss at 1.575 GHz for optimum performance, though the system may tolerate up to 10 dB of cable loss with minimal performance. Lower elevation satellite tracking suffers the most with more than 7 dB insertion loss.
- In-line amplifiers suitable for all GNSS frequencies may be used to increase the length of the antenna cable, but care should be exercised that tracking performance is not degraded due to multiple connections, noise from the amplifier, and possible ingress of moisture and dust to the in-line amplifier. In-line amplifier or splitter devices must pass DC power from the receiver to the antenna or source the appropriate voltage and current to the antenna. In-line amplifiers may also over-saturate the receiver front-end if improperly used. Contact C-Nav Sales (cnav-sales@oceaneering.com) for more information on available in-line amplifier solutions.

8.8 Coaxial Cable Installation

1. Prior to connecting the coaxial antenna cable to the antenna, ensure that all connections are free of dirt and other debris. Connect the coaxial cable and hand-tighten firmly. Wrap the connection with self-amalgamating tape to prevent water ingress.
2. Create a service loop with the coaxial cable and zip tie firmly to the antenna-mounting pole or nearby solid structure to prevent any undue strain on the cable connector or antenna connector.
3. With the cable connected to the antenna, run the cable down the mast, securing with zip ties every two or three feet. Carefully lay the cable along the chosen route to further detect any potential kinks, bends or spots where the cable may become damaged.
4. Secure the cable along the cable route with tape or zip ties and place a label at the GNSS sensor end of the cable for identification purposes.

Connect the coaxial cable to the female TNC connector on the GNSS receiver labeled **GNSS1** Ensure that any slack in the cable is neatly stowed and that the minimum bend radius is not exceed during this process.

Table 18: Acceptable Coaxial Cable Lengths

Cable Type	Atten. (dB) per 100 Ft.	Cable Length in Feet	Loss in dB	Atten. (dB) per 100 m	Cable Length in Meters	Loss in dB
RG-58C	19.605	36.00	7.06	64.32	11.00	7.08
RG-142	16.494	43.00	7.09	54.12	13.00	7.04
RG-213	9.564	74.00	7.08	31.38	22.50	7.06
RG-223	17.224	41.00	7.06	56.51	12.50	7.06
LMR600	3.407	207.00	7.05	11.18	63.00	7.04
LMR400	5.262	133.00	7.00	17.26	41.00	7.08
LMR240	10.127	70.00	7.09	33.23	21.00	6.98
LMR195	14.902	47.00	7.00	48.89	14.00	6.85

8.9 Iridium Edge

The Iridium Edge antenna is a satellite receiver with a data modem, power supply and antenna in a sealed enclosure. It is able to receive Iridium Burst data and also receive / transmit Iridium Short Burst Data (SBD).

The maximum cable length is 100m, with 25m, 50m and 75m variants available.

8.10 Iridium Edge IMEI Number

Before an installation, the Iridium Edge's IMEI number should be noted. The Iridium Edge's IMEI number is the network address for the Iridium Edge, a unique serialised number.

The IMEI number is located on the bottom of the Iridium Edge as per the picture below. This can also be queried through C-Controller once the C-NavX1 is powered on and the Iridium Edge cable connected.

Figure 28: Location of Iridium Edge IMEI Number

The Iridium Edge includes four additional IMEI labels. These labels are located on the bottom of the Iridium Edge shipping box as per the figure below. If the Iridium Edge is mounted in a difficult to reach place or if its IMEI label is covered, the spare IMEI label can be optionally affixed to an accessible location such that the IMEI can be easily read.

The IMEI number is also available on C-Nav software, Receiver Information menu

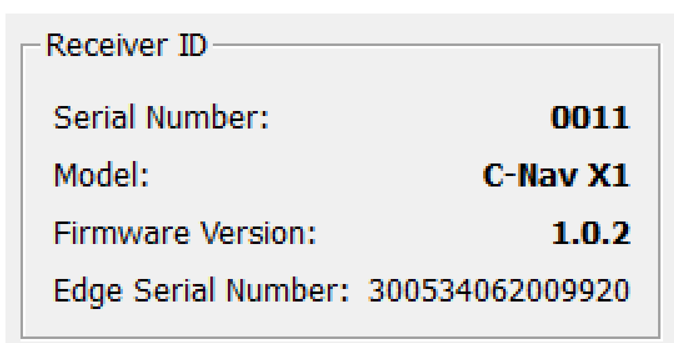


Figure 29: Receiver Information section for Edge SN

8.11 Iridium Edge Antenna Location

CAUTION:

Install the Iridium Edge safely and securely. Failure to do so could result in dislodging of the Iridium Edge especially when operating in areas of high winds or when mounted on moving vehicles, which could result in injury or damage.

For the best performance Iridium Edge antennas should be installed in a location with the following properties -

- A good clear 360° sky view as high as is practicably possible – to ensure that all available Iridium satellites can be tracked at all times.
- Not close to any other Tx / Rx antennas – to avoid unintentional interference.
- Not behind any structure – to ensure that the risk of masking is mitigated.
- Maximum cable run should not exceed 100m using one of the Iridium Edge cables provided.
- The location must provide a safe and secure installation.
- The Iridium Edge is not intended to be operated near a person. Always ensure that the Iridium Edge is mounted more than 20 cm from persons for compliance with RF exposure limits.
- Select a flat, horizontal mounting location for optimal uniform satellite performance.
- Make sure that the mounting location provides a clear unobstructed 360 degrees' view of the sky in all directions. Typically, this means selecting a mounting location that has no masking.
- Do not install the Iridium Edge inside a building or under metal surfaces.
- Make sure that the mounting location will not heat up the Iridium Edge causing its temperature to exceed the maximum operating temperature. If the surface can get hot, especially in the direct sun, an insulating material should be used between the mounting surface and the Iridium Edge.
- Never mount the Iridium Edge close to any other communication equipment or antennas.
- Never install the Iridium Edge in a location where water can collect.
- Never install the Iridium Edge near an exhaust which can deposit fumes and carbon, and which can affect satellite operation.

8.12 Iridium Edge Antenna Universal Mounting Bracket

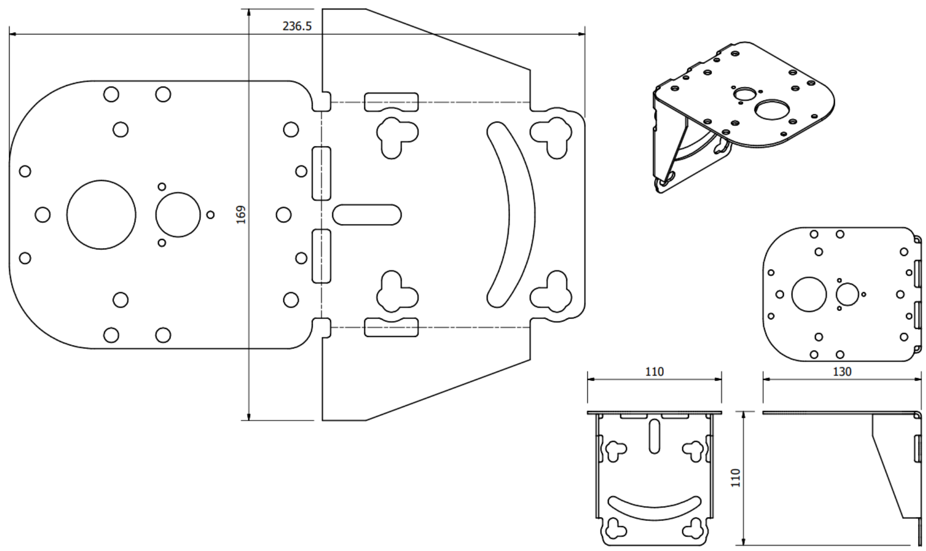


Figure 30: Universal Mounting Bracket and Iridium Edge Antenna

8.13 Iridium Edge Cable Installation

1. Carry out a reconnaissance to establish the most appropriate location to install the Iridium Edge antenna and agree with the senior client representative.

2. Carry out a reconnaissance to establish the most appropriate Iridium Edge antenna cable run and agree with the senior client representative.

3. Install the Iridium Edge antenna in the agreed location.

4. Prior to running your Iridium Edge antenna cable to your device, turn a loop in the Iridium Edge antenna cable and secure it to a mounting point. This will protect the connector by reducing the strain caused by the cable pulling on the connector.

5. Connect the Iridium Edge connector to the Iridium Edge antenna connector and wrap the connector and cable with self-amalgamating tape.

6. Prior to running the cable, ensure that there are no sharp edges that might cut into the cable, ensure that any required bends in the cable do not exceed the maximum bend radius for the cable.

7. Run the Iridium Edge antenna cable from the Iridium Edge antenna to your device ensuring at all times that the cable is secure neat and tidy and does not create a hazard.

8. Ensure that any excess cable is coiled neat and tidy.

9. Prior to connecting your Iridium Edge antenna cable to your device, turn a service loop in the Iridium Edge antenna cable and secure. This will protect the connector by reducing the strain caused by the cable pulling on the connector.

10. Connect the Iridium Edge cable connector to the **IRIDIUM** connector on your device.

11. Make good as required leaving the location as you found it and agree and sign off the installation with the senior client representative.

Below 2 options Screw & Bottom mounts are from the Iridium Edge Manual, which type would be applicable for the universal bracket option?

8.14 Screw Mount

The Iridium Edge has 4 mounting holes designed to accommodate M4 screws.

1. Do not remove the red plastic over the double side tape. Removing the red tape, exposes the double-sided tape which may cause the tape to inadvertently adhere the Iridium Edge to the mounting surface.
2. Screw selection is installation specific depending on the mounting surface thickness and its material type.
3. The Accessory Bag contents are not required for the Side Mount installation. These can be set aside.
4. Use Iridium Edge to carefully mark the mounting holes.
5. Drill four (4mm) holes in the mounting surface and / OR use the bracket that secures the Iridium Edge.
6. Select a side channel for the cable to exit, depending on cable routing and installation restrictions.
7. Remove the grey plug from the selected channel by gently prying it out with a sharp flat head screwdriver. If the plug needs to be re-inserted, ensure the plug is flat to the baseplate before pressing in with your thumb. Do not use any instruments to re-insert. Optionally remove the second grey plug as it is provided for aesthetic purposes only.
8. Firmly press the pigtail cable into the selected channel, making sure that the cable is flush with the baseplate. Do not use any sharp instruments. In the event that the pigtail cable must be removed from the side channels, always keep a thumb over the center of the Iridium Edge where the pigtail connector exits. It is very important to be careful with the pigtail cable when it is not secured in the side channel.
9. If the supplied aesthetic grey plug is not used, optionally fill the unused channel with silicon sealant to prevent the insertion of sharp tools under Iridium Edge.
10. Insert mounting screws and tighten the screws and nuts.

Please note:

Do not exceed torque over 40 N-m.

11. Secure all mounting nuts with an appropriate thread locker that meets the installation requirements for factors such as vibration and temperature

Figure 31: Screw Mount Installation

8.15 Edge Cable

Proper installation of Edge cable is important to ensure successful communication between the antenna and the GNSS sensor.

The connector used on the C-NavX1 GNSS receiver is a M12 female, labeled IRIDIUM on the rear panel of the C-NavX1 sensor

The Iridium antenna connector provides +5 V ± 0.5 V at 100 mA. Do not disconnect the antenna when the GNSS unit is powered on.

8.16 Cable Route

When choosing a cable route for coaxial cable, consider the following:

- Avoid running Edge cable across, or parallel to power cables and high-power RF cables.
- Ensure that the cable route is free of sharp edges or places where the cable could become pinched, kinked, sliced, or damaged in any way.
- Ensure the cable does not exceed the recommended minimum bend radius suggested by the manufacturer.
- Ensure there is sufficient space at the cable entry point to the bulkhead as to not damage the connector during installation.

8.17 Lightning Protection

Where the GNSS antenna is exposed to sources of electromagnetic discharge such as lightning, install a properly grounded in-line electrical surge suppressor between the GNSS receiver and antenna. Install protective devices in compliance with local regulatory codes and practices. Protective devices must pass DC power from the receiver to the antenna. Contact C-Nav Support (cnavsupport@oceaneering.com) for more information on available lightning protection solutions.

8.18 GNSS Sensor Mounting

Mount the C-NavX1 GNSS receiver to a flat surface. Shock isolators suitable for 0.50 kg (1.1 lbs) may be necessary for environments with high vibration, i.e. Earth moving equipment or aircraft installation.

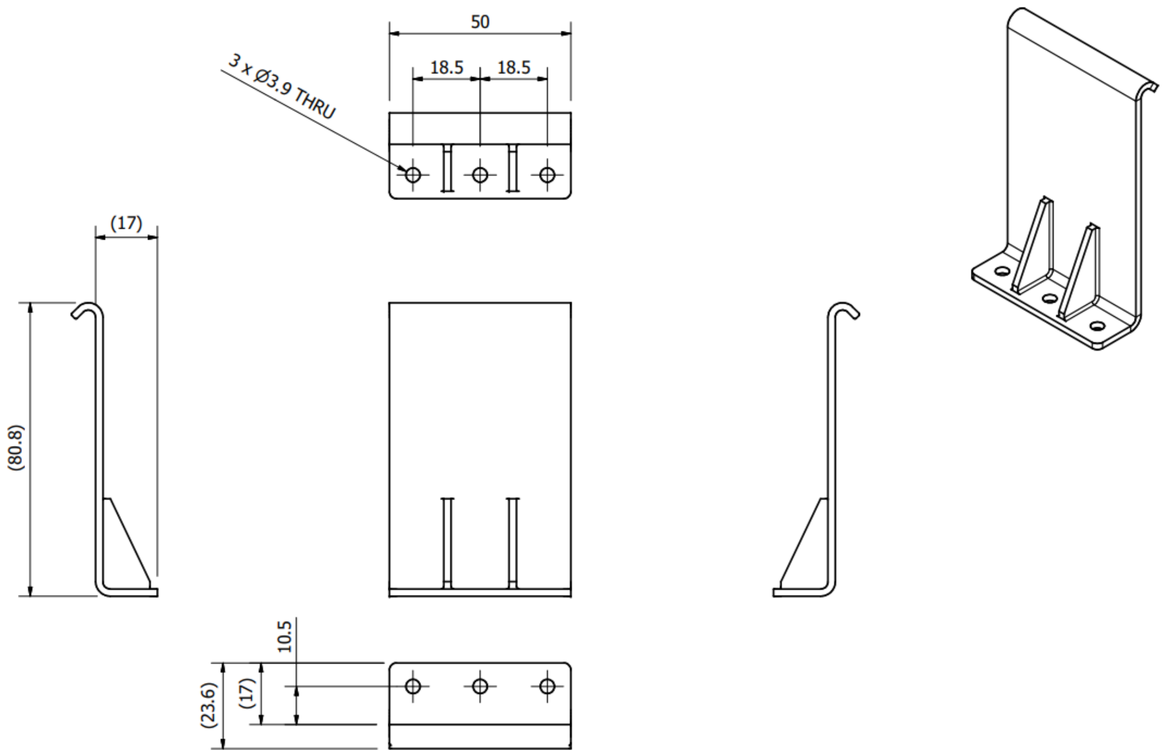


Figure 32: C-NavX1 Mounting Brackets

Do not place the sensor in a confined space or where it may be exposed to excessive heat, moisture, or humidity.

Technical specifications for the C-NavX1 GNSS receiver GNSS sensor are located in Table 27: Physical and Environmental Specifications.

⚠ There are no user-serviceable parts inside the C-NavX1 GNSS receiver. Removing the screws that keep the receiver together will void the equipment warranty.

9 CONFIGURATION

There are four methods available to configure and control the C-NavX1 GNSS receiver:

- **C-NaviGator IV Control and Display Unit** - The C-NaviGator IV Touchscreen Control and Display unit allows users to monitor real-time system and position quality information. Includes: multiple NMEA inputs and selectable outputs, three RS-232 serial, two Ethernet and four USB ports, on-screen help menu, and an intuitive and easy to use interface. Please refer to the Product Brochure, or alternatively the included C-Nav thumb drive or Contact C-Nav Sales (cnav-sales@oceaneering.com) for product brochures and information.

- **Oceaneering® C-Monitor®** QA/QC software - C-Monitor® QA/QC software is a Windows application for monitoring and evaluating real-time DGNSS QA / QC, precise point positioning information and supports the observation and analysis of one or more differential GNSS systems. Please refer to the Product Brochure, or alternatively the included C-Nav thumb drive or Contact C-Nav Sales (cnav-sales@oceaneering.com) for product brochures and information.

- **C-Scape** - Position monitoring and situational awareness software provides independent real-time monitoring of any dynamic positioning (DP) system. The simple, intuitive interface furnishes situational awareness to users during drillship, dive boat, remotely operated vehicle (ROV) vessel, and other operations by blending multiple sensors with map file overlays. Please refer to the Product Brochure, or alternatively the included C-Nav thumb drive or Contact C-Nav Sales (cnav-sales@oceaneering.com) for product brochures and information.

- **C-Setup** - C-Setup is a free Windows utility for control of C-Nav GNSS systems. C-Setup is available for download from the C-Nav Support website (https://www.oceaneering.com/positioning-solutions/customer-access-and-resources/) or by contacting C-Nav Support (cnavsupport@oceaneering.com).

<u>C-NavX1 I/O Ports</u>

The C-NavX1 has the following ports each of which can be configured as a control port, or a data output port,

2 x RS 232

2 x RS 422

1 X USB 2.0 A (considered a serial port)

8 x Ethernet Sockets

Control devices PCs / C-Navigators can use one serial port and/or one Ethernet port, for a maximum of 2 separate control devices per C-NavX1

For data output, the user has full control over the utilized message types via C-Nav control software's 'Output Configuration' menu.

<u>USB-A (MAIN Cable)</u>

- Configuration - Control or Data Port
- Rate - USB 2.0: 480 Mbps
- Does not require a custom driver uses the standard Windows USB serial emulator. Appears in device manager as a serial port.

RS232 Port-1 (MAIN Cable)

- Configuration - Control or Data Port
- Rate - RS-232: 9.6 to 115.2 kbps

The serial ports are normally used to output data to other devices that make use of the various data messages available from the C-NavX1 GNSS receiver. The data port output either Binary Messages or NMEA Messages.

RS232 Port-2 (MAIN Cable)

- Configuration - Control or Data Port
- Rate - RS-232: 9.6 to 115.2 kbps

The serial ports are normally used to output data to other devices that make use of the various data messages available from the C-NavX1 GNSS receiver. The data port output either Binary Messages or NMEA Messages.

RS422 Port-3 (AUX Cable)

- Configuration - Control or Data Port
- Rate - RS-422: 9.6 to 115.2 kbps

The RS422 ports are normally used where long cable runs are required or extra immunity to interference is required such as input to DP systems.

RS422 Port-4 (AUX Cable)

- Configuration - Control or Data Port
- Rate - RS-422: 9.6 to 115.2 kbps

The RS422 ports are normally used where long cable runs are required or extra immunity to interference is required such as input to DP systems.

ETHERNET

- Configuration - Control or Data Port
- Rate - RS-232: 9.6 to 115.2 kbps; Ethernet: 10 to 100 Mbps

These ports (ETH1, ETH2, ETH3, ETH4, ETH5, ETH6, ETH7, and ETH8) normally used to input and output proprietary messages used for navigation and receiver setup.

The C-NavX1 is normally used on a closed subnet with a fixed IP address.

BNC (AUX Cable)

- Configuration – 1PPS
- Rate – 1 Pulse Per Second

This port is used to output a 1PPS (1 Pulse Per Second) to other devices or machines to be used for a variety of Time / Mark applications where relative timing is required.

9.1 Output Messages

NMEA Messages

The C-NavX1 GNSS receiver does not output NMEA messages by default. The user, via controller software, must enable NMEA messages. Refer to Appendix D – NMEA Data Output Messages, for complete descriptions of the NMEA output messages available from the C-NavX1 GNSS receiver.

9.2 Receiver Settings

The C-NavX1 GNSS receiver utilizes commands or groups of commands, to set the various port assignments / parameters, navigation parameters, and output message lists.

To save the current configuration settings of the receiver for future use, the user creates a C-Nav Settings File (.cns) which is a dump of the current setting state. A controller solution, such as C-Monitor QA/QC software, is used to saved and or reload these settings files.

> ***Please note:***
>
> New .cns file loaded will overwrite **every** setting stored currently with the settings used in the .cns file.

For example:

The default navigation elevation mask is 7°. The user changes the elevation mask to 12° in a profile named "Test". The user subsequently sends profile "RTK" to the receiver. It replaces "Test", and changes navigation mode settings and port assignments. But profile "RTK" does not specify a setting for the navigation elevation mask. So, the elevation mask remains at 12°, as previously set by the "Test" profile.

10 SAFETY INSTRUCTIONS

The C-NavX1 GNSS receiver users must be familiar with the use of portable GNSS equipment, the limitations thereof and these safety instructions prior to use of this equipment.

10.1 Transport

Always carry C-Nav equipment in either the original packing material or packaging that provides protection to the receiver and antenna against shock and vibration. Utilize all original packaging when transporting via rail, ship, or air.

> **Please note:**
>
> A ruggedized transportation case (P/N CNV-TCL-540H245) is available to for users requiring additional shock and vibration protection for their C-Nav equipment. Contact C-Nav Sales (cnav-sales@oceaneering.com) for more information.

10.2 Maintenance

C-Nav equipment may be cleaned using a lint free cloth moistened with pure alcohol. Connectors must be inspected and, if necessary, cleaned before use. Always use the provided connector protective caps to minimize moisture and dirt ingress when not in use. Inspect cables regularly for kinks and cuts as these may cause interference and equipment failure.

Damp equipment must be dried at a temperature less than +40° C (104° F), but greater than 5° C (41° F) at the earliest opportunity.

10.3 External Power Source

The C-NavX1 GNSS receiver can be powered by an external DC source or using an AC Power Adapter (P/N CNV-C-PSU-X1-2-2). The C-NavX1 GNSS receiver must be connected to the chosen external power solution in accordance with Section 3 - Interfacing (Page 37). It is important that the external power source allow sufficient current draw for proper operation. Insufficient supplied current will cause damage to your external power source and may also provide insufficient power for the antenna to work.

> **Please note:**
>
> Negative & Positive Switch Spikes on the Ethernet port may cause invalid duplicate epoch data. Users should take care to ensure both the C-NavX1 and connected equipment are operated on stable input power which may require additional conditioning if communications problems are experienced.

10.4 Safety First

The owner of this equipment must ensure that all users are properly trained prior to using the equipment and are aware of the potential hazards and how to avoid them.

Other manufacturer's equipment must be used in accordance with the safety instructions issued by that manufacturer. This includes other manufacturer's equipment that may be attached to C-Nav equipment.

Always use the equipment in accordance with local regulatory practices for safety and health at work.

There are no user serviceable parts inside the C-NavX1 GNSS receiver. Accessing the inside of the equipment will void the equipment warranty.

Consumables/wearables are all considered external e.g. cabling.

Take care to ensure the C-NavX1 GNSS receiver does not come into contact with electrical power installations, the unit is securely fastened, and there is protection against electromagnetic discharge in accordance with local regulations.

11 APPENDICES

11.1 Appendix A – GNSS Sensor Specifications

The technical specifications of this unit are detailed below. C-Nav is constantly improving and updating our offerings. For the latest technical specifications for all products go to: oceaneering.com/cnav.

This GNSS sensor is fitted with an internal Lithium cell battery used to maintain GNSS time when power is removed from the unit. This allows faster satellite acquisition upon unit power-up. The cell has been designed to meet over five years of service life before requiring replacement at a C-Nav approved maintenance facility.

11.1.1 Features

- Completely independent and redundant C-Nav LEO correction delivery system, exclusively delivered using Iridium's extensive global satellite communications network
- Global correction coverage (Pole to Pole)
- All-in-view parallel tracking with 226 channels for navigation and SBAS, plus Iridium Burst and SBD Service Channels.
- Satellite-based augmentation system (SBAS) tracking (WAAS / EGNOS / MSAS / QZSS / GAGAN)
- Multi-constellation GNSS navigation using (GPS, GALILEO and GLONASS)
- Multi-constellation carrier and code tracking of:

  - GPS: L1 C/A, L1P, L2C, LP2, L5Q
  - GLONASS: G1 C/A, G1P, G2 C/A, G2P, G3
  - Galileo: E1B, E5A, E5B, E5AltBOC
  - BeiDou: B1, B2
  - QZSS: L1 C/A, L1C, L1-SAIF, L2C, L5
- C-Nav LEO Correction Service via Iridium
- Ability to activate, configure, interrogate, log, access and download all input and output data from the unit via LTE or locally.
- High-sensitivity / low-signal level tracking
- Fast signal acquisition / re-acquisition
- Manages correction outages for up to 10 minutes
- 1Hz output rate
- 1 pulse-per-second (PPS) output
- PC control software available or C-NaviGator III touchscreen control unit
- Communication Ports: 2 x RS-232, 2 x RS-422, USB 2.0 and Ethernet

11.1.2 Performance

C-NavX1 GNSS receiver performance is dependent on antenna SKYVIEW, geographic location, satellite geometry, atmospheric conditions, and GNSS correction.

11.1.3 Tracking Characteristics

The C-NavX1 GNSS receiver engine has 226 signal channels with the required flexibility to track all civilian GNSS and SBAS signals. The C-NavX1 GNSS receiver engine is also capable of tracking the code and carrier from all GNSS signals.

The C-NavX1 GNSS receiver tracks LEO Iridium satellites for its correction delivery, these satellites are in Polar orbit, The constellation consists of 66 satellites, with each being in view for approximately 10 minutes. Each satellite is in communication with the four adjacent satellites to facilitate a smooth handover.

11.1.4 Pull-In Times

Table 19: Pull-In Times

C-Nav CCS	45 minutes, typical

11.1.5 Signals Tracked

Table 20: Signals Tracked

Navigation & Public Correction Signals	
Services include GPS L1, and SBAS; all at the same frequency:	1575.42 MHz, ± 16 MHz
Services include GPS (L2, L2C[1,2]); all at the same frequency:	1227.60 MHz, ± 16 MHz
Services include GPS L5[1,2], Galileo[1,2] E5A, E5B, Beidou[1,2] B2 all at the same frequency:	GPS: 1176.45 MHz, ± 16 MHz Galileo: 1176.45MHz, ±12.5 MHz
G1 services include: GLONASS	1602.00 MHz, ± 3.9375 MHz
G2 services include: GLONASS	1246.00 MHz, ± 3.0625 MHz

[1]Hardware ready

[2]Beidou, GPS L2C/L1C signals are not used in the navigation engine. Other performance restrictions may exist with the use of these signals. No guarantee exists that these signals will be utilized now or in the future.

11.1.6 Time-To-First-Fix (measured per ION-STD 101)

Table 21: Time-To-First-Fix

Cold Start:	< 65 seconds	Old ephemeris >2hrs old, time error>10mS or position unknown.
Warm Start:	< 55 seconds	Position <60Km from last known position, time error <0.5mS and current ephemeris
Hot Start:	< 20 seconds	Valid Ephemeris available (less than 4 hours old)

11.1.7 Signal Reacquisition

Table 22: Signal Reacquisition

< 30 second loss:	< 2 seconds

11.1.8 Measurement Performance

Table 23: Measurement Performance

C-Nav LEO (multi-constellation)	
Position(H): Position(V):	+ 10cm, 2σ; + 5cm, 1σ GNSS. + 15cm, 2σ, + 10cm, 1σ GNSS
Enhanced SBAS (WAAS/EGNOS/MSAS/GAGAN) Position Accuracy	
Position(H): Position(V):	+150cm,2σ; + 300cm, 2σ;
Velocity (for all DGPS described above)	
Velocity:	0.1 m/s*

*

Please note:

- The specifications herein are based on the following: PDOP < 4, 2-sigma (95%; unless otherwise noted), 24-hour averaged set of data. Further, performance is dependent upon, but not limited to, location, satellite geometry, atmospheric conditions (i.e., solar storm activity), local interference, DoD signal degradation (i.e., Selective Availability or similar techniques), satellite messaging or timing errors, and augmentation correction messages.

11.1.9 Receiver Noise Figure

Table 24: Receiver Noise Figure

20.0 dB +2dB @ 290º Kelvin; 1 Hz RBW

11.1.10 Dynamics

Table 25: Dynamics

Acceleration:	Up to 6 g
Speed:	< 515 m/s[1] (1,000 knots)
Altitude:	< 18.3 km[1] (60,000 ft)

[1]Restricted by USA export laws

11.1.11 1PPS

Table 26: 1PPS

Accuracy:	±13 ns (Relative; User Configurable)
Pulse Width:	10 ms

11.1.12 Data Latency

Table 27: Data Latency

PVT:	< 10 ms
Raw Data:	< 10 ms

11.1.13 Physical and Environmental Specifications

Table 28: Physical and Environmental Specifications

Size (L x W x H)	265 x 165 x 90 mm (10.43 x 6.5 x 3.5 inches)
Weight: Not including mounting bracket	2.2 kg (4.85 lb)
Power Consumption: Input Voltage: Output Voltage: Output Current:	10 Watts 9 to 36 VDC, +5 V ±0.5 V power for each GNSS/ Iridium antenna via antenna connector 100 mA per antenna connector 400 mA USB port
Temperature (ambient) Operating: Storage	 -15º C to +55º C (-5º to +131º F) -30º C to +70º C (-22º to +158º F)
Humidity:	95% Non-Condensing
Vibration:	EN 60945 Section 8.7 2Hz – 13.2Hz @ 1.0mm peak amplitude 13.2Hz -100Hz @ 0.7g 2h @ 30Hz / resonance
Shock:	EN 60945
Ingress Protection:	IP67* in compliance with EN60945

Marine Electronics Directive Compliant	IEC 60945 NMEA-0183 compatibility up to V4.1. FCC Part 15 Class B CE RoHS WEEE QC message strings comply with the recommendations OGP 373-19 and IMCA S015 (July2011).
Minimum Compass Safe Distance	300 mm

* Compliant only when cables are connected and properly seated

11.1.14 Correction Sources

Table 29: Correction Sources

Publicly broadcast services: (Not guaranteed)	SBAS (WASS/EGNOS/MSAS/GAGAN/SNAS/QZSS
Private subscription service: (Guaranteed)	C-Nav LEO Correction Services (CCS)

11.1.15 LED Display Functions

Table 30: LED Display Functions

GNSS Status	Acquiring / tracking GNSS satellites
Correction Age Status	Age of corrections
C-NavX1 Device Status	State of receiver boot process
Iridium Status	Iridium connection status
LTE Status	Status of LTE connection

11.1.16 Input / Output Data Messages

Table 31: Input/Output Data Messages

Control Commands (Input Only):	C-Nav proprietary commands (contact C-Nav Support (cnavsupport@oceaneering.com) for more information)
NMEA-0183 Messages (Output only):	DTM, GBS, GGA, GLL, GNS, GRS, GSA, GST, GSV, RMC, RRE, VTG, ZDA, PNCTGGA, PNCTGST, PNCTMDE, PNCTSET

11.1.17 Block Diagrams

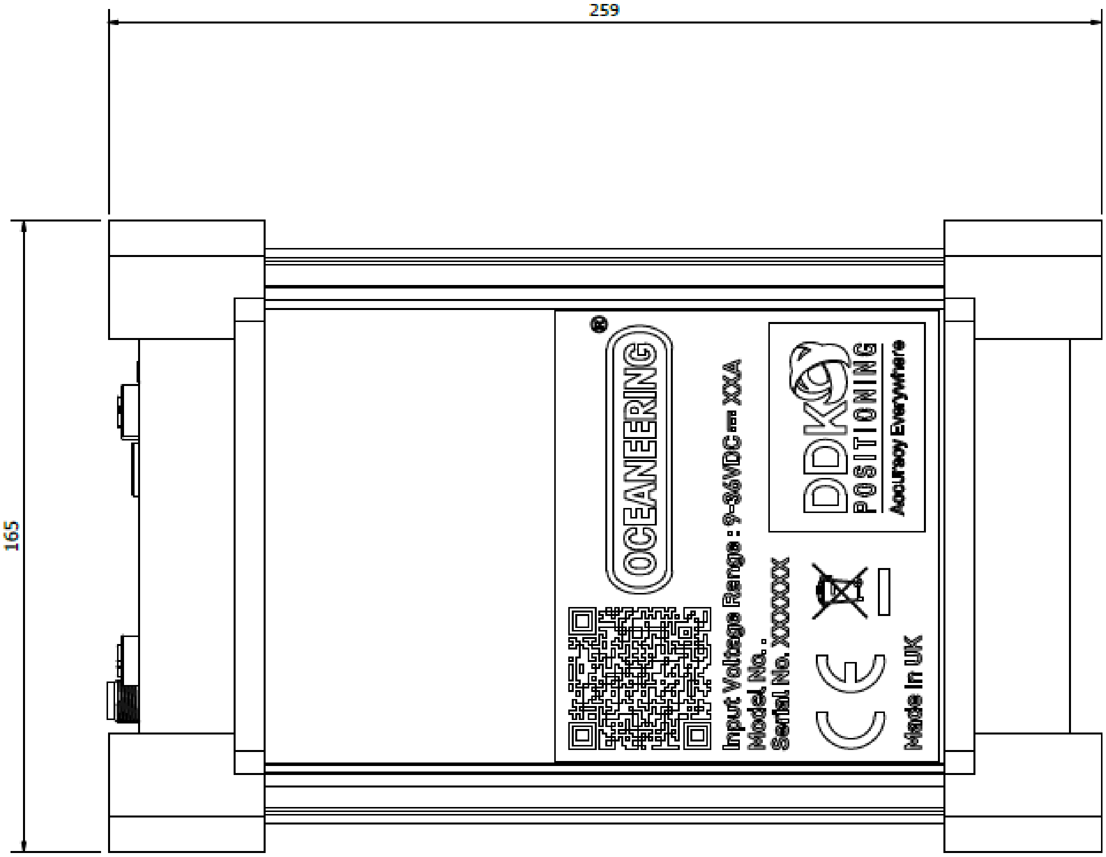


Figure 33: C-NavX1 Dimensions [Top] – Length 259mm x width 165mm

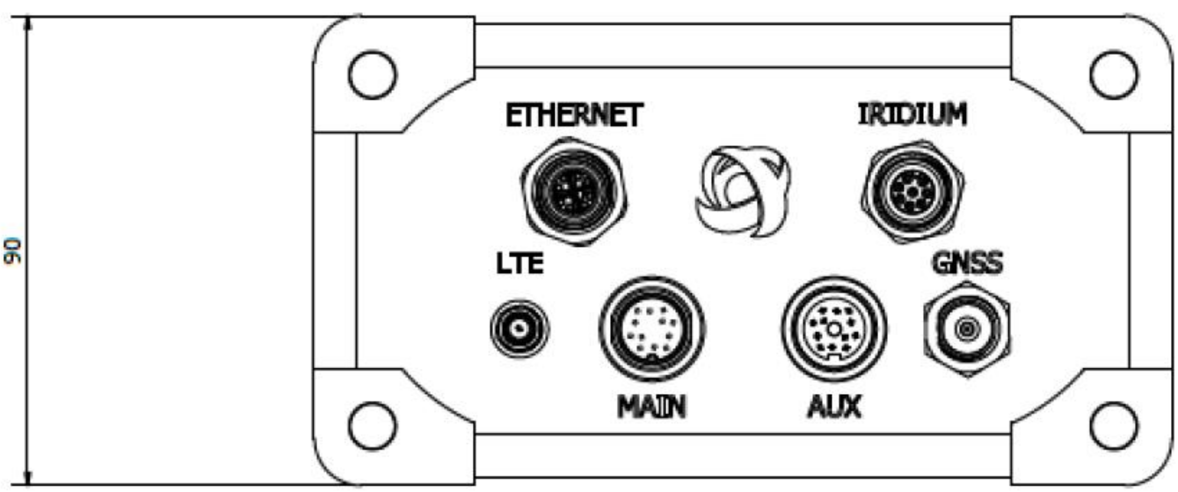


Figure 34: C-NavX1 Dimensions [Back] – Height 90mm x width 165mm

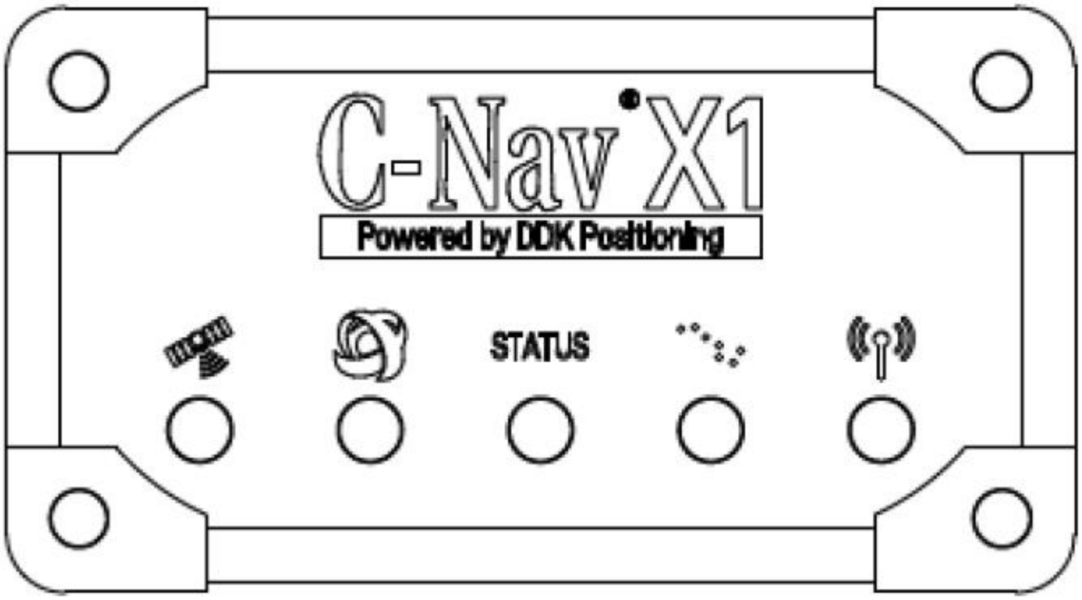


Figure 35: C-NavX1 Dimensions [Front] – Height 90mm x width 165mm

11.2 Appendix B - Antenna Specifications

11.2.1 C-Nav289 Specifications

Table 32: C-Nav289 Antenna Specification Sheet

Part Number	**CNVAT1675-289B**
Polarization Axial Ratio Radiation Coverage	RHC (Right Hand Circular) 3 dB LEO @ Boresight +5.0 dBic 0° = 0° -2.0 dBic 0°<Ø < 75° -3.0 dBic 75°< Ø < 80° -4.0 dBic 80°< Ø < 85° -5.0 dBic Horizon
Passbands	L-Band/GPS L1/GLONASS G1/Galileo B1/Beidou B1: 1,525 – 1,610 MHz GPS L2/GLONASS G1/Galileo E5a, E5b/Beidou B2: 1,160 – 1,252 MHz
Out of Band Rejection	> 90 dB (INMARSAT uplink) > 65 DB (IRIDIUM uplink)
Antenna Phase Center	L1 = 2.35 in / 59.7mm L2 = 2.72 in / 69.1mm
LNA / Filter Combined Gain	39 dB (±2 dB)
Total Noise Figure (NF)	2.6 dB (LEO)
VSWR	≤2.0:1
Impedance	50 Ohms
Power Requirements	
Input Voltage	+4.2V - +15V dc
Power Consumption	65 mA (LEO)
Environmental	
Operating Temperature	-40°C to + 70°C (-40°F to 158°F)
Storage Temperature	-55°C to + 85°C (-67°F to 185°F)
Water/Dust	IP67
Mechanical	
Enclosure Construction	Weather-resistant polymer housing
Cable Connector	TNC Female
Dimensions	177.8 mm x 80.52 mm (7.0 in x 3.17 in)
Weight	1 lb / 0.45 kg
Mounting	5/8 -11 UNC-2B Thread Mount

11.2.2 C-Nav289 Drawing

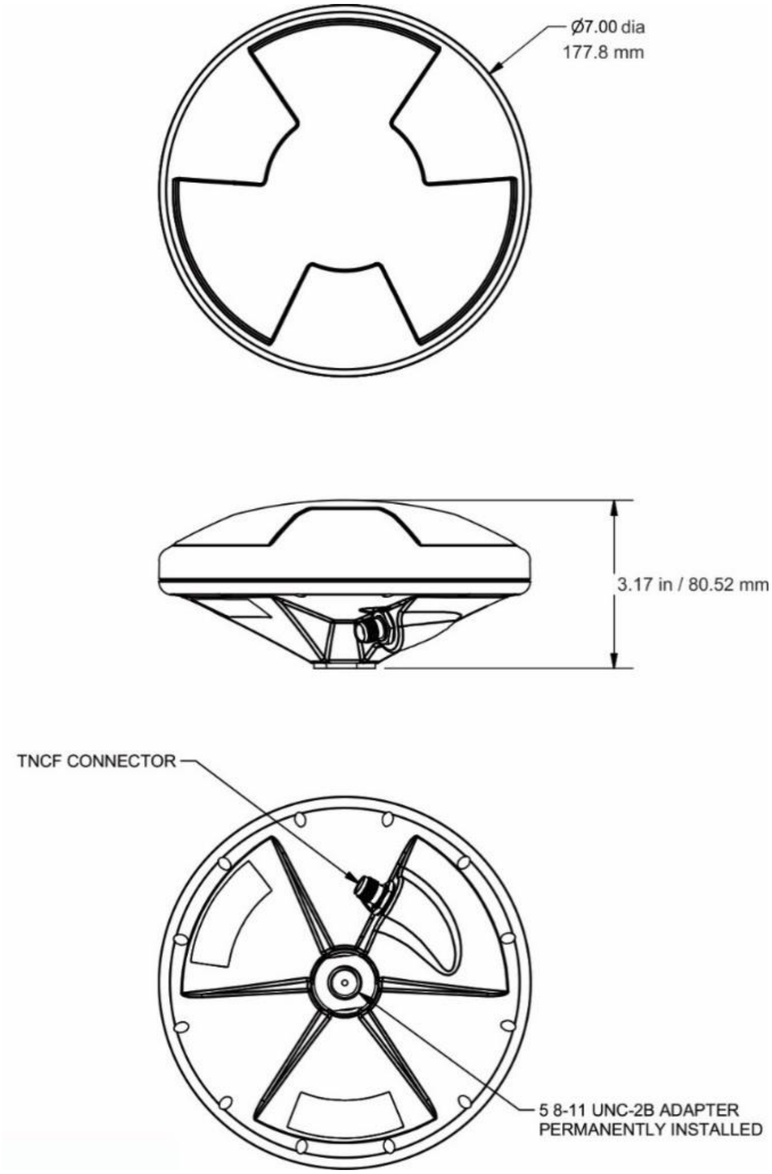


Figure 36: C-Nav289 Antenna Drawing

11.2.3 Iridium Edge Antenna Specifications

Table 33: Iridium Edge Antenna Specification Sheet

Part Number	CNV-A-IRDM-EDGE-1
RF Specifications	
Polarization	RHCP
Multiplexing Method	TDMA/FDMA
Duplexing Method	TDD (Time Domain Duplex)
Frequency Range	1616 MHz to 1626.5 MHz
Average Power during Transmit Slot	1.6 W (maximum)
Power Requirements	
Input Voltage	+9V - +32V DC
Reverse Polarity Protection	+32V DC
Power On – maximum Current	0.5A
Operational – maximum Current	0.3A
Environmental	
Operating Temperature	-40□C to + 85□C (-40□F to 185□F)
Storage Temperature	-40□C to + 85□C (-40□F to 185□F)
Water/Dust	IP67 (When connected with pigtail)
Mechanical	
Cable Connector	M12 – 8 Pin Male
Weight	205g (0.45lbs) +/- 10g
Mounting	Universal Mounting Bracket

11.2.4 Iridium Edge Antenna Drawing

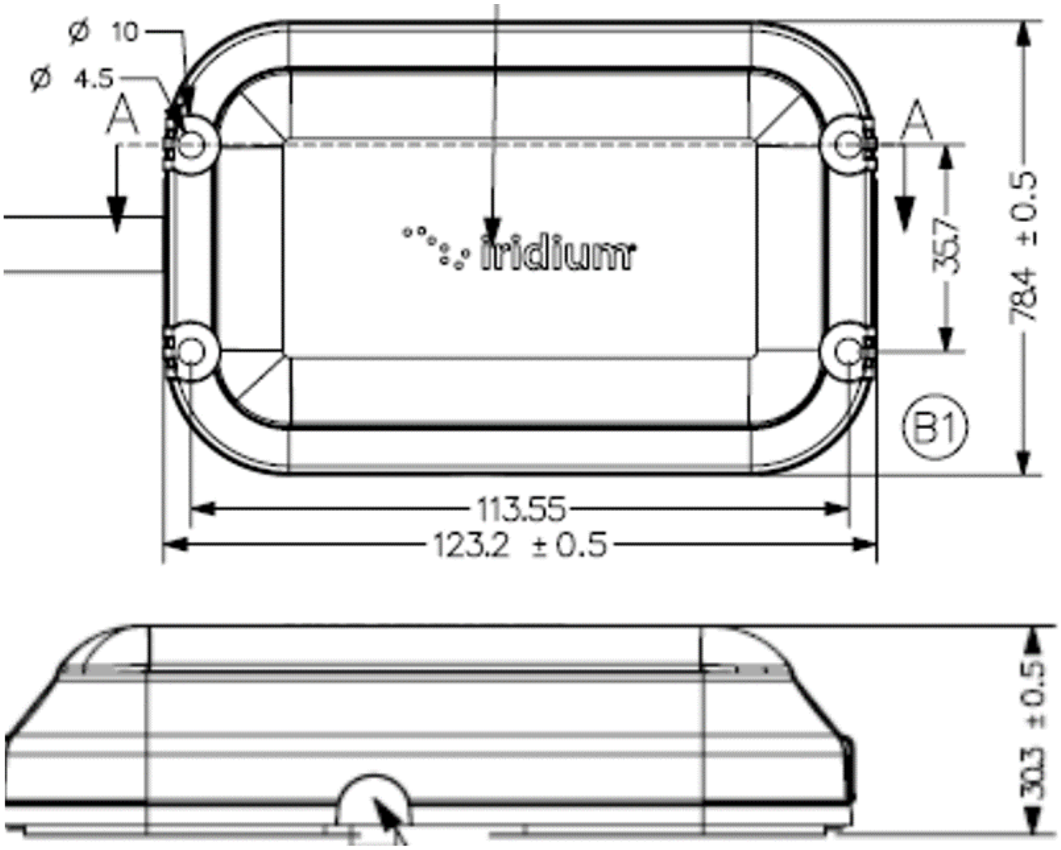


Figure 37: Iridium Edge Antenna diagram

11.2.5 Iridium Edge Cable Specifications

Table 34: SUPER-PAAR-TRONIC-C-PUR Edge cable Specification Sheet

Part Number	**CNV-C-EDGE-XX-2 (XX denotes length in m)**
Technical Data	
Temperature Range	Flexible -30 °C to +70°C Fixed -40°C to +70°C
Test Voltage core/core	1500V
Mutual Capacitance core/core	At 800Hz, approx. 60 pF/m
Couple Resistance	At 30MHz, approx. 250 Ohm/km
Minimum bend radius	Flexible 0.14 – 0.25mm²: 7.5 x Outer – Ø 0.5 - 1 mm²: 10 x Outer-Ø Fixed 0.14 - 0.25 mm²: 4 x Outer-Ø 0.5 - 1 mm²: 5 x Outer-Ø
Cable Structure	
Description	Copper wire bare, extra finely stranded, color coded 0.5 - 1 mm²: acc. to DIN VDE 0295 Class 6 / IEC 60228 Class 6
Wire Structure	0.14 mm²: approx. 18 x 0.1 mm 0.25 mm²: approx. 32 x 0.1 mm
Screening	Fleece wrapped, braided screen of tinned copper wire, approx. coverage 85%
Outer Sheath	Special grade grey polyurethane, length marked in meters.
Tests	
oil-resistant acc. to	DIN VDE 0473-811-404 / DIN EN 60811-404 / IEC 60811-404
UV-resistant acc.	DIN EN ISO 4892-2
weather-resistant acc.	DIN EN ISO 4892-2

Iridium Edge Cable Drawing

Figure 38: Iridium Edge Cable

11.2.6 Paddle LTE Antenna Specifications

Table 35: Paddle LTE Antenna Specification Sheet

Part Number	CNV-A-LTE-PAD-1
RF Specifications	
Polarization	Linear Vertical
Frequency bands:	824 – 2700 MHz
Gain (LEO):	≤3.0 dBi
VSWR Port 1 & 2:	≤3.0 across 92% of the band
Input Impedance	50 Ohms (Nominal)
Environmental	
Operating Temperature	-20□C to + 80□C (-40□F to 176□F)
Storage Temperature	-20□C to + 80□C (-40□F to 176□F)
Mechanical	
Cable Connector	Direct Mount (SMA)
Dimensions	190 x 16 mm
Mounting	N/A

11.2.7 Poynting LTE Antenna Specifications

Table 36: Poynting LTE Antenna Specification Sheet

Part Number	CNV-A-LTE-PYG-1
RF Specifications	
Polarization	Linear Vertical
Frequency bands:	450-470 MHz 698-960 MHz 1710-2700 MHz
Peak Gain	7 dBi
VSWR	≤ 2.5:1 across 90% of the band
Input Impedance	50 Ohms (Nominal)
Environmental	
Operating Temperature	-40C to + 80C (-40F to 176F)
Storage Temperature	-40C to + 80C (-40F to 176F)
Water/Dust	IP68
Mechanical	
Cable Connector	N Female
Dimensions	560 x 75 mm (inc. Marine Bracket)
Weight	0.576kg
Mounting	Marine Adapter (1'' -14 TPI) & L-bracket (Ø30-50mm Pole)

11.2.8 Poynting LTE Antenna Drawing

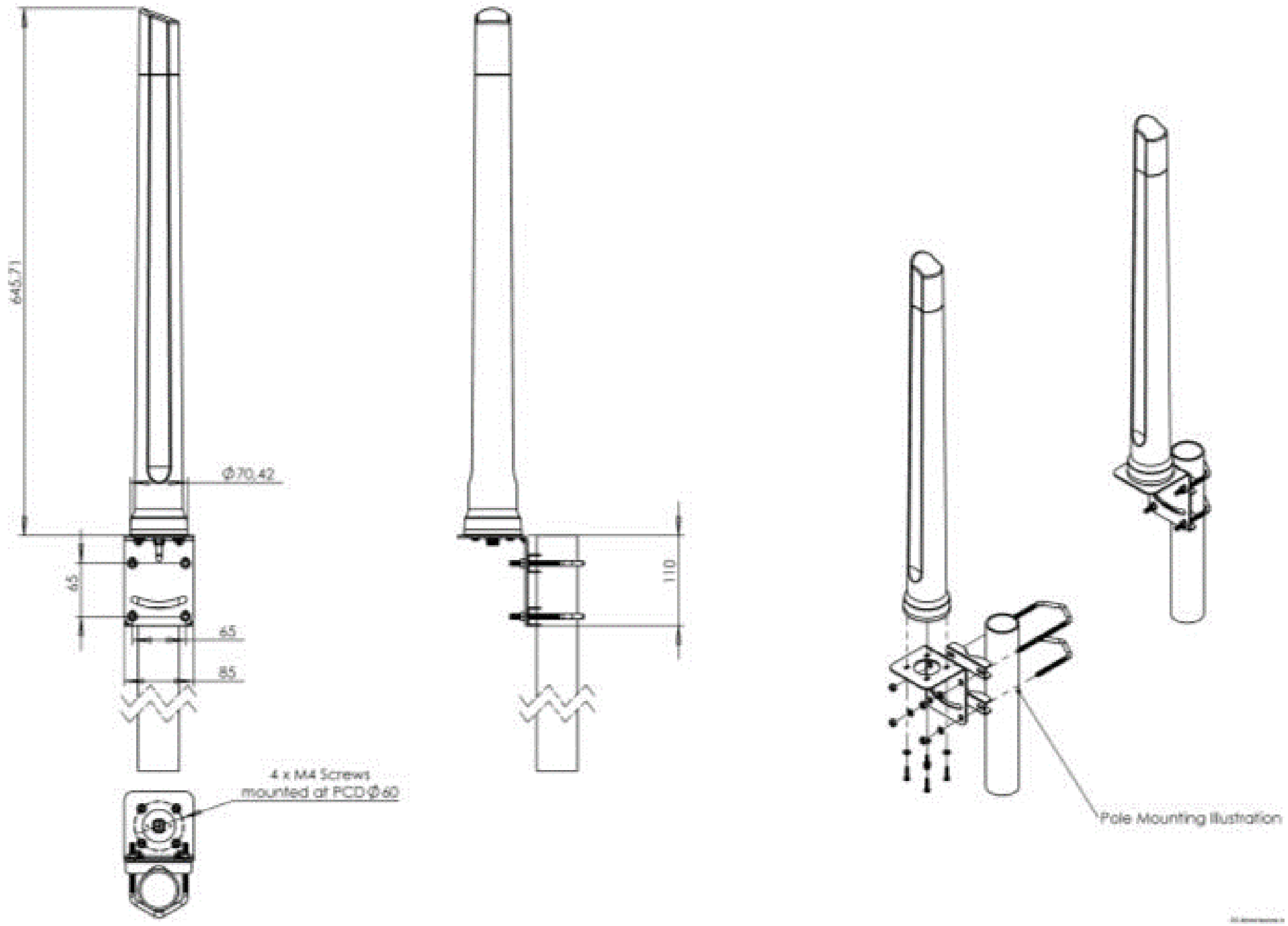
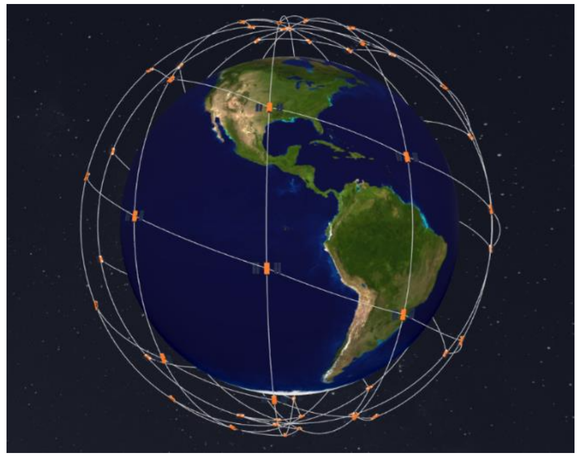


Figure 39: Poynting LTE Antenna diagram

11.3 Appendix C - C-Nav LEO Correction Service (CCS)

11.3.1 Description



The C-Nav LEO Correction Service (CCS) is a global system for the distribution of corrections giving the user the ability to measure their position anywhere in the world with exceptional reliability and unprecedented accuracy of better than 10 cm. Because the corrections are broadcast via IRIDIUM low earth orbit satellites, the user needs no local reference stations or post-processing to get this accuracy level. Furthermore, the same accuracy is available virtually anywhere on the earth's surface on land or sea due to IRIDIUM's exceptional coverage.

11.3.2 Infrastructure

Constellation

- 66 active satellites
- 6 orbital planes
- 11 satellites in each plane
- 9 in orbit spares
- 6 ground spares

Orbit

- 780 Km Polar Orbit
- 10 min visibility, 100 min orbit

L-Band Link

- Weather independent transmissions
- Satellite footprint radius 2200 Km

Satellite Crosslinks

- Each Satellite share data with the four adjacent satellites
- Creates low latency connections

Reference Stations

- Data is handled by two sets of master / backup cloud-based processors
- Corrector streams are sent to the primary uplink site in Arizona, and to three fallback upload sites, located in Alaska, Norway and Chile.
- The network is a fully automated self-monitoring system.

Low-Earth Orbit (LEO) satellites are used to bring reliable communications anywhere in the world. Satellite Crosslinks creates low-latency, resilient, high-quality connections utilizing neighboring satellites for efficient and reliable data transfer. Modern processing of the raw satellite data works via Amazon web services' cloud based solution. 4 uplink centers are spread globally which complete the satellite link, 2 as primary, with 2 backups. Giving quadruple layer redundant topology for all stages from clock and orbit sources to processing to uplink to satellite broadcast.

The entire system meets or exceeds a target availability of 99.99%. To achieve this, every part of the infrastructure has a built-in back-up system.

All the reference stations are built with duplicate receivers, processors, and communication interfaces, which switch automatically or in response to a remote-control signal from the processing centers. The data links from the reference stations use the Internet as the primary data link and are backed up by dedicated communications lines, but in fact the network is sufficiently dense that the reference stations effectively act as back up for each other. If one or several fail, the net effect on the correction accuracy is not impaired.

11.3.3 How to Activate and De-Activate a C-Nav LEO License

In order to use the C-Nav LEO GNSS PPP augmentation service to position yourself, globally from pole-to-pole, you will need to activate your device. Once activated your device will start to receive the C-Nav LEO GNSS PPP augmentation service [corrections] via the Iridium satellite communications network, concurrently your billing period will also start, and you will start to be charged for the service.

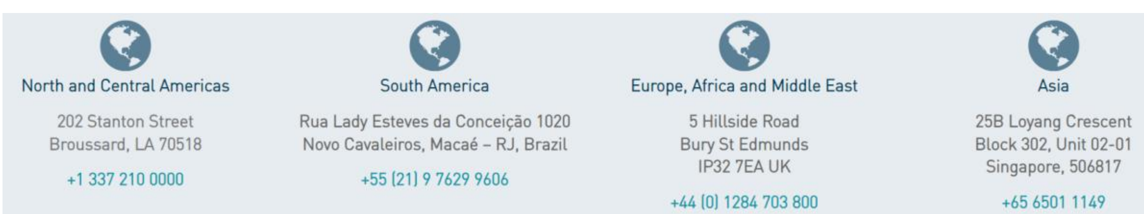
To stop receiving the C-Nav LEO GNSS PPP augmentation service, you will need to deactivate your device. Once deactivated your device will stop receiving C-Nav LEO GNSS PPP augmentation, concurrently your billing period will cease, and you will stop being charged for the service.

To activate or deactivate your device please note down the serial number of your device, then visit the link below to use the online form provided: cnavauthcode.oceaneering.com

Alternatively, you can e-mail cnavauthcode@oceaneering.com, activate via your C-Nav Portal account at https://cnavportal.oceaneering.com or call your local C-Nav office providing the following information:

- Vessel Info and brief project description (Name / Number, Location) Customer Info (Company Name, PO / Ref. Num. Point of Contact)
- C-Nav Equipment Details (Receiver Type, Firmware version, Serial Number, P/N's, etc.)
- Required Start / Stop Date or Period
- Service Type (Land or Offshore / Activation or Deactivation)
- Operational Region (Asia, Australia, China, South and Central America, Caribbean, Africa, Middle East, or Other)
- Detailed Contact Information (Phone, Fax, E-Mail, Billing / Shipping Addresses)

It is highly recommended to use the web-form as it allows for a efficient smooth process to quickly capture all information required.



The figure shown below indicates the location of the device serial number on the device ident sticker, placed on the top-front of the device.

The Serial Number of the unit can be found via any of the C-Nav software applications or via the bottom of the unit:

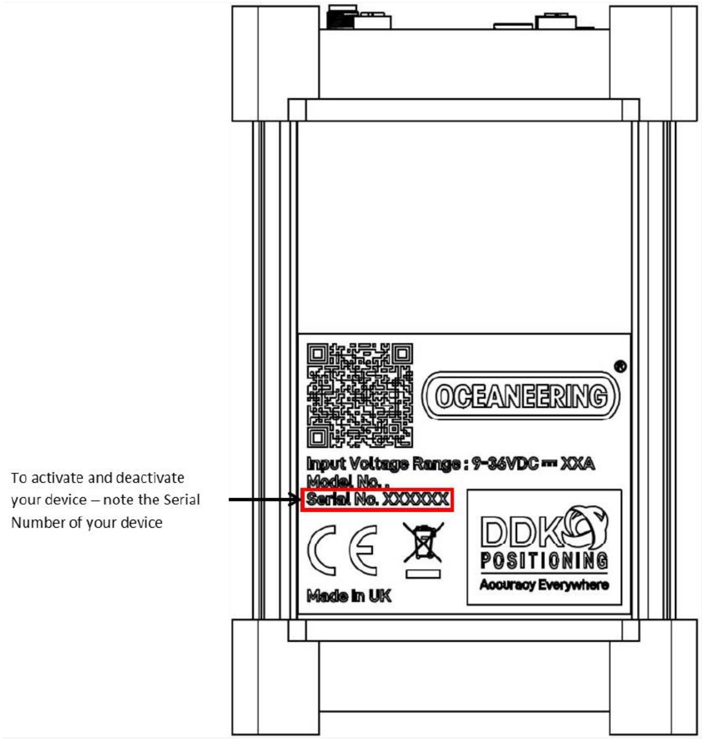


Figure 40: Serial Number Location on Bottom of Receiver

11.3.4 Over-The-Air (OTA) Broadcast

The C-Nav license is typically broadcast Over-The-Air when the license is generated.

> ***Please note:***
>
> To ensure reception, turn on the receiver before the specified broadcast time. Do not turn off the receiver until verifying that the license is saved.
>
> The receiver must be tracking C-Nav satellites at the broadcast times, though the receiver is not required to be operating in CCS mode during the broadcasts.

Verify License Is Active

Once a C-Nav license is activated, the C-Nav Status LED on the C-NavX1 GNSS receiver Front Panel will be solid green.

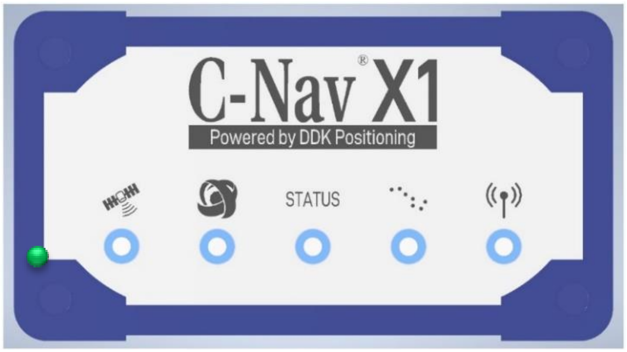


Figure 41: Front Panel C-Nav Status LED - Showing Active C-Nav License

11.4 Appendix D – NMEA Data Output Messages

11.4.1 NMEADTM (ASCII)

This output stream reports the local geodetic datum and datum offsets from a reference datum. It is in compliance with NMEA-0183 Standards version 4.1.

Default: *The NMEADTM message will be scheduled to display automatically before the most frequent NAV message (NMEAGGA, NMEAGLL or NMEARMC). If the frequency or any other NAV message is changed, the adjusted NMEADTM message will automatically display before the most frequent one*

- When the datum code is unknown (e.g. RTK mode), the output will be empty.

Table 37: DTM Message Output Format

Field #	**Field Name**	**Description**
F1	Local datum code	Local Datum Code W84 = WGS84 W72 = WGS72 S85 = SGS85 PE90 = P90 999 = User defined
F2	Local datum subdivision code	Local datum subdivision code (if available)
F3	Lat offset	Latitude offset from reference position (in minutes)
F4	N/S	Direction of latitude (N=north, S= south)
F5	Lon offset	Longitude offset from reference position (in minutes)
F6	E/W	Direction of longitude (E= east, W= west)
F7	Altitude offset	Altitude offset from reference position (in meters)
F8	Reference datum code	Reference Datum Code W84 = WGS84 W72 = WGS72 S85 = SGS85 PE90 = P90
F9		Checksum

11.4.2 NMEAGBS (ASCII)

This output stream reports Receiver Autonomous Integrity Monitoring (RAIM) data. Given that a GNSS receiver is tracking enough satellites to perform integrity checks of the positioning quality of the position solution, this sentence reports the output of the process, in compliance with NMEA-0183 Standards version 3.0. The addition of Fields F9 and F10 bring this message in compliance with version 4.1 of the NMEA standard.

Table 38: GBS Message Output Format

Output Format:	$xxGBS,UTC,Lat,Lon,Alt,SVID,Det,Bias,StdDev*checksum (As NMEA v 3.0)	
Field#	**Field Name**	**Description**
F1	UTC	UTC time of the associated GGA or GNS fix (hhmmss.ss)
F2	Lat	Expected error in latitude (+/- 9.9)
F3	Lon	Expected error in longitude (+/- 9.9)
F4	Alt	Expected error in altitude (+/- 9.9)
F5	SVID	ID number of most likely failed satellite (01-32)
F6	Det	Probability of missed detection for most likely failed satellite (9.9)
F7	Bias	Bias estimate on most likely failed satellite (9.9 meters)
F8	StdDev	Standard deviation of bias estimate (9.9)
F9	System ID	1 for GPS, 2 for GLONASS (NMEA v4.1 only)
F10	SigID	Specific frequency likely failed for the given satellite(NMEA v4.1 only)
F11		Checksum

Example:

*$GPGBS,161816.00,0.0,-0.0,-0.0,13,0.8,0.0,0.0*6C (As NMEA v3.0)*

11.4.3 NMEAGGA (ASCII)

These output messages reports position and fix related status information and is in compliance with NMEA-0183 Standards version 3.0.

Table 39: GGA Message Output Format

Output Format:	$xxGGA,time,lat,N/S,lon,E/W,quality,used,hdop,alt,M,separation,M,age,id*checksum	
Field #	**Field Name**	**Description**
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	Lat	Latitude in degrees and decimal minutes (ddmm.mmmmmm) (0000.000000 to 8959.999999)
F3	N/S	Direction of latitude (N = north, S = south)
F4	Lon	Longitude in degrees and decimal minutes (dddmm.mmmmmm) (00000.000000 to 17959.999999)
F5	E/W	Direction of longitude (E = east, W = west)
F6	quality	Quality of the position fix (0 to 8) 0 = fix not available, or invalid 1 = GPS SPS Mode, fix valid 2 = Differential GPS SPS Mode, fix valid 3 = GPS PPS Mode, fix valid 4 = Real Time Kinematic, fixed integers 5 = Float RTK, floating integers 6 = estimated (dead reckoning) Mode 7 = Manual input mode 8 = Simulation mode
F7	used	Number of satellites in the position fix, 00 - 12
F8	hdop	Horizontal Dilution of Precision, 1 (ideal) to > 20 (poor)
F9	Alt	Altitude above mean sea level (geoidal height) in meters, a theoretical value for practical purposes can range from -50 or so for low places on Earth, to very large positive values for the heights.
F10	M	Units for altitude (M = meters)
F11	separation	Geoidal separation: the difference between the WGS-84 earth ellipsoid surface and mean-sea-level (geoid) surface. “-“ = mean-sea-level surface below WGS-84 earth ellipsoid surface. Note: if no geoid is loaded, geoidal separation is reported as 0.
F12	M	Units for geoidal separation (M = meters)
F13	age	Time since last dGPS data was received, in seconds
F14	Id	Reference station ID number (0000 -1023)
F15		checksum

Example:

*$GNGGA,161611.00,3350.477102,N,11820.624805,W,2,15,0.8,8.911,M,0.000,M,10.0,0402*42*

When the GGA message goes invalid, the time of the last known position fix is output as is the last known position, and the quality flag in F6 is changed to “0” or invalid. This is the correct behavior as defined by international regulatory agencies.

11.4.4 NMEAGLL (ASCII)

This output message reports geographic position (latitude and longitude) information and is in compliance with NMEA-0183 Standards version 3.0.

Table 40: GLL Message Output Format

Output Format:	$xxGLL,lat,N/S,lon,E/W,time,status,mode*checksum	
Field#	**Field Name**	**Description**
F1	lat	Latitude in degrees and decimal minutes (ddmm.mmmmmm) (0000.000000 to 8959.999999)
F2	N/S	Direction of latitude (N=north, S= south)
F3	lon	Longitude in degrees and decimal minutes (dddmm.mm) (00000.000000 to 17959.999999)
F4	E/W	Direction of longitude (E= east, W= west)
F5	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F6	status	status indicator A= Data valid V= Data not valid
F7	mode	Position mode indicator A= Autonomous D= Differential E= Estimated (dead reckoning) M= Manual Input S= Simulator N= Data not valid
F8		Checksum

Example:

*$GPGLL,3713.870070,N,12148.058706,W,032618.00,A,D*7C*

11.4.5 NMEAGNS (ASCII)

This output message reports geographic position (latitude and longitude) information for single or combined satellite navigation systems and is in compliance with NMEA-0183 Standards version 3.0.

Table 41: GNS Message Output Format

Output Format:	$xxGNS,time,lat,N/S,lon,E/W,mode,used,HDOP,alt,separation,age,ID,status*checksum	
Field#	**Field Name**	**Description**
F1	Time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	Lat	Latitude in degrees and decimal minutes (ddmm.mmmm) (0000.0000) to 8959.9999) High precision: (ddmm.mmmmmm) (0 to 8959.999999)
F3	N/S	Direction of latitude (N=north, S= south)
F4	Lon	Longitude in degrees and decimal minutes (dddmm.mmmm) (00000.0000 to 17959.9999) High precision: (dddmm.mmmmmm) (0 to 17959.999999)
F5	E/W	Direction of longitude (E= east, W= west)
F6	Mode indicator	A variable length character field with the first two characters defined: the first character indicates use of GPS satellites, and the second character indicates use of GLONASS satellites. A= Autonomous D= Differential F= Float RTK N= No fix P= Precise R= Real Time Kinematic (RTK)
F7	Used	Total number of satellites in use (00-99)
F8	HDOP	Horizontal Dilution of Position, 1 (ideal) to >20 (poor)
F9	Alt	Altitude above mean sea level (geoidal height) in meters.
F10	Separation	Geoidal separation: the difference between the WGS-84 ellipsoidsurface and mean-sea-level (geoid) surface. Note: If no geoid is loaded, then geoidal separation will be reported as 0.
F11	Age	Time since last dGPS data was received, in seconds.
F12	ID	Reference station ID number (0000-1023)
F13	Status	Navigational status indicator S= Safe (If the Horizontal Position Error is less than or equal to the Selected Accuracy Level) C= Caution (If there is no valid Horizontal Position Error (noRAIM data)) U= Unsafe (If the Horizontal Position Error is greater than or equal to the Selected Accuracy Level) V= Navigational status not valid (If there is no Nav Solution)
F14		Checksum

Examples:

Tracking both GPS and GLONASS satellites in Precise mode:

*$GNGNS,232439.00,3350.4708,N,11820.6172,W,PP,16,0.8,45.0,-36.0,,,S*28*

*$GPGNS,232439.00,,,,,,08,,,,6.0,0402,S*1B*

*$GLGNS,232439.00,,,,,,08,,,,6.0,0402,S*07*

Tracking both GPS and GLONASS satellites in Autonomous mode (note: one GNGNS message):

*$GNGNS,233839.00,3350.4710,N,11820.6173,W,AA,16,0.7,45.0,-36.0,,,S*22*

Tracking only GPS satellites in Precise mode:

*$GPGNS,232744.00,3350.4708,N,11820.6172,W,PN,08,1.3,44.8,-36.0,,,S*0A*

Tracking only GPS satellites in Autonomous mode:

*$GPGNS,232939.00,3350.4708,N,11820.6172,W,AN,08,1.2,44.8,-36.0,,,U*3F*

Tracking both GPS and GLONASS satellites in Differential mode:

*$GNGNS,233459.00,3350.4709,N,11820.61723W,DD,16,1.2,44.1,-36.0,,,S*24*

*$GPGNS,233459.00,,,,,,08,,,,5.0,0138,S*13*

*$GLGNS,233459.00,,,,,,08,,,,5.0,0138,S*0F*

Please note:

- Mode 0 means the residuals were used to calculate the position given in the matching GGA or GNS sentence.
- Mode 1 means the residuals were recomputed after the GGA or GNS position was computed.
- The order of the range residuals must match the order of the satellite ID numbers given in the GSA command.

11.4.6 NMEAGRS (ASCII)

This output stream reports Receiver Autonomous Integrity Monitoring (RAIM) data, reporting Range Residuals in compliance with NMEA-0183 Standards version 3.0. NMEA-0183 version 4.1 is given by the addition of fields F9 and F10.

Table 42: GRS Message Output Format

Output Format:	$xxGRS,UTC,Mode,Res…, Res, *checksum (As NMEA v3.0)	
Field#	**Field Name**	**Description**
F1	UTC	UTC time of the associated GGA or GNS fix (hhmmss.ss)
F2	Mode	How the residuals were calculated (see notes below)
F3	Res	Up to 12 range residuals (+/- 999 meters) (See notes below)
F9	System ID	1 for GPS (GP), 2 for GLONASS (GL) (NMEA v4.1 only)
F10	Signal ID	1 for Single Mode and 0 for Dual Mode (NMEA v4.1 only)
F11		Checksum

Example:

*$GPGRS,162404.00,0,-0.2,-0.9,-0.3,0.2,0.4,0.1,0.6,0.7,0.5,*4F (As NMEA v3.0)*

11.4.7 NMEAGSA (ASCII)

This output message reports 2D / 3D solution mode, DOP values and active satellite information, and is in compliance with NMEA-0183 Standards version 3.0. Field F7 is added to comply with version 4.1 of the NMEA standard.

Table 43: GSA Message Output Format

Output Format:	$xxGSA,mode,solution,used,pdop,hdop,vdop,*checksum (As NMEA v3.0)	
Field#	**Field Name**	**Description**
F1	mode	Mode M= manual (forced to operate in 2D or 3D mode) A= automatic (allowed to automatically switch between 2D/3D)
F2	solution	Solution 1= fix not available 2= 2D 3= 3D
F3	used	ID numbers of satellites used in solution.
F4	pdop	Dilution of position
F5	hdop	Horizontal dilution of position
F6	vdop	Vertical dilution of position
F7	GNID	1 for GPS (GP), 2 for GLONASS (GL) (NMEA v4.1 only)
F8		Checksum

Example:

*$GPGSA,A,3,03,08,13,16,20,23,25,27,,,,,2.4,1.4,1.9,1*36 (As NMEA v3.0)*

11.4.8 NMEAGST (ASCII)

This output message reports pseudo-range noise (PRN) statistic information and is in compliance with NMEA-0183 Standards version 3.0.

Table 44: GST Message Output Format

Output Format:	$xxGST,time,rms,majoraxis,minoraxis,orientation,lateer,loner,alterr*checksum	
Field#	**Field Name**	**Description**
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	rms	Total RMS standard deviation of ranges inputs to the navigation solution
F3	majoraxis	Standard deviation of semi-major axis of error ellipse in meters
F4	minoraxis	Standard deviation of semi-minor axis of error ellipse in meters
F5	orientation	Orientation of semi-major axis of error ellipse in true north degrees (0 to 180°)
F6	laterr	Standard deviation of latitude error in meters
F7	lonerr	Standard deviation of longitude error in meters
F8	alterr	Standard deviation of altitude error in meters
F9		Checksum

Example:

*$GPGST,032746.00,22236.0738,0.0552,0.0355,019.4414,0.0543,0.0368,0.0991*6A*

11.4.9 NMEAGSV (ASCII)

This output message reports data associated with satellites in view, based on almanac data. Data includes PRN number, elevation, azimuth, and SNR values. Note that one GSV sentence can only provide data for up to 4 satellites, so several sentences may be required for full “satellite in view” information. The format for this message is in compliance with NMEA-0183 Standards version 3.0. The addition of Field F8 brings this message compliant to NMEA version 4.1.

Table 45: GSV Message Output Format

Output Format:	$xxGSV,total,message,totalsv,prn1,elev1,azim1,snr1,…..,prn4,elev4,azim4,snr4*checksum (As NMEA v3.0)	
Field#	**Field Name**	**Description**
F1	Total	Total number of messages for full information
F2	Message	Message number
F3	Totalsv	Total number of satellites in view that will be included in the sentences (up to 4 satellites per sentence)
F4	Prn	Satellite ID numbers 1-99 1-32= reserved for GPS 33-64= reserved for SBAS 65-96= reserved for GLONASS
F5	Elev	Elevation for the corresponding satellite in degrees (0 to 90)

F6	Azim	Azimuth for the corresponding satellite in degrees (0 to 359)
F7	Snr	Signal to Noise ratio for the corresponding satellite
F8	Signal ID	1 for L1CA, and 0 for L1+L2 (NMEA v4.1 only)
F9		Checksum

Examples (As NMEA v3.0):

*$GPGSV,3,1,11,13,68,347,50,23,66,87,50,25,56,40,0,27,45,277,46*78*

*$GPGSV,3,2,11,16,23,44,45,20,22,174,36,08,21,259,38,03,21,103,36*43*

*$GPGSV,3,3,11,19,09,128,32,04,05,266,34,02,01,301,30,,,,*44*

Example of NMEA v4.1 format:

*$GPGSV,3,1,10,26,20,048,47,06,19,316, 46, , , , , , , ,,1*66*

*$GPGSV,3,2,10,18,71,254,53,21,65,360,51,29,46,145,52,15,43,083,51,0*6C*

*$GPGSV,3,3,10,22,29,237,49,30,22,265,50,16,21,298,48,03,04,320,43,0*69*

*$GLGSV,2,1,07,81,77,060,54,66,66,018,54,67,56,229,51,82,34,331,51,1*7D*

*$GLGSV,2,2,07,88,28,132,49,65,12,034,,68,05,219,46,,,,,1*4C*

11.4.10 NMEARMC (ASCII)

This output message reports minimum recommended GPS information, including position, velocity, and time information, and is in compliance with NMEA-0183 Standards version 3.0. The update of Field F12 and the addition of Field F13 comply with NMEA version 4.1.

Table 46: RMC Message Output Format

Output Format:	$GPRMC,time,status,lat,N/S,lon,E/W,speed,course,date,variation,E/W,mode*checksum (As NMEA v3.0)	
Field#	**Field Name**	**Description**
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	status	Status V= void (invalid data) A= active (valid data) Value set to V for all modes listed is F12 except for A and D
F3	lat	Latitude in degrees and decimal minutes (ddmm.mmmmmm) (0000.000000 to 8959.999999)
F4	N/S	Direction of latitude (N=north, S= south)
F5	lon	Longitude in degrees and decimal minutes (dddmm.mmmmmm) (00000.000000 to 17959.999999)

F6	E/W	Direction of longitude (E= east, W= west)
F7	speed	Speed over ground in knots (the product puts no upper limit on this value, reporting the actual data, which itself is likely limited to an extreme upper limit of mach 3 or so)
F8	course	Course over ground in degrees true (0 to 359.9)
F9	date	Current date in the format: ddmmyy
F10	Variation	Magnetic variation in degrees (0-359.99)
F11	E/W	Direction of variation (E= east, W= west)
F12	mode	Position mode indicator A= Autonomous D= DGPS E= Estimated (dead reckoning) S= Simulator N= Data not valid P= Precise (NMEA v4.1 only) R= RTK solutions (except RTK Float) (NMEA v4.1 only) F= Float (NMEA v4.1 only)
F13	Nav Status	Navigational Status Indicator (NMEA v4.1 only) S= Safe. C= Caution. U= Unsafe. V= Not valid
F14		Checksum

Example:

*$GPRMC,033341.00,A,3713.870096,N,12148.058706,W,0.03,0.0,180407,0.0,E,D*19*

(As NMEA v3.0)

11.4.11 NMEAVTG (ASCII)

This output message reports velocity and course over ground information and is in compliance with NMEA-0183 Standards version 4.1.

Table 47: VTG Message Output Format

Output Format:	$xxVTG,track,T,track,M,speed,N,speed,K,mode*checksum (As NMEA v3.0)	
Field#	**Field Name**	**Description**
F1	track	True track (course over ground) in degrees (0 to 359.9)
F2	T	True track orientation (T= true north)
F3	track	Magnetic track in degrees (0 to 359.9)
F4	M	Magnetic track orientation (M= magnetic north)
F5	speed	Speed over ground in knots (0 to 1000)
F6	N	Speed over ground units (N= knots)
F7	speed	Speed over ground in kilometers (0 to 1852)
F8	K	Speed over ground units (K= km/h (kilometers/ hour))
F9	mode	Position mode indicator A= Autonomous D= DGPS E= Estimated (dead reckoning) S= Simulator N= Data not valid P= Precise (NMEA v4.1 only)
F10		Checksum

Example:

*$GPVTG,0.0,T,,M,0.03,N,0.06,K,D*0D (As NMEA v3.0)*

11.4.12 NMEAZDA (ASCII)

This output message reports date and time information and is in compliance with NMEA-0183 Standards version 4.1.

Table 48: ZDA Message Output Format

Output Format:	$xxZDA,time,day,month,year,offset_hour,offset_min*checksum	
Field#	**Field Name**	**Description**
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	day	Current day (01 to 31)
F3	month	Current month (01 to 12)
F4	year	Current year (0000 to 9999)
F5	Offset_hour	Local zone hours (-13 to +13)
F6	Offset_min	Local zone minutes (00 to 59)
F7		Checksum

Example:

*$GPZDA,035751.00,18,04,2007,00,00*6B*

11.4.13 NMEAPNCTGGA (ASCII)

This message reports position and fix related status information. It is a C-Nav proprietary NMEA type message, and it conforms to the header, checksum and electrical characteristics of a standard NMEA string, but is not recognized by the NMEA governing body as an officially sanctioned message.

Table 49: PNCTGGA Message Output Format

Output Format:	$PNCTGGA,time,lat,N/S,lon,E/W,quality,used,hdop,alt,M,separation,M,age,Id*checksum	
Field #	**Field Name**	**Description**
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	Lat	Latitude in degrees and decimal minutes (ddmm.mmmmmm) (0000.000000 to 8959.999999)
F3	N/S	Direction of latitude (N = north, S = south)
F4	Lon	Longitude in degrees and decimal minutes (dddmm.mmmmmm) (00000.000000 to 17959.999999)
F5	E/W	Direction of longitude (E = east, W = west)
F6	quality	Quality of the position fix (0 to 8) 0 = fix not available, or invalid 1 = GPS SPS Mode, fix valid

		2 = Differential GPS SPS Mode, fix valid 3 = GPS PPS Mode, fix valid 4 = Real Time Kinematic, fixed integers 5 = Float RTK, floating integers 6 = estimated (dead reckoning) Mode 7 = Manual input mode 8 = Simulation mode
F7	used	Number of satellites in the position fix, 00 - 12
F8	hdop	Horizontal Dilution of Precision, 1 (ideal) to > 20 (poor)
F9	Alt	Altitude above mean sea level (geoidal height) in meters, a theoretical value for practical purposes can range from -50 or so for low places on Earth, to very large positive values for the heights.
F10	M	Units for altitude (M = meters)
F11	separation	Geoidal separation: the difference between the WGS-84 earth ellipsoid surface and mean-sea-level (geoid) surface. “-“ = mean-sea-level surface below WGS-84 earth ellipsoid surface. Note: if no geoid is loaded, geoidal separation is reported as 0.
F12	M	Units for geoidal separation (M = meters)
F13	age	Time since last dGPS data was received, in seconds
F14	Id	4-digit integer as denoted as XXYY, where XX is always 00 and YY is the GPS correction signal type being used
F15		checksum

Example:

*$PNCTGGA,032215.00,3713.870081,N,12148.058703,W,2,08,1.8,59.608,M,-33.440,M,8.0,0022*47*

11.4.14 NMEAPNCTGST (ACSII)

This message satisfies the UKOOA compliance requirements by starting with the standard NMEA GST message and scaling all error statistics by 1.96, and by adding a value for the F-Test of Unit Variance.

Table 50: PNCTGST Message Output Format

Output Format:	$PNCTGST,time,rms,majoraxis,minoraxis,orientation,lateer,loner,alterr,fisher*checksum	
Field#	**Field Name**	**Description**
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	rms	Total RMS standard deviation of ranges inputs to the navigation solution
F3	Majoraxis*	Standard deviation of semi-major axis of error ellipse in meters
F4	Minoraxis*	Standard deviation of semi-minor axis of error ellipse in meters
F5	orientation	Orientation of semi-major axis of error ellipse in true north degrees (0 to 180°)
F6	Laterr*	Standard deviation of latitude error in meters
F7	Loner*	Standard deviation of longitude error in meters
F8	Alter*	Standard deviation of altitude error in meters
F9	fisher	Fisher Test Result
F10		Checksum

*Indicates the result is scaled by 1.96. This output stream reports pseudo-range noise statistic information and is in compliance with NMEA-0183 Standards version 3.0.

Examples:

*$GNGST,192518.00,0.3762,0.1054,0.0953,074.8583,0.0960,0.1048,0.2168*7A*

*$PNCTGST,193028.00,0.2993,0.1722,0.1448,084.7181,0.1451,0.1720,0.3391,1*65*

11.4.15 NMEAPNCTMDE (ASCII)

This output stream reports the Marginally Detectable Error (MDE) generated by the receiver as part of the self-monitoring duties performed to support Receiver Autonomous Integrity Monitoring (RAIM). It is a C-Nav proprietary NMEA type message, and it conforms to the header, checksum and electrical characteristics of a standard NMEA string, but is not recognized by the NMEA governing body as an officially sanctioned message.

Table 51: PNCTMDE Message Output Format

Output Format:	$PNCTMDE,time,svid,Type,bias,mde,laterr,longerr,alterr,*checksum	
Field#	**Field Name**	**Description**
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	svid	The GNSS svid
F3	Type	Measurement type: 0 = CA, 1 = P1, 2 = L1, 3 = P2, 4 = L2, 5 = RCCode, 6 = RC PHASE

F4	bias	Standardized bias which is non centrality parameter for w-test
F5	med	MDE in meters
F6	laterr	Expected error in latitude (meters)
F7	longerr	Expected error in longitude (meters)
F8	alterr	Expected error in altitude (meters)
F9		Checksum

Example:

*$PNCTMDE,165535.00,,,,,,,*6A*

11.4.16 NMEAPNCTSET (ASCII)

This output message reports C-Nav proprietary SET (Solid Earth Tides), PT (Polar Tides) and OL (Ocean Loading) values. It is a C-Nav proprietary NMEA type message, and it conforms to the header, checksum, and electrical characteristics of a standard NMEA string, but is not recognized by the NMEA governing body as an officially sanctioned message.

Table 52: PNCTSET Message Output Format

Output Format:	$PNCTSET,time,SET_dN,SET_dE,SET_dU,PT_dN,PT_dE,PT_dU,OL_dN,OL_dE, OL_dU*checksum	
Field#	**Field Name**	**Description**
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	SET_dN	Solid earth tides, delta North (meters)
F3	SET_dE	Solid earth tides, delta East (meters)
F4	SET_dU	Solid earth tides, delta Up (meters) (range TBD)
F5	PT_dN	Polar Tides, delta North (meters) (range TBD)
F6	PT_dE	Polar Tides, delta East (meters) (range TBD)
F7	PT_dU	Polar Tides, delta Up (meters) (range TBD)
F8	OL_dN	Ocean Loading, delta North (meters) (range TBD)
F9	OL_dE	Ocean Loading, delta East (meters) (range TBD)
F10	OL_dU	Ocean Loading, delta Up (meters) (range TBD)
F11		Checksum

Example:

*$PNCTSET,214040.00,-0.060,-0.018,0.110,,,,,,*47*

11.5 Appendix E – Software License Agreement

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11.5.1 Open-Source Software License Appendix

No open-source software is utilized in this product.

12 GLOSSARY

12.1 Abbreviations

Abbreviation	Full Form
1PPS	1 Pulse Per Second
2dRMS	Twice the distance Root Mean Square
A/S	Anti spoofing
APC	Antenna Phase Center
BER	Bit Error Rate
bps	bits per second
BSW	British Standard Whitworth
C/A	Coarse/Acquisition
CCS	C-Nav Correction Service
CCS OTI	C-Nav Correction Service Over-The-Internet
CEP	Circular Error Probable
CDU	Control Display Unit
COM	Communication
CMR	Compact Measurement Record
Db	Decibel
DCE	Data Communications Equipment
Deg	Degree
DGPS	Differential Global Positioning System
DOP	Dilution of Precision
DTE	Data Terminal Equipment
ECDIS	Electronic Chart Display & Information System
ECEF	Earth Centered, Earth Fixed
EGNOS	European Geostationary Navigation Overlay Service
FCC	Federal Communications Commission (U.S.)
GAGAN	GPS Aided Geo Augmented Navigation
GDOP	Geometric Dilution of Precision
GIS	Geographic Information System
GLONASS	GLObalnaya NAvigatsionnaya Sputnikovaya Sistema
GMT	Greenwich Mean Time
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision

HF	High Frequency
HOW	Hand Over Word
Hz	Hertz
I/O	Input / Output
IGN	Ignition
IMO	International Maritime Organization
INS	Inertial Navigation System
IODC	Issue of Data, Clock
Iridium	Low earth orbit satellite constellation
ITRF	International Terrestrial Reference Frame
JPL	Jet Propulsion Laboratory
Kbps	Kilobits per second
KHz	Kilohertz
LAN	Local Area Network
Lat	Latitude
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LES	Land Earth Station
LF	Low Frequency
Long	Longitude
LORAN	Long Range Navigation System
LNA	Low Noise Amplifier
MED	Marine Equipment Directive
MSAS	MTSAT Satellite-based Augmentation System
MSL	Mean Sea Level
NAD27	North American Datum 1927
NAD83	North American Datum 1983
NASA	National Aeronautics and Space Administration
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration (U.S.)
NMEA	National Marine Electronics Association (U.S.)
NTRIP	Network transport of RTCM Internet Protocol
P/N	Part Number
PCM	Pulse Code Modulation
PDOP	Positional Dilution of Precision
PPS	Precise Positioning Service

prn	pseudo-random noise
PVT	Position, Velocity, Time
RAIM	Receiver Autonomous Integrity Monitoring
RHCP	Right-hand Circular Polarization
RINEX	Receiver Independent Exchange
RMS	Root Mean Square
RTCM	Radio Technical Commission for Maritime Services
RTK	Real-time Kinematic
S/A	Selective Availability
SBAS	Satellite Based Augmentation System
SEP	Spherical Error Probable
SI	International System of Units
SNR	Signal-to-Noise Ratio
SPS	Standard Positioning Service
SSR	Spread Spectrum Radio
SV	Space Vehicle
TDOP	Time Dilution of Precision
UHF	Ultra-High Frequency
USB	Universal Serial Bus
USGS	U.S. Geological Survey
UTC	Universal Time Coordinated
VDOP	Vertical Dilution of Precision
VHF	Very High Frequency
WAAS	Wide Area Augmentation System
WADGPS	Wide Area Differential Global Positioning System
WDOP	Weighted Dilution of Precision
WGS84	World Geodetic System 1984

12.2 Definitions

1 Pulse Per Second (1PPS) is a precision electronic pulse output (at LVTTL levels) from the GNSS receiver that marks exact second intervals. It is used for precise timing and to synchronize receivers and acquisition computers.

.yym files see meteorological files (where yy = two-digit year data was collected).

.yyn files see navigation files (where yy = two-digit year data was collected).

.yyo files see observation files (where yy = two-digit year data was collected).

Absolute Positioning is the ability of a GNSS receiver to produce positional values without another receiver for reference.

Accuracy is the degree of conformity of a measured or calculated quantity to a standard or true value. Accuracy is therefore related to the quality of the results.

Almanac is found in subframe 5 of the Navigation Message. It is a data file that helps the receiver track and lock-on to satellites as it contains a summary of orbital parameters for all GPS satellites. The almanac can be acquired from any GPS satellite.

Almanac Files an almanac file contains orbit information, clock corrections, and atmospheric delay parameters for all satellites tracked. It is transmitted to a receiver from a satellite and is used by mission planning software.

Altitude is the vertical distance above the ellipsoid or geoid. It is always stored as height above ellipsoid in the GNSS receiver but can be displayed as height above ellipsoid (HAE) or height above mean sea level (MSL).

Ambiguity is the unknown number of whole carrier wavelengths between satellite and receiver.

Antenna is a device used to collect and amplify the electromagnetic GNSS signals broadcast by a satellite. These electromagnetic waves are then converted into electrical currents that are decoded by the receiver. Patch or Microstrip antennas are most commonly used in GNSS.

Antenna Phase Center (APC) is the point in an antenna where the GNSS signal from the satellites is received. The height above ground of the APC must be measured accurately to ensure accurate GNSS readings. The APC height can be calculated by adding the height to an easily measured point, such as the base of the antenna mount, to the known distance between this point and the APC.

Antispoofing (A/S) is an encryption technique developed by the US Department of Defense (DoD) that when implemented, denies access to the P-Code by any unauthorized users. With Antispoofing on, the user will need a DoD issued "key" in order to gain access to the P-Code.

Apogee is the point in the orbit of a satellite about the earth that is the greatest distance from the center of the earth.

Autocorrelation in reference to code is a plot of the scalar product of the noise sequence with a delayed copy of itself.

Autonomous positioning (GNSS) is a mode of operation in which a GNSS receiver computes position fixes in real time from satellite data alone, without reference to data supplied by a reference station or orbital clock corrections. Autonomous positioning is typically the least precise positioning procedure a GNSS receiver can perform, yielding position fixes that are precise to 100 meters with Selective Availability on, and 30 meters with S/A off.

Average Deviation is a measure of variability in a data set but it is more robust than standard deviation. It is not related to the bell-shaped curve. It is the average of the absolute deviations of the values from the mean. The data values are subtracted from the mean producing a list of deviations from the mean. The deviations are not squared like they are for the standard deviation; the absolute values of the deviations are used.

Azimuth the azimuth of a line is its direction as given by the angle between the meridian and the line measured in a clockwise direction from the north branch of the meridian.

Bad Packets refer to the number of bad C-Nav Correction Service (CCS) packets received since the unit was turned on.

Bandwidth is a measure of the width of the frequency spectrum of a signal expressed in Hertz.

Baseline is the resultant three-dimensional vector (V) between any two stations from which simultaneous GP data have been collected and processed. Generally given in earth-centered Cartesian coordinates where: $V = (\Delta x, \Delta y, \Delta z)$

Base Station see reference station.

Baud Rate (*bits per second*) is the number of bits sent or received each second. For example, a baud rate of 9600 means there is a data flow of 9600 bits each second. One character roughly equals 10 bits.

Beat Frequency is either of the two additional frequencies obtained when two signals of two frequencies are mixed, equal to the sum or difference of the original frequencies.

Binary Biphase Modulation is a phase change on a constant frequency carrier of either 0 or 180 degrees. These represent the binary digits 0 and 1, respectively.

Binary Code is a system used in communication where selected strings of 0s and 1s are assigned definite meanings.

Binary Pulse Code Modulation is a two-state phase modulation using a string of binary numbers or codes. The coding is generally represented by 1 and 0 with definite meanings attached to each.

Bits per second see baud rate.

Broadcast Ephemeris is the ephemeris broadcast by the GNSS satellites.

British Standard Whitworth (BSW) is a type of coarse screw thread. A 5/8" diameter BSW is the standard mount for survey instruments. (1" Mount included).

C-Nav Correction Service (CCS) is a set of real-time global orbit and clock corrections for GNSS satellites. C-Nav equipped receivers are capable of real-time decimeter positioning (see **Error! Reference source not found.** (Page **Error! Bookmark not defined.**)).

C/A code see Coarse Acquisition code.

CAN BUS is a balanced (differential) 2-wire interface that uses an asynchronous transmission scheme. Often used for communications in vehicular applications.

Carrier is a high-frequency radio wave having at least one characteristic (frequency, amplitude, or phase), which may be varied by modulation from an accepted value. In general, the carrier wavelength is much shorter than the wavelength of the codes.

Carrier Beat Phase is the difference between the phase of the incoming Doppler shifted satellite carrier signal and the phase of the nominally constant reference frequency generated in the receiver.

Channel a channel of a GNSS receiver consists of the circuitry necessary to receive the signal for a single GNSS satellite.

Chip *a*. The minimum transition time interval for individual bits of either a 0 or 1 in a binary pulse code usually transmitted in a pseudo-random sequence. *b*. A tiny square piece of thin semiconductor material on which an integrated circuit is formed or is to be formed.

Circular Error Probable (CEP) is a measurement of precision using standard deviation that is applicable in horizontal stations. Probability for CEP is 50%, meaning that if 100 observations are made, half of them will be within the circular error probable with

Radius = 0.5887 ($\sigma x + \sigma y$)

Civilian code see Coarse Acquisition code.

Clock Bias is the difference between GNSS Time and UTC.

Coarse Acquisition code (C/A or Civilian code) is the pseudo-random code generated by GPS satellites. It is intended for civilian use and the accuracy of readings using this code can be degraded if selective availability (S/A) is introduced by the US Department of Defense.

Collimate is to physically align a survey target or antenna over a mark.

COM is the shortened form of the word Communications. Indicates a data communications port to/from the GNSS receiver to a controller or data collection device.

Compact Measurement Record (CMR / CMR+) is a standard format for DGNSS corrections used to transmit corrections from a reference station to rover receivers. See Related Standards in Notices.

Controller is a device consisting of hardware and software used to communicate and manipulate the I/O functions of the GNSS receiver.

Control Point is a point to which coordinates have been assigned. These coordinates can then be held fixed and are used in other dependent surveys.

Control Segment is a worldwide network of GNSS monitoring and control stations that ensure the accuracy of the GNSS satellite orbits and operation of their atomic clocks. The original control segment for GPS consists of control facilities in Diego Garcia, Ascension Island, Kwajalein, and Hawaii, with a master control station at the Consolidated Space Operations Center (CSPOC) at Colorado Springs, Colorado.

Convergence Period is the time necessary for the received C-Nav signal corrections to be applied and the position filtered to optimal performance. The convergence period is typically 30 to 45 minutes to achieve decimeter accuracy.

Cycle Ambiguity see Ambiguity.

Cycle Slip is a discontinuity in measured carrier beat phase resulting from a temporary loss of lock in the carrier-tracking loop of a GNSS receiver.

Datum A reference datum is a known and constant surface, which can be used to describe the location of unknown points. Geodetic datums define the size and shape of the earth and the origin and orientation of the coordinate systems used to map the earth.

DB9P A type of electrical connector containing 9 contacts. The P indicates a plug pin (male).

DB9S A type of electrical connector containing 9 contacts. The S indicates a slot pin (female).

DCE Data Communications Equipment. Defined pin assignments based on the IEEE RS-232 signaling standard. See Figure 42:

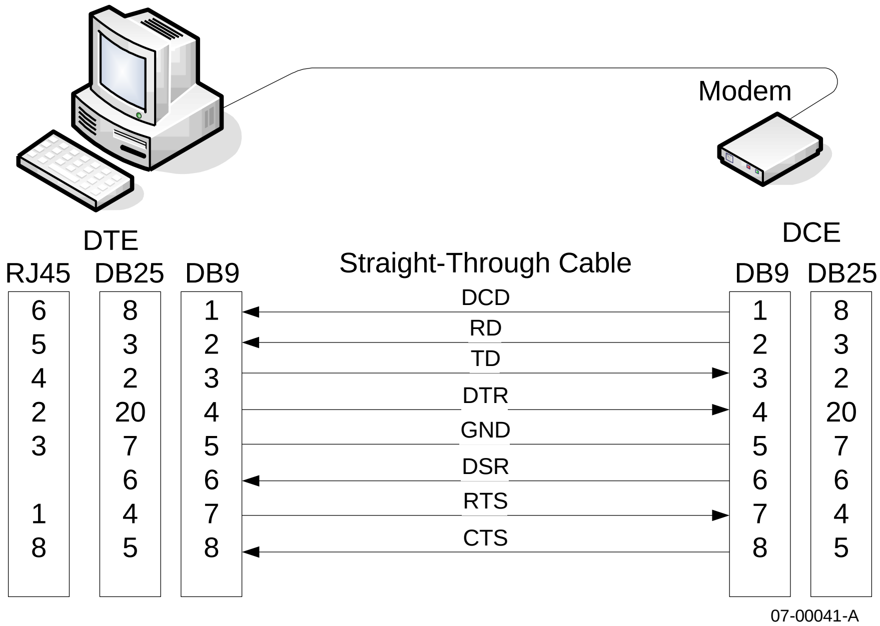

Figure 42: DTE to DCE RS-232 Pin Assignments

Deflection of the Vertical is the angle between the perpendicular to the geoid (plumb line) and the perpendicular to the ellipsoid.

DGNSS see Differential GPS / GNSS.

DGPS see Differential GPS / GNSS.

Differencing is a technique used in baseline processing to resolve the integer cycle ambiguity and to reduce a number of error sources including oscillator variations and atmospheric and orbital modeling errors. This technique "differences" the measurement of the carrier beat phase across time, frequency, receivers, satellites, or any combination of these. The most popular differences are single, double and triple.

Differential GPS / GNSS (DGPS / DGNSS) is a positioning procedure that uses two receivers, a rover at an unknown location and a reference station at a known, fixed location. The reference station computes corrections based on the actual and observed ranges to the satellites being tracked. The coordinates of the unknown location can be computed with sub-meter level precision by applying these corrections to the satellite data received by the rover.

Dilution of Precision (DOP) is a class of measures of the magnitude of error in GNSS position fixes due to the orientation of the GNSS satellites with respect to the GNSS receiver. There are several DOPs to measure different components of the error. Note: this is a unit-less value. See also PDOP.

Doppler Aiding is a signal processing strategy that uses measured Doppler shifts to help the receiver smoothly track the GNSS signal, allowing more precise velocity and position measurement.

Doppler Shift is the apparent change in frequency of a received signal due to the rate of change of the distance between the transmitter and receiver.

Double Difference between receivers and between satellites is found by differencing the single difference for one satellite with the single difference for another satellite where both single differences are from the same epoch.

Dual-Frequency is a type of GPS receiver that uses both L1 and L2 signals from GPS satellites. A dual-frequency receiver can compute more precise position fixes over longer distances and under more adverse conditions because it compensates for ionospheric delays.

Dynamic Mode when a GNSS receiver operates in dynamic mode, it assumes that it is in motion and certain algorithms for GNSS position fixing are enabled in order to calculate a tighter position fix.

Dynamic Positioning (GNSS) is the determination of the position of a moving receiver such as one mounted on a boat. Generally, each set of coordinates is computed from a single data sample. GPS was originally conceived for dynamic positioning of a single receiver; however, it may be used in a differential mode to increase relative accuracy.

Eccentricity is the ratio of the distance from the center of an ellipse to its focus on the semi-major axis.

ECEF (Earth Centered Earth Fixed) a Cartesian coordinate system used for GPS, sometimes known as a "conventional terrestrial" system.

EGNOS (European Geostationary Navigation Overlay Service) a European satellite system used to augment the two military satellite navigation systems now operating, the US GPS and Russian GLONASS systems.

Elevation is the distance above or below Local Vertical Datum.

Elevation Mask the lowest elevation, in degrees, at which a receiver can track a satellite. Measured from the horizon to zenith, 0º to 90º.

Ellipsoid is a mathematical model approximating the earth's surface, generated by rotating an ellipse on its minor axis. GNSS positions are computed relative to the WGS-84 ellipsoid. An ellipsoid has a smooth surface, which does not match the earth's geoidal surface closely, so GNSS altitude measurements can contain a large vertical error component. Conventionally surveyed positions usually reference a geoid, which has an undulating surface and approximates the earth's surface more closely to minimize altitude errors.

Ephemeris is a tabulation of the positions of all GNSS satellites at given points in time.

Epoch is a period of time, or a date selected as a point of reference.

Error Ellipse is a statistical measure of the positional error at a given point computed from the propagation of all errors affecting the position solution and expressed by its semi-major and semi-minor axis (vectors of greatest and least magnitude) and the covariance (rotation angle in the reference coordinate system). Two-dimensional errors are typically propagated at one standard deviation (39.4% probability that the positioning lies on or within the ellipse) or 2.1447 times the standard deviation (95% confidence) level.

European Geostationary Navigation Overlay Service (EGNOS) a European satellite system used to augment the two military satellite navigation systems now operating, the US GPS and Russian GLONASS systems.

Fractional Instantaneous Phase Measurement is a measurement of the carrier beat phase that does not include any integer cycle count.

Frequency Band is a range of frequencies in a region of the electromagnetic spectrum.

Frequency Spectrum is the distribution of signal amplitudes as a function of frequency of the constituent signal waves.

G1 carrier frequency the primary L-Band carrier used by GLONASS satellites to transmit satellite data. The frequency is 1603.00MHz.

G2 carrier frequency the secondary L-Band carrier used by GLONASS satellites to transmit satellite data. The frequency is 1247.00MHz.

GAGAN (GPS Aided Geo Augmented Navigation) an Indian satellite system that provides a set of corrections for the GPS satellites, which are valid for the Indian region. They incorporate satellite orbit and clock corrections.

Geodetic Leveling Network is a network of vertical control or benchmarks whose heights are known as accurately as possible, and whose horizontal position is known only approximately.

Geoid is the gravity-equipotential surface that best approximates mean sea level over the entire surface of the earth. The surface of a geoid is too irregular to use for GNSS readings, which are measured relative to an ellipsoid. Conventionally surveyed positions reference a geoid. Calculating the distance between the geoid and ellipsoid at each position and subtracting this from the GNSS altitude measurement can obtain more accurate GNSS readings.

Geoidal Height is the undulation of the geoid above or below the reference ellipsoid.

Geographical Information System (GIS) is a computer system capable of assembling, storing, manipulating, updating, analyzing, and displaying geographically referenced information, i.e. data identified according to their locations. GIS technology can be used for scientific investigations, resource management, and development planning. GIS software is used to display, edit, query, and analyze all the graphical objects and their associated information.

Global Positioning System (GPS) geometrically, there can only be one point in space, which is the correct distance from each of four known points. GPS measures the distance from a point to at least four satellites from a constellation of 24 NAVSTAR satellites orbiting the earth at a very high altitude (approximately 20,200 km). These distances are used to calculate the point's position.

GLONASS short for GLObalnaya NAvigatsionnaya Sputnikovaya Sistema, is a Russian satellite-based navigation system that works alongside GPS (Global Positioning System) to provide position information to compatible devices. With an additional 24 satellites to utilize, GLONASS compatible receivers can acquire satellites up to 20% faster than devices that rely on GPS alone.

GPS Time is a measure of time. GPS time is based on UTC but does not add periodic 'leap seconds' to correct for changes in the earth's period of rotation. As of June 2012 GPS time is 16 seconds ahead of UTC.

Greenwich Mean Time (GMT) is the local time of the 0° meridian passing through Greenwich, England.

Handover Word is the word in the GPS message that contains time synchronization information for the transfer from the C/A-code to the P-code.

Horizontal Geodetic Network is a network for which the horizontal, coordinate, latitude, and longitude of the control points in the network are determined as accurately as possible, and heights are known only approximately.

Independent Baseline those baselines that provide a unique position solution for a given station.

Integer-cycle Ambiguity is the unknown number of whole carrier cycles between the satellite and the receiver.

IODC Issue of Data, Clock - The IODC indicates the issue number of the data set and thereby provides the user with a convenient means of detecting any change in the correction parameters. The transmitted IODC will be different from any value transmitted by the satellite during the preceding seven days.

Ionosphere is the region of the earth's atmosphere between the stratosphere and the exosphere approximately 50 to 250 miles above the earth's surface.

Ionospheric Refraction Delay is a delay in the propagation of the GNSS signal caused by the signal traveling through the ionosphere.

Issue of Data, Clock (IODC) indicates the issue number of the data set and thereby provides the user with a convenient means of detecting any change in the correction parameters. The transmitted IODC will be different from any value transmitted by the satellite during the preceding seven days.

Kalman Filtering is a linear system in which the mean squared error between the desired output and the actual output is minimized when the input is a random signal generated by white noise. The Kalman filter looks at a target to remove the effects of the noise and get a good estimate of the location of the target at the present time (filtering), at a future time (prediction), or at a time in the past (interpolation or smoothing). The Kalman filter is a recursive estimator with two phases: predict and update. The predict phase uses the estimate from a previous state to produce an estimate of the current state. The update phase uses the current state measurements to arrive at a new more accurate estimate.

L-Band is the group of radio frequencies extending from approximately 400 MHz to approximately 1600 MHz. The GPS carrier frequencies L1 (1575.4 MHz) and L2 (1227.6 MHz) are in the L-Band range.

L1 carrier frequency is the primary L-Band carrier used by GPS satellites to transmit satellite data. The frequency is 1575.42 MHz. It is modulated by C/A code, P-code, or Y-code, and a 50-bit / second navigation message. The bandwidth of this signal is 1.023 MHz.

L2 carrier frequency is the secondary L-Band carrier used by GPS satellites to transmit satellite data. The frequency is 1227.6 MHz. It is modulated by P-code, or Y-code, and a 50-bit/second navigation message. The bandwidth of this signal is 10.23 MHz.

L2C carrier frequency a L-Band carrier used by GPS satellites to transmit satellite data. The frequency is 1227.6MHz. It is identical to L2 carrier frequency except that it is also modulated by C/A code, which provides a narrower band and is easier to track.

L5 carrier frequency a L-Band carrier used by GPS satellites to transmit satellite data. The frequency is 1176.45MHz. Like L2, L5 better characterizes the ionosphere and the atmosphere.

Land Earth Station (LES) is the point on the earth's surface where data is up linked to a satellite.

Latitude (Lat) is the north / south component of the coordinate of a point on the surface on the earth; expressed in angular measurement from the plane of the equator to a line from the center of the earth to the point of interest. It is often abbreviated as Lat.

Least Squares Adjustment is a mathematical technique used on data sets that attempts to find the number that provides the 'best fit' to the data. It does so by minimizing the sum of the squares of the residuals, which are the difference between the estimated 'best fit' and the data point squared. It is carried out using an iterative process. Furthermore, it is a method of determining the curve that best describes the relationship between expected and observed sets of data by minimizing the sums of the squares of deviation between observed and expected values.

LED acronym for Light Emitting Diode.

LEMO is a type of data or power connector.

Logging Interval is the frequency at which positions generated by the receiver are logged to data files.

Longitude (Lon) is the east/west component of the coordinate of a point on the surface of the earth; expressed as an angular measurement from the plane that passes through the earth's axis of rotation and the 0° meridian and the plane that passes through the axis of rotation and the point of interest. It is often abbreviated as Lon.

Mean Sea Level (MSL) is a vertical surface that represents sea level.

Meridian one of the lines joining the north and south poles at right angles to the equator, designated by degrees of longitude, from 0° at Greenwich to 180°.

MSAS (MTSAT Satellite-based Augmentation System) a Japanese satellite system that provides a set of corrections for the GPS satellites, which are valid for the Japanese region. They incorporate satellite orbit and clock corrections.

Meteorological (.YYm) files one of the three file types that make up the *RINEX* file format. Where YY indicates the last two digits of the year the data was collected. A meteorological file contains atmospheric information.

Monitor Station is one of five worldwide stations maintained by the DoD and used in the GPS control segment to monitor and control satellite clock and orbital parameters. Corrections are calculated and uploaded to each satellite at least once per day. See Control Segment.

Multi-Frequency-GNSS Receiver a type of receiver that is capable of using multiple signals, for example, GPS (L1, L2, L2C, L5), GLONASS (G1, G2), CCS, L-band, SBAS (WAAS, EGNOS, MSAS, GAGAN), and QZSS signals. The use of multiple signals provides compensation for ionospheric effects. In addition, reception of multiple signals provides redundancy that results in a more stable navigation solution during adverse conditions.

Multipath is a phenomenon whereby GNSS signals from a satellite arrive at an antenna having traversed different paths. The signal traversing the longer path may have been reflected off one or more objects - the ground, a vehicle, boat, building or some other surface - and once received by the antenna, will yield a larger pseudo-range estimate, and increase the error.

Multipath Error is a positioning error resulting from interference between radio waves that has traveled between the transmitter and the receiver by two paths of different electrical lengths.

Navigation Code uses the two GPS carrier waves and operates on a very low frequency (about 50 Hz). This code communicates the GPS message (a string of data) from the GPS satellites to the GPS receivers on L1 and L2 carrier waves.

Navigation (.YYn) files one of the three file types that make up the *RINEX* file format. Where YY indicates the last two digits of the year the data was collected. A navigation file contains satellite position and time information.

Navigation Message is the 1500-bit message broadcast by each satellite at 50bps on both L1 and L2 beacons. This message contains system time, clock correction parameters, ionospheric delay model parameters, and the vehicle's ephemeris and health. This information is used to process the GPS signal to obtain user position and velocity.

NAVSTAR is the name given to GPS satellites, originally manufactured by Rockwell International.

National Marine Electronics Association (NMEA) is a worldwide organization promoting the standardization of digital interfaces to marine electronics devices.

OEM (Original Equipment Manufacturer) is typically a company that uses a component made by a second company in its own product or sells the product of the second company under its own brand. The specific meaning of the term varies in different contexts.

Observation (.YYo) files one of the three file types that make up the *RINEX* file format. Where YY indicates the last two digits of the year the data was collected. An observation file contains raw GPS position information.

P-code is the extremely long pseudo-random code generated by a GPS satellite. It is intended for use only by the U.S. military, so it can be encrypted to Y-code, and then denies unauthorized user's access.

Parity is a method of detecting communication errors by adding an extra parity bit to a group of bits. The parity bit can be a 0 or 1 value so that every byte will add up to an odd or even number (depending on whether odd or even parity is chosen).

PDOP Mask is the highest PDOP value at which a receiver computes position.

Perigee is the point in the orbit of a satellite about the earth that is the least distant from the center of the earth.

Phase Center is the point in an antenna where the GNSS signal from the satellites is received. The height above ground of the phase center must be measured accurately to ensure accurate GNSS readings. The phase center height can be calculated by adding the height to an easily measured point, such as the base of the antenna mount, to the known distance between this point and the phase center.

Phase Lock is the technique where the phase of a signal is set to replicate the phase of a reference signal by comparing the phase of the two signals and then using the resultant phase difference to adjust the reference oscillator to eliminate the difference.

Phase Measurement is measurement expressed as a percentage of a portion of a wave (e.g. a sine wave). For example, a complete wavelength

PNT Positioning Navigation and Timing

Position is the latitude, longitude, and altitude of a point. An estimate of error is often associated with a position.

Position Dilution of Precision (PDOP) is a measure of the magnitude of Dilution of Position (DOP) errors in the x, y, and z coordinates.

Post-processing is a method of differential data correction, which compares data logged from a known reference point to data logged by a roving receiver over the same period of time. Variations in the position reported by the reference station can be used to correct the positions logged by the roving receiver. Post-processing is performed after the user collects the data and returns to the office, rather than in real time as data is logged, so it can use complex, calculations to achieve greater accuracy.

Precise code see P-code.

Precise Ephemeris is the ephemeris computed after the transmission of the satellite signal and based on satellite tracking information. It is used in post-processing of collected GNSS data.

Precision is the degree of agreement or repeatability among a series of individual measurements, values, or results. The precision of a numerical value can refer to the number of significant digits used to express a quantity or that an instrument can measure to. Precision is related to the quality of the operation through which the result is obtained.

PRN (Uppercase) typically indicates a GPS satellite number sequence from 1 – 32.

Projection is a mathematical formula that transforms feature locations between the earth's curved surface and a map's flat surface. A projected coordinate system includes the information needed to transform locations expressed as latitude values to x,y coordinates. Projections cause distortion in one or more of these spatial properties-distance, area, shape and direction.

Protected code see P-code.

Pseudo-Random Noise (*prn*) is a sequence of data that appears to be randomly distributed but can be exactly reproduced. Each GNSS satellite transmits a unique PRN in its signals. GNSS receivers use PRNs to identify and lock onto satellites and to compute their pseudo-ranges.

Pseudo-range is the apparent distance from the reference station's antenna to a satellite, calculated by multiplying the time the signal takes to reach the antenna by the speed of light (radio waves travel at the speed of light). The actual distance, or range, is not exactly the same because various factors cause errors in the measurement.

PVT GNSS information depicting Position, Velocity, Time in the NCT proprietary message format.

QZSS Quasi Zenith Satellite System.

Radio Technical Commission for Maritime Services (RTCM) is a standard format for Differential GNSS corrections used to transmit corrections from a base station to rovers. RTCM allows both real-time kinematic (RTK) data collection and post-processed differential data collection. RTCM SC-104 (RTCM Special Committee 104) is the most commonly used version of RTCM message.

Range is the distance between a satellite and a GNSS receiver's antenna. The range is approximately equal to the pseudo-range. However, errors can be introduced by atmospheric conditions, which slow down the radio waves, clock errors, irregularities in the satellite's orbit, and other factors. A GNSS receiver's location can be determined if you know the ranges from the receiver to at least four GNSS satellites. Geometrically, there can only be one point in space, which is the correct distance from each of four known points.

Real-Time Kinematic (RTK) is a GNSS system that yields very accurate 3D position fixes immediately in real-time. The base station transmits its GNSS position to roving receivers as the receiver generates them, and the roving receivers use the base station readings to differentially correct their own positions. Accuracies of a few centimeters in all three dimensions are possible. RTK requires dual frequency GNSS receivers and high speed radio modems.

Receiver Independent Exchange (RINEX) is a set of standard definitions and formats designed to be receiver or software manufacturer independent and to promote the free exchange of GNSS data. The *RINEX* file format consists of separate files, the three most commonly used are:

Observation (.YYo) file,
Navigation (.YYn) file,
Meteorological (.YYm) files;

Where YY indicates the last two digits of the year the data was collected.

Reference station a reference station collects GNSS data for a fixed, known location. Some of the errors in the GNSS positions for this location can be applied to positions recorded at the same time by roving receivers which are relatively close to the reference station. A reference station is used to improve the quality and accuracy of GNSS data collected by roving receivers.

Right Hand Circular Polarization (RHCP) is used to discriminate satellite signals. GNSS signals are RHCP.

RINEX (Receiver Independent Exchange) is a file set of standard definitions and formats designed to be receiver or software manufacturer independent and to promote the free exchange of GNSS data. The *RINEX* file format consists of separate files, the three most commonly used are:

the observation (.YYo) file,

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meteorological (.YYm) files; where YY indicates the last two digits of the year the data was collected.

Root Mean Square (RMS) is a measurement of precision also applicable for horizontal stations. Probability for RMS is 68.3%, meaning that if 100 observations are made, 68 of them will be within the root mean square, 1 standard deviation.

Rover is any mobile GNSS receiver and field computer collecting data in the field. A roving receiver's position can be differentially corrected relative to a stationary reference GNSS receiver or by using GNSS orbit and clock corrections from a SBAS such as the C-Nav Correction Service (CCS).

Roving Receiver see rover

Satellite Based Augmentation System (SBAS) this is a more general term, which encompasses WAAS, C-Nav Correction Service ,and EGNOS type corrections.

Satellite Constellation is the arrangement of a set of satellites in space.

Satellite Message is sometimes referred to as the Data (D) code. A low-frequency (50 Hz) stream of data on both carriers (L1 and L2) of the satellite signal. The stream of data is designed to inform the user about the health and position of the satellite. The satellite message can be decoded by the receiver and used for positioning in real time.

SBAS (Satellite Based Augmentation System) this is a more general term, which encompasses WAAS, C-Nav Correction Service (CCS), and EGNOS type corrections.

Selective Availability (S/A) is the deliberate degradation of the GPS signal by encrypting the P-code and dithering the satellite clock. When the US Department of Defense uses S/A, the signal contains errors, which can cause positions to be inaccurate by as much as 100 meters.

Signal-to-Noise Ratio (SNR) is a measure of a satellite's signal strength.

Single Difference between receivers is the instantaneous difference in the complete carrier beat phase measurements made at two receivers simultaneous observing the same signal.

Single-frequency is a type of receiver that only uses the L1 GPS signal. There is no compensation for ionospheric effects. The C-Nav5000 GNSS receiver could be optioned as a single frequency receiver.

SNAS is a satellite system being developed by the People's Republic of China called the Satellite Navigation Augmentation System (SNAS). These stations will complement the 11 ones already installed in around Beijing.

Space Segment is the portion of the GNSS system with major components in space (e.g., satellites).

Space Vehicle (SV) a GNSS satellite.

Spread Spectrum Radio (SSR) is a radio that uses wide band, noise like (pseudo-noise) signals that are hard to detect, intercept, jam, or demodulate making any data transmitted secure. Because spread spectrum signals are so wide, they can be transmitted at much lower spectral power density (Watts per Hertz), than narrow band signals.

Standard Deviation is a measure of how widely values are dispersed from the mean. The larger the standard deviation is, the more spread out the values are from the mean. It is the square root of the average squared deviations of each of the values from the mean.

SV (Space Vehicle) a *GPS* satellite.

Time Tag is when a time value is appended to an actual measurement.

Triple Difference between receivers, between satellites, and between epochs (time) is the difference between a double difference at one epoch and the same double difference at the following epoch.

Troposphere is the inner layer of the atmosphere, located between 6 and 12 miles above the earth's surface.

Twice Distance Root Mean Square (2dRMS) is a measurement that varies in its probability from 95.4% to 98.2%, meaning that if 100 observations are taken, between 95 and 98 of those observations will be within the 2dRMS where approximation = 2σ

Universal Time Coordinated (UTC) a time standard maintained by the US Naval Observatory, based on local solar mean time at the Greenwich meridian. GPS time is based on UTC.

User Segment is the portion of the GNSS system with major components that can be interfaced by the user (e.g., GNSS receivers).

Wide Area Augmentation System (WAAS) is a set of corrections for the GPS satellites, which are valid for the Americas region. They incorporate satellite orbit and clock corrections.

Wide Area Differential GNSS (WADGNSS) is a set of corrections for the GPS satellites, which are valid for a wide geographic area.

World Geodetic System 1984 (WGS84) is the current standard datum for global positioning and surveying. The WGS-84 is based on the GRS-80 ellipsoid.

Y-code is the name given to encrypted P-code when the U.S. Department of Defense uses selective availability.

Z-count Word is the GPS satellite clock time at the leading edge of the data subframe of the transmitted GPS message.