C-Nav5000™ User Guide

Revision 0

Revision Date: April 2019

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Release Notice

This is the April 2019 release of the C-Nav5000™ User Guide.

Revision History

0	April 2019	Initial document creation	L. Cortes
Revision	**Date**	**Description**	**Author**

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Manual Organization

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

Section 1 - Getting Started (Page 20) provides instructions to enable the robust functionality of the Oceaneering C-Nav5000 GNSS receiver.

Section 2 - Introduction (Page 32) introduces the user to the system overview of the C-Nav5000 GNSS receiver.

Section 3 - Interfacing (Page 45) instructs the user on how to interface with the C-Nav5000 GNSS receiver.

Section 4 - Installation (Page 63) provides installation instructions.

Section 5 - Configuration (Page 71) provides instructions on four ways to configure a C-Nav5000 GNSS receiver.

Section 6 - Safety Instructions (Page 76) provides the safety information for the user.

Appendix A - GNSS Sensor Specifications (Page 78) provides the user with specifications on the C-Nav5000 GNSS receiver.

Appendix C - C-Nav Corrections Service (CCS) (Page 93) provides information on the Oceaneering C-Nav corrections service.

Appendix D - NMEA Data Output Messages (Page 101) describes the many different NMEA messages that the C-Nav5000 GNSS receiver can output.

Appendix E - Software License Agreement (Page 133) provides legal information in regards to the software used in the C-Nav5000 GNSS receiver.

Glossary (Page 140) provides the user with abbreviations and definitions relative to the C-Nav5000 GNSS receiver.

Notices

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.

C-Nav Licensing

Access to the C-Nav Corrections Service (CCS) requires a subscription that must be purchased. Licenses are non-transferable, and are subject to the terms of the C-Nav License Agreement. Subscriptions are based upon a predetermined period of usage. Subscriptions can be left to expire, or if service is no longer needed prior to the date of expiration of service, a deactivation code can be obtained by contacting C-Nav Authcode (cnavauthcode@oceaneering.com).

For further details on the C-Nav Corrections Service, subscriptions, deactivations, terms, conditions and its capabilities, refer to Appendix C - C-Nav Corrections Service (CCS) (Page 93), of this manual or send an email inquiry to C-Nav Support (cnavsupport@oceaneering.com).

Software License Agreement

By powering on and using this GNSS C-Nav Corrections Service receiver, you agree to the terms and conditions of the C-Nav World DGNSS Receiver Software License and Open Source Software Licenses. The complete terms and conditions of these software licenses may be found in the C-Nav5000 User Guide, Appendix E - Software License Agreement (Page 133).

USG FAR

Technical Data Declaration (Jan 1997)

The Contractor, Oceaneering International, Inc., 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.

Global Navigation Satellite Systems

Global Navigation Satellite Systems (i.e., GPS and GLONASS) 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-Nav5000 GNSS receiver.

Revisions to this User Guide can be obtained in a digital format from the C-Nav website (oceaneering.com/cnav).

Related Documents

C-Nav5000 Quick Start Guide

Provides instructions to quickly set up the standard configuration of the C-Nav5000 GNSS receiver, and how to obtain a C-Nav license.

Related Standards

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, 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

Publicly-Operated SBAS Signals

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.

Manual Conventions

Arial font is used for plain text in this document.

Arial italic font is used for settings names.

"Arial quoted" font is used for settings values.

Arial Bold font is used for button names.

Arial Bold Italic font is used for menu items.

Arial Blue font is used for cross-references.

Arial Blue Underline font is used for hyperlinks.

Arial red italic is used for typed commands.

Arial Bold font size 10 is used for captions.

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

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

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

Important notes are displayed in shaded text boxes.

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

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

```
#Sample File
Version 0.1
```

Section 1 - Getting Started

Hardware Setup

This chapter provides instructions to enable the robust functionality of the C-Nav5000 GNSS receiver.

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

- Table 1: C-Nav5000 Supplied Equipment Description and Part Numbers
- Table 3: C-Nav5000 Software Bundles - Part Numbers
- Table 5: Additional Software Options - Part Numbers
- Table 4: Data Output Rates - Part Numbers
- Table 6: DC Power Cable w/ Filter - Part Number
- Table 7: AC Power Supply Kit - Part Numbers
- Table 8: Optional Data Cables - Part Numbers
- Table 9: Optional Antenna Cable - Part Numbers
- Table 2: Optional Antennas - Part Numbers
- Table 11: C-NaviGator III Bundle - Part Numbers
- Table 13: Optional Ruggedized Transportation Cases - Part Numbers

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

Telephone: +1 337 210-0000

E-mail: cnavsupport@oceaneering.com

Join the C-Nav alert mailing list (https://www.oceaneering.com/positioning-solutions/c-nav-alert-signup/) to receive important announcements from C-Nav Support.

Please note:

Your C-Nav5000 GNSS receiver has already been tested and configured by qualified C-Nav service technicians. Refer to the following steps to connect equipment and operate the receiver.

Connect Equipment

Figure 1: C-Nav5000 GNSS Receiver Rear View

Refer to Figure 1 for the steps below.

1. Use one of the two supplied data cables for communications:
   - Ethernet RJ45 / DB9S female Y-cable (CNV5K-PH96235870): Connect the Positronic 9-Pin connector of the cable to **COM1 - LAN** at the rear of C-Nav5000 GNSS receiver. Connect the DB9S end to the computer or C-NaviGator III CDU.

Or…

   - HDD – 26 to USB1 Device/Com2/4 Serial cable (CNV5K-PH96229301): Connect the Sub HDD 26 Pin connector of the cable to **COM 2/4 – USB1/2** at the rear of C-Nav5000 GNSS receiver. Connect the DB9S end to the computer or C-NaviGator III CDU.

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 **GNSS1**, at the rear of the C-Nav5000 GNSS receiver.

4. Perform these steps to setup power:

a. If you are connecting using the Positronic 9-Pin Female Unterminated Power Cable (CNV5K-PH96235771), connect the power cable to the connector labeled **PWR- 1PPS**, at the rear of the C-Nav5000 GNSS receiver. Connect the unterminated end of the power cable to a DC power source (9 to 32 VDC, 8 W) typical, see Section 3 - Interfacing (Page 45) (for power cable pin assignments).

b. If you are connecting using the AC Power Supply Kit (CNV5K-PH96235770), connect the Positronic 9-Pin Female connector of the Power Supply Unit to the connector labeled **PWR- 1PPS**, at the rear of the C-Nav5000 GNSS receiver. Insert an AC Power Cord into the 2-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.

5. Press the front panel On / Off switch to turn on the C-Nav5000 GNSS receiver. All front panel LEDs illuminate for 5 seconds during power-up as the receiver performs its built-in-test. The Power / GNSS Status LED changes from red to green. Refer to Section 3 - Interfacing (Page 45) for LED status descriptions.

Figure 2: C-Nav5000 LED Indicator Panel

Please note:

If the supplied universal AC/DC power adapter is used to power the C-Nav5000 GNSS receiver, the front panel switch acts as a reset button adding an additional 2-seconds to the startup time.

6. Your C-Nav5000 GNSS receiver hardware is now properly connected.

7. At this point you may connect to C-Setup controller software via PC, or to a C-NaviGator III Control & Display Unit to view real-time positioning data and control the C-Nav5000 GNSS receiver. Contact C-Nav Support for more information.

Please note:

- Refer to Section 5 - Configuration (Page 71), for instructions on I/O data port configuration.
- The C-Nav Corrections Service license is not a standard feature of any Software Bundle. It is purchased separately. Refer to Appendix C - C-Nav Corrections Service (CCS) (Page 93) for more information on obtaining a C-Nav Corrections Service license.
- The C-Nav Corrections Service (CCS) Software Option is standard for all C-Nav5000 GNSS receiver Software Bundles (refer to Table 3: C-Nav5000 Software Bundles - Part Numbers.
- If the C-Nav5000 GNSS receiver does not function properly, contact C-Nav Support immediately.

Supplied Equipment

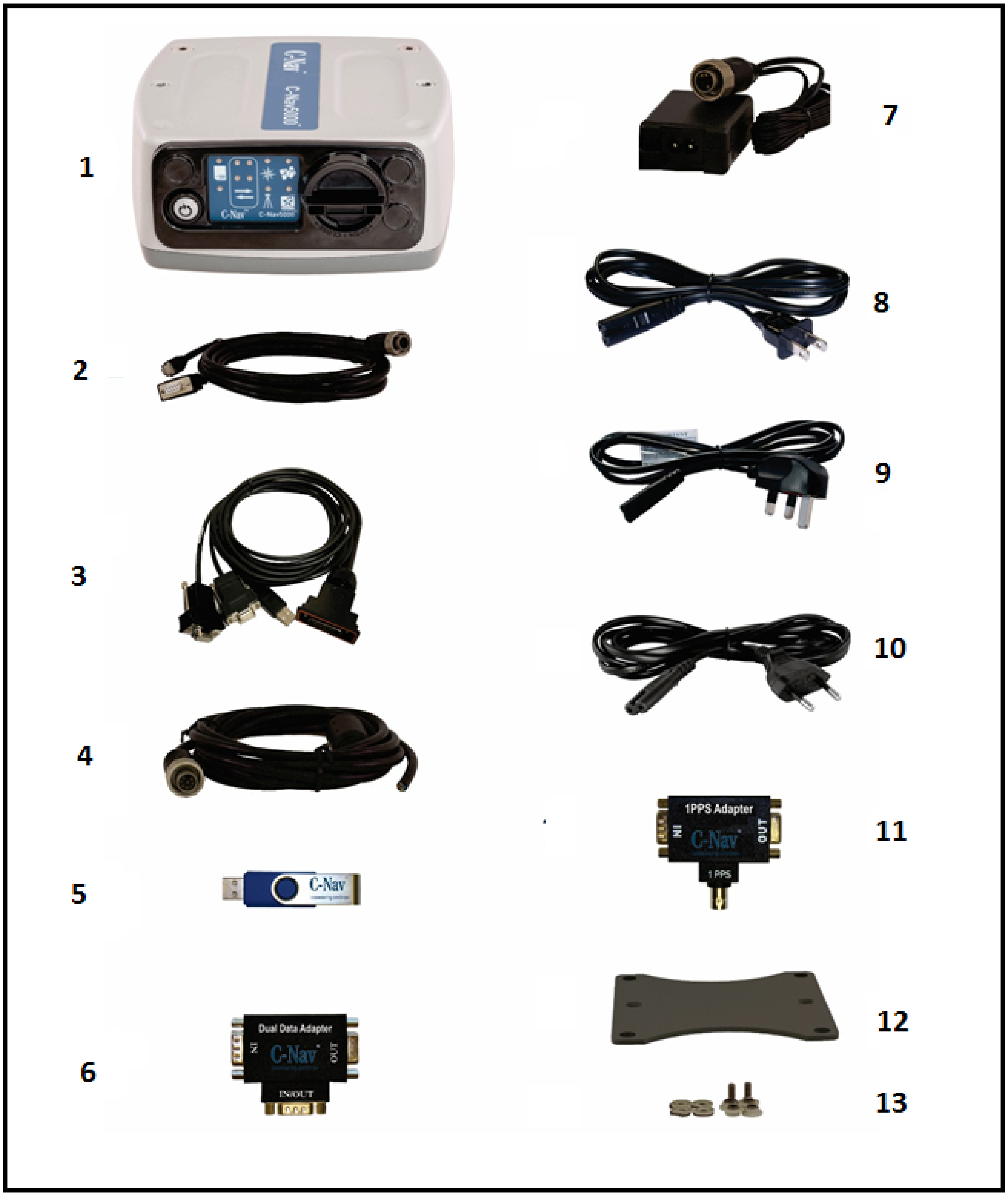


Figure 3: C-Nav5000 Supplied Equipment

Description	Part Number
C-Nav5000 GNSS Sensor Kit Bundle	BUNDLE_C-NAV5000
Includes the following items:	
1. C-Nav5000 GNSS Sensor	CNV5K-PH90229916
2. COM1 – Ethernet/Serial (1PPS) Data Cable	CNV5K-PH96235870
3. HDD – 26 to USB1 device/Com2/4 Serial cable	CNV5K-PH96229301
4. Unterminated Ext Power/1PPS/Event with Filter	CNV5K-PH96235771
5. C-Nav5000 USB Flash Drive	CNV7CNG002-0
6. Dual Data Adapter	CNVCNV335G001-0
7. 110/220 VAC Power Adapter	CNV5K-PH96237115
8. Harns Power Cord 2-Prong North America	CNV73-200002-00LF
9. Cord, Power, IEC320-C7 (EURO)	CNV4250012-220
10. Cord, Power, IEC320-C7 (UK)	CNV4250013-240
11. 1PPS Adapter/DB9-BNC	CNVCNV335G002-0
12. Mounting Bracket, Top & Bottom	CNV5K-PH60229636
13. Phenolic Washer Kit	CNV5K-PH95232908
14. C-Nav5000 Quick Start Guide (Not Shown)	

Table 1: C-Nav5000 Supplied Equipment Description and Part Numbers

Optional Antennas

Figure 4: Optional Antennas

Description	Part Number
1. C-Nav289 GNSS/L-Band/INMARSAT/ IRIDIUM Out of Band Rejection	CNVAT1675-289-K
2. AD591 Out of Band Rejection Antenna	CNVALIAD591

Table 2: Optional Antennas - Part Numbers

Please note:
In order to access the C-Nav Corrections Service, users must purchase a Software Bundle, in addition to a C-Nav Corrections Service license. For more information on obtaining a C-Nav license, refer to Appendix C - C-Nav Corrections Service (CCS) (Page 93).

Receiver Software Options

Software Bundles

Description	Part Number
C-Nav5000 Bundle 'G' SW and C-Nav Enabled	CNV5K-310041-3303

Table 3: C-Nav5000 Software Bundles - Part Numbers

PVT and Raw Data Output Rates

Description	Part Number
PVT and Raw Data, 25 Hz	CNV5K-310041-3382
PVT and Raw Data, 10 Hz	CNV5K-310041-3381
PVT and Raw Data, 5 Hz (Standard)	

Table 4: Data Output Rates - Part Numbers

Additional Software Options

Description	Part Number
RTK Option	CNV5K-310041-3341
RTK Extend	CNV5K-310041-3342
1PPS / Event Option	CNV5K-310041-3351
C-Nav Corrections Service Over-The-Internet (CCS OTI)	CNV97-310041-3309

Table 5: Additional Software Options - Part Numbers

Electrical Power

Power Cable w/ Filter

Figure 5: DC Power Cable w/ Filter

An unterminated power cable is included for those applications requiring using an extra serial port (COM3), 1PPS, and able to power the C-Nav5000 GNSS receiver with a DC power source.

Description	Part Number
Cable, Power / 1PPS / Event, Positronic 9-Pin Female Unterminated, 10ft, w/ Filter	CNV5K-96235771

Table 6: DC Power Cable w/ Filter - Part Number

AC Power Supply Kit

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

Figure 6: AC Power Supply Kit

Description	Part Number
Positronic 9-Pin Female Universal AC/DC Power Adapter 110-220 VAC, 12 VDC, 1.50 A	CNV5K-PH96237115
AC Power Cord, IEC320-C7, Shotgun Termination, US	CNV73-200002-00LF
AC Power Cord, IEC320-C7, Shotgun Termination, Euro	CNV4250012-220
AC Power Cord, IEC320-C7, Shotgun Termination, UK	CNV4250013-240

Table 7: AC Power Supply Kit - Part Numbers

Optional Data Cables

This optional cable is used for those applications where it requires using the AC/DC power adapter and using the COM3 serial port.

Description	Part Number
Universal AC/DC Power Adapter 110-220V w/Serial Cable	CNV5K-PH96229422

Table 8: Optional Data Cables - Part Numbers

Optional Antenna Cables

LMR400 Antenna Cable

Figure 7: 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

Table 9: Optional Antenna Cable - Part Numbers

LDF4-50 Heliax Cable

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

Figure 8: Optional Heliax Antenna Cable

Description	Part Number
LDF4-50 Heliax LDF Coax Cable 50 Ohms	CNVCOMLDF4RK-50A
Heliax N Female Connector	CNVCOML4TNF-PSA
Heliax N Male Connector	CNVCOML4TNM-PSA

Table 10: Heliax Cable – Part Numbers

C-Nav Display Unit Controller

Figure 9: C-NaviGator III Control & Display Unit

Description	Part Number
C-NaviGator III Bundle	BUNDLE_C-NAVIG_III
Includes the following items:	
C-NaviGator III Control & Display Unit, Touchscreen	CNVC-Navigator-III
AC/DC Power Adapter, C-NaviGator III	CNVHT00255-OPT-A1
C-NaviGator USB Flash Drive	CNV7CNG002-0
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
C-NaviGator User Manual	CNV5CNG001-XX

Table 11: C-NaviGator III Bundle - Part Numbers

Optional GNSS Sensor Mounting Options

Figure 10: C-Nav5000 Mounting Options

Description	Part Number
C-Nav5000 Front mounting bracket	CNV5K-PH60229634
C-Nav5000 Side mounting bracket	CNV5K-PH60229635

Table 12: Mounting Options - Part Numbers

Optional Transportation Case

Figure 11: Ruggedized Transportation Case

Description	Part Number
Ruggedized Case, C-Nav5000, Black, 20” x 14” x 7.7”	CNV5K-PH60229634
Ruggedized Case, C-NaviGator III, Black, 20” x 14” x 7.7”	CNV5K-PH60229635

Table 13: Optional Ruggedized Transportation Cases - Part Numbers

Section 2 - Introduction

System Overview

Figure 12: C-Nav5000 GNSS Receiver

GNSS Sensor System

The C-Nav5000 GNSS receiver delivers superior accuracy to the marine / offshore community. This unique receiver is designed with a robust and long-term performance upgrade path to meet changing needs via software upgrades. Increased functionality does not typically require the costly purchase of additional hardware.

The C-Nav5000 GNSS receiver software-enabled features, bundled or purchased individually, cover a wide variety of applications.

The C-Nav5000 GNSS receiver is uniquely suited for real-time applications in areas such as surveying, machine control, precise positioning, and construction. The sensor delivers the required millimeter measurement precision and fast update rates at low data latency. Depending on the software bundle, the C-Nav5000 GNSS receiver provides flexibility to be configured as a base station or as a rover.

Superior interference suppression (both in-band & out-band), multipath mitigation, and measurement accuracy are only a few of the sensor's technological advances. The C-Nav5000 GNSS receiver GNSS engine incorporates several patented innovations advancing the existing GNSS technology to the next generation. The receiver provides near optimal GPS P-code recovery, providing a significant signal to noise ratio advantage over competing technologies, among other benefits.

Depending upon the software options selected, the C-Nav5000 GNSS receiver provides, but is not limited to:

- C-Nav Corrections Service (CCS): A worldwide Satellite Based Augmentation System (SBAS) for decimeter level position accuracy
  For more information on the C-Nav Corrections Service and obtaining a license, refer to Appendix C - C-Nav Corrections Service (CCS) (Page 93).

Please note:
Dependent on the bundle: Subscription and Software Option Required

- RTK: The C-Nav5000 GNSS receiver is designed to integrate easily into Real-Time Kinematic (RTK), field data verification, topographical surveys, and a wide variety of surveying applications. The system resolves ambiguities at startup or on satellite reacquisition typically within two seconds. The C-Nav5000 GNSS receiver delivers centimeter level position accuracy via external RTK correction formats (*additional software option required*). The receiver is capable of NCT RTK / Ultra RTK^{TM}, RTCM 2.3, and RTCM 3.1 (code and phase; single base solution), DGPS operating methods.

Please note:
Dependent on the bundle: Subscription and Software Option Required

- Signal Reception: The C-Nav5000 GNSS receiver engine includes a digital ASIC to handle high speed signal processing. The sensor provides proven unparalleled performance in spite of adverse signal tracking conditions by incorporating the use of GPS (L1, L2, L2C, L5), GLONASS (G1, G2), and SBAS (WAAS, EGNOS, MSAS, GAGAN, and SNAS) signals (standard for most software bundles). The receiver tracks and provides raw measurements data for Beidou (B1 and B2) and Galileo (E1, E5a, and E5b) satellite signals. Beidou and Galileo signals are not used in the navigation engine. Other performance restrictions may exist with the use of these signals. No guarantee exists that these signal will be utilized now or in the future for PNT output.

- 255 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. Three channels are dedicated to tracking C-Nav Correction Signals.

- 1PPS / Event: A pulse is available from the C-Nav5000 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. In addition, the C-Nav5000 GNSS receiver accepts an event input pulse to synchronize external incidents requiring precise GNSS time tagging, such as aerial photography. For example, the action of a camera's shutter creates an input pulse to the Event port.

- PVT and Raw Data Output Rates from 1 to 25Hz. 5 Hz maximum is the standard PVT and Raw Data Rate for the C-Nav5000 GNSS receiver.

Applications

The C-Nav5000 GNSS receiver meets the needs of a large number of applications. Depending on the purchased software bundle, the applications include, but are not limited to:

Offshore

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

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

Survey and GIS

- Boundary Survey
- Topographical Surveys in Rough Terrain

- Construction Site Stake-out
- High-Accuracy Data Collection for Post-Processing
- Hydrographic Survey

Military Applications

- Non-Weaponized Military Positioning Applications
- Unmanned Systems
- Oceanographic Survey and Research

Specialty Applications

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

Accuracy

SBAS

When WAAS, EGNOS, MSAS, or GAGAN (RTCA / DO-229D compliant) SNAS, SBAS correction signals are used, the system provides < 30 cm 2D position accuracy (1σ). System accuracy with WAAS, EGNOS, MSAS or GAGAN signals is subject to the quality and update rate of these publicly operated signals. Refer to *Related Standards / Publicly Operated SBAS Signals* in the fore-matter for contact information regarding the organizations that implement the RTCA / DO-229D standard.

Contact C-Nav Support for information on disabling WAAS, EGNOS, and MSAS in the C-Nav5000 GNSS receiver.

C-Nav Corrections Service (CCS)

The system provides < 5 cm position accuracy when CCS Dual Frequency signals are used.

RTK

The system provides immediate < 1 cm position accuracy (1σ) when UltraRTK[1] correction signals are used (baseline, < 40 km, ±1 cm +0.5 ppm, *additional software option required*). Also it applies to Moving Base RTK. After RTK correction signals are received, the baseline determines how long it takes to enter RTK mode. A rover close to the base enters RTK mode almost immediately. For longer baselines, it may take a minute or two. For L1/G1 RTK, antenna model selection is also a factor in ambiguity resolution and time required to enter RTK.

Features That Apply to All Bundles

Output Data Rate

The C-Nav5000 GNSS receiver can output proprietary raw data at programmable rates from ≤1Hz to predetermined rates up to 25Hz[1] and Position Velocity Time (PVT) data at programmable rates from ≤1Hz to predetermined rates up to 25Hz[1] through the data ports[2] with less than 10ms latency. Accuracies are maintained as each output is independently calculated based on an actual GNSS position measurement, as opposed to an extrapolation/ interpolation between 1Hz measurements.

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: Dependent on Software bundle options. Rates beyond 25Hz are possible, but required further product and business development.

Note 2: Port dependent, refer to Communications Ports for details

NCT Binary Proprietary Data

The sensor can output proprietary raw data containing information including (but not limited to):

- Satellite Ephemeris (EPHEM1B)
- Satellite Almanac (ALM1B)
- Raw Pseudo-range Measurements (MEAS1B)
- Position, Height, Velocity, Time & statistics (PVT1B)
- Heading, bearing and distance to moving base (MBRTK1B)

- Signal to Noise (CHNLSTATUS1B)
- Channel Status (CHNLSTATUS1B)
- Measurement Quality (PVT1B and PSEUDORANGESTATSB)
- Correction Data (mirror data ECHODGPS; RTKSTATUS1B)
- Event/Marker (EVENTLATCHA)
- 1PPS
- Measurement Quality (PVT1B and PSEUDORANGESTATSB)

These data messages can be integrated in real-time positioning applications or post-processed against any number of software applications designed to handle NCT or RINEX raw data.

RTCM Data

The following RTCM 2.3 messages are available for output from the C-Nav5000 GNSS receiver:

- RTCM1 and RTCM9: Code GPS Corrections
- RTCM3: Base Position
- RTCM19 and RTCM21: GPS RTK Corrections
- RTCM22: Base Position Extension (Requires RTCM3)
- RTCM22: Extended Reference Station Parameters
- RTCM24: Base Position (Combined RTCM3 and RTCM22)
- RTCM31 and RTCM34: Code GLONASS Corrections

The following RTCM 3.1 messages are available for output from the C-Nav5000 GNSS receiver:

- RTCM1001: L1-Only GPS RTK Observables
- RTCM1002: Extended L1-Only GPS RTK Observables
- RTCM1003: L1 and L2 GPS RTK Observables
- RTCM1004: Extended L1 and L2 GPS RTK Observables
- RTCM1005: Stationary RTK Reference Station ARP
- RTCM1006: Stationary RTK Reference Station ARP with Antenna Height
- RTCM1007: Antenna Descriptor (Base Only)
- RTCM1008: Antenna Descriptor and Serial Number (Base Only)

- RTCM1009: L1-Only GLONASS RTK Observables
- RTCM1010: Extended L1-Only GLONASS RTK Observables
- RTCM1011: L1 and L2 GLONASS RTK Observables
- RTCM1012: Extended L1 and L2 GLONASS RTK Observables
- RTCM1019: GPS Ephemerides
- RTCM1020: GLONASS Ephemerides
- RTCM1033: Receiver and Antenna

NMEA-0183 Data

The C-Nav5000 GNSS receiver is capable of outputting several standard NMEA-0183 data strings (see Appendix D - NMEA Data Output Messages (Page 101)) and several proprietary data strings. Each data is headed with $GN, except for MLA, which is headed with $GL. All header formats are accepted (i.e. $GP, $GL). Proprietary data strings are denoted with a $PNCT prefix.

Standard

- ALM: GPS Almanac Data
- DTM: Datum Reference
- GBS: GPS Satellite Fault Detection
- GFA: GNSS Fix Accuracy and Integrity
- 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
- HDT: Heading Degrees True
- MLA: GLONASS Almanac Data
- RMC: Recommended Min. Specific GNSS Data
- ROT: Rate of Turn
- RRE: Range Residual Errors (Not defined in NMEA-0183 Standard version 3.0)
- TTM: Tracked Target Message
- VTG: Course Over Ground & Ground Speed
- ZDA: Time & Date

Proprietary (prefix $PNCT)

- DTM: Datum Reference for user-selected reference frame
- GGA: GPS Fix with Field 14, which shows the Beam Selection ID (See Table 61) and Navigation Mode (See Table 63).
- GST: GNSS Pseudo-range Error Statistics
- MDE: Marginally Detectable Error
- SET: Solid Earth Tide

Unique Features

The C-Nav5000 GNSS receiver has many unique features:

Performance Upgrade Path

The C-Nav5000 GNSS receiver is designed with a robust and long-term performance upgrade path to meet changing needs via software upgrades. Increased functionality does not typically require the purchase of additional hardware. The C-Nav5000 GNSS receiver software-enabled features cover a wide variety of applications

C-Nav Corrections Service (CCS)

The ability to receive C-Nav Corrections Service (CCS) signals is fully integrated within each unit. A single set of corrections 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-Nav position outputs are referenced to the ITRF-2014 datum (default) and can be steered to WGS-84. Refer to Appendix C - C-Nav Corrections Service (CCS) (Page 93) for more information. The CCS also incorporates the Rapid Recovery feature to quickly regain CCS converged-level accuracy after brief satellite blockage.

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

C-Nav Corrections Service Over-The-Internet (CCS OTI)

This is a new option offered for the C-Nav5000 GNSS receiver. The C-Nav Corrections Service signals can also be received over the Internet as

C-Nav Corrections Service Over-The-Internet (CCS OTI). This feature allows the user to request messages from an independent NTRIP server / caster and can choose between four data delivery rates (1 s, 15 s, 30 s, and 60 s) for maximum ability. Refer to Appendix C - C-Nav Corrections Service (CCS) (Page 93) for more information.

Web Server

The Web Server feature allows the user to access positioning information and control the receiver via a standard web browser and is the primary user interface for live streaming data. Each receiver can be configured with a unique IP address that can be accessed from any computer using Firefox, Chrome, Safari or Internet Explorer. Easily accessible web pages can be used to view satellite data and configure a variety of functions.

NCT RTK / UltraRTK

The RTK / UltraRTK algorithm provides fast initialization and the ultra-compact binary data format for RTK / UltraRTK ensures robust data throughput. The C-Nav5000 GNSS receiver is capable of outputting or accepting legacy 0x5B (RTK) or new NCT62 (UltraRTK) binary formats.

Positioning Flexibility

The C-Nav5000 GNSS receiver is capable of using WAAS, EGNOS, MSAS, and GAGAN (RTCA / DO-229 D compliant) code corrections via two internal Satellite Based Augmentation System (SBAS) channels. The C-Nav5000 GNSS receiver automatically configures to use the most suitable correction source available and changes as the survey dictates (this feature can be overridden).

RTK Extend™

RTK Extend enables continuous RTK-level positioning accuracy during radio communication outages by utilizing the global C-Nav Corrections Service (CCS). Traditionally, when an RTK rover loses communication with the base station, it is unable to provide centimeter position updates for more than a few seconds, resulting in user downtime and reduced productivity. With RTK Extend, a C-Nav receiver operating in RTK mode can transition to RTK Extend mode and maintain centimeter level positioning during communication loss for up to 15 minutes. RTK Extend allows more efficient and uninterrupted work, enabling focused concentration on the work rather than the tools.

RTK Extend is a unique patented technique, not available on any other manufacturer's receivers.

Multi-Format RTK

Contact C-Nav Support for more information on Multi-Format RTK and its applications.

User-Defined Datum

Users can check the current datum (a reference surface to be used in defining the 3D coordinates of a position) or set a specific datum to be used as the position for all PVT data output. Contact C-Nav Support for more information.

Heading

The C-Nav5000 GNSS receiver heading system consists of two C-Nav5000 GNSS receivers connected via either a serial cable or through one of the eight ETH Ports (ETH1 through ETH 8). Each receiver's antenna is located on the platform at the maximum possible separation. One of the units is configured as a moving base and computes its position ten times per second (10 Hz) using any available augmentation signal. The moving base outputs position and RTK measurement corrections to the other unit, which is configured as a heading rover. The heading rover computes the heading looking from the base antenna to the rover antenna and outputs the heading and position of both antennae up to a rate of 10 Hz. Applications include construction equipment such as excavators and marine applications such as dredging.

Coordinated Machines

A C-Nav5000 GNSS receiver configured as a moving base is located on a reference platform. A C-Nav5000 GNSS receiver configured as a rover is located on one or more additional platforms. All of the C-Nav5000 GNSS receiver rovers are connected to the moving base via wireless communication link. The moving base computes its position ten times per second (10 Hz) using any available augmentation signal. The moving base outputs position and RTK measurement corrections to the rovers. The rovers compute the range and bearing to the moving base and output the range and bearing, plus their position, and the position of the moving base, at up to ten times per second (10 Hz). Applications include those requiring the relative positions of two or more moving platforms, such as leader-follower vehicle applications or the relative positions of planes or marine vessels.

Data Sampling

GPS (L1, L2, L2C, L5), GLONASS (G1, G2), and SBAS (WAAS, EGNOS, MSAS, GAGAN, and SNAS) raw measurement and PVT data is up to 5 Hz in the standard C-Nav GNSS Sensor Kit. Optional upgrades allow 10, and 25 Hz raw measurement and PVT data via high-speed ports for highly dynamic applications.

Ethernet Connection

An Ethernet connection may be setup for the C-Nav5000 GNSS receiver. Contact C-Nav Support for instructions on configuring and establishing an Ethernet connection.

Continuously Operating Reference Station (CORS) Support

When optioned as an RTK Base Station, the C-Nav5000 GNSS receiver is capable of computing and outputting RTK message streams in multiple formats and raw satellite measurement data for post-processing simultaneously. All message formats can be output on one of the high-speed USB or Ethernet ports, or messages can be distributed among any of the eight user ports. For IGS or similar permanent Base applications, C-Nav offers a Choke Ring antenna option to significantly reduce multipath errors on signal reception.

NTRIP Support

The generation of differential GNSS correction data is usually done directly on the GNSS receiver of a reference station, but this data can also be derived from observations obtained by networked reference stations. The combined data stream is then fed into a network computer and made available on the internet. Contact C-Nav Support for more information on NTRIP and the C-Nav5000 GNSS receiver.

GNSS Performance

The C-Nav5000 GNSS receiver utilizes the Onyx GNSS engine, which incorporates several patented innovations. Onyx's industry leading receiver sensitivity provides more than 50% signal to noise ratio advantage over competing technologies. This results in improved real time positioning, proven through independent tests, when facing various multipath environments.

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-Nav5000 is also designed to comply with the relevant type approval procedures for marine equipment of the Marine Equipment Directive (MED) 96/98/EC.

The rugged design of the C-Nav5000 GNSS receiver system components provide protection against the harsh environment common to areas such as construction sites, offshore vessels, and mines.

Antennas

C-Nav289

Figure 13: C-Nav289 Antenna

The C-Nav289 is a GNSS antenna (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 Corrections (CCS) Service (L-Band differential corrections), and SBAS (WAAS / EGNOS / MSAS / GAGAN) signals.

AD591

Figure 14: AD591 Antenna

The AD591 is GNSS antenna (ALIAD591) housed in hard anodized, dichromate, and nickel acetate sealed Aluminum with 4mm thick GRP pressure molded radome. It has >95 dB of out of band rejection of the IMMARSAT up link. It tracks GPS (L1, L2, L2C, L5), GLONASS (G1, G2), C-Nav Corrections (CCS) Service (L-Band differential corrections), and SBAS (WAAS / EGNOS / MSAS / GAGAN) signals. See Table 38: AD591 Antenna Specification Sheet for more information.

Section 3 - Interfacing

This chapter details the C-Nav5000 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 round Positronic connectors must be fitted with o-rings which are properly seated on the female connector and all data connectors must be fully seated in the mating connector. In addition, the SD card cover must be fully seated with the turn handle aligned in the notched 9 0'clock closed indicator position.

Electrical Power

There are two ways to power the C-Nav5000. Both cable options are provided with the system.

- Unterminated power cable connected direct to a DC power source.
- Universal AC/DC power supply

⚠ 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 vehicles battery without in-line protection.

Unterminated Power Cable

A rear panel 9-pin Positronic male connector provides electrical power to the C-Nav5000 GNSS receiver. This cable is used for applications that requires to use a DC power source, 1PPS signal, or need an additional serial output (COM3).

Figure 15: Unterminated Power Cable with Filter

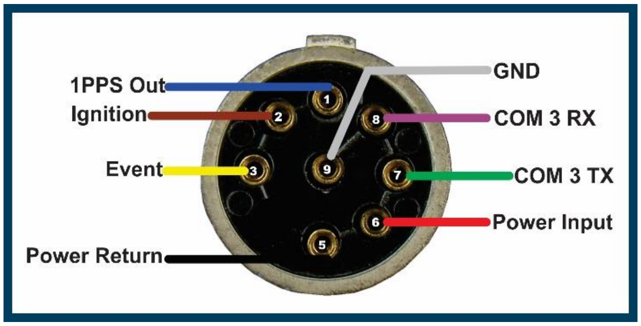


Figure 16: Unterminated Power Cable Pin-Out

Color	Signal	Pin No
Blue	1PPS Out *	1
Brown	Ignition	2
Yellow	Event	3
Black	Power Return	5
Red	Power Input (9 to 32VDC, 6W typical)	6
Green	COM 3 TX	7
Violet	COM 3 RX	8
Gray	GND	9

Table 14: DC Power Cable Pin Assignments

Please note:

- Pin 4 has no connection on this cable.
- * Note that the 1PPS signal is at TTL level and care must be taken if extending the length of the supplied cable to maintain the integrity of the pulse leading edge.

Universal AC/DC Power Supply

An AC Power Supply Kit 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 17: Universal Power Adapter and Power Cord

Please note:

- Optional AC/DC power adapter 110-220V with Serial Cable and 1PPS functionality is available (must be purchased separately P/N: CNV5K-PH96229422).

Front Panel Button Functionality

The C-Nav5000 front panel button  has two different functions depending on which power supply/cable is used.

1. When the Universal Power Adapter is used, the functionality of the front panel button acts as a “**Reset**”.

    a. To turn **ON** the C-Nav5000, the power to the universal adapter must be connected. When the power is applied to the unit, the C-Nav5000 automatically turns **ON** without the assistance of the operator.

    b. To turn **OFF** the C-Nav5000, the power to the universal power adapter must be disconnected.

2. When the Unterminated Power Cable is connected to the C-Nav5000 the front panel button has two different functionalities depending if the “**Ignition**” wire is connected to power.

    A. When the “**Ignition**” wire is connected to the power source, the front panel button acts as a “**Reset**”.

        1. To turn **ON** the C-Nav5000, the DC power source must be connected. When the power is applied to the unit, the C-Nav5000 automatically turns **ON** without the assistance of the operator.

        2. To turn **OFF** the C-Nav5000, the DC power source must be disconnected.

    B. When the “**Ignition**” wire is not connected see Figure 18, then the front panel button can be used to turn **ON**/**OFF** the C-Nav5000.

Please note:

- With this arrangement the C-Nav5000 will not start automatically when power is applied.

1. To turn **ON** the C-Nav5000, press and hold the **ON/OFF** switch for more than 2 seconds.

2. To turn **OFF** the C-Nav5000, press and hold the **ON/OFF** switch button.

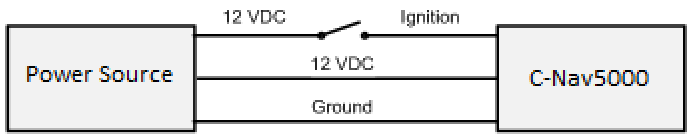


Figure 18: Proper External Power Source Setup

Communication Ports

The C-Nav5000 GNSS receiver provides one 9-pin female Positronic connector communication ports labeled **COM1 - LAN** and one DB26 connector labeled as **COM 2/4 – USB 1/2** located at the rear of the sensor, as shown in Figure 19 below.

Figure 19: C-Nav5000 GNSS Receiver Rear View

COM1- LAN conforms to the EIA RS-232 standard with data rates from 9.6 to 115kbps max. It also conforms to the IEEE 802.3 Ethernet standard with data rates from 10 to 100Mbps.

The COM1-LAN connector pin-outs are described in Table 15.

COM2 and COM 4 conform to the EIA RS-232/RS-422 standard with data rates from 9.6 to 115.2kbps max. USB1 and USB2 are USB 2.0 compliant with 480Mbps maximum data rate.

The COM 2/4 – USB connector pin-outs are described in Table 16.

The C-Nav5000 is configured as a DCE device. Laptop and desktop computers are configured as DTE devices. If the supplied cable is not long enough, a straight-through cable will provide proper connectivity.

Supplied Data Cables

There are two supplied interface data cables:

1. Positronic 9-Pin Male to Ethernet (LAN) / DB9S (RS-232) (CNV5K-PH96235870): constructed as described in Figure 20.

2. HDD – DB26 Pin to USB1 device/Com2/4 Serial cable (CNV5K-PH96229301): Constructed as described in Figure 23.

Figure 20: COM1-LAN Cable

The part number for the Positronic plug on data cable is FR11MP922LM0/AA, pin type: MC422N/AA.

COM1 - LAN & Ethernet / DB9S Y-Cable

The **COM1 - LAN** connector pin-outs relative to the supplied Ethernet (LAN) / DB9S (RS-232) Y-cable/1PPS TTL line (CNV5K-PH96235870) is described below:

Please note:

- **COM1 - LAN** is the only LAN compliant port
- Used for CCS OTI functions.

Signal	Ethernet Pins	Positronic Pins	DB9S Pins
RX-	6	1	
RX+	3	2	
1PPS		3	8
COM1 RXD		4	3
COM1 TXD		5	2
TX+	1	6	
TX-	2	7	
		8	
GND		9	5

Table 15: Ethernet (LAN) / RS-232 Y-Cable Pin Assignment

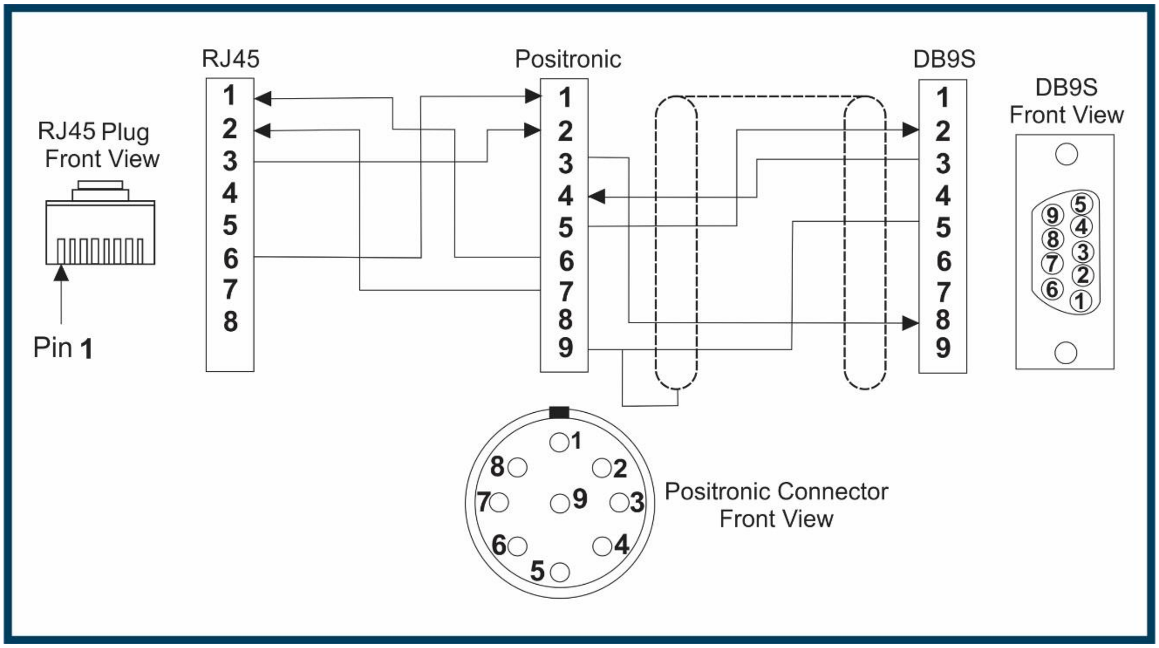


Figure 21: Ethernet (LAN) / RS-232 / Y-Cable/1PPS Pin Assignment

HDD–DB26 Pin to USB1 device/Com2/4 Serial

The second cable provided has three different connectors, 2 x Serial (COM2 and COM4), and USB. COM2 and COM4- cable connectors can be used as RS232/RS422 serial output protocols. The USB1 cable is used a device mode that can output GNSS data.

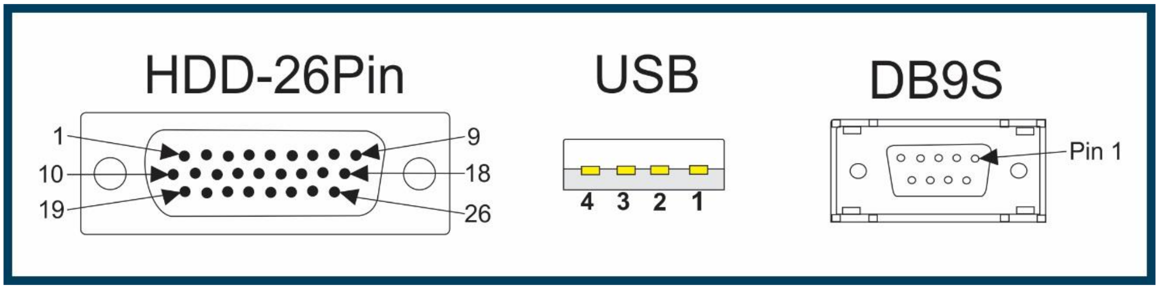


Figure 22: HDD-26 Cable Connectors

Figure 23: HDD-26 Pin COM2/COM4/USB Cable

HDD26 Pins	Signal Nomenclature	USB Pins	COM2 DB9S Pins	COM4 DB9S Pins
1	COM4 TXD+	-	-	7
2	COM4 TXD-	-	-	2
5	USB1 D-	2	-	-
6	USB1 D+	3	-	-
8	COM2 TXD+	-	7	-
9	COM2 TXD-	-	2	-
10	COM4 RXD+	-	-	8
11	Isolated Ground	-	-	5
15	Ground / Shield	4	-	-
17	COM2 RXD+	-	8	-
18	Isolated Ground	-	5	-
19	COM4 RXD-	-	-	3
23	USB1 POWER	1	-	-
26	COM2 RXD-	-	3	-

Table 16: HDD-26 Pin Layout

RS-232 / RS-422 Dual-data Adapter

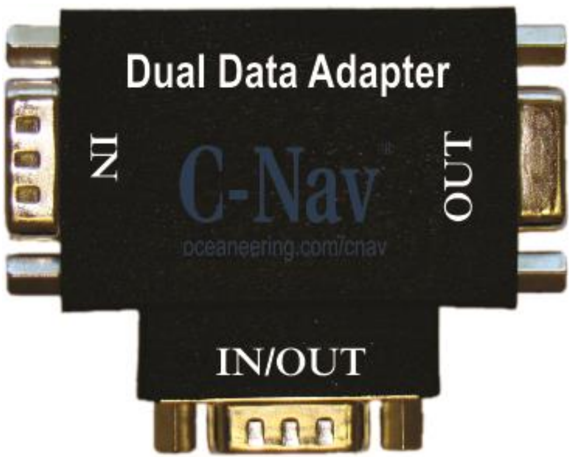


Figure 24: RS-232 / RS-422 Dual-data Adapter

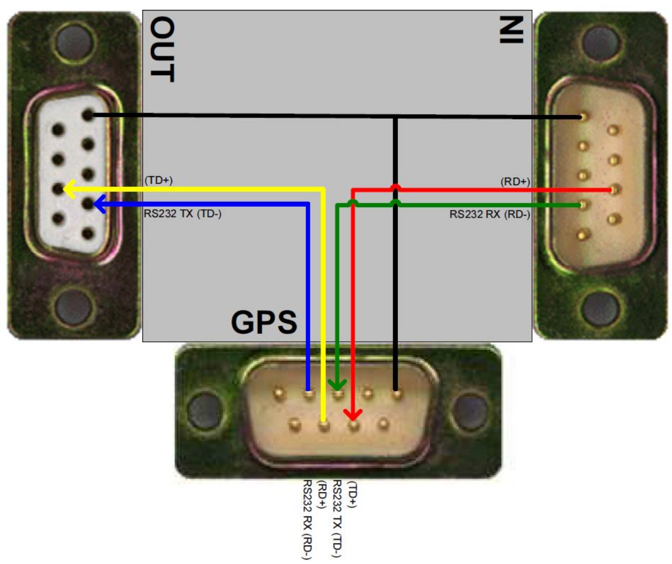


Figure 25: RS-232 / RS-422 Dual-data Adapter Pin Assignment

Mounting Brackets

Phenolic Washer Kit – PN: CNV5K-PH90232615

Figure 26: Phenolic Washer Kit

This kit Includes hardware for all three mounting bracket types (supports one bracket). This hardware enables the receiver to be electrically isolated from the mounting surface.

Top/Bottom, GNSS Receiver Bracket – PN: CNV5K-PH60229636

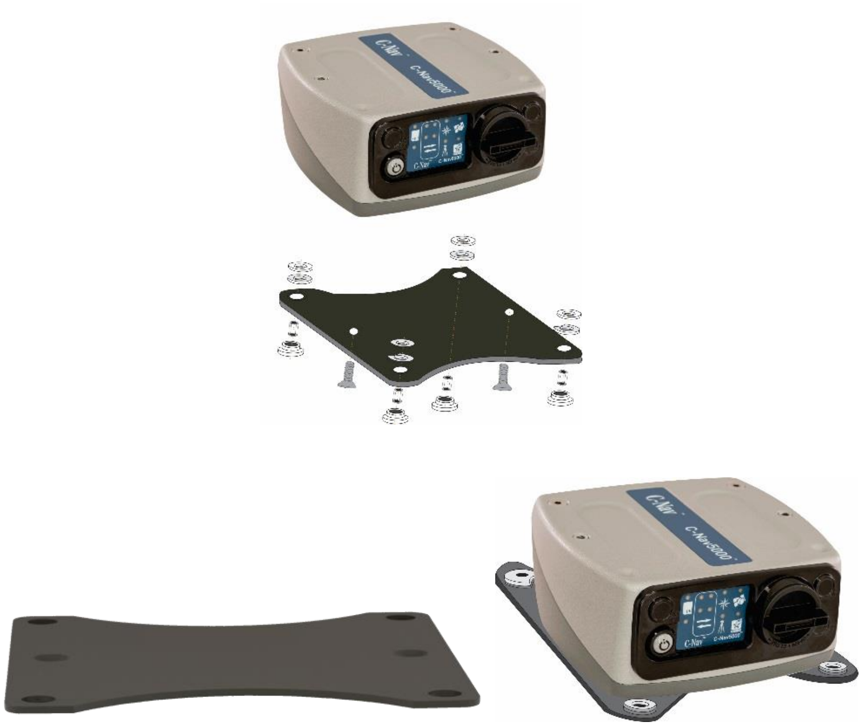


Figure 27: Top/Bottom, GNSS Receiver Painted Bracket

This bracket provides the same footprint as the C-Nav3050 mounting brackets; the product which preceded the C-Nav5000. The corner positions mount the receiver to the desired surface. The two center holes align with the receiver and are countersunk on the surface away from the receiver to accept the two metric M6 x 1.0 x 16mm, flat head machine screws included with the receiver

Side GNSS Receiver Bracket (Optional) - PN: CNV5K-PH60229635

Figure 28: Side GNSS Receiver Painted Bracket

This bracket allows the C-Nav5000 to be mounted 90° from its normal horizontal orientation. The short flange mounts the receiver to the desired surface. The two center holes align with the receiver and are countersunk on the surface away from the receiver to accept the two metric M6 x 1.0 X16mm, flat head machine screws included with the receiver. The bracket can be attached on either the receiver's top or bottom and set to hang or base mount.

Front GNSS Receiver Bracket (Optional) - PN: CNV5K-PH60229634

Figure 29: Front GNSS Receiver Painted Bracket

This bracket allows the C-Nav5000 to be panel mounted in a 19" or 24" inch rack. The short flange mounts the receiver to the desired surface. The two center holes align with the receiver and are countersunk on the surface away from the receiver to accept the two metric M6 x 1.0 X16mm, flat head machine screws included with the receiver. The bracket can be attached on either the receiver's top or bottom.

Event

The C-Nav5000 GNSS receiver accepts an event input pulse to synchronize external incidents requiring precise GNSS time tagging, such as aerial photography. For example, the action of a camera's shutter creates an input pulse to the Event port. The C-Nav5000 GNSS receiver outputs position and time information relative to each event received. The Event is input on Pin 3 of the 9-pin male Positronic connector power port on the rear of the sensor.

Specifications:

- Selectable Input Voltage, 5 V or 12 V
- Minimum pulse width, 100 nS
- Rising or Falling edge Synchronization

Figure 30 details the wiring of the optional Event cable assembly, part number PH96235771. Refer to Chapter 3/Event for detailed electrical specifications. Table 16 details the wiring configuration required for Event pulse sensing.

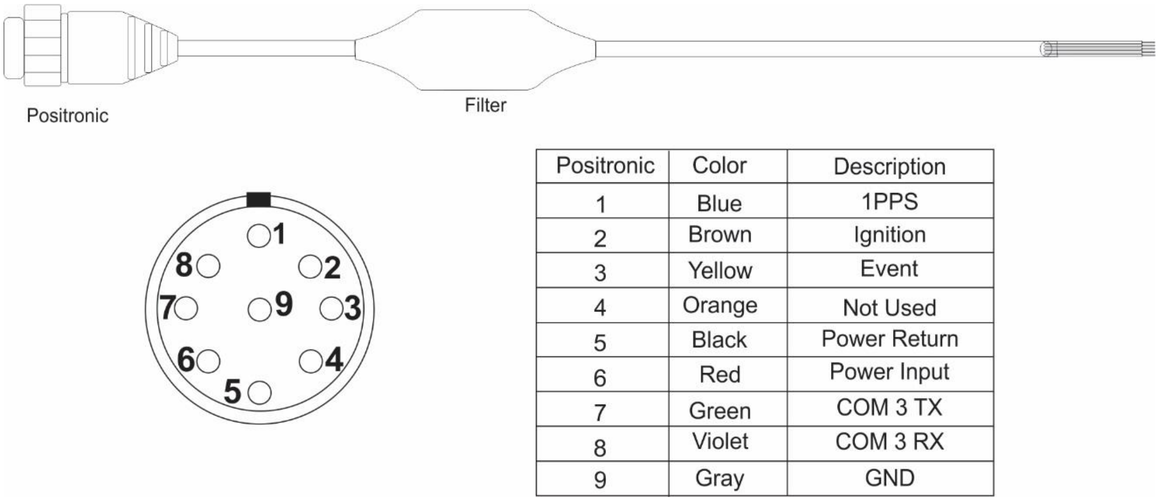


Figure 30: Unterminated Power Cable Wiring Diagram

Pin #	Signal Name	Event Sync Wiring
3	Event	Tie Event to Ground
9	Ground	N/A

Table 17: Event Wiring Connections

Once the cable is wired to correspond with the event pulse requirements, configure the receiver to output the message containing a time mark – referenced to the time kept within the receiver indicating when the event is sensed.

1PPS

A pulse is available from the C-Nav5000 GNSS receiver via the **COM1 & POWER** connectors 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. Additional software options required.

Specifications:

- 25 ns relative accuracy
- Better than 100 ns absolute accuracy
- 5 V TTL Logic level output
- 1PPS Output Impedance > 50 Ohms
- Pulse width, default 1 mS
- Pulse delay, default 0 mS
- Rising or Falling Edge Synchronization

1PPS Adapter

- For use on **COM1/Unterminated Cable** with either the Positronic 9-Pin Male to Ethernet (LAN) / DB9S (RS-232 / 1PPS) (CNV5K-PH96235870) Data Cable, or Positronic 9-Pin Male to DB9S (RS-232 / RS-422 / 1PPS) Data Cable (CNV5K-PH96235871): Optional Cable and unterminated.

Figure 31: 1PPS Adapter

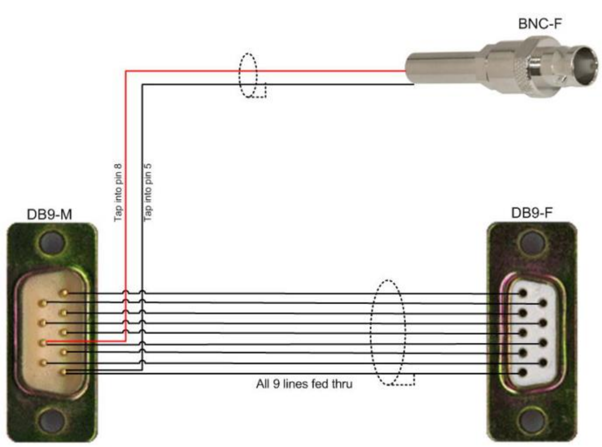


Figure 32: 1PPS Adapter Pin Assignment

Indicator Panel

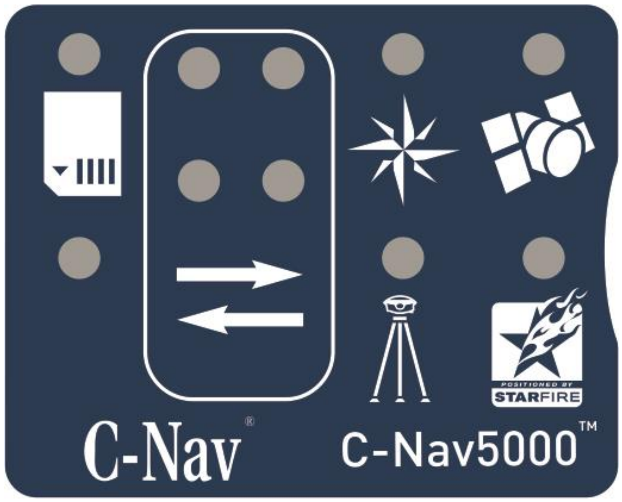


Figure 33: C-Nav5000 GNSS Receiver Front Indicator Panel

The indicator panel provides a quick status view of the GNSS navigation / operating mode, C-Nav signal strength, and the On / Off (I/O) switch

GNSS LEDs

Icon	Indicator	Status	Description
	***Power / GNSS***	**Off**	Power off
		Red	Power on but not tracking
		Green Blinking	Acquiring or tracking GNSS satellites (no position fix yet)
		Green	Using GNSS satellites (position fix)

Table 18: GNSS LED Indication

C-NavLink LEDs

Icon	Indicator	Status	Description
	C-Nav *LINK*	Red Steady	No signal
		Red Blinking	No C-Nav License (or expired)
		Green Blinking	Acquiring C-Nav signal
		Green Steady	Tracking C-Nav signal

Table 19: C-Nav Link LED Indication

Navigation Mode LEDs

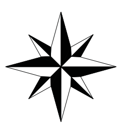
Icon	Indicator	Status	Description
	**Positioning**	Green Steady	RTK
		Green Blinking	RTK Extend
		Red Steady	C-Nav CCS
		Orange Steady	Code Differential, SBAS (WAAS/EGNOS/MSAS/GAGAN)
		Orange Blinking	Autonomous

Table 20: Navigation Mode LED Indication

Base RTK Mode LEDs

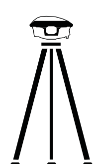
Icon	Indicator	Status	Description
	**Base RTK Mode**	**Off**	Not in Base mode
		Red Steady	Correction data is transmitting
		Red Blinking	Correction data is not transmitting

Table 21: Base RTK Mode LED indication

Data I/O Active LEDs

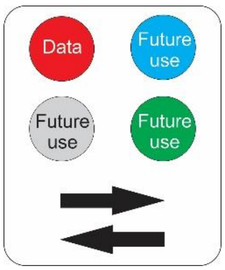
<table>
<tr><th>Icon</th><th>Indicator</th><th>LED</th><th>Status</th><th>Description</th></tr>
<tr><td rowspan="11">
</td><td rowspan="11">Data</td><td rowspan="2">Data
Upper-Left</td><td>Off</td><td>Data I/O inactive</td></tr>
<tr><td>Red Blinking</td><td>Data I/O active</td></tr>
<tr><td rowspan="3">Future use</td><td>N/A</td><td>N/A</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td rowspan="2">Future use</td><td>N/A</td><td>N/A</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td rowspan="3">Future Use
Lower-Left</td><td>N/A</td><td>N/A</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
</table>

Table 22: Data I/O Active LED Indication

Section 4 - 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 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.

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 in order to avoid shading by surrounding structures.

Figure 34: C-Nav289 GNSS Antenna

Antenna Location

- Locate the antenna where it has a clear view of the sky, to an elevation angle of 7º if possible. Obstructions below 15º elevation generally are not a problem, though this is dependent on satellite availability for the local region.

- Avoid placing the antenna where more than 90º azimuth of the sky is obstructed. When more than 90º of azimuth is shaded, it is often still possible for the receiver to navigate; however, poor satellite geometry (due to satellite shading) will provide poor positioning results. Even 10º of shading can have a negative effect on performance, though this generally is not the case.
- Avoid placing the antenna on or near metal or other electrically reflective surfaces.
- Do not paint the antenna enclosure with a metallic-based paint.
- 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-Nav5000 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.
- Use satellite prediction software with a recent satellite almanac to assess the impact on satellite visibility at your location. An L-Band Communication Satellite Locator tool is available on the C-Nav Support website and Product DVD to aid in determining potential obstructions to the C-Nav Signal: Geostationary Satellite Calculator
- A clear line of sight between the antenna and the local INMARSAT satellite is required to track the C-Nav Corrections Service (CCS) signal. INMARSAT satellites are geo-synchronized 35,786 kms above the Equator.

Antenna Mounting Pole

Included with the C-Nav289 Antenna is a 1 ft Antenna Mounting Pole (P/N CNVWES534610). See Figure 35 below.

Figure 35: Antenna Mounting Poles

Antenna Mounting Pole Adaptor

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

Figure 36: 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 37: Antenna, Adaptor and Mounting Pole

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.

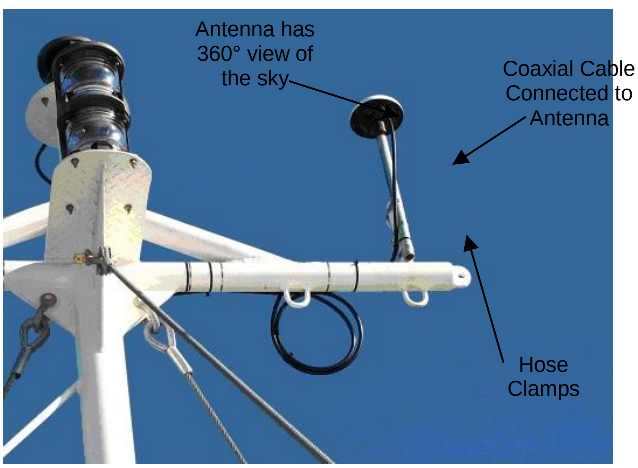


Figure 38: C-Nav5000 GNSS Receiver Antenna Mast Installation

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-Nav5000 GNSS receiver is a TNC female, labeled **ANT** on the rear panel of the sensor as shown in Figure 19.

⚠ 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.

Cable Route

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

- Avoid running coaxial cable across, or parallel too 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 23 for acceptable cable lengths in relation to attenuation loss at the frequencies in use. The cable length between the antenna and C-Nav5000 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 Support

(cnavsupport@oceaneering.com) for more information on available in-line amplifier solutions.

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. Apply silicone grease to the connector threads and wipe off any excess, ensure not to get any lubricant on the contact. Connect the coaxial cable and hand-tighten firmly. Wrap the connection with self-amalgamating tape or another weather sealant such as Coax-seal® to prevent water ingress.
2. Slacken the coaxial cable and tape firmly to the antenna-mounting pole. This will prevent any undue strain on the cable connector and antenna.
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.
5. Connect the coaxial cable to the female TNC connector on the GNSS receiver labeled **GNSS1** (See Figure 19). Ensure that any slack in the cable is neatly stowed and that the minimum bend radius is not exceed during this process.

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

Table 23: Acceptable Coaxial Cable Lengths

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 for more information on available lightning protection solutions.

GNSS Sensor

Mount the C-Nav5000 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.

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

Technical specifications, compass safe distance and block diagrams for the C-Nav5000 GNSS receiver GNSS sensor are located in Table 33: Physical and Environmental Specifications.

⚠ There are no user-serviceable parts inside the C-Nav5000 GNSS receiver. Removing the screws that secure the Top and bottom end plates will void the equipment warranty.

Communication Port Connectivity

There is no default control port or data port on the receiver. **COM1 - LAN** is the only Ethernet (LAN) compliant port. **COM2/4 – USB1** is the only USB1 Device compliant port.

Basics of RTK Surveying

RTK (Real-Time Kinematic) is a GNSS system that yields very accurate 3D position fixes immediately in real-time.

A reference station (base station) transmits its GNSS position to roving receivers as the base receiver generates them. The roving receivers use the reference station readings to differentially correct their own positions. Accuracies of a few centimeters in all three dimensions are possible. RTK requires multi-frequency GNSS receivers and high speed radio modems.

Proper setup of a reference station minimizes GNSS errors in the rover. The reference GNSS sensor is set up at a known surveyed location. With this position locked in, it transmits its code, clock, and reference station coordinate information to the roving sensor(s). The roving sensor(s) uses this information to correct each GNSS measurement it receives.

The C-Nav5000 GNSS receiver, when configured as a reference station, can transmit corrections to any number of roving receivers capable of picking up the radio signal and decoding one of these correction formats (NCT, RTCM 2.3, and RTCM 3.1). The signal can be received in less than ideal environments, though some data loss may occur. Setup of the reference station sensor above the roving sensors is recommended to enable transmission to all rovers in all directions with minimal obstruction. High frequency radio signals generally travel a shorter distance than lower frequency signals, and do not penetrate obstructions as well over distance.

Section 5 - Configuration

The C-Nav5000 GNSS receiver has a rich interface and detailed control language, allowing each unit to be individually programmed to a specific application.

There are essentially four methods available to configure and control the C-Nav5000 GNSS receiver:

- C-NaviGator III Control and Display Unit - The C-NaviGator III Touchscreen Control and Display unit allows users to monitor real-time system and position quality information. Includes: multiple NMEA inputs and selectable outputs, six (four RS-232 and two RS-422) serial, one Ethernet and two USB ports, on-screen help menu, and an intuitive and easy to use interface. Contact C-Nav Support (cnavsupport@oceaneering.com) or refer to the included C-Nav Product thumb drive 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. Contact C-Nav Support or refer to the included C-Nav thumb drive 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.
- Web Interface - The web interface for the C-Nav5000 GNSS receiver allows the user to view the receiver's performance and configure the receiver with a web browser (Chrome, Firefox, Safari, or Internet Explorer). The web interface offers a sub-set of the available functions in C-Setup, C-Monitor® QA/QC software, or the C-NaviGator III CDU. The functions that are not visually present in the web interface can be accessed through a series of ASCII commands using the Input Terminal page. The web interface can be accessed on receiver firmware versions 3.3.x or later.

There is no default control port on the receiver. When any port is connected to control software, such as C-Monitor® QA/QC software, that port then becomes the control port.

COM1 - LAN

- Configuration - Control or Data Port
- Rate - RS-232: 9.6 to 115.2 kbps; Ethernet: 10 to 100 Mbps
- TTL 1PPS available

These ports (COM1, ETH1, ETH2, ETH3, ETH4, ETH5, ETH6, ETH7, and ETH8) normally used to input and output proprietary messages used for navigation and receiver setup. It is also the only port that can be used to receive NTRIP or CCS OTI through the RJ-45 Ethernet plug on the **COM1 – LAN** cable. This section describes the default messages needed to best initiate surveying with minimal effort.

The user has full control over the utilized message types and their associated rates via C-Nav proprietary software.

COM2 – COM4 – USB1

- Configuration - Control or Data Port
- Rate - RS-232 / RS-422: 9.6 to 115.2 kbps USB 2.0: 480 Mbps

These ports are normally used to output data to other devices or machines that can make immediate use of the precise positioning data available from the C-Nav5000 GNSS receiver. The data port outputs NCT Binary Messages and NMEA Messages, and when applying external DGNSS corrections, also serves as the DGNSS correction input port.

COM3

Com 3 is available on the unterminated power cable or in the optional power supply cable (PN: CNV5K-PH96229422).

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

Output Messages

NCT Binary Output Message Descriptions:

- **ALM1B (Packed Almanac):**
  Data corresponding to each satellite in the GPS constellation, including GPS Week number of collected almanac, GPS Time of week [in seconds] of collected almanac, almanac reference week, almanac reference time, almanac source, almanac health, pages 1-25, and sub-frames 4 and 5. Packed almanac data for 32 GPS or 24 GLONASS satellites.
- **CHNLSTATUS1B (Channel Status):**
  Receiver channel status information containing GNSS engine status, number of satellites viewed / tracked, PDOP, tracked satellite identity, satellite elevation and azimuth, C/No for tracked signals and correction age for each satellite.
- **EPHEM1B (Packed Ephemeris):**
  Individual satellite tracking information including GPS Week number of collected ephemeris, GPS Time of week [in seconds] of collected ephemeris, IODC, and sub-frame 1, 2, and 3 data. Packed ephemeris data for 32 GPS or 24 GLONASS satellites.
- **MEAS1B (Raw Measurement Data):**
  Raw Measurement Data Block containing Raw measurements from satellites so measurements can be post-processed to achieve precise point positions, the GPS Week, GPS Time of Week, Time Slew Indicator, Status, Channel Status, CA Pseudo-range, L1 Phase, P1-CA Pseudo-range, P2-CA Pseudo-range, L2 Phase, GPS L5, GLONASS G1 and G1 Code and Phase, and SBAS Code and Phase. This data stream is repeated for each individual tracked satellite.
- **SFSTATUS1B (CCS Signal Status):**
  Provides the status of C-Nav Corrections Service (CCS) signals including signal status, signal strength, CCS license status, and good and idle packet counts.
- **PSEUDORANGESTATSB (Pseudo-range Noise Statistics):**
  Provides pseudo-range noise statistic information including orientation and standard deviations of latitude, longitude, altitude, semi-major axis of the error ellipse, and semi-minor of the error ellipse.
- **PVT1B (Position, Velocity, and Time):**
  Provides GPS Week number, GNSS satellites used, latitude, longitude, navigation mode, and DOP information.

NMEA Messages

The C-Nav5000 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 (Page 101), for complete descriptions of the NMEA output messages available from the C-Nav5000 GNSS receiver.

RTCM Messages

The C-Nav5000 GNSS receiver does not output RTCM messages by default. The user, via controller software, must enable RTCM messages. The following RTCM messages are available for output from the C-Nav5000 GNSS receiver:

- RTCM1 and RTCM9: Code GPS Corrections
- RTCM3: Base Position
- RTCM19 and RTCM21: GPS RTK Corrections
- RTCM22: Base Position Extension (Requires RTCM3)
- RTCM22: Extended Reference Station Parameters
- RTCM24: Base Position (Combined RTCM3 and RTCM22)
- RTCM31 and RTCM34: Code GLONASS Corrections
- RTCM1001: L1-Only GPS RTK Observables
- RTCM1002: Extended L1-Only GPS RTK Observables
- RTCM1003: L1 and L2 GPS RTK Observables
- RTCM1004: Extended L1 and L2 GPS RTK Observables
- RTCM1005: Stationary RTK Reference Station ARP
- RTCM1006: Stationary RTK Reference Station ARP with Antenna Height
- RTCM1007: Antenna Descriptor (Base Only)
- RTCM1008: Antenna Descriptor and Serial Number (Base Only)
- RTCM1009: L1-Only GLONASS RTK Observables
- RTCM1010: Extended L1-Only GLONASS RTK Observables
- RTCM1011: L1 and L2 GLONASS RTK Observables
- RTCM1012: Extended L1 and L2 GLONASS RTK Observables
- RTCM1019: GPS Ephemerides
- RTCM1020: GLONASS Ephemerides
- RTCM1033: Receiver and Antenna Descriptors

Base and Rover Navigation Setup

C-Setup, C-Scape, C-Monitor QA/QC software, and C-NaviGator III CDU provide Base and Rover setup capabilities. Contact C-Nav Support for details.

Profiles

The C-Nav5000 GNSS receiver utilizes commands or groups of commands, known as **Profiles**, to set the various port assignments / parameters, navigation parameters, and output message lists. The C-Nav5000 GNSS receiver provides for storage of up to twenty profiles.

To save the current configuration settings of the receiver for future use, the user creates and names a profile. A controller solution, such as C-Monitor QA/QC software, is used to activate a profile by its name.

Please note:

A new profile sent to the receiver replaces the currently used profile, but it does not necessarily replace all the current parameter settings. The new profile replaces only those parameter settings that it specifies.

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.

Section 6 - Safety Instructions

The C-Nav5000 GNSS receiver is designed for precise navigation and positioning using the GPS and GLONASS. Users must be familiar with the use of portable GNSS equipment, the limitations thereof and these safety instructions prior to use of this equipment.

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 CNV3050CASE) is available to for users requiring additional shock and vibration protection for their C-Nav equipment. Contact C-Nav Support (cnavsupport@oceaneering.com) for more information.

Maintenance

C-Nav equipment may be cleaned using a new 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.

External Power Source

The C-Nav5000 GNSS receiver can be powered by an external power cable (P/N CNV5K-PH96235771) or using an AC Power Adapter (P/N CNV5K-PH96235770) both included with every C-Nav5000 GNSS receiver. The C-Nav5000 GNSS receiver must be connected to the chosen external power solution in accordance with Section 3 - Interfacing (Page 45). 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.

If your chosen external power source is a disposable battery, please dispose of the battery in accordance with your local regulations.

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-Nav5000 and connected equipment are operated on stable input power which may require additional conditioning if communications problems are experienced.

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-Nav5000 GNSS receiver. Accessing the inside of the equipment will void the equipment warranty.

Take care to ensure the C-Nav5000 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.

Please note:

Shorting on the Ethernet port may cause data on the Ethernet port to halt. Users should take care to ensure connected equipment are operated with appropriate fail-safes to ensure appropriate equipment response for safety of life and property if communications problems are experienced. The appropriate response to this failure mode is to re-established and Ethernet connection.

Appendix A - GNSS Sensor Specifications

The technical specifications of this unit are detailed below. C-Nav is constantly improving, and updating our technology. 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.

Features

- Full constellation coverage with up to 252 signals tracked simultaneously, plus three C-Nav Corrections Service (CCS) channels
- SBAS (WAAS, EGNOS, MSAS, GAGAN, SNAS) tracking
- Built in C-Nav Corrections Service receiver and demodulator
- L1C/A, L2P, L2C, L5, G1C/A, G2P, C1, C2 C5b, C6, E1, E5A, E5B, E6 code and full wavelength carrier phase tracking
- High Sensitivity/low signal lever tracking
- Fast acquisition/re-acquisition
- Superior interference suppression (both in-band & out-of-band)
- Patented multipath rejection
- Minimal data latency
- 2 GB of internal memory; 4 to 32GB SD Card (customer supplied)
- Network RTK, RTCM 2.3 and 3.0 (code & carrier), and NTRIP
- Output NMEA-0183, NCT Binary, NCT ASCII formats
- Configurable as RTK base or rover
- Moving Base Code
- MBRTK (Moving Base RTK)
- RTK Extend

- Heading (requires two C-Nav5000 GNSS receivers)
- Programmable output rates
- Event Marker input
- 1PPS Output
- Communication Ports: RS-232, RS-422, USB 2.0 (Device and Host), and Ethernet
- C-Nav Corrections Service over IP via the Internet

Performance

C-Nav5000 GNSS receiver performance is dependent on location, satellite geometry, atmospheric conditions, and GNSS corrections.

Tracking Characteristics

The C-Nav5000 GNSS receiver engine has 255 signal channels with the required flexibility to track all civilian GNSS and SBAS signals. The C-Nav5000 GNSS receiver engine is also capable of tracking the code and carrier from all GNSS signals.

- Shade: G2 provides the best results, though positioning is less accurate in shade.
- Open Sky: L5 provides the best positioning accuracy.

Tracking of newer navigation satellite signals (L2C and L5) is subject to:

- The availability of the signals from newer satellites
- The "health bit" set to "healthy"
- The C-Nav5000 GNSS receiver navigation software updated to a version compatible with the signals

Pull-In Times

C-Nav CCS	45 minutes, typical

Table 24: Pull-In Times

Signals Tracked

Navigation & Public Correction Signals	
Services include: GPS L1, and SBAS (WAAS, EGNOS, MSAS, GAGAN); 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
C-Nav Signals	
L-Band Differential Correction:	1525 to 1560 MHz

Table 25: Signals Tracked

[1]Hardware ready

[2]Beidou, Galileo, 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 signal will be utilized now or in the future for PNT output.

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

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)

Table 26: Time-To-First-Fix

Signal Reacquisition

< 30 second loss:	< 2 seconds

Table 27: Signal Reacquisition

Measurement Performance

RTK Positioning – Multi-Frequency <40kms	
Position (H): Position (V):	+ 1.5 cm, +1ppm, 2σ; + 1 cm, +0.5ppm, 1σ + 3.0cm, +2ppm, 2σ; + 2 cm, +1ppm, 1σ
RTK WL Positioning – Multi-Frequency <40kms (RMS) (see note below)	
Position (H): Position (V):	+ 5cm +2ppm + 10cm +2ppm
RTK Extend (see note below)	
Position (H): Position (V):	+ 4.5cm, +1ppm, 2σ; + 3cm +1ppm, 1σ + 10cm, +2ppm, 2σ; + 6cm +2ppm, 1σ
RTK Float	
Position (H): Position (V):	+ 30cm, +3ppm, 2σ + 60cm, +3ppm, 2σ
CCS (multi)	
Position (H): Position (V):	+ 7cm, 2σ; + 5cm, 1σ GNSS; + 10cm, 1σ GPS + 14cm, 2σ, + 10cm, 1σ GNSS, + 15cm, 1σ GPS
Rapid Recovery (CCS GNSS only)	
Position (H): Position (V): Outage Duration: Recovery Period:	+ 7cm, 2σ + 14cm, 2σ < 55sec Up to 4min
CCS -LP	
Position (H): Position (V):	100cm, 2σ 200cm, 2σ
Code Differential GPS <200kms (RMS)	
Position (H): Position (V):	+ 45cm +3ppm + 90cm +3ppm
Enhanced SBAS (WAAS/EGNOS/MSAS/GAGAN) Position Accuracy	
Position (H): Position (V):	+ 80cm, 2σ; + 30cm, RMS + 150cm, 2σ; + 60cm, RMS
Heading	
Multi-Frequency	0.1 degrees Requires 10Hz update rate
Velocity (for all DGPS described above)	
Velocity:	0.01m/s

Figure 39: Measurement Performance

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. Equipment operated on a single-frequency (i.e., L1 / G1) is more susceptible to atmospheric solar storm activity than multi-frequency operated equipment.
- RTK WL is a positioning mode that is necessary for phase ambiguity resolution. However when this navigation mode is indicated, it is likely that the receiver is in a corner navigation condition. As such, it is likely that the end user will not wish to use it as a valid navigation mode.

  If the above conditions are met, then the receiver will not need to be put into RTK-WL mode.

- RTK Extend is a purchased software option, which uses C-Nav proprietary differential processing techniques to provide continuous RTK positioning during non-reception of RTK corrections. When a C-Nav enabled receiver with RTK Extend falls out of RTK mode, the system automatically transitions to RTK Extend mode. Positioning is maintained because of the close correlation in phase measurement corrections between RTK and the C-Nav proprietary differential processing techniques.
- Depending on how long the RTK base station has been running and is C-Nav fixed, the duration of RTK Extend is limited to:
  - 2 to 15 minutes for a NCT base station
  - 2 to 15 minutes for a non-NCT base station

  For RTK Extend to achieve maximum performance, the rover must be fully converged, which typically requires one (1) hour of operation.

- The correlation between RTK and C-Nav phase measurement corrections decreases over time, until the system automatically transitions out of RTK Extend mode to the next available DGNSS mode.
- This option is only required on the Rover receiver. If a Base receiver may be used as a Rover at a future date, it should be optioned for RTK Extend as well.

Receiver Noise Figure

20.0 dB +2dB @ 290º Kelvin; 1 Hz RBW

Table 28: Receiver Noise Figure

Dynamics

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

Table 29: Dynamics

[1]Restricted by USA export laws

1PPS

Accuracy:	±13 ns (Relative; User Configurable)
Pulse Width:	User defined from 25 to 1600000 nS inclusive; 1000000 default

Table 30: 1PPS

Data Latency

PVT:	< 10 ms
Raw Data:	< 10 ms

Table 31: Data Latency

Connector Assignments

GNSS1 (primary): **GNSS 2** (When two antenna applications are active)	TNC (female), GNSS/C-Nav RF Input, RF Ground TNC (female), GNSS RF Input, RF Ground GNSS2 is for future capabilities
COM 1 – LAN: (FR11MP922LM0/AA Pin: MC422N/AA)	Positronic (female) RS-232, from 9.6 to 115.2 kbps Ethernet, 10 to 100 Mbps; up to 8-sessions TTL 1PPS connection
COM 2/4 – USB1/2: (DB26S)	DB26 Pin Connector 2 x RS-232 / RS-422, from 9.6 to 115.2 kbps USB 2.0, 12Mbps max data rate
PWR 1PPS: (connector: FR11FP922LM0/AA; pin: FC422N6/AA).	Positronic (male) Power port, from 9 to 32 VDC, 8 W typical, Power Input 1, 2; Power Ground 1PPS / Event Marker 1 x RS-232, from 9.6 to 115.2 kbps

Table 32: Connector Assignments

Physical and Environmental Specifications

Size (L x W x H)	176.3 x 168 x 72 mm (6.94 x 6.6 x 2.8 inches)
Weight: Not including mounting bracket	3.8 lb (1.72 kg)
Power Consumption: Input Voltage: Output Voltage: Output Current:	8 Watts 9 to 32 VDC, 110/220 VAC, 18W, 1.5A auto ranging +5 V ±0.5 V power for each GNSS/ L-band antenna via antenna connector 100 mA per antenna connector 400 mA USB port
Temperature (ambient) Operating: Storage	 -40º C to +70º C (-40º to +158º F) -40º C to +85º C (-40º to +185º F)
Humidity:	95% Non-Condensing
Vibration:	MIL-STD-810G Method 514.6
Shock:	ML-STD-810G

	Method 514.6
Ingress Protection:	IP67*
Regulatory Certifications	FCC Part 15 RoHS WEEE REACH (EC1907/2006 R&TTE: EN 301 489-1 v1.8.1: 2008 (for transmitting devices) AS/NZS CISPR 22 (2006)
Marine Electronics Directive Compliant	Software: IEC 61108-1, IEC 61162-1:2011 with backward compatibility to IEC 61162-1:2008 and NMEA-0183v4.1 Hardware IEC 60945:2002 (Including Corr.1:2008)
Minimum Compass Safe Distance	300 mm

Table 33: Physical and Environmental Specifications

* Compliant only when cables are connected and properly seated and the SD card cover is fully seated with the turn handle aligned in the 12 o'clock locked indicator position.

Satellite Based Augmentation System Signals (SBAS)

Publicly broadcast services:	SBAS (WASS/EGNOS/MSAS/GAGAN/SNAS)
Private subscription service:	C-Nav Corrections Services (CCS)

Table 34: Satellite Based Augmentation Systems Signals (SBAS)

LED Display Functions

GNSS	Acquiring / tracking GNSS satellites
C-Nav Link	Verifying C-Nav License Acquiring / tracking C-Nav Corrections Satellites
Data I/O	Data I/O activity
Navigation Mode	Current navigation mode
Base RTK Mode	Verifying if receiver is in base mode / correction

	data is being transmitted

Table 35: LED Display Functions

Input / Output Data Messages

Control Commands (Input Only):	C-Nav proprietary commands (contact C-Nav Support for more information)
Differential Correction (I/O):	RTCM 2.3 and 3.0, RTCM types 1, 3, 9, 31 and 34, SBAS (WAAS / EGNOS / MSAS / GAGAN), and CCS
RTK Correction Data (I/O):	RTCM types 3, 18-22, and 1001-1012, 1019-1020, 1033: NCT types 0x62 (hex)
NMEA-0183 Messages (Output only):	ALM, DTM, GBS, GFA, GGA, GLL, GNS, GRS, GSA, GST, GSV, HDT, MLA, RMC, RRE, VTG,TTM, ZDA, PNCT

Table 36: Input/Output Data Messages

CCS Rapid Recovery

The CCS Rapid Recovery feature provides a way to more quickly recover from the loss of CCS corrected positioning after loss and recovery of navigation. The receiver starts using these corrections when the link to the navigation satellites has been lost, or has degraded to a specified quality value called Figure of Merit (FOM) which represents the best-guest accuracy of the horizontal position. Convergence time in CCS mode is virtually eliminated under certain conditions following a very brief navigational outage. C-Nav recommends using a FOM in the range of 5-10. This feature is available only on the GPS portion of the CCS correction, which constitutes the larger weighted component of the correction.

CCS Rapid Recovery with Quick Start

CCS enables Rapid Recovery when an accurately known ITRF-2014 position is used to initialize CCS navigation. This is typically a position previously surveyed and converted to ITRF-2014 prior to initialization. This feature is available for the CCS GNSS only. The receiver must have a CCS Dual Frequency solution prior to initiating.

- This feature is available with the CCS GNSS only
- The receiver must have a CCS Dual Frequency solution prior to initiating Quick start.

- Rapid Recovery is available only on the GPS portion of the CCS correction, which constitutes the larger weighted component of the correction.
- Rapid Recovery is not available for the first 5 minutes after a successful quick start is completed.
- When a lower FOM limit value is input, the receiver is more constrained in completing a Rapid Recover process.
- In order for Rapid Recovery to function, the outages must not exceed 2 minutes.
- Requires one minute to complete.
- Option to manually enter coordinates to initiate feature.

Block Diagrams

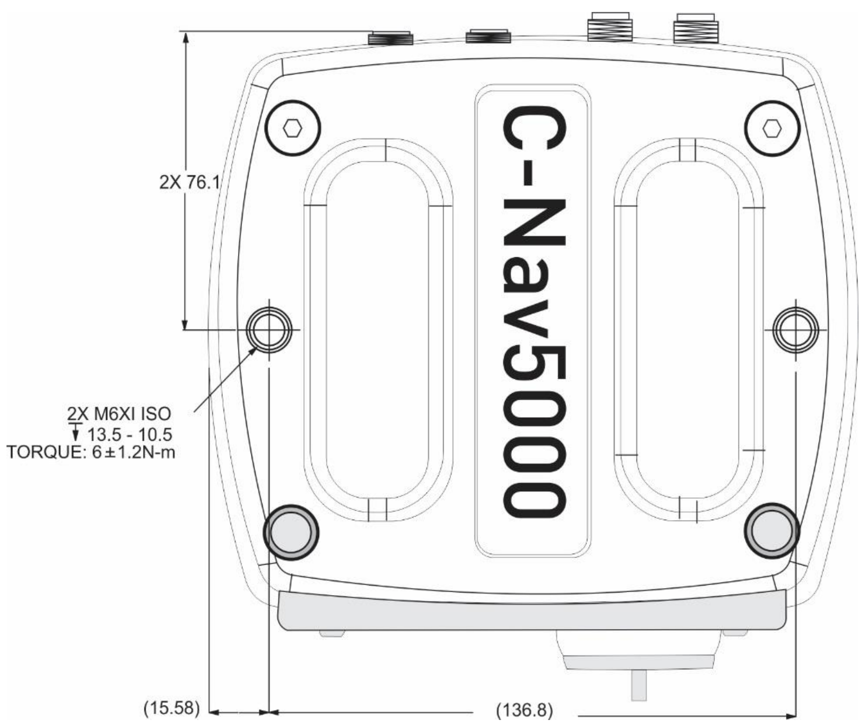


Figure 40: C-Nav5000 Base Plate Dimensions without Mounting Brackets

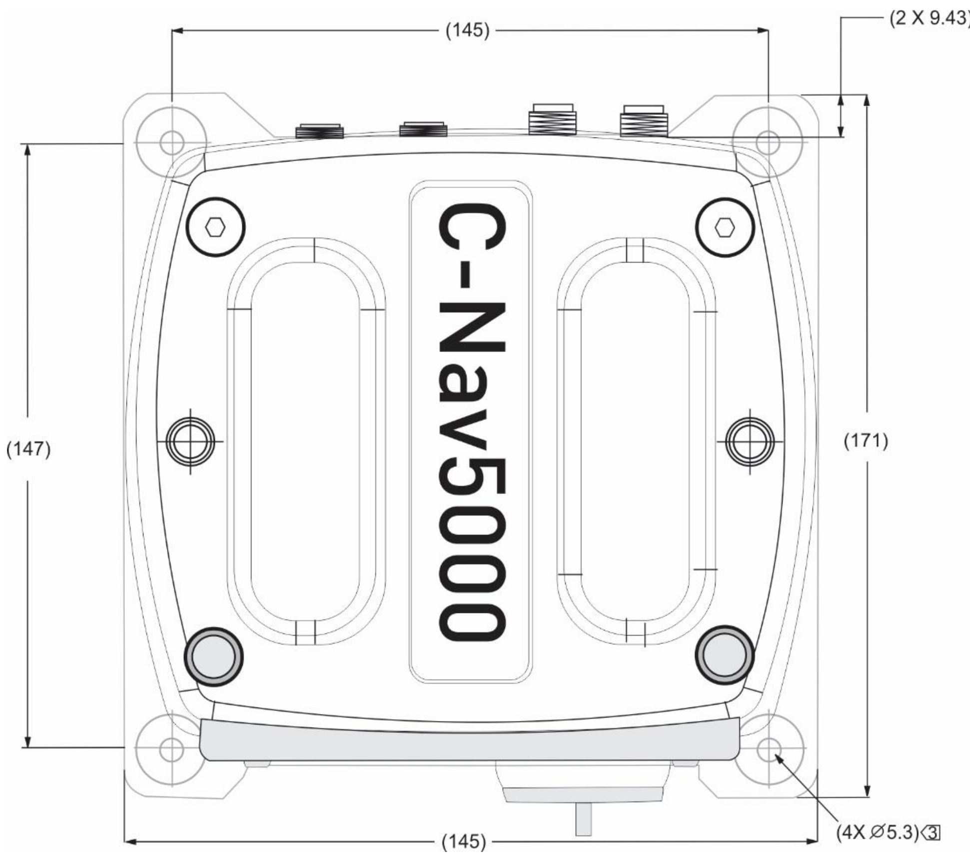


Figure 41: C-Nav5000 Base Plate Dimensions with Mounting Brackets

Appendix B – Antenna Specifications

C-Nav289 Specifications

Part Number	CNVAT1675-289-K
Polarization Axial Ratio Radiation Coverage	RHC (Right Hand Circular) 3 dB MAX @ 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 (max)
VSWR	≤2.0:1
Impedance	50 Ohms
Power Requirements	
Input Voltage	+4.2V - +15V dc
Power Consumption	65 mA (max)
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

Table 37: C-Nav289 Antenna Specification Sheet

C-Nav289 Drawing

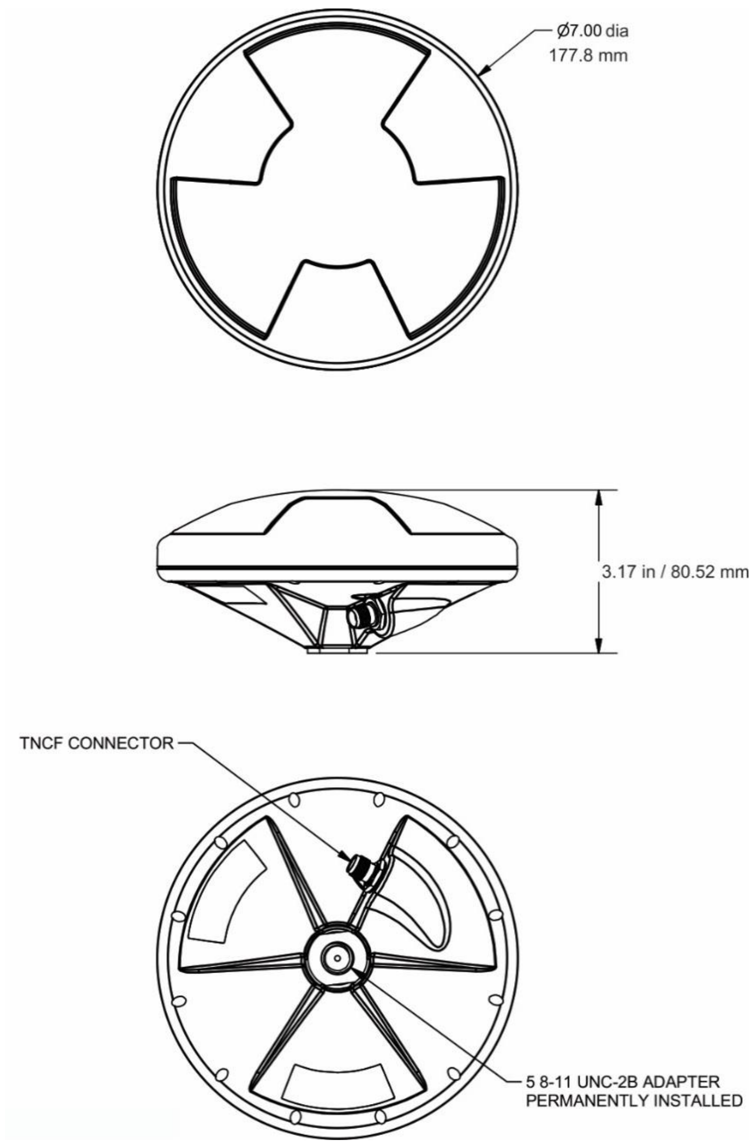


Figure 42: C-Nav289 Antenna Drawing

AD591 Antenna Specifications

Part Numbers	CNVALIAD591
Antenna Type	Dual patch stacked antenna elements
Polarization	RHCP (+/- 0.5db at zenith) and Omnidirectional in azimuth
Passbands	L-Band/GPS L1/GLONASS: 1525-1611 MHz GPS L2/L5 / GLONASS: 1164-1254 MHz
Out of Band Rejection	> 95 dB @ 1626.5 – 1660 MHz
Antenna Phase Center	L-Band dB @ 1626.5 – 1660 (INMARSAT up link)
LNA / Filter Combined Gain	39 dB
Total Noise Figure (NF)	3 dB (Typical)
Impedance	50 Ohms
Power Requirements	
Input Voltage	+5V - +20V dc
Power Consumption	45 mA (max)
Environmental	
Operating Temperature	-30°C to + 70°C (-22°F to 158°F)
Storage Temperature	-40°C to + 70°C (-40°F to 158°F)
Water/Dust	IP67
Mechanical	
Cable Connector	TNC Female
Weight	4kg (8.82lbs)
Mounting	Aluminum Bracket with clamps (included)

Table 38: AD591 Antenna Specification Sheet

AD591 Antenna Drawing

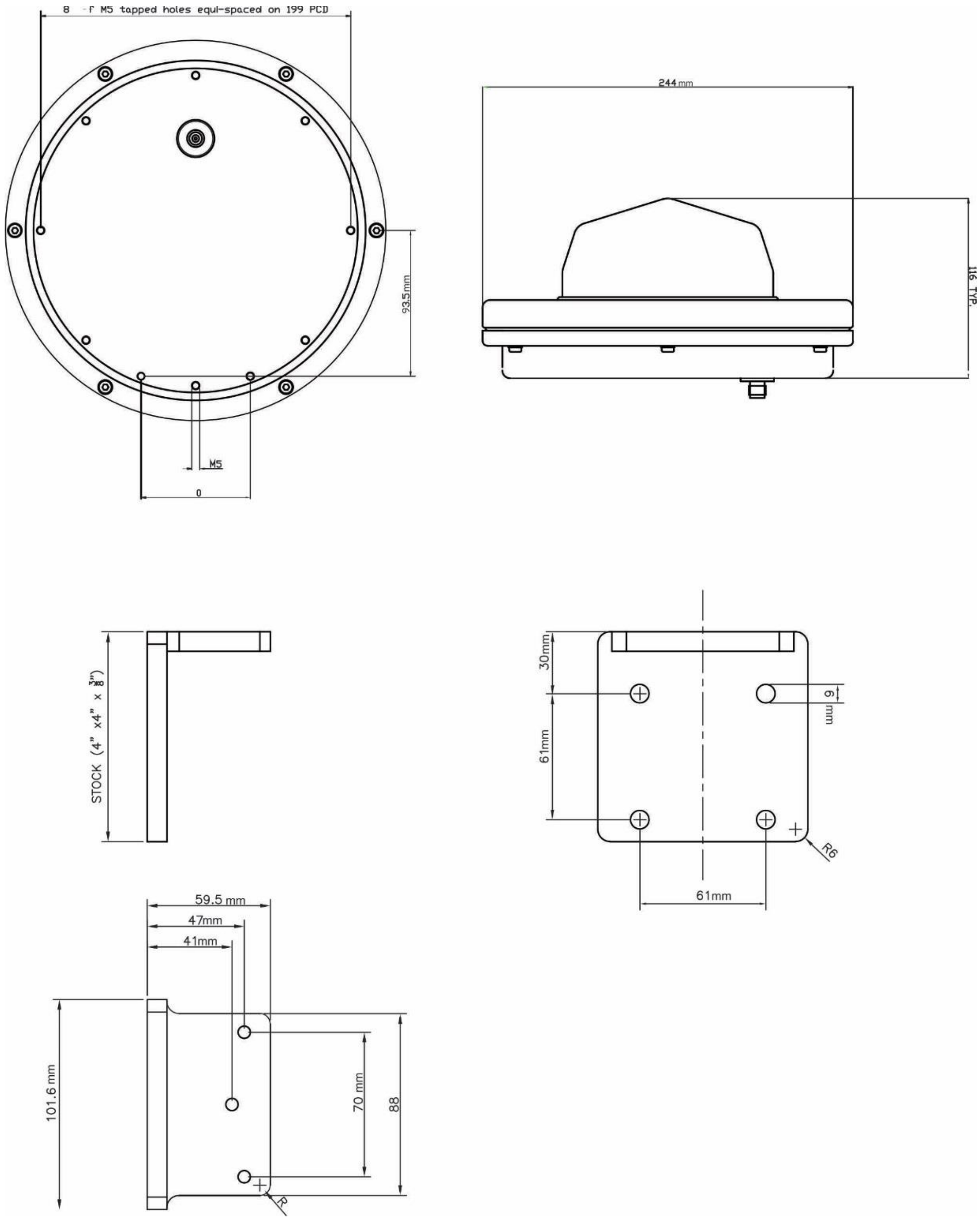
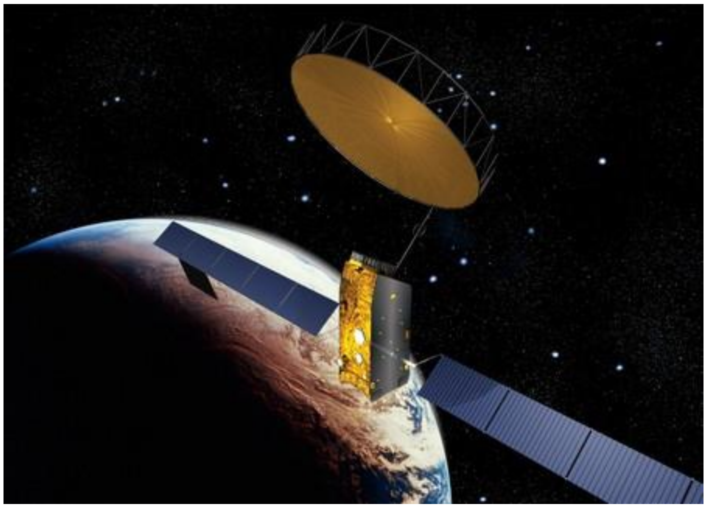


Figure 43: AD591 Antenna diagram

Appendix C - C-Nav Corrections Service (CCS)

Description



The C-Nav Corrections Service (CCS) Dual Frequency Service is a global system for the distribution of SBAS corrections giving the user the ability to measure their position anywhere in the world with exceptional reliability and unprecedented accuracy of better than 5 cm. Because the SBAS corrections are broadcast via INMARSAT geo-stationary satellites, the user needs no local reference stations or post-processing to get this exceptional accuracy. Furthermore, the same accuracy is available virtually anywhere on the earth's surface on land or sea from a 10 degree look angle, due to the worldwide coverage of these geo-stationary satellites.

Infrastructure

The system utilizes GNSS satellite systems, L-Band communication satellites, and a worldwide network of reference stations, to deliver real-time high-precision positioning.

To provide this unique service, C-Nav has built a global network of multi-frequency reference stations, which constantly receive signals from GNSS satellites as they orbit the earth. Data from these reference stations is fed to two USA processing centers, in Torrance, California and Moline, Illinois, where they are processed to generate the differential corrections.

From the two processing centers, the correction data is fed via redundant and independent communication links to satellite uplink stations at Laurentides, Canada; Perth, Australia; Burum, The Netherlands; Santa Paula, California; and Auckland, New Zealand Connecticut for rebroadcast via the geo-stationary satellites.

The key to the accuracy and convenience of the C-Nav Corrections Service is the source of SBAS corrections. GNSS satellites transmit navigation data on several L-Band frequencies[1]. The C-Nav reference stations are all equipped with geodetic-quality, multi-frequency receivers. These reference receivers decode GNSS signals and send precise, high quality, multi-frequency pseudo-range and carrier phase measurements back to the processing centers together with the data messages, which all GNSS satellites broadcast.

At the processing centers, C-Nav proprietary differential processing techniques are used to generate real-time precise orbits and clock correction data for each satellite in the GNSS constellations. This proprietary Wide Area DGNSS (WADGNSS) algorithm is optimized for a multi-frequency system such as the C-Nav Corrections Service, in which multi-frequency ionospheric measurements are available at both the reference receivers and the user receivers. It is the use of multi-frequency receivers at both the reference stations and the user equipment, together with the advanced processing algorithms, which makes the exceptional accuracy of the C-Nav Corrections Service possible.

Creating the corrections is just the first part. From our two processing centers, the differential corrections are then sent to the Land Earth Station (LES) for uplink to L-Band communications satellites. The uplink sites for the network are equipped with C-Nav built modulation equipment, which interfaces with the satellite system transmitter and uplinks the correction data stream to the satellite that broadcasts it over the coverage area. Each L-Band satellite covers more than a third of the earth.

Users equipped with a C-Nav precision GNSS receiver actually have two receivers in a single package, a GNSS receiver, and an L-Band communications receiver, both designed by C-Nav for this system. The GNSS receiver tracks all the satellites in view and makes pseudo-range measurements to the GNSS satellites. Simultaneously, the L-Band receiver receives the correction messages broadcast via the L-Band satellite. When the corrections are applied to the GNSS measurements, a position measurement of unprecedented real-time accuracy is produced.

The **Oceaneering C-Nav C²** correction signal network ground reference frame transitioned from the ITRF-2008 to the ITRF-2014 system on March 1, 2017.

The **Oceaneering C-Nav C[1]** correction signal transitioned from ITRF-2008 to the ITRF-2014 system on March 31, 2017.

Reliability

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.

There are two continuously running processing centers, each receiving all of the reference site inputs and each with redundant communications links to the uplink LES. The LESs are equipped with two complete and continuously operating sets of uplink equipment arbitrated by an automatic fail over switch. Finally, a comprehensive team of support engineers maintains round the clock monitoring and control of the system.

The network is a fully automated self-monitoring system. To ensure overall system integrity, an independent integrity monitor receiver, similar to a standard C-Nav user receiver, is installed at every reference station to monitor service quality. Data from these integrity monitors is sent to the two independent processing hubs in Torrance, California and Moline, Illinois. Through these integrity monitors the network is continuously checked for overall SBAS positioning accuracy, L-Band signal strength, data integrity and other essential operational parameters.

C-Nav Corrections Service (CCS) Satellites

Network	Satellite ID	Longitude	Satellite Name	Uplink Site
NET1	402	98.0W	PAC-E	Laurentides
NET1	525	25E	IND-W	Burum
NET1	643	143.5E	PAC-W	Auckland
NET2	446	54W	AOR-W	Southbury
NET2	564	64E	IOR	Perth
NET2	678	178E	POR	Santa Paula

Table 39: C-Nav Corrections Service Satellites

Please note:

The number of CCS broadcasting satellites and their locations are subject to change without notice.

CCS Over-The-Air C-Nav Licensing

CCS Over-The-Air (OTA) C-Nav licensing is the easiest way to install a C-Nav license. The installation of a purchased license is accomplished via radio broadcast. CCS Over-The-Air C-Nav licensing is especially convenient for receivers in remote locations in the field.

The requirements to obtain a C-Nav license are:

- Valid Purchase Order
- Signed License Agreement
- Appropriate Credit Terms with Oceaneering International, Inc. or an Authorized Dealer; including a valid P.O.

C-Nav recommends that customers process new C-Nav license requests through an authorized dealer or a C-Nav sales representative 15 to 30 days before the expiration of the current license.

The customer should do the following in order to properly receive the CCS Over-The-Air broadcast of the C-Nav license:

1. Turn on the C-Nav5000 GNSS receiver.
2. Ensure that the C-Nav5000 GNSS receiver antenna has clear access to the CCS tracking satellite.
3. Request the C-Nav license.

How to Obtain a C-Nav License

C-Nav corrections are based on a subscription service. The user pays a subscription fee, which licenses the use of the service for a predetermined period of time.

An authorized subscription will provide an encrypted code, which is specific to the Serial Number of the C-Nav GNSS receiver to be authorized. This is entered into the receiver Over-the-Air, or via the provided controller solution (C-Setup).

When contacting C-Nav regarding subscription or deactivation of service, please provide 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)

Requests for Service Activation / Deactivation can be made using the web form at C-NavAuthcode Authorization Portal or by emailing the above information to C-Nav Authcode (cnavauthcode@oceaneering.com) or by contacting the C-Nav authorized representative in your region.

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-Nav5000 GNSS receiver Front Panel will be solid green.

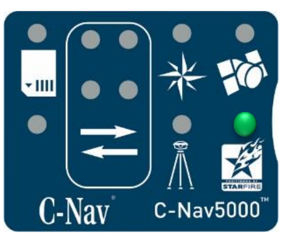


Figure 44: Front Panel C-Nav Status LED - Showing Active C-Nav License

For special-case scenarios, customers may request to receive the C-Nav license via email to manually upload via a C-Nav controller solution. The request must be specified in the P.O.

The broadcast procedure for Over-The-Air C-Nav Corrections Service licensing is subject to change.

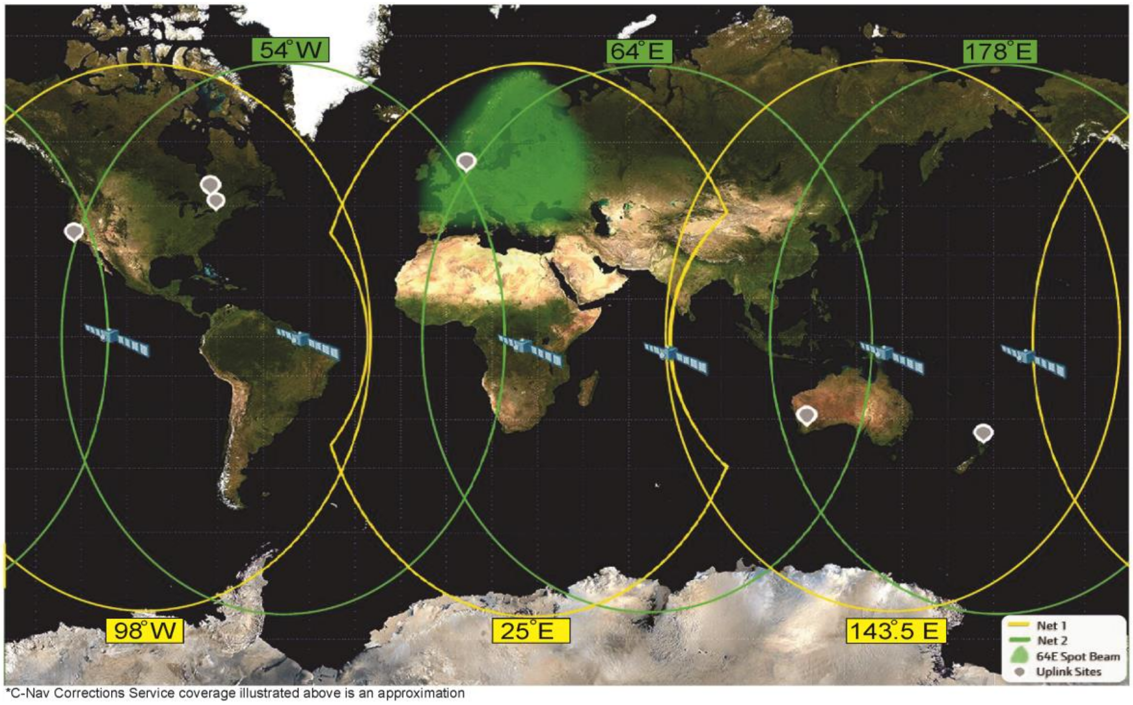


Figure 45: C-Nav Corrections Service Coverage Map

C-Nav Corrections Service Over-The-Internet (CCS OTI)

C-Nav Corrections Service can also be received over the Internet. This feature allows the user to request messages from a single independent NTRIP server / caster by means of an Internet Connection. The user can select between several data delivery rates (1 s, 15 s, 30 s, and 60 s) for maximum ability.

CCS OTI is available as a software option. Contact C-Nav Support (cnavsupport@oceaneering.com) for additional information.

As with the OTA delivered corrections, the CCS OTI requires a normal Authcode license to operate as well. Contact C-Nav Authcode (cnavauthcode@oceaneering.com) to purchase a license as you normally would to access other corrections.

Hardware Setup and Configuration

For information regarding the setup and configuration of CCS OTI, please send an email to Contact C-Nav Support (cnavsupport@oceaneering.com).

Appendix D - NMEA Data Output Messages

NMEAALM (ASCII)

This output message reports orbital data (almanac) for the specified GPS satellite, and is in compliance with NMEA-0183 Standards version 4.1.

Output Format:	$GPALM,total,message,prn,week,health,eccentricity,reftime,inclination,ascension,axis,perigee,node,anomaly,F0clock,F1clock*checksum	
Field #	**Field Name**	**Description**
F1	total	Total number of messages (01 to 32)
F2	message	Message number (01 to 32)
F3	PRN	GPS Satellite PRN number (01 to 32)
F4	week	GPS week number (4 digits)
F5	health	SV health (ASCII hex, 2 bytes)
F6	eccentricity	Eccentricity (ASCII hex, 4 bytes)
F7	reftime	Almanac reference time (ASCII hex, 2 bytes)
F8	inclination	Inclination angle (ASCII hex, 4 bytes)
F9	ascension	Rate of right ascension (ASCII hex, 4 bytes)
F10	axis	Root of semi-major axis (ASCII hex, 2 bytes)
F11	perigee	Argument of perigee (ASCII hex, 6 bytes)
F12	node	longitude of ascension node (ASCII hex, 6 bytes)
F13	anomaly	Mean anomaly (ASCII hex, 6 bytes)
F14	F0clock	F0 clock Parameter (ASCII hex, 3 bytes)
F15	F1clock	F0 clock Parameter (ASCII hex, 3 bytes)
F16		Checksum

Table 40: ALM Message Output Format

Example:
*$GPALM,32,1,01,1423,00,35BF,7B,1F38,FD5B,A10D8B,78C23F,B7E3C6, 379706,080,001*36*

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.

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

Table 41: DTM Message Output Format

Output values depend on navigation mode and [DATUM] selection.

Navigation Mode	[DATUM]	Local	Reference	Offsets

	(user command)	**Datum**	**Datum**	
Non-Diff, SBAS	DEFAULT or WGS84	W84	W84	0
	GDA94 or USERDATUM	999	W84	Offsets from WGS84
C-Nav Correction Services	DEFAULT	999	999	0
	WGS84	W84	W84	0
	GDA94 or USERDATUM	999	W84	Offsets from WGS84
RTK, RTK-X, RTCM-code	Any	blank	blank	blank

Table 42: DTM Message Output for Each Nav Mode

This message will be scheduled onchange automatically on the port which NMEAGGA, NMEAGLL or NMEARMC is output. This applies to all ports except for the NTRIP port

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.

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 (See Table 62: Signal ID) (NMEA v4.1 only)
F11		Checksum

Table 43: GBS Message Output Format

Example:

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

NMEAGFA (ASCII)

This sentence is used to report the results of the data quality check associated with a position solution. If only a single constellation (GPS, GLONASS, etc.) is used for the reported position solution, the talker ID is GP, GL, etc. and the data pertain to the individual system. If satellites from multiple systems are used to obtain the reported position solution, the talker ID is GN and the parameters pertain to the combined solution. This provides the quality data of the position fix and is associated with the GNS sentence. This sentence is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$xxGFA,UTC,HPL,VPL,Std_X,Std_Y,Theta,Std_H,SAL,IntStatus*checksum	
Field#	Field Name	Description
F1	UTC	UTC time of the associated GGA or GNS fix (hhmmss.ss)
F2	HPL	Horizontal protection levels in meters (xxxx.x).
F3	VPL	Vertical protection levels in meters (xxxx.x)
F4	Std_X	Standard deviation of semi-major axis of error ellipse in meters (xxx.xx)
F5	Std_Y	Standard deviation of semi-minor axis of error ellipse in meters (xxx.xx)
F6	Theta	Orientation of semi-major axis of error ellipse (xxx.xxxx degrees from true north)
F7	Std_H	Standard deviation of altitude in meters (xxx.xx)
F8	SAL	Selected accuracy level in meters (xxxx.x)
F9	IntStatus	Integrity status: The integrity status field is a variable length character field which indicate the status of the various integrity sources. This field shall not be Null. V= Not in use S= Safe (when integrity is available and Horizontal Protection Limit (HPL) < Horizontal Alert Level (HAL) C= Caution (no integrity is available) U= Unsafe (when integrity is available and HPL > HAL)
F10		Checksum

Table 44: GFA Message Output Format

Example:

*$GNGFA,224229.00,0001.7,0002.9,000.43,000.22,014.4868,000.83,0010.0,SCC*0C*

In RTK mode, fields F2, F3, F4 and F5 are zeroes. They are correct values since RTK provides very accurate solutions, beyond the resolution provided by the NMEA standard

NMEAGGA (ASCII)

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

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

Table 45: GGA Message Output Format

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.

NMEAGLL (ASCII)

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

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

Table 46: GLL Message Output Format

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

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.

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 ellipsoid surface 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 (no RAIM 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

Table 47: GNS Message Output Format

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.

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 are given by the addition of fields F9 and F10.

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 (See Table 62: Signal ID) (NMEA v4.1 only)
F11		Checksum

Table 48: GRS Message Output Format

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)*

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.

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

Table 49: GSA Message Output Format

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

NMEAGST (ASCII)

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

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

Table 50: GST Message Output Format

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

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.

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 (See Table 62) (NMEA v4.1 only)
F9		Checksum

Table 51: GSV Message Output Format

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*

NMEAMLA (ASCII)

This output stream reports orbital data (almanac) for the specified GLONASS satellite and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GLMLA,total,Sentence,SID,Na,CH,eccentricity,Tn,perigee,tMSB,dtnaco,tascmd,Long_asc,Corr_incl,tLSB,tss*checksum	
Field#	**Field Name**	**Description**
F1	total	Total number of sentences (24)
F2	Sentence	Sentence number (01 to 24)
F3	SID	Satellite ID (slot) number (01 to 24)
F4	Na	Calendar day count within the four year period beginning with the previous leap year
F5	CH	Cn(a) and Hn(a), generalized health of the satellite (0x80) and carrier frequency number (0x7F)
F6	eccentricity	Eccentricity (S32)
F7	Tn	DOT, rate of change of the draconic circling time (S32)
F8	perigee	Argument of perigee (S32)
F9	tMSB	16 MSB of system timescale correction (U16)
F10	dtnaco	Correction of average value of the draconic circling time (S32)
F11	tascmd	Time of the ascension node, almanac reference time (S32)
F12	Long_asc	Greenwich longitude of the ascension node (S32)
F13	Corr_incl	Correction to the average value of the inclination angle (S32)
F14	tLSB	12 LSB of system timescale correction (U16)
F15	tss	Course value of the timescale shift (S32)
F16		Checksum

Table 52: MLA Message Output Format

Example:

*$GLMLA,24,1,65,568,18,0000,0000,0000,8000,000000,000000,000000,000000,16F,000*18*

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.

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

Table 53: RMC Message Output Format

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)

NMEARRE (ASCII)

This output stream report Receiver Autonomous Integrity Monitoring (RAIM) data, reporting Range Residual Errors. Note that this command is not defined in NMEA-0183 Standards version 3.0.

Output Format:	$xxRRE,count,<SVID,Res>...,Herr,Verr*checksumrms,majoraxis,minoraxis,orientation,lateer,loner,alterr*checksum	
Field#	**Field Name**	**Description**
F1	count	Count of satellites included here (01 - 12)
F2	SVID	Satellite ID for this residual (+/- 9999)
F3	Res	Residual for this satellite (+/- 9999)
F4	Herr	Horizontal position error (+/- 9999)
F5	Verr	Vertical position error (+/- 9999)
F6		Checksum

Table 54: RRE Message Output Format

Example:

*$GPRRE,10,03,-0.2,07,-0.1,08,0.3,10,-0.5,13,-0.3,19,0.5,23,- 0.5,25,0.5,27,0.6,28,0.0,000.1, 000.1*7E*

NMEATTM (ASCII)

This output stream is only supported on MBRTK Rover and displays baseline information including the baseline distance, bases speed and direction and closest point of approach based on NMEA-0183 Standards version 4.0.

Output Format:	$xxTTM,Base Number, Base Distance,...,UTC, Type of Acq*checksum	
Field#	**Field Name**	**Description**
F1	Base Number	Last 2 digits of the MBRTK Base ID
F2	Base Distance	3D Baseline Distance (m)
F3	Base Bearing	Base 2D bearing from the Rover, N=0°, E=90° (0°-360°)
F4	Bearing Units	True or Relative (T/R), R is not supported
F5	Base Speed	3D speed of the Base (m/s)
F6	Base Course	Base 2D direction, N=0°, E=90° (0°-360°)
F7	Course Units	True or Relative (T/R), R is not supported
F8	CPA Dist	Distance at the closest point of approach. This is how close the Base and Rover would ever get given their course and speed in 2D (m)
F9	CPA Time	Time until 2D CPA -means it has passed (min)
F10	Speed/Dist Units	Units of measurements used: K= Kilometers (metric, used) N= Knots (unused) S= Statute miles (unused)
F11	Base Name	Full Base ID
F12	Base Link Status	Tracking status of the Base: L= Lost track of Base (Non RTK Mode) Q= Query, acquiring (RTK Float) T= Tracking (RTK Fixed)
F13	Tracking Ref	R if base is used to determine own position (always true)
F14	UTC	Standard UTC time (hhmmss.ss)
F15	Type of Acquisition	A= Automatic (used) M= Manual (unused)
F16		Checksum

Table 55: TTM Message Output Format

Example:
*$GNTTM,30,16.75,134.27,T,0.03,34.96,T,15.99,2.63,K,530,T,R,201345.00,A*45*

Please note:
There will be some noise in the base velocity due to the baseline velocity of the rover. This noise will increase if the rover is moving in a non-linear path.

⚠ The conventional use of the TTM message is to carry the information on a “tracked” target generated by the ARPA section of the radar on the ship where it is being used. Usual usage on the ship is to convey the target information to an ECDIS or ECS for display on the navigational chart. However when the TTM message is used from the GNSS rover receiver, it is not intended to be used in this manner. An example of the intended use is to give MBRTK users ASCII access to the rover-base distance; for example, where the rover is mounted on a seismic cable tail buoy with TTM message sent back to the vessel by radio.

NMEAVTG (ASCII)

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

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

Table 56: VTG Message Output Format

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

NMEAZDA (ASCII)

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

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

Table 57: ZDA Message Output Format

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

NMEAPNCTDTM (ASCII)

This output stream reports local geodetic datum and datum offsets from a reference datum. It is in compliance with NMEA-0183 Standards version 4.1. The difference between NMEADTM and NMEAPNCTDTM is the added datum codes for ITRF and GDA94. When the datum code is unknown (e.g. RTK mode), the output will be empty.

Field#	Field Name	Description
F1	Local datum code	Local Datum Code W84 = WGS84 W72 = WGS72 S85 = SGS85 PE90 =P90 999 = User defined ITR = ITRF G94 = GDA94
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 ITR = ITRF G94 = GDA94
F9		Checksum

Table 58: PNCTDTM Message Output Format

Navigation Mode	[DATUM] (user command)	Local Datum	Reference Datum	Offsets
Non-Diff, SBAS	DEFAULT or WGS84	W84	W84	0
	GDA94	G94	W84	Offsets from WGS84
	USERDATUM	999	W84	Offsets from WGS84
C-Nav Corrections Service	DEFAULT	ITR	ITR	0
	WGS84	W84	W84	0
	GDA94	G94	W84	Offsets from WGS84
	USERDATUM	999	W84	Offsets from WGS84
RTK, RTK-X, RTCM-code	Any	blank	blank	blank

Table 59: PNCTDTM Message Output for Each Nav Mode

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.

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 the satellite beam in use (See Table 61), and YY is the GPS correction signal type being used (See Table 63)
F15		checksum

Table 60: PNCTGGA Message Output Format

Example:

*$PNCTGGA,032215.00,3713.870081,N,12148.058703,W,2,08,1.8,59.608,M,-33.440,M,8.0,0122*47*

Network	Code (XX)	Designation	Satellite ID	Longitude	Uplink Site
Net 1	00	N/A	N/A	Unknown	Unknown
	01	4F3	402	98.0W	Laurentides
	02	4F2	525	25E	Burum
	03	4F1	643	143.5E	Auckland
Net 2	04	3F3	678	178E	Santa Paula
	05	3F4	446	54W	Southbury
	06	3F1	564	64E	Perth
	09	N/A	N/A	Manual Override	

Table 61: Beam Selection ID

System	Signal ID	Signal Channel
GPS	0 1 2 3 4 5 6 7 8 9-F	All Signals L1 C/A L1 P(Y) L1 M L2 P(Y) L2C-M L2C-L L5-I L5-Q Reserved
GLONASS	0 1 2 3 4 5-F	All Signals G1 C/A G1 P G2 C/A GLONASS (M) G2 P Reserved

Table 62: Signal ID

ID (YY)	GPS Correction Signal
00	Non dGPS
01	dGPS, RTCM type 1 (GPS-code); and type 31 (GLONASS – code) or type 9 (GPS – code); and type 34 (GLONASS partial correction set – code), Single Freq. and Dual Freq.
02	WAAS/EGNOS, Single Freq. (GPS)
03	WAAS/EGNOS, Dual Freq. (GPS)
04	Reserved
05	Reserved
06	C-Nav Correction Services (CCS), Single Freq. (no “Tide” Adjustment) (GPS)
07	Reserved
08	Reserved
09	Reserved
10	dGPS/dGLONASS, RTCM type 1 or 9 and 31 or 34, Dual Freq.

11	C-Nav Correction Services (CCS), Dual Freq. (no “Tide” Adjustment) (GPS)
12	Code base Nav, Single Freq. NCT Proprietary Format
13	Code base Nav, Single Freq. RTCM 18/19 (GPS and GLONASS)
14	Code base Nav, Single Freq. RTCM 20/21 (GPS and GLONASS)
15	Code base Nav, Single Freq. CMR (GPS and GLONASS)
16	Code base Nav, Dual Freq. NCT Proprietary Format (GPS and GLONASS)
17	Code base Nav, Dual Freq. RTCM 18/19 (GPS and GLONASS)
18	Code base Nav, Dual Freq. RTCM 20/21 (GPS and GLONASS)
19	Code base Nav, Dual Freq. CMR (GPS and GLONASS)
20	RTK Mode, NCT Proprietary Format 5e/5c (GPS and GLONASS) or 5b/5c (GPS)
21	RTK Mode, RTCM 18/19 (GPS and GLONASS)
22	RTK Mode, RTCM 20/21 (GPS and GLONASS)
23	RTK Mode, CMR (GPS and GLONASS)
24	C-Nav Correction Services (CCS), Single Freq., Adjusted for “Tides” (GPS)
25	C-Nav Correction Services (CCS), Dual Freq., Adjusted for “Tides” (GPS)
26	RTK Extend Active (C-Nav Correction Services filling in for missing RTK epochs) (GPS)
33	GNSS, Single Freq., no “Tides”
34	GNSS, Dual Freq., no “Tides”
35	GNSS, Single Freq., Adjusted for “Tides”
36	GNSS, Dual Freq., Adjusted for “Tides”

Table 63: Navigation Mode

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.

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

Table 64: PNCTGST Message Output Format

*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*

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.

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 = RC Code, 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

Table 65: PNCTMDE Message Output Format

Example:

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

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.

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

Table 66: PNCTSET Message Output Format

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

Appendix E - Software License Agreement

Software License Agreement for C-Nav, A Division of Oceaneering International, Inc. C-Nav5000 Receiver.

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Asia, Australia, New Zealand	
Europe	
Africa, Middle East	
Latin & South America	

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Open Source Software License Appendix

No open source software is utilized in this product.

Glossary

Abbreviations

1PPS -	1 Pulse Per Second
2dRMS -	Twice the distance Root Mean Square
A/S -	Antispoofing
APC -	Antenna Phase Center
BER -	Bit Error Rate
bps -	bits per second
BSW -	British Standard Whitworth
C/A -	Coarse/Acquisition
CCS -	C-Nav Corrections Service
CCS OTI -	C-Nav Corrections 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
INMARSAT -	International Maritime Satellite Consortium, Ltd.
INS -	Inertial Navigation System
IODC -	Issue of Data, Clock
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

Definitions

1 Pulse Per Second (1PPS) is a precision electronic pulse output (at TTL 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 Corrections 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 Corrections 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 Appendix C - C-Nav Corrections Service (CCS) (Page 93)).

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 46:

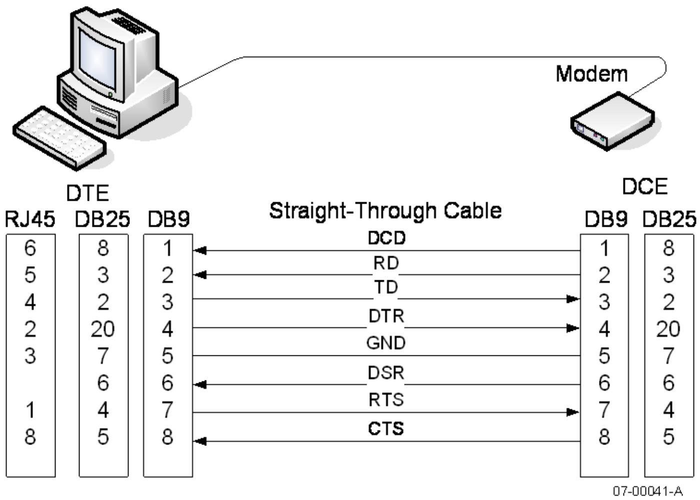

Figure 46: DTE to DCE RS-232 Pin Assignments

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 positions.

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,

the navigation (.YYn) file,

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 Corrections Service (CCS).

Roving Receiver see rover

Satellite Based Augmentation System (SBAS) this is a more general term, which encompasses WAAS, C-Nav Corrections 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 Corrections 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.