POS LV V5 Installation and Operation Guide

Document # **PUBS-MAN-003758**
Revision: **13**
Date: **December 4, 2017**

POS LV V5 Installation and Operation Guide

Congratulations on your purchase of a POS LV™ system. Applanix develops, manufactures, sells and supports precision products that accurately and robustly measure the position and orientation of vehicles in dynamic environments. Applanix Position and Orientation Systems (POS™) are used in a variety of applications including road profiling, aerial survey and mapping, railroad track maintenance and seafloor mapping. Applanix strives to support customers around the world with exceptional service - anywhere, at anytime.

PUBS-MAN-003758

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General Notice

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This manual describes the POS LV V5™ in detail and contains full installation and operating instructions.

Read chapters 3 and 4 thoroughly before beginning your installation.

This manual is an important part of the system. It should remain accessible to those who will operate and maintain the system.

It is the customer’s responsibility to ensure that there are adequate mounting facilities, and carefully plan the component layout. Applanix will not be responsible for damage caused by improper installation or inadequate environmental conditions.

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Liability and Safety Information

⚠ **Important**: All cables connected to the POS LV equipment shall be constructed of (in order of preference): a) halogen free, b) low smoke and c) high temperature materials.

Ethernet Cable - Applanix supplies a suitable Ethernet cable. However, if supplied by the customer the cable shall incorporate a braid shield, having at least 90% coverage that has a 360 degree termination at both connectors, and be rated as CAT5 or better. The RJ45 connectors used in the cable shall also be shielded.

Serial Cables - Applanix can by request supply suitable COM port serial cables, each are about 3.6 m (12.0 ft) in length. If the cables are supplied by the customer each cable shall incorporate a braid shield, having at least 90% coverage that has a 360 degree termination at the backshells of both connectors.

Regulatory Information

⚠ **Caution**: Do not make mechanical or electrical modifications to the POS LV system or any of their components. Changes or modifications not expressly approved by Applanix could void the compliance and negate your authority to operate the product.

Certification was achieved using the following original or replacement equipment supplied by Applanix: DMI, DMI cable, GNSS antennas, GNSS antenna cables, Ethernet cable, IMU, IMU cable and RS-232 serial cables.

CE DECLARATION OF CONFORMITY

Manufacturer's Name:	Applanix Corporation
Manufacturer's Address:	85 Leek Crescent Richmond Hill, Ontario, Canada L4B 3B3
EC Representative's Name:	Applanix Corporation
EC Representative's Address:	85 Leek Crescent Richmond Hill, Ontario, Canada L4B 3B3
Equipment Model Designation:	POS LV V5
Equipment Description:	POS LV is a fully integrated, turnkey position and orientation system for Land vehicles.
Applicable Equipment Part Numbers:	PCS-76

Application of Council Directive: 2006/95/EC on the harmonization of the laws related to Member States relating to electrical equipment designed for use within certain voltage limits and Council Directive 2004/108/EC on the approximation of the laws related to Member States relating to electromagnetic compatibility.

Referenced Safety Standards:	**Referenced EMC Standards:**
EN 60950-1 : 2006	EN 55022 : 2006 (Class B)
	EN 55024 : 98 with Amendments A1:2001 and A2:2003

CE **DECLARATION OF CONFORMITY**

Manufacturer's Name:	Applanix Corporation
Manufacturer's Address:	85 Leek Crescent Richmond Hill, Ontario, Canada L4B 3B3
EC Representative's Name:	Applanix Corporation
EC Representative's Address:	85 Leek Crescent Richmond Hill, Ontario, Canada L4B 3B3
Equipment Model Designation:	POS LV V5
Equipment Description:	POS LV is a fully integrated, turnkey position and orientation system for Land vehicles.
Applicable Equipment Part Numbers:	PCS-86

Application of Council Directives:

2014/35/EU on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits (recast).

Referenced Standard:

EN 60950-1:2006/A2:2013

2014/30/EU on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (recast).

Referenced EMC Standards:

EN 55024: 2010
EN 55032: 2012 (Class A)

2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast).

Referenced RoHS Standard:

EN 50581:2012

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EC Representative's Name:	Applanix Corporation
EC Representative's Address:	85 Leek Crescent Richmond Hill, Ontario, Canada L4B 3B3
Equipment Model Designation:	POS LV V5
Equipment Description:	POS LV is a fully integrated, turnkey position and orientation system for Land vehicles.
Applicable Equipment Part Numbers:	PCS-92

Application of Council Directive: 2006/95/EC on the harmonization of the laws related to Member States relating to electrical equipment designed for use within certain voltage limits and Council Directive 2004/108/EC on the approximation of the laws related to Member States relating to electromagnetic compatibility.

Referenced Safety Standards:

EN 60950-1:2006 with Amendment A2:2013

Referenced EMC Standards:

EN 55022:2010 (Class B) / CISPR 22:2008

EN 55024:2010 / CISPR 24:2010

FCC Section 15.21 Information to the user.

Changes or modifications not expressly approved by Applanix could void the user's authority to operate the equipment.

FCC Section 15.105 Information to the user.

NOTE: This equipment (PCS-76 and PCS-92) has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

Industry Canada

This Class B digital apparatus (PCS-76 and PCS-92) complies with Canadian ICES-003.
Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

VCCI (For PCS-76 and PCS-92)

この装置は、情報処理装置等電波障害自主規制協議会（ＶＣＣＩ）の基準に基づくクラスＢ情報技術装置です。この装置は、家庭環境で使用することを目的としていますが、この装置がラジオやテレビジョン受信機に近接して使用されると、受信障害を引き起こすことがあります。

取扱説明書に従って正しい取り扱いをして下さい。

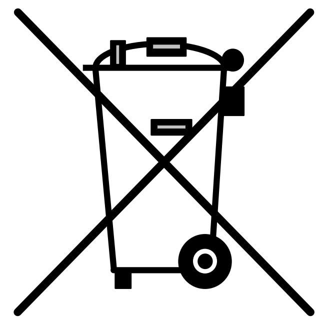
English Translation: This is a Class B product based on the standard of the Voluntary Control Council for Interference from Information Technology Equipment (VCCI). If this is used near a radio or television receiver in a domestic environment, it may cause radio interference. Install and use the equipment according to the instruction manual.

Australian/New Zealand Standard

POS LV V5 (PCS-92) digital apparatus complies with AS/NZS CISPR 22: 2009.

For Our European Union Customers
the WEEE Recycling Program

Applanix recognizes the importance of minimizing the environmental impacts of our products. We endeavour to meet your needs, not only when you purchase and use our products, but also when you are ready to dispose of them. Applanix is actively pursuing, and will continue to pursue, the expanded use of environmentally friendly materials in all its products. In addition, we have established a convenient and environmentally friendly recycling program.



As Applanix makes additional recycling facilities available for your use, we will post their locations and contact information on our recycling instructions Web page. In the meanwhile see Appendix A, page A-1, for Applanix contact information.

WEEE is Waste Electrical and Electronic Equipment, products that operate on electrical power.

About this Document

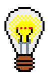
Text Conventions

The following text conventions are used in this manual:

- Emphasize a term - italic font (e.g. “An *Inertial Frame* is a”)
- Referring to another manual or to a file name - italic font (e.g. “read *Power Requirements*” or “locate the *start.exe* file”)
- Referring to a placard label - regular font (e.g. “the COM (2) connector”)
- Referring to a screen label - bold font (e.g. “select the **Add, Remove Programs** from”)
- Path statement - bold font (e.g. “select directory **C:\ My Computer\ Working Files**”), leave a space after each back slash (\) to permit line wrapping of the string
- Menu statement - bold font (e.g. “select **Insert, AutoText, Closing** screen menu”)
- Web address statement - bold font (e.g. “select **http://www.applanix.com** from”)

Symbols

The following symbols appear in this document:

	Warning - operating procedures, practices, etc., which, if not correctly followed, could result in personal injury or loss of life		Caution - procedures, practices, etc., which, if not correctly followed, could result in damage or destruction of equipment, or loss of data
	Electrostatic Discharge (ESD) sensitive material		Fragile/Breakable
	Hint - provides a suggested method or approach		Electrocution hazard

Document Number

PUBS-MAN-003758, Revision 13, dated 16-January-2017.

This document describes the POS LV V5 (µPOS) hardware and associated LV POSView controller. For information on all other POS LV hardware versions, including V4 (mPOS), please consult the appropriate document or contact Applanix Customer Support for assistance.

References

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List of Abbreviations, Synonyms and Symbols

°C	Degree Celsius
°F	Degree Fahrenheit
µs	Microsecond
A	Ampere
ac	Alternating Current
ASCII	American Standard Code for Information Interchange
ASSY	Assembly
att	Attitude
AUX	Auxiliary
AWG	American Wire Gauge
bps	Bits Per Second
BPSK	Bi-Phase Shift Key Modulation
C/A	Coarse Acquisition
CC	Composite Clock
CD	Carrier Detect
CD	Compact Disk
cm	Centimetre
CMR	Compact Measurement Record
CPU	Central Processing Unit
CTS	Clear To Send
dB	Decibel
dBm	Decibel (referenced to 1 milliwatt)
dc	Direct Current
deg	Degree (plane angle)
DGPS	Differential Global Positioning System
dia	Diameter
DIMM	Dual In-Line Memory Module
DIN	Deutsche Industrinorm
DIO	Digital I/O
DMI	Distance Measuring Indicator
DoD	Department of Defence (USA)

DSR	Data Set Ready
DTR	Data Terminal Ready
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FAX	Facsimile
FDIR	Fault Detection, Isolation, and Reconfiguration
ft	Foot
FTP	File Transfer Protocol
g	Gravity (acceleration due to gravity)
GAMS	GNSS Azimuth Measurement Subsystem
GB	Gigabyte
GIS	Geographic Information System
gnd	Ground
GMT	Greenwich Mean Time
GND	Signal Ground
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
hr	Hour
Hz	Hertz
I/O	Input/Output
IP	Internet Prototcol
I/P	Input
IARTK	Inertially-Aided Real-time Kinematic
IEEE	Institute of Electrical and Electronics Engineers
IERS	International Earth Rotation and Reference Systems Service
IMU	Inertial Measurement Unit
in	Inch
IP	Internet Protocol
kb	Kilobit
kB	Kilobyte
kbps	Kilobits Per Second
kHz	Kilohertz

lat	Latitude
long	Longitude
LSB	Least Significant Bit
m	Metre
mA	Milliampere
Mb	Megabit
MB	Megabyte
MHz	Megahertz
min	Minute (time interval)
mm	Millimetre
mPOS	mini – POS
ms	Millisecond
MSB	Most Significant Bit
mux	Multiplexer
N/C	No Connection
NED	North, East and Down
NMEA	National Marine Electronics Association
NRG	No Range Given
NVM	Non-Volatile Memory
O/P	Output
OTF	On-the-Fly
PC	Personal Computer
PCS	POS Computer System
PDOP	Positional Dilution of Precision
POS	Position and Orientation System
POS LV	Position and Orientation System for Land Vehicles
PPS	Precise Positioning Service
PPS	Pulse Per Second
RAM	Random Access Memory
REF	Drawing Reference Designation
RFI	Radio Frequency Interference
rms	Root Mean Square
ROM	Read Only Memory

RTCM	Radio Technical Commission for Maritime Services
RTK	Real-time Kinematic
RTS	Request To Send
RX	Receive Data
s	Second (time interval)
S/N	Signal-To-Noise
SI	International System of Units
SOSR	Sum Of Squared Residuals
STP	Shielded Twisted Pair
SV	Space Vehicle
sync	Synchronous
TAI	Temps Atomique International
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TDM	Time Division Multiplex
TOV	Time of Validity
TRS	Trimble Reference Station
TTL	Transistor-Transistor Logic
TX	Transmit Data
UDP	Universal Datagram Protocol
UHF	Ultra High Frequency
UPS	Uninterruptible Power Supply
UTC	Universal Time Coordinated (or Coordinated Universal Time)
Vac	Volt Alternating Current
Vdc	Volt Direct Current
VDOP	Vertical Dilution Of Precision
VHF	Very High Frequency
W	Watt
WAAS	Wide Area Augmentation System
ZUPT	Zero Velocity Update
Ω	Ohm
µPOS	micro - POS

1.0 Introduction

Unparalleled Position and Orientation Accuracy

POS LV (Position and Orientation System for Land Vehicles) is a fully integrated, turnkey position and orientation system. Based on aided inertial technology, the system provides continuous and accurate vehicle position and orientation information through areas of poor or no Global Navigation Satellite System (GNSS) service. Whether used for the measurement of vehicle dynamics, motion compensating sensors for mobile data collection, or for vehicle navigation, POS LV provides a robust positioning solution you can always rely on.

Ready to Use - No Integration Required

The core of the POS LV system is a high-accuracy inertial sensor that measures linear accelerations and angular rates. Data from this sensor is supplemented by the integrated GNSS receivers and a Distance Measuring Indicator (DMI). Integration is seamless to the user, requiring that the system components be mounted in the vehicle before the POS LV is ready to output position and orientation data.

Applanix has well over a decade of experience developing commercial aided inertial systems, having created products for a number of specialized positioning applications in airborne, marine and land markets. The advanced inertial aiding and processing techniques perfected over that time allow POS LV to offer a positioning solution of outstanding reliability.

Applications

POS LV provides position and orientation for applications beyond those served by GNSS alone. Applications developers' use aided inertial position and orientation data for an ever growing list, including:

- Motion compensation for vehicle-mounted sensors (e.g. rutbar, video or frame camera)
- Vehicle testing (vehicle dynamics and safety testing)
- Evaluation of consumer-grade navigation systems
- Geomatics engineering
- Rapid data collection for direct entry to Geographic Information System (GIS) databases
- Civil engineering
- Pavement management data collection
- Corridor surveys (video logging)
- Road track geometry (horizontal and vertical)

- Risk Management
- Intelligent vehicle highway system applications
- Ground penetrating radar
- Position and orientation feedback for robotic vehicle control

Accuracy and Reliability

POS LV is ideal for position and orientation measurements under the most difficult GNSS conditions:

- Urban canyons
- Full tree canopy
- Tunnels and bridges

POS LV provides measurements of position and orientation in difficult areas with minimal degradation in positional accuracy. This includes areas of total GNSS satellite blockage and extended stretches of availability of less than four satellites. For data collection applications, this means that using POS LV eliminates the need to manually tie collected data (and eliminate the resultant reduced data accuracy) or to resurvey areas of poor GNSS coverage.

A Proven Solution

Used for a variety of survey, mapping and testing/calibration applications, Applanix POS systems offer user-friendly installation and operation. Available with each system is our industry-leading customer support. Please contact Applanix for details, see Appendix A1.

Key Features

Unique system features that make POS LV the market-leading inertial/ heading gyro system include:

- Accelerometers and gyros for each axis - unlike heading gyro systems, the POS LV provides a true representation of vehicle motion along all three axis, significantly reducing data drift rate and eliminating erroneous readings due to centripetal accelerations. This provides a full six degrees of freedom solution.
- Two GNSS receivers - heading aiding provided by a direct measurement of vehicle heading supplements inertial heading, significantly increasing heading accuracy.
- Tightly coupled integration - raw GNSS satellite data are processed directly within POS LV, allowing the use of data from as few as one satellite for system aiding (as opposed to a minimum of four satellites with systems that use receiver position). This significantly reduces position drift through satellite outages, reduces Real-Time Kinematic (RTK) re-acquisition time and further strengthens system reliability in areas of intermittent GNSS.

- DMI aiding - wheel rotation data constrains drift, especially during vehicle stoppages in areas of intermittent GNSS coverage.

Complete System Includes

The system comprises a Position and Orientation System (POS) Computer System, an Inertial Measurement Unit (IMU), a Distance Measuring Indicator (DMI) and Global Navigation Satellite System (GNSS) antennas. Not shown in Figure 1 is the LV-POSView software that ships with the POS LV system.

Not provided is a Microsoft Windows® based computer to run the LV-POSView software, real-time GNSS corrections transmission hardware or auxiliary sensors.

Figure 1: POS LV System Components

POS LV System Overview

The POS LV system consists of the POS Computer System (PCS) and external sensors: an IMU, a DMI, and one or two GNSS antennas. The PCS uses data from the sensors to produce accurate measurements of vehicle navigation parameters and performance metrics.

POS LV has the capability of monitoring sensor health, isolating sensors that show degraded performance and reconfiguring itself to maintain optimal performance. Sensor errors are estimated on an ongoing basis using a Kalman filtering technique.

With the application of aerospace technology in both its sensors and data processing, POS LV is designed for reliable operation in a variety of vehicle environments. The system provides continuous data regardless of GNSS availability.

POS LV is controllable either by the Windows® based LV-POSView software or can be used independently in the Stand-Alone mode. The LV-POSView software is used to configure the system after a new installation in a vehicle. Once the POS LV is configured, the program may be used to monitor POS LV performance. Conversely, POS LV may be used independently of LV-POSView.

POS LV communicates with the LV-POSView software via a thin-wire Ethernet interface. Display data broadcast from the POS LV uses the Universal Datagram Protocol (UDP), a broadcast protocol. Therefore, multiple computers on the same Ethernet network can monitor the POS LV data simultaneously. LV-POSView sends commands to POS LV using Transmission Control Protocol/Internet Protocol (TCP/IP) and thereby prevents other computers from receiving or sending commands to POS LV.

Data are transmitted to the LV-POSView software for display once per second. POS LV is capable of transmitting at a high data rate across an Ethernet connection for logging or for real-time use.

Additionally, POS LV is able to log data to a USB flash drive. If required, the data logged by POS LV can be used for post-processing. Refer to the Data Logging description on page 12-1 for further information.

Principle of Operation

POS LV uses an IMU, DMI and two GNSS receivers as its core navigation sensors, see Figure 2. In particular, POS LV integrates data from the DMI to achieve improved performance and robustness during GNSS dropouts.

The POS LV embedded navigation software runs an inertial navigation algorithm that solves Newton’s equations of motion using the acceleration and angular rate data from the IMU.

A Kalman Filter compares the inertial solution with corresponding data from the primary GNSS receiver, GNSS Azimuth Measurement Subsystem (GAMS) and the DMI, estimating the inertial navigation errors. A tightly coupled ambiguity resolution algorithm is in use when real-time GNSS corrections data are available. The navigation software then adjusts the inertial navigation solution by the Kalman Filter estimated errors.

This process of inertial navigation, navigation error estimation and error correction forms a closed error regulation loop that requires the inertial navigator data to be consistent with the aiding sensor data. When Real-time Kinematic (RTK) corrections are provided to the system, errors are regulated to centimetre level accuracy, while velocity and attitude errors are controlled to similarly small values.

The POS LV GAMS is designed to provide accurate heading information. Using two GNSS antennas and a sophisticated ambiguity resolution algorithm, GAMS is able to provide heading data with an accuracy of up to 0.02 degrees, independent of geographic latitude.

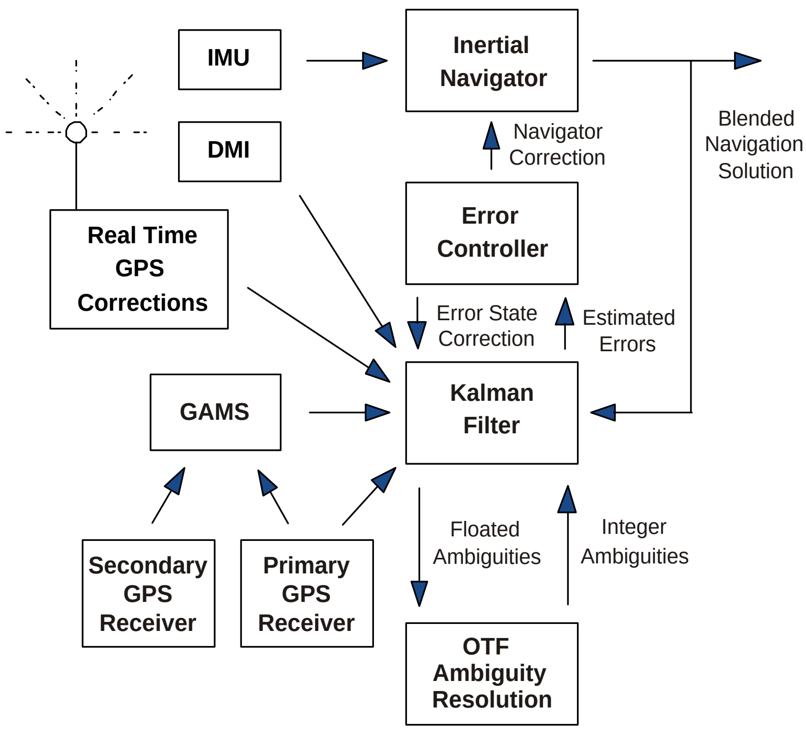


Figure 2: POS LV Aided Inertial Navigation Processing

Major Components

POS LV consists of the following components.

Basic Components

- POS Computer System (PCS)
- Data logging device (part of the PCS)

- GNSS receivers (installed inside the PCS)
- Inertial Measurement Unit (IMU)
- Distance Measuring Indicator (DMI)
- GNSS antennas
- LV-POSView software
- Interconnect cables

Optional Components

- POSPac post-processing software

POS Computer System

The PCS is a computer contained in a rugged housing. It contains all the data acquisition and processing hardware, two GNSS receivers and supplies power for the IMU, DMI and GNSS antennas. As the heart of the system, it acquires data from various sensors, processes the data to produce real-time vehicle navigation data and records the data to a logging device for further post-processing.

Removable Media Logging

A USB flash drive is used to record the mission data and can be directly transferred to any computer with a USB slot.

Back-up Data Logging

When Removable Media Logging is active, the same data are written to an internal storage device within the PCS.

GNSS Receivers - Primary and Secondary

POS LV models house one dual antenna GNSS receiver inside the PCS; referred to as primary receiver and secondary receiver. The receiver provides raw GNSS satellite observable information from both antennas to POS LV.

The secondary antenna information is used by GAMS for heading aiding. Its data are used in conjunction with information from the primary receiver for GAMS heading calculations.

Inertial Measurement Unit

The IMU senses 3-axis acceleration and 3-axis angular rotation measured at the IMU sensing centre and outputs data as digital incremental velocities and angles.

The IMU is a self-contained unit that is connected to the PCS via the supplied IMU cable.

Distance Measuring Indicator

The DMI is an external sensor that is attached to one of the vehicle's wheels; referred to as the Instrumented Wheel. It outputs pulses representing fractional revolutions of the Instrumented Wheel. POS LV converts these pulses to incremental distance and sums these pulses to provide a measure of the distance travelled by the vehicle.

GNSS Antennas

The GNSS antennas are external components that require mounting on the roof of the vehicle. The antennas provide signals to the GNSS receiver inside the PCS.

LV-POSView Software

The LV-POSView software is a program that runs on an IBM-compatible PC using Microsoft Windows®. It is used to configure, control and monitor the POS LV operation.

POSPac Post-Processing Software

POSPac is a set of software tools available from Applanix and is used to obtain the most accurate position and orientation solution from logged POS LV data.

Since POSPac is not bound by the constraints of real-time processing, the software provides a navigation solution that is more accurate than the real-time navigation solution output by POS LV.

Function and Performance

POS LV provides the following functions:

- Motion measurement (real-time position & orientation measurement)
- Installation parameter storage
- Data logging (Removable media and back-up logging)
- AutoStart (automatically transitions from Standby mode to Navigate mode on power-up)
- AutoLog (automatically starts removable media logging on power-up)
- Fault Detection, Isolation and Reconfiguration (FDIR)
- Time and distance tagging
- Event tagging

Motion Measurement

One of the main functions of the POS LV is to provide real-time navigation data. Other, user-supplied sensors that require real-time position and/or orientation can be used with this data. POS LV provides the following:

- Position (latitude, longitude, and altitude)
- Geographic velocity - North, East and Down (NED)
- Attitude (roll, pitch, and heading)
- Acceleration (xyz in reference frame)
- Angular rate
- Distance travelled
- RMS error measures (position, velocity, attitude, angular rates)

Installation Parameter Storage

POS LV requires that certain parameters be specified in order to operate properly in real-time. The POS LV can store these parameters and use them for initialisation on power-up.

Alterations to the operational parameters can be made at any time. Once altered, saving them will permanently retain the new parameters.

Removable Media Data Logging

Data logging allows the POS LV to store both raw sensor data and real-time processed navigation data to a removable USB flash drive for post-processing; post-processing enhances navigation solution accuracy. The USB flash drive is transferable between the PCS and any Microsoft Windows® based computer with a USB slot and running post-processing software.

Back-up Data Logging

When the removable media logging is active, the same data are written to an internal storage device within the PCS. In the event that removable media logging fails or the USB flash drive gets lost or corrupted, File Transfer Protocol (FTP) may be used to recover the mission data from the PCS with user name *guest* and password *applanix*.

AutoStart

Enabling the AutoStart feature automatically transitions POS LV to the Navigate mode after power-up. AutoStart may be enabled or disabled using the LV-POSView software.

AutoLog

Enabling AutoLog automatically triggers data logging to a USB flash drive after power-up, allowing hands-free operation of the system.

Fault Detection, Isolation and Reconfiguration

The Fault Detection, Isolation and Reconfiguration (FDIR) feature combines the POS LV sensor data in a manner that provides the best navigation solution at any point in time. Active in the Navigate mode, FDIR is able to monitor the sensors, determine which sensors show degraded performance and recombine the data as necessary.

Time and Distance Tagging

POS LV attaches time and distance tags to all of its outputs to permit synchronization with data from other sensors or systems. The time tag is based on Universal Time Coordinated (UTC), GPS, POS or User Time, and is accurate to one microsecond. The distance tag is set as either the DMI or POS distance travelled. The following identifies the types of time and distance tags:

- UTC
- GPS
- POS time - time since system power-up
- USER time - time base supplied by the user via the control port
- POS distance - estimated by the navigator software within the PCS
- DMI distance - raw distance from the DMI sensor

Note: Refer to the POS-GPS Timing description starting on page J-1 for more information.

Event Tagging

The POS LV is capable of simultaneously marking time and distance tag events through the Input/Output (I/O) connector on the PCS rear panel. These tags may be used to identify the start and/or end of data collection and to synchronize the POS LV data with data from other sensors or systems.

Events are tagged with GPS, UTC, POS or User Time, and distance is computed by the PCS from the DMI or POS distance data. To tag an event, a signal in the range of 3 to 50 volts is input into POS LV. The rising or falling edge corresponds to the exact time and distance of the event. The signal is connected to an event line of the I/O connector, described in the Event Interface topic on page 5-9.

Event time tagging occurs when the POS LV detects a rising or falling edge on an event line. The time of the edge (accurate to within one microsecond) and the distance travelled at the time of the edge is captured. The time and distance of the event is then output and may be logged for use in post-processing or real-time applications.

Note: Refer to the POS-GPS Timing description starting on page J-1 for more information.

Modes of Operation

POS LV has two standard modes of operation, Standby and Navigate.

Standby Mode

In Standby mode, the PCS accepts command messages and outputs raw sensor data, but does not perform any data processing. Thus, no navigation data are output by the system.

Standby mode is used to record IMU, GNSS and DMI data to the removable logging media for later use with POSPac post-processing software. In this case, POS LV functions strictly as a data acquisition system.

Navigate Mode

Either the LV-POSView software or the AutoStart function is used to switch the POS LV to the Navigate mode. When POS LV enters the Navigate mode, it performs an initialization and alignment of its inertial navigator. Once computing starts, it outputs real-time navigation data using the Ethernet or serial ports.

SECTION 1

HARDWARE INSTALLATION AND SPECIFICATIONS

2.0 Packing & Environmental Considerations

Handle all POS products with extreme care. POS LV contains sensitive components that have special handling requirements. Read the handling instructions below before removing any items from the shipping container.

Unpacking

All Position and Orientation System for Land Vehicles (POS LV) systems are subject to electrical and mechanical acceptance tests before shipping. These tests are performed in accordance with Applanix Corporation documents; *POS LV Tightly Coupled Factory Production Test* and *POS LV Tightly Coupled System Acceptance Test*. Each system is packed in shock-protecting shipping cases to prevent any damage during shipment. It should arrive free of any defects and in operating condition.

Inspect the shipment on arrival to ensure that no damage has occurred. In the event of damage, inform both the shipping company and Applanix Corporation immediately, see Technical Support and Service on page A-1.

Remove all items from their shipping cases and retain the cases for re-use in case the POS LV system is removed from the vehicle for storage or repair. Alternatively, a replacement set of shipping cases can be ordered from Applanix. Please contact Applanix for details, see Appendix A1.

The supplied POS LV components are listed on the packing list shipped with the system. Verify that each item is present.

Handling

Important:

1. Equipment shall be serviced only by qualified personnel.
2. The PCS (POS LV V5) shall be grounded via the safety ground stud.
3. Power to the POS system should be protected by a user-supplied, resettable circuit breaker.

POS Computer System

The POS Computer System (PCS) is designed to operate in the environment of an on-road vehicle, see Figures 3 and 4. The PCS is rugged and sealed against moisture and dust. As a sealed unit the PCS needs to be able to conduct heat through the mounting or radiate it to the surrounding air.

Inertial Measurement Unit

Handle the IMU with care. The POS LV IMU contains components that may be damaged by shock. Do not drop or bump the IMU.

The Inertial Measurement Unit (IMU) is a delicate device and can be damaged by shock or vibration. Alert anyone performing maintenance in the proximity of the IMU of its sensitivity to shock and vibration; normally a clear shock sensor is mounted on the IMU casing. A red sensor indicates that the IMU has experienced dangerous shock levels and may require service; contact the Applanix technical support group for directions; see Technical Support and Service on page A-1

Distance Measuring Indicator

Always hold the DMI by the optical encoder. Do not hold it by the restraint rod. Placing excessive demands on the rod hinge will cause it to break. The rod is not designed to support the weight of the DMI.

Figure 4 shows the Distance Measuring Indicator (DMI) complete with its restraint rod, cable and hub adapter. The unit is a rugged device, designed to withstand the environment outside a moving vehicle. Take care to avoid dropping the device. Severe shocks may warp the DMI shaft and damage the DMI internal components.

GNSS Antenna, PCS, IMU, DMI and USB flash drive

Figure 3: (1 of 2) POS LV Components

DMI, Restraint Rod, Cable and Hub Adapter

Figure 4: (2 of 2) POS LV Components

GNSS Antennas

Do not place metallized labels on the radome. Signal attenuation will result.

Two Global Navigation Satellite System (GNSS) antennas are included with the system, see Figure 3. Handle the antennas with care to avoid scratching or otherwise damaging their weather resistant polymer shells.

Storage

Ensure the following conditions are maintained for the POS LV system components when storing for an extended period:

- Protect the PCS from dust and moisture, excessive humidity (>80%) or temperature extremes (below -40 °C or above +85 °C).
- Protect the IMU from accidental damage by storing in its original shipping case.
- Store all remaining components in their original shipping cases.

Power Requirements

Power rating for PCS-76 is:

Voltage:	10 to 34 Vdc
Current:	5.5 A Max (@ 10V)

Power rating for PCS-86 is:

Voltage:	8 to 34 Vdc
Current:	7 A Max (@ 8V)

Power rating for PCS-92 is:

Voltage:	9 to 34 Vdc
Current:	2.5 A Max (@ 9V)

Operating power for the IMU, DMI, and the GNSS antennas is supplied by the PCS. For PCS-76 the IMU power is simply switched on and off by the PCS, so the minimum acceptable input voltage may depend on the IMU type and length of cable. PCS-86 boosts the input voltage if necessary to ensure IMU operation for all cable lengths.

Environmental Requirements

POS Computer System

The PCS is an IP65 sealed unit and as such can tolerate water and dust. It does need to dissipate heat either through contact with the mounting surface or by radiating to the surrounding air.

The following are environmental limits for the PCS:

Operating temperature:	-20 °C to +55 °C
Storage temperature:	-50 °C to +85 °C
Relative humidity:	0 to 95%

Inertial Measurement Unit

Applanix uses various IMUs from multiple manufacturers to meet the unique performance levels of each POS model. IMU types 7 and 17 are packaged in an Applanix designed, IP67 sealed housing and as such can withstand water and dust. Other IMUs are shipped in their original housings and may have different levels of environmental protection (refer to Appendix M for housing details). Even though an IMU may be sealed, it is wise to take care to protect the IMU from the environment.

Note: If the case is mounted on a steel plate, a ¼ Inch (in) thick stainless steel spacer is recommended to prevent galvanic corrosion of the IMU case.

The following are environmental limits for IMU types 7 and 17:

Operating temperature:	-40 °C to +60 °C
Storage temperature:	-50 °C to +85 °C
Relative humidity:	0 to 100%

Distance Measuring Indicator

The DMI is mounted on one of the vehicle's wheels, as described in the Distance Measuring Indicator description on page 3-3. It is designed to withstand its external location, minor rough road impacts and water spray. Do not submerge the DMI in liquid and take care to minimize impact forces.

The following are environmental limits for the DMI:

Operating temperature:	-40 °C to +105 °C
Storage temperature:	-40 °C to +105 °C
Relative humidity:	0 to 98%, non-condensing

GNSS Antennas

Both antennas are designed to mount on the roof of the vehicle, clear of any surface that may cause multipath reception.

⚠ **Moisture intrusion into the GNSS antenna connection may cause weak signal reception, damage the internal GNSS antenna circuitry or the GNSS receiver in the PCS.**

Wrap the connectors between the GNSS antenna cables and the antennas with self-fusing tape (supplied) to prevent moisture intrusion into the connection, see page 3-1 for application instructions.

The following are environmental limits for the GNSS antenna and cable:

GNSS Antenna

Temperature:	-40 °C to +70 °C
Relative humidity:	0 to 100%

GNSS Antenna Cable

RG-303:	-55 °C to +200 °C
RG-400:	-55 °C to +200 °C

3.0 Hardware Installation

Voltages present in the POS LV system are sufficient to cause serious injury or death.

Handle all POS products with extreme care. POS LV contains sensitive components that have special handling requirements. See the Handling description starting on page 2-1 for more information.

Important:

1. Equipment shall be installed by qualified personnel.
2. The PCS shall be grounded via the safety ground stud.
3. Power to the POS system should be protected by a user-supplied, resettable circuit breaker.
4. Upstream breaker used to protect POS system shall be limited to 20Amp rating.
5. Antenna connection shall be provided only after making the permanent safety earth connection.

Preparation

Review all of this section prior to beginning installation of the Position and Orientation System for Land Vehicles (POS LV) system. Provide careful thought to the layout of the components to ensure a trouble-free installation. Adequate mounting facilities must be provided for each of the POS LV components.

Before choosing a permanent mounting location for the POS LV components review the Power Requirements and the Environmental Requirements descriptions on pages 2-3 to 2-5.

The POS LV system is shipped with a Packing List that identifies the contents of the shipping containers. Among these items are software and manuals for the system.

Note: Review all written documentation thoroughly before proceeding with the installation.

Using Self-Fusing Tape

Self-fusing tape sticks to itself and cable connectors, and forms a permanent watertight bond shortly after application.

Application

Stretch the tape during application to form a positive seal. Layer the tape to provide the desired insulation. In tight areas, the tape may be applied in short lengths without compromising its strength or sealing properties. Jacketing of the tape for protection is not required.

Removal

Cut along the axis of the splice and peel the insulation away as a single unit. There is no residue to be scraped away or removed with solvent.

POS Computer System

The POS Computer System (PCS) is designed for mounting in a mount that provides isolation from both shock and vibration. Do not expose the PCS to excessive heat.

Inertial Measurement Unit

IMPORTANT

Rigidly mount the IMU to the vehicle frame. Select a structurally sound location that is not prone to flexing (bending motion of the vehicle chassis).

If the POS LV is intended to motion-compensate data from a particular sensor, then mount the Inertial Measurement Unit (IMU) as close as possible to this sensor.

The POS LV will provide a position and orientation solution at any user-defined point in or around the vehicle. Therefore, mount the IMU in any reasonable location ensuring that the mounting location permits access to the IMU cable.

To simplify installation parameter measurements, mount the IMU with its base plate horizontal and orient either the X or Y-axis towards the front of the vehicle. The sensing axis are labelled on the IMU case.

IMUs come in various enclosures depending on the IMU type, and some have optional adaptor plates to facilitate mounting or for backward compatibility. Refer to Appendix M - Drawings for details.

Typically there will be four holes for mounting bolts plus two holes drilled in the IMU base plate to accept alignment pins. These holes maintain IMU alignment when the unit is replaced. One or both of the holes will be offset from the centre line to ensure the unit can be installed in only one orientation. Tighten the mounting bolts in a uniform manner, exercising care not to over torque them.

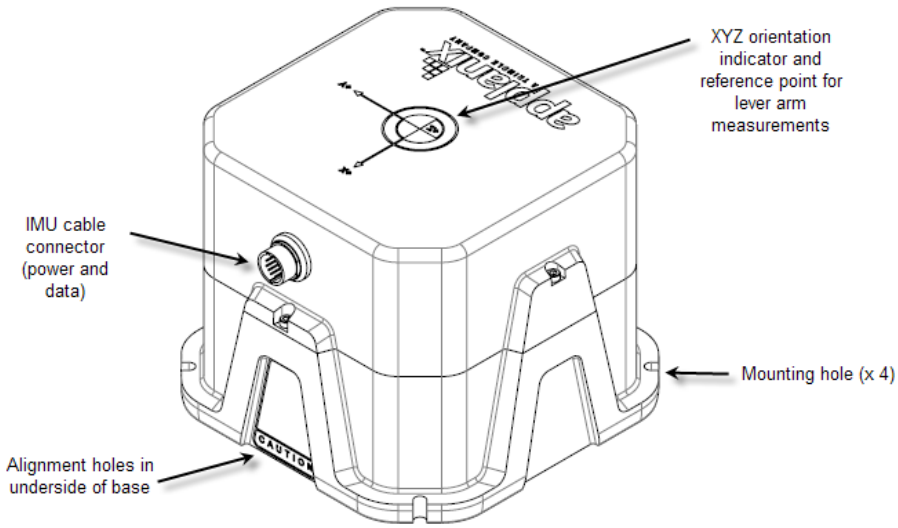


Figure 5: Typical IMU Mounting Features

Route the IMU power and data cable between the IMU and PCS case, providing cable loops at each connector for strain relief. Coil any unused cable length and store in an out of the way location. Secure the cable to the vehicle using tie wraps or other fasteners. If the IMU case is mounted on the vehicle's exterior, it is recommended that fusion tape be used to keep the IMU cable connection clean.

Distance Measuring Indicator

The Distance Measuring Indicator (DMI) functions on either rear wheel. Applanix recommends mounting the DMI on the driver's side rear wheel to facilitate visual monitoring of the device.

Do not mount the DMI on a steered wheel, as the DMI will yield incorrect information. Damage to the DMI and mounting hardware may result.

Mounting Brackets

Applanix recommends the installation of the Permanent DMI Restraint Bracket kit. The (optional) Temporary DMI Restraint Bracket kit is not suitable for use in permanent or long-term installations. Failure of the temporary bracket components may result in damage to the DMI assembly.

Each DMI is supplied with a Permanent DMI Restraint Bracket kit containing a bracket and self-threading metal screws. Optional are extra collets, collet spacers and replacement parts for the DMI sensor assembly (permanent DMI restraint and temporary DMI restraint bracket kit). These optional items are available from Applanix. Refer to Technical Support and Service on page A-1 for procedures.

To Attach Permanent Bracket

1. Drill $^{1}/_{8}$ in (~3 mm) holes in rear fender lip, above wheel hub - use permanent bracket as template (Figure 10).
2. Do not mount DMI restraint bracket at this time (to ensure DMI restraint rod is vertical once DMI is installed).

To Attach Temporary Bracket (“Optional”)

1. Clean vehicle surface for placement of suction cups or magnetic strip.
2. Temporarily attach suction cups or magnetic strip.
3. Predetermine requirement for spacers, note special body features such as fender and body protrusions (use of spacers is on an ‘as required’ basis).
4. Thread spacers onto temporary bracket.
5. Either thread on suction cups (onto spacers), or use supplied nylon screws to attach magnetic strip instead.
6. Do not mount DMI restraint bracket and spacers at this time.

Assemble Distance Measuring Indicator

The Universal Hub Adapter (Figure 6) has pre-cut slots to accommodate three, four, five, six, seven, eight, nine and ten bolt wheels. All installations use the reference slot (marked with an ‘x’) and the slots labelled with the corresponding number of wheel bolts.

Note: Wheels with six bolts or more may require a larger diameter Universal Hub Adapter (Figure 6). Contact Applanix Corporation for assistance, refer to Technical Support and Service on page A-1 for procedures.

The following are installation examples:

- On a four-bolt wheel use the reference slot ‘x’ and the slots labelled 4
- On a three-bolt wheel, use the slots labelled 6 and ‘x’
- On an eight-bolt wheel, use the slots labelled 4 and ‘x’

⚠ **A minimum of three collets must be used to mount the Universal Hub Adapter. It is not necessary to use a collet for each lug bolt on the wheel.**

To assemble the DMI, universal hub adapter and collets perform the following (Figure 6 and Figure 7):

1. Select sufficient collet spacers (optional), to position restraint rod perpendicular to road with DMI and universal hub adapter installed. No interference between restraint rod and vehicle fender and body is permitted.
2. Select bolts 1 in (2.54 cm) longer than total collet spacer height.
3. Assemble DMI using universal hub adapter, collet spacers, collets, washers and bolts in order (Figure 6).
4. Keep bolts loose permitting collet jaws to fit over wheel nuts.

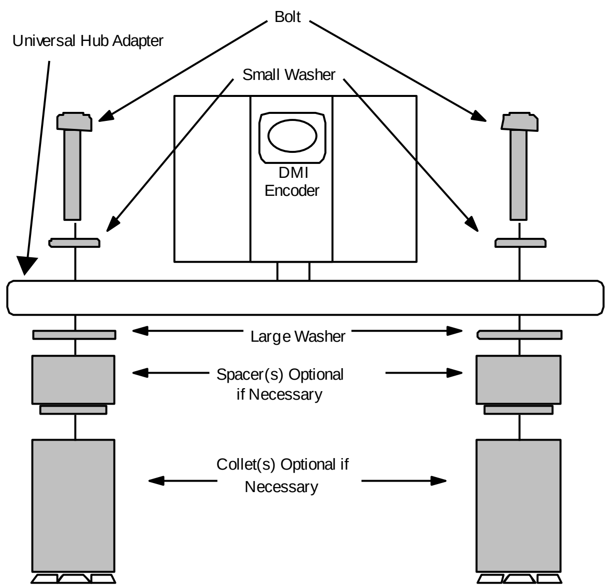


Figure 6: DMI Collet Mounting Guide

Figure 7: Attach Collets to Universal Hub Adapter

Install Distance Measuring Indicator

The collet grips the wheel nut as the collet bolt is tightened. Failure of a collet may result in damage to the DMI components. Thoroughly remove rust and dirt from each wheel nut. Replace damaged or corroded wheel nuts.

To install the assembled DMI on the vehicle perform the following:

5. Slip collets over wheel nuts (Figure 8).
6. Use circular grooves etched on universal hub adapter so that collets are equal distance from DMI encoder shaft; off-centre placement of universal hub adapter will increase data noise and cause excessive mechanical vibration.
7. Apply thread-lock compound to collet bolt threads prior to insertion. For successful bonding, knowledge of adhesive characteristics is essential.

   Over tightening of the collet bolts may result in thread stripping. Under tightening of the collet bolts may result in a poor mechanical connection and subsequent damage to the DMI assembly.

8. Tighten collet bolts in a uniform manner using supplied $^{7}/_{16}$ in or $^{1}/_{2}$ in nut driver - do not exceed a torque value of 25 pound-force-inch (2.83 Newton metres) for the $^{1}/_{4}$ in - 20 bolts and 50 pound-force-inch (5.66 Newton metres) for the $^{5}/_{16}$ in - 18 bolts.
9. Slip (permanent or temporary) restraint bracket over restraint rod and position rod perpendicular to road (Figure 9).
10. Attach DMI restraint bracket:
    - Permanent - attach bracket using predrilled holes in rear fender lip using metal screws (refer to Mounting Brackets on page 3-3 and Figure 10).
    - Temporary using suction cups - thread spacers (if required) and suction cups onto fender bracket, then fix fender bracket to vehicle body.
    - Temporary using magnetic body strip - thread spacers (if required) and use flat head nylon screws to attach the magnetic strip, then fix fender bracket to vehicle body.

Figure 8: Slip Collets over Wheel Lug Nuts

Figure 9: Slip DMI Restraint Bracket over Restraint Rod

Figure 10: Attach Permanent DMI Restraint Bracket to Vehicle Fender

Install DMI Cable

Use tie-wraps to secure the DMI power and data cable along the routing path. Wrap the cable/DMI connection with self-fusing tape to keep dust and moisture out of the connection, see page 3-1 for application instructions.

<u>To install the DMI cable perform the following (Figure 11):</u>

1. Plug DMI power and data cable into socket on DMI encoder.
2. Route cable along length of the restraint rod, secure with tie wraps.

Figure 11: Attach DMI Cable to Restraint Rod

⚠ **To prevent damage to the DMI sensor or cable, leave cable slack at the DMI connector and fender bracket to accommodate suspension movement.**

3. Route DMI power and data cable to PCS.

Consider suspension movement and vehicle flexing during cable routing. Prevent cable contact with the ground or moving parts. Leave cable loops to prevent cable damage.

4. Connect DMI cable to PCS rear connector labelled DMI.

5. Figure 12 provides an example of DMI cable routing. The cable may be routed through drilled holes or passed through the vehicle's side doors or screens.

Figure 12: DMI Cable Installation

GNSS Antennas

To ensure system performance, Applanix recommends a configuration that incorporates the GNSS antennas shipped with the system.

IMPORTANT

Using third-party antennas with the POS LV system may require an Antenna Splitter Kit for optimum reception. Applanix cannot guarantee system performance using third-party antennas and cables.

Contact Applanix Customer Support for details; refer to Technical Support and Service on page A-1.

The following are guidelines for installing a generic GNSS antenna. Each GNSS antenna, associated coaxial cable and receiver is configured for optimum performance.

Mount the GNSS antennas on the roof of the vehicle using the following guidelines:

- GNSS antennas require line-of-sight signals from the GNSS satellites; obstructions may cause signal degradation due to blockage or reflections. Ensure the mounting location is free from obstructions caused by other installed equipment sharing the vehicle roof.
- Increasing antenna separation enhances the accuracy of the GNSS Azimuth Measurement Subsystem (GAMS) at resolving vehicle heading. The minimum antenna separation is 1.5m (~59 in); however, Applanix recommends 2.0m (~79 in) or more, up to a distance of five metres.
- Wrap the GNSS antenna connector connection with the supplied self-fusing tape to prevent moisture intrusion, see page 3-1 for application instructions. Moisture intrusion will cause signal degradation and may damage the GNSS antenna or receiver.
- The three components of the Lever Arm between the primary GNSS antenna and the IMU must be measured with centimetre accuracy, refer to the Installation Parameters description on page 4-1. Select a GNSS antenna location that does not restrict these measurements.

After GNSS antenna installation, connect the primary GNSS antenna to the ANT1 port and the secondary GNSS antenna to the ANT2 port located on the PCS rear panel.

Note: Although tight cable bends are not preferred, the minimum radius of cable bends is two inches. Cable loops placed at each end of the GNSS antenna cable will provide strain relief.

Note: If the primary GNSS receiver is a dual frequency unit, ensure that an L1/L2 antenna is connected to the ANT1 port on the PCS rear panel.

Verify that an L1/L2 antenna is connected to a dual frequency primary GNSS receiver by using the LV-POSView software program. Select **View, GNSS Data, Primary** tab. The L2 signal-to-noise ratio should be a reasonably stable value. If the L2 signal-to-noise ratio varies randomly, then an L1 only GNSS antenna is connected at the ANT1 port; replace it with an L1/L2 antenna.

4.0 Installation Parameters

General

Distance and orientation measurements are performed after the Inertial Measurement Unit (IMU), Global Navigation Satellite System (GNSS) antennas, Distance Measuring Indicator (DMI), POS Computer System (PCS) and the third party sensors are installed.

Four types of measurements are made:

- Mounting Angles - differences in orientation between two object frames
- Lever Arms - vector displacements between two points
- Scale Factors - conversion factors
- Separations - linear displacements between two points

Be sure to record these measurements. They must be loaded into POS LV via the supplied LV-POSView software the first time the system is powered-on for a new installation. See the POS LV Installation Parameter Set-up description starting on page 8-1 for more information on storing installation parameters in POS LV.

Accurate measurements of the mounting parameters are necessary to ensure optimum POS LV performance. Seven sets of parameters require measurement and declaration before POS LV can navigate.

These parameters are:

- Lever Arm - Reference to IMU
- Lever Arm - Reference to DMI
- Lever Arm - Reference to GNSS Antenna
- Mounting Angles - Reference Frame with Respect to Vehicle Frame
- Mounting Angles - IMU Frame With Respect to Reference Frame
- DMI scale factor

Other parameters:

- Lever Arm - Reference to Auxiliary GNSS 1 Antenna
- Lever Arm - Reference to Auxiliary GNSS 2 Antenna

The accuracy of the above measurements is important. Review the POS LV Installation Parameter Set-up description starting on page 8-1 for information on how to input installation data.

Example: If vehicle roll is measured with an accuracy of 0.1 degrees, then the orientation of the IMU Body Frame with respect to the Reference Body Frame must be better than 0.1 degrees. If the measurement accuracy does not meet requirements, then a constant angular offset is present in the output, which must be corrected.

Lever Arms and Mounting Angles for the IMU, as well as the Lever Arms for the primary GNSS and DMI may be estimated using the Applanix POSPac post-processing software. This software may be used to further refine the installation parameter values. Refer to the *POSPac User Manual*, shipped with the POS LV System for more information.

In many instances, the misalignment angles between the various frames (IMU, Reference and Vehicle) have to be determined by using a boresighting procedure.

A test based on the attributes of the sensor must be devised that involves a survey of control points or control surfaces that will expose angular biases in the POS LV sensor solution. This test determines the angular offsets to the remote sensing instruments such as cameras or LIDAR.

If in doubt, please contact Applanix Corporation Customer Support, refer to Technical Support and Service on page A-1 for contact information.

Body Frames

Vehicle Frame Definition

The Vehicle Frame is defined as the right-handed orthogonal coordinate system with its origin at an arbitrary, user-defined point. The orientation of the Vehicle Frame is fixed so that the x-axis is towards the front of the vehicle, the y-axis is towards the right of the vehicle and the z-axis is towards the bottom of the vehicle. The Vehicle Frame is closely related to the Reference Frame, defined in the next section.

Reference Frame Definition

The Reference Frame is defined as the right-handed orthogonal coordinate system with its origin at an arbitrary, user-defined point (the Reference Point). It is coincident, but not necessary co-aligned, with the Vehicle Frame defined above. Its location should be chosen for the ease of Lever Arm and mounting angle measurement. Since the POS LV navigation solution is valid at the Reference Frame origin, the frame is often collocated with a sensor of interest.

Typically, the Reference Frame is defined with the same orientation as the Vehicle Frame (i.e. the x-axis is toward the front of the vehicle, the y-axis is towards the right of the vehicle and the z-axis is towards the bottom of the vehicle).

IMU Frame Definition

The IMU Body Frame is defined as the right-handed orthogonal coordinate system with its origin at the sensing centre of the IMU. The IMU Frame axes are fixed to the IMU and are labelled directly on the IMU case, see Figure 13. The IMU target (painted on the case), along with the table of IMU sensing centre offsets (Table 1), serve to locate the IMU Frame origin.

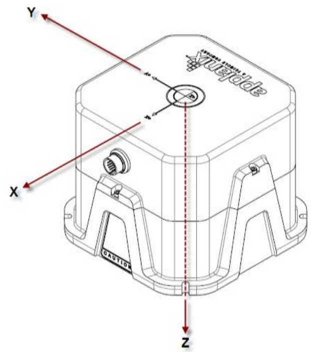


Figure 13: IMU Body Frame

DMI Frame Definition

The DMI Frame is defined as the right-handed orthogonal coordinate system with its origin at the Instrumented Wheel's point of contact with the road (located at the centre of the tread). Thus, the DMI Frame is co-located with the DMI sensing centre. The frame's axes coincide with the Vehicle Frame's orientation (i.e. the x-axis points towards the front of the vehicle, the y-axis points towards the right and the z-axis points down); see Figure 14.

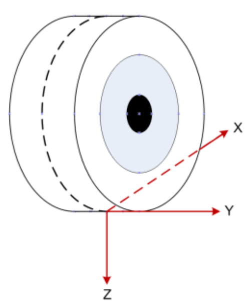


Figure 14: DMI Body Frame

Lever Arms

Reference to IMU Lever Arm

A Reference to IMU Lever Arm is a three-dimensional vector defining the displacement from the Reference Frame origin to the sensing centre of the IMU. This displacement is measured with respect to the user-defined Reference Frame.

Distances are measured from the user-defined Reference Frame origin to the target painted on the top of the IMU case. The IMU target to the sensing centre offsets are specified on the IMU case and are shown in Table 1. They have to be added to the measured Reference-to-target values. Note that these offsets can be applied 'as is' only if there are no non-zero mounting angles. The resulting distance from the Reference Frame origin to the IMU sensing centre is resolved in the Reference Frame. See Figure 16.

Table 1: IMU Target to Sensing Centre Offsets

IMU Type	X Offset	Y Offset	Z Offset
Type 7	5 mm	-6 mm	90 mm
Type 17	0 mm	0 mm	71 mm
Type 21	0 mm	0 mm	81 mm
Type 26	0 mm	0 mm	53 mm
Type 31	-9 mm	33 mm	112 mm
Type 40	13 mm	17 mm	118 mm
Type 42	0 mm	1 mm	87 mm
Type 43	0 mm	0 mm	30 mm
Type 46	0 mm	0 mm	112 mm
Type 52	0 mm	0 mm	97 mm
Type 55	0 mm	0 mm	30 mm
Type 56	0 mm	0 mm	30 mm
Type 57	-14 mm	-10 mm	63 mm
Type 64	0 mm	1 mm	87 mm
Type 66	5 mm	-6 mm	90 mm
Type 69 (LV125)	0 mm	0 mm	53 mm
Type 80	0 mm	0 mm	112 mm

1 – Measured from target on top of IMU

Example: If the Reference and Vehicle Frames are co-aligned (zero alignment angles), then from the Reference Frame origin, x is positive towards the front of the vehicle, y is positive towards the driver's right side and z is positive down towards the road (right-hand rule), see Figure 15.

Reference to DMI Lever Arm

A Reference to DMI Lever Arm is a three-dimensional vector defining the displacement from the Reference Frame origin to the sensing centre of the DMI. This displacement vector is measured in the Vehicle Frame.

Lever Distances are measured from the Reference Frame origin to the centre of the tread (where the wheel makes contact with the road) of the DMI instrumented wheel. The DMI instrumented wheel must be a non-steering wheel, see Figure 16.

Example: If the Reference and Vehicle Frames are co-aligned (zero alignment angles), then from the Reference Frame origin, x is positive towards the front of the vehicle, y is positive towards the driver's right side and z is positive down towards the road (right-hand rule).

In the case where an external DMI is not used and the DMI measurements are taken directly from the vehicle electronics, the DMI sensing center may not be rigorously defined. To find the sensing center, consider the position of each wheel that may be contributing to the DMI measurement and then use the average horizontal position. The vertical lever arm will still be measured to the road surface.

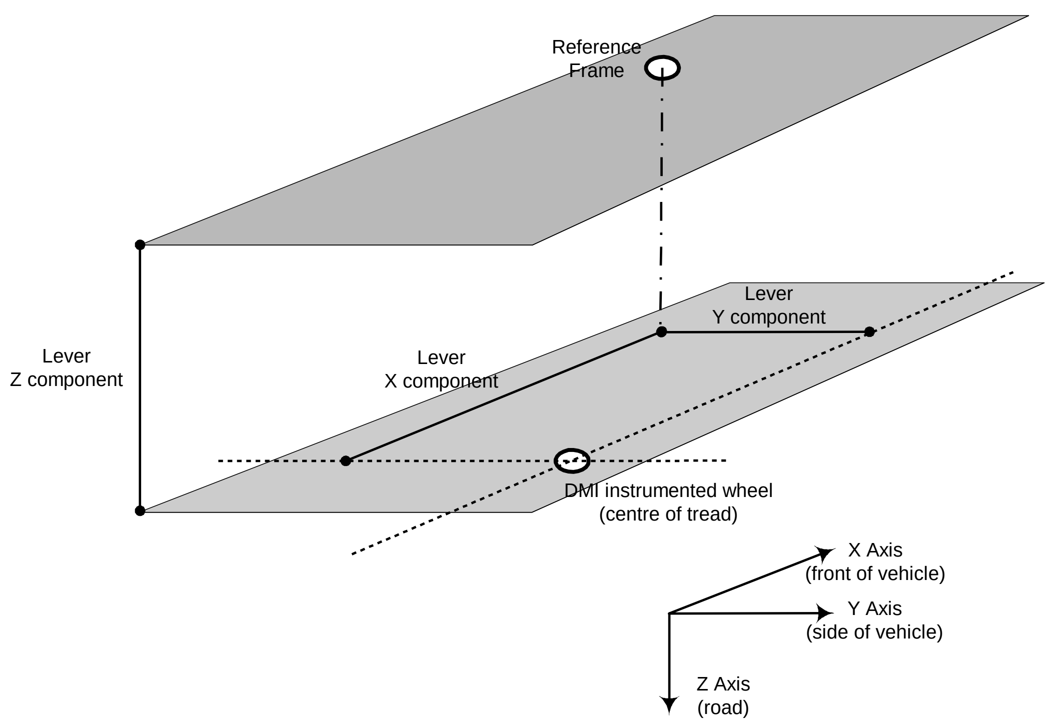


Figure 15: Three Dimensional Vector Lever Arm

Reference to Primary GNSS Antenna Lever Arm

A Reference to primary GNSS antenna Lever Arm is a three-dimensional vector defining the displacement from the Reference Frame origin to the phase centre of the primary GNSS antenna. This displacement vector is measured in the Vehicle Frame. See Figure 16.

Typically, a vertical offset is specified on the GNSS antenna, which must be added to the measured values, since it is impossible to measure the sensing centre of the antenna directly.

Example: If the Reference and Vehicle Frames are co-aligned (zero alignment angles), then from the Reference Frame origin, x is positive towards the front of the vehicle, y is positive towards the driver's right side and z is positive down towards the road (right-hand rule).

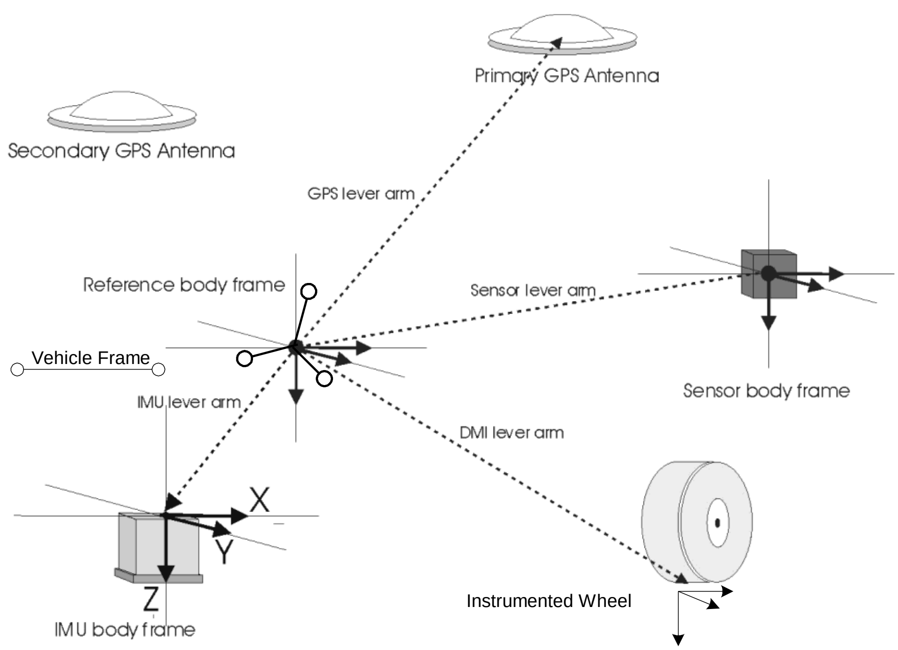


Figure 16: Lever Arms

Reference to Auxiliary GNSS Lever Arms

A Reference to auxiliary GNSS antenna Lever Arm is a three-dimensional vector defining the displacement from the Reference Frame origin to the phase centre of an auxiliary GNSS antenna. This displacement is measured with respect to the user-defined Reference Frame, and is required only if using one or more auxiliary GNSS receivers.

The measurement method is analogous to the measurements for the Reference to primary GNSS antenna Lever Arm, with measurements made in the Reference Frame.

Mounting Angles

The Mounting Angles are defined as physical angular offsets of a Body Frame with respect to a second Body Frame (see *Vehicle, Reference* and *IMU* Frame definitions).

These angles define the Tait-Bryan sequence of rotations that bring the first Body Frame into alignment with the second. For example, when defining Body Frame A (second frame) with respect to B (first frame), the Mounting Angles would be the sequence of rotations of frame B to bring it into alignment with frame A. The orientation angles follow the sequence of rotation given as follows: right-hand rotation of θ_z about the z-axis of body frame B, followed by a rotation of θ_y about the once rotated y-axis, followed by a rotation of θ_x about the twice-rotated x-axis. See page E-1 for a more detailed explanation of the Tait-Bryan sequence.

Make note of all measured mounting angles for later input into the POS LV.

Reference Frame with respect to Vehicle Frame

These mounting angles are the physical angular offsets of the Reference Frame with respect to the Vehicle Frame. The Vehicle Frame is defined as the right-handed orthogonal coordinate system with its origin defined at any point the user wishes. The Vehicle Frame orientation is fixed such that the x-axis points forward (in the vehicle’s direction of travel), the y-axis points out the driver’s right side of the vehicle and the z-axis points down toward the ground.

The Reference body frame is defined as the right-handed orthogonal coordinate system with its origin collocated with the origin of the Vehicle Frame. The POS LV navigation solution is valid in the Reference body frame and can be placed at any location the user wishes.

A sequence of rotations defines angles that bring the Vehicle Frame into alignment with the Reference frame. The angles follow the Tait-Bryan sequence of rotation given as follows: right-hand rotation of θ_z about the z-axis followed by a rotation of θ_y about the once-rotated y-axis followed by a rotation of θ_x about the twice-rotated x-axis.

IMU Frame with respect to Reference Frame

These Mounting Angles are the physical angular offsets of the IMU sensing centre frame with respect to the user-defined Reference Frame. The Reference Frame is defined as the right-handed orthogonal coordinate system with its origin defined at any point the user wishes.

The IMU Body Frame is defined as the right-handed orthogonal coordinate system with its origin at the sensing centre of the IMU. These axes are fixed to the IMU and are labelled on the IMU case.

A sequence of rotations defines angles that bring the Reference Frame into alignment with the IMU body frame. The angles follow the Tait-Bryan sequence of rotation given as follows: right-hand rotation of θ_z about the z-axis followed by a rotation of θ_y about the once-rotated y-axis followed by a rotation of θ_x about the twice-rotated x-axis. Angles θ_x, θ_y and θ_z may be thought of as IMU Frame roll, pitch and yaw with respect to the Reference Frame. Figure 17 shows a possible IMU Frame with respect to the Reference Frame. It shows the bottom view of the IMU body.

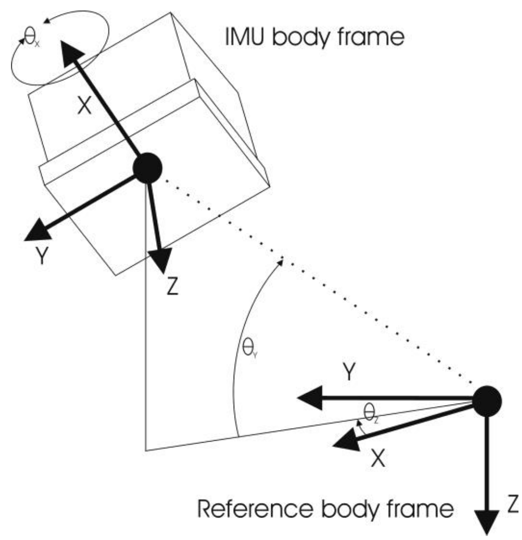


Figure 17: IMU with respect to Reference Frame Mounting Angles

DMI Scale Factor Calculation

The DMI measures wheel rotation by generating a fixed number of pulses per wheel revolution. POS LV converts wheel rotation into distance traveled by multiplying the DMI pulse count by a scale factor that converts pulses to metres. The following formulas are used to compute the scale factor:

Pulse and Direction DMI (Type 1): $s = \frac{n}{d\pi}$

Quadrature DMI (Type 2): $s = \frac{4n}{d\pi}$

Where *n* is the number of DMI pulses per revolution, and *d* is the Instrumented Wheel diameter in metres.

Note: The number of DMI pulses per revolution is typically stamped on the DMI nameplate.

Example (Type 1):

- Wheel diameter is 0.5 metres
- DMI generates 4096 pulses per revolution
- $s = \frac{4096}{d\pi} = \frac{4096}{0.5 \times 3.14} \cong 2609 \text{ pulses/m}$

The DMI direction sense is programmed by setting the sign on the DMI scale factor value. If the DMI is mounted on the driver's left side of the vehicle, use a positive scale factor value. If the DMI is mounted on the driver's right side of the vehicle, use a negative scale factor value.

5.0 Cable Characteristics

Important:

1. Equipment shall be serviced only by qualified personnel.
2. The PCS shall be grounded via the safety ground stud.
3. Power to the POS system should be protected by a user-supplied, resettable circuit breaker

This section describes the characteristics of the connectors and connecting cables for the Position and Orientation System for Land Vehicles (POS LV) connectors located on the rear panel of the POS Computer System (PCS).

Applanix supplies the necessary cables and adapters for POS LV operation. Customized and additional cables are available and may be procured by contacting Applanix Customer Support; refer to Technical Support and Service on page A-1.

All cables are labelled and in some cases have different terminations on each end. Route cables away from sources of electrical noise and protect from physical damage. Secure cables to permanent supports that are close to cable connectors to provide relief from shock and vibration due to vehicle movement. Coil and stow excess cable and secure with tie wraps.

Use the most direct path when routing cables to the PCS avoiding hazards such as:

- Hot surfaces
- Wheels
- Excessive tension caused by suspension movement and vehicle flexing (provide cable slack in these areas)
- Sharp or abrasive surfaces
- Door and screen jams
- Corrosive fluids or fuel

Ensure that POS LV is powered-off before connecting or disconnecting cables. Failure to do so could result in damage to the PCS and related equipment.

POS LV Connector Overview

There are ten connectors located on the rear panel of the PCS, see Figure 18. Each rear panel connector supports a single cable except for the I/O and COM connectors, which support a multi-connector breakout cable. Table 2 provides a summary of the connectors used in the POS LV configuration.

Circular Connectors

The majority of connectors on POS LV V5 are high quality, push-pull, IP67 Lemo ® connectors. These connectors use spring loaded latches that engage when the connector is pushed fully into the socket. Once engaged the connector is very secure against shock, vibration and pulling on the cable, ensuring a reliable connection. To disengage the connector you must pull back on the outer release sleeve. Since pulling back on the release sleeve often results in some force on the entire connector body the latches can experience some friction and not retract smoothly. If possible, it is better to hold the cable forward while pulling back on the release sleeve and then sliding the connector out of the socket. Applying excess force could damage the latch mechanism.

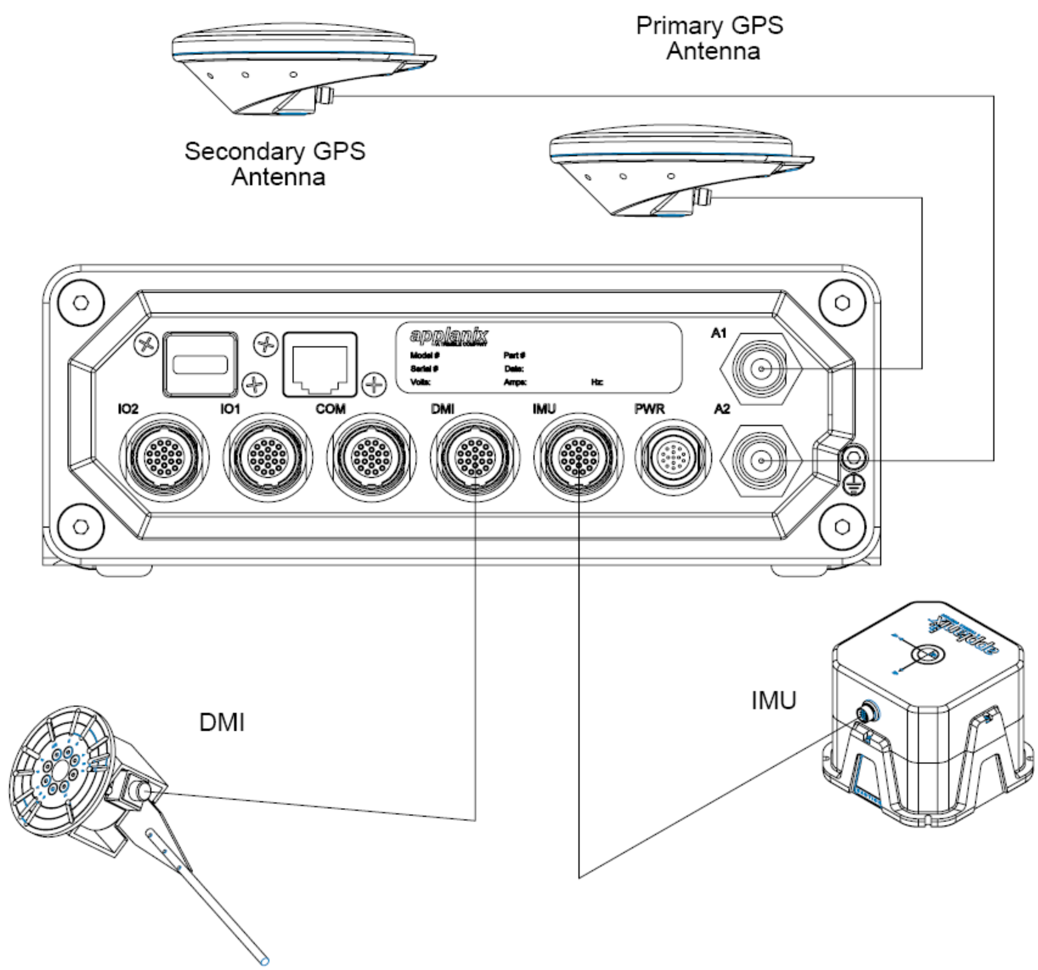


Figure 18: PCS-86 Rear Panel Configuration

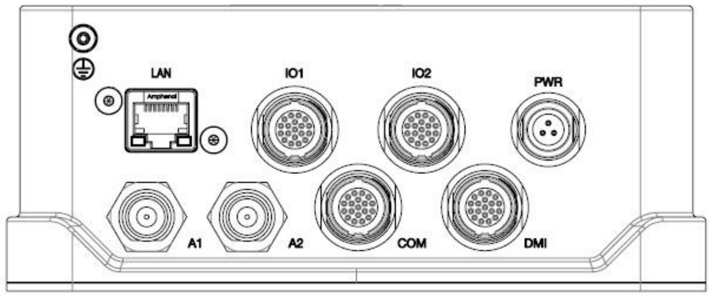


Figure 19: PCS-92 Rear Panel Configuration

Table 2: Connector and Port Summary

Connector	Port	Description
PWR		Connects to a dc customer source (see Power Requirements)
IMU		• RS-422 serial I/O data port • Supplies dc power to IMU
COM	COM (1)	RS-232 Serial I/O port (digital) with Tx/Rx/CTS/RTS
	COM (2)	RS-232 Serial I/O port (digital) with Tx/Rx/CTS/RTS
	PPS In	• Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirement • Only effective if external GNSS option is enabled through POSConfig
I/O 1	COM (3)	• RS-232/422 Serial I/O port (digital) with Tx/Rx only • Software control of 232 / 422 switch • Software switch to connect with Primary GNSS receiver COM 1 for software upgrade - contact Applanix Customer Support for details
	DIO - Event 1	• Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirement • Event 1 time tagging
	DIO - Event 2	• Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirement • Event 2 time tagging
	PPS Out	• One pulse per second for synchronization with GPS time • TTL signal level

Table 2: Connector and Port Summary

Connector	Port	Description
I/O 2	COM (4)	• RS-232/422 Serial I/O port (digital) with Tx/Rx only • Software control of 232 / 422 switch • Software switch to connect with Secondary GNSS receiver COM 1 for software upgrade - contact Applanix Customer Support for details
	DIO - Event 3	• Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirement • Event 3 time tagging
	DIO - Event 4	• Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirement • Event 4 time tagging
	PPS Out	• One pulse per second for synchronization with GPS time • TTL signal level
DMI		• Digital I/O port • Input 3 – 50 Vdc data from DMI • Output 12 Vdc to DMI, maximum 200 mA
Ethernet		• 10/100 Base-T • Communication between POS LV and LV-POSView
USB		• USB 2.0 Host • No functionality currently supported
ANT1		I/O TNC connector - supplies dc power and receives signal from primary GNSS antenna
ANT2		I/O TNC connector - supplies dc power and receives signal from secondary GNSS antenna

Power Connector

Table 3 and Figure 20 identify the pin assignments for the power connector.

Table 3: PWR Connector Pin Assignment

PIN	Pin Description
1	dc power source (see Power Requirements)
2	N/C
3	Return

POS LV Receptacle:
Lemo HES-1F-303-CLDP

3 pin male (shown)

Cable Plug:
Lemo FGS.1F.303.CLM

Figure 20: PWR Connector Pin Arrangement

IMU Connector

Do not disconnect the IMU cable while the PCS is powered-on. Damage to the IMU or the PCS hardware may result.

The IMU data/power interface is a **multi-pin female circular connector** on POS LV V5. PCS-92 has the IMU inside the PCS enclosure and therefore does not have an IMU connector.

Physical Interface

A proprietary shielded cable, supplied with the system, connects the IMU to the PCS. Ensure the cable is secure by locking the connector shell to the base.

COM Connector

There is one COM connector which supports a multi-connector breakout cable (COM cable) that provides access to two independent, 4 wire RS232 serial communication ports.

Table 6 and Figure 23 provide the pin assignment for the COM connector and pin mapping of the COM cable.

Table 4: COM Connector Pin Assignment

I/O Pin	Pin Description	I/O Cable Mapping		Signal Type	Signal Direction
		PIN	Connector		
1	COM 1 Rx	2	DE-9 (Male)	RS232	Input
3	COM 1 Tx	3		RS232	Output
4	COM 1 RTS	7		RS232	Output
2	COM 1 CTS	8		RS232	Input
10	Signal Ground	5		Common	Common
8	COM 2 Rx	2	DE-9 (Male)	RS232	Input
6	COM 2 Tx	3		RS232	Output
5	COM 2 RTS	7		RS232	Output
7	COM 2 CTS	8		RS232	Input
11	Signal Ground	5		Common	Common
9	PPS In	4		**see notes	Input
12	PPS In Return	12		Return	Input

** PPS In is an optically isolated digital input.
** The input (and return line) is not referenced and is independent of internal µPOS power supplies and GND.
** PPS input can be triggered from an external 3 – 50 Vdc source capable of supplying a minimum of 1 mA of sourcing or sinking current.

POS LV Receptacle:
Lemo HEN.2F.312.CLNP
12 pin female (shown)

Cable Plug:
Lemo FGN.2F.312.CLC

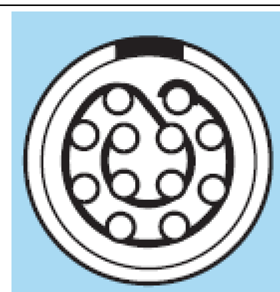


Figure 21: COM Connector Pin Arrangement

Physical Interface

To ensure data integrity, use high quality RS-232 cable with its shielding connected through the back shell to ground at both cable ends.

Interface Configuration

Table 5 identifies the possible configurations for the COM connector COM ports (default in bold).

Table 5: COM Connector COM Port Configuration

Setting	Value
Baud Rate	2400 to 115200 (**9600**)
Parity	**None**, Even, Odd
Data Bits	7, **8**
Stop Bits	**1**, 2
Flow Control	Hardware, Software, **None**

PPS Input

The PCS requires the one Pulse Per Second (PPS) signal for internal timing requirements. This signal is normally obtained from the primary GNSS receiver but may be from an external GNSS receiver. The PPS input signal is only effective if the external GNSS option is enabled through the POSConfig menu selection in LV-POSView (refer to the Manage Multiple POS LV Configurations Using LV-POSView description on page 8-19). Figure 22 provides a functional diagram.

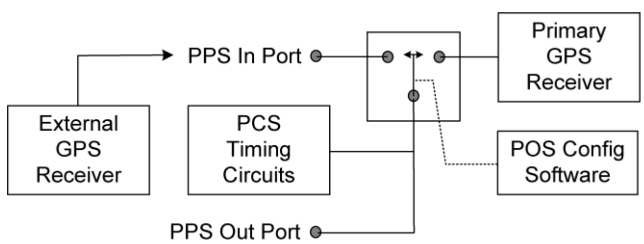


Figure 22: PPS Port Signal Sources - Functional Diagram

I/O Connector

There are two identical I/O connectors which support a multi-connector breakout cable (I/O cable) that permits access to the following signals:

- One 2-wire RS232/RS422 multi-function COM port
- Two Event input ports
- One output for the One Pulse Per Second (PPS) signal
- One Strobe output port

Table 6 and Figure 23 provide the pin assignment for the I/O connector and pin mapping of the I/O cable.

Table 6: I/O Connector Pin Assignment

I/O Pin	Pin Description	I/O Cable Mapping PIN	I/O Cable Mapping Connector	Signal Type	Signal Direction
3	COM 3(4) Rx+	1	DE-9 (Male)	RS422	Input
4	COM 3(4) Rx	2		RS232 / RS422	Input
2	COM 3(4) Tx	3		RS232 / RS422	Output
1	COM 3(4) Tx+	4		RS422	Output
15	Signal Ground	5		Common	Common
7	Strobe 1(2) Out	1	DE-9 (Female)	5V TTL	Output
16	Strobe 1(2) Out Return	5		5V TTL	Output
13	Event 1(3) In	2		**see notes	Input
11	Event 1(3) In Return	7		**see notes	Input
10	Event 2(4) In	3		**see notes	Input
9	Event 2(4) In Return	8		**see notes	Input
12	PPS Out	4		5V TTL	Output
14	PPS Return	9		5V TTL	Output
5, 6, 8, 17, 18, 19	Reserved			N/A	N/A

** All Event Inputs are optically isolated digital inputs.
** Inputs (and their return lines) are not referenced and are independent of internal µPOS power supplies and GND.
** Event inputs can be triggered from an external 3 – 50 Vdc source capable of supplying a minimum of 1 mA of sourcing or sinking current.

POS LV Receptacle:
Lemo HEP.2F.319.CLNP
19 pin female (shown)

Cable Plug:
Lemo FGP.2F.319.CLC

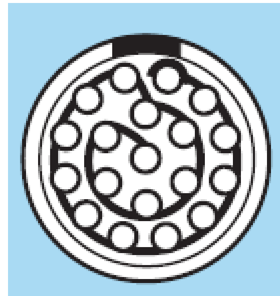


Figure 23: I/O Connector Pin Arrangement

COM Port Configuration

Table 7 identifies the possible configurations for the I/O connector COM ports (default in bold).

Table 7: I/O Connector COM Port Configuration

Setting	Value
Interface	**RS232**, RS422
Baud Rate	2400 to 115200 (**9600**)
Parity	**None**
Data Bits	**8**
Stop Bits	**1**
Flow Control	**None**

GNSS Access

The serial digital port for each GNSS receiver is accessible for upgrading the receiver through the I/O COM ports. Access to the GNSS serial port is under software control in the same way that other functions are assigned to COM ports.

Event Interface

Two independently isolated event inputs are available on each IO cable. Digital pulses in the range of 3 to 50 Vdc will trigger the event time tagging.

Refer to the Event Tagging description on page 1-9 for a detailed description.

Examples of possible configurations of Event inputs are shown in Figure 24.

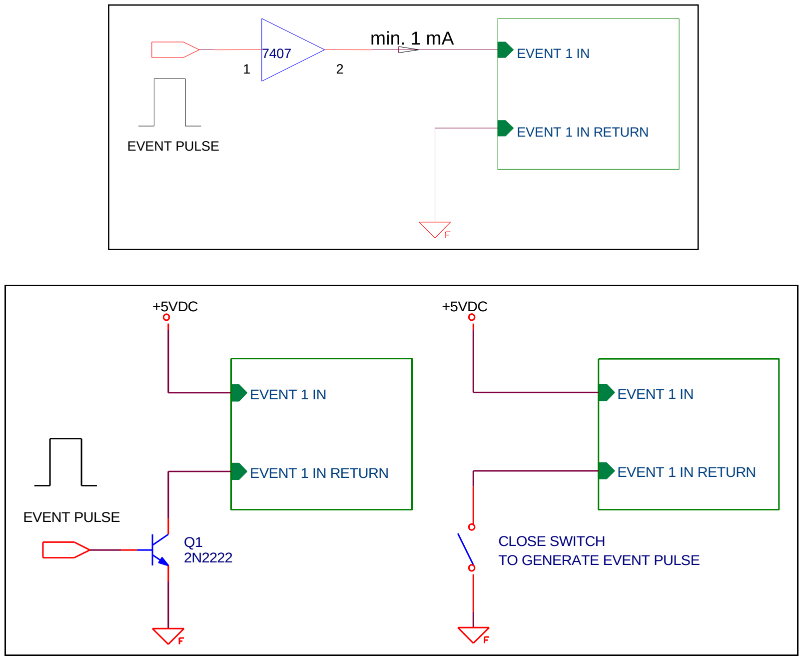


Figure 24: Sample Event Input Circuit Configurations

PPS Output

The PCS uses the one Pulse Per Second (PPS) signal from a GNSS receiver for internal timing requirements. A user customizable version of this signal is provided on the connector to allow external equipment to be synchronized with POS LV. A dialog in LV-POSView allows control of the polarity and pulse width of the PPS output signal.

⚠ **The PPS output port is an active circuit. Ensure that an 'input signal' is NOT connected to the PPS output port, otherwise damage may result.**

The 1PPS signal is a TTL level strobe that occurs at a 1 Hz rate. The leading edge of the strobe is coincident with the exact GPS second. The corresponding time message that specifies the UTC time of the 1PPS is available in multiple formats from any COM port by selecting the desired configuration through LV POSView. Refer to the GPS Timing Basics description starting on page J-2.

Ethernet Connector

A 10/100 Base-T Ethernet interface provides communication between the PCS and other PCs for monitoring or controlling the system. The Ethernet port can also be used to transmit POS LV data to a host PC for real-time processing or for data logging and subsequent post-processing. The Ethernet port supports both Transmission Control Protocol/Internet Protocol (TCP/IP) and Universal Datagram Protocol (UDP).

Physical Interface

An Ethernet cable is supplied with the POS LV system: a shielded straight through cable. The Ethernet interface on the PCS is auto detecting so a cross-over cable is not required. The cable is terminated with shielded RJ-45 connectors. Ensure that replacement cables meet the RJ-45 Cat5 standard, or better (i.e. Cat6, Cat6e), to avoid an impedance mismatch inside the PCS; refer to the Liability and Safety Information located in the manual front matter. In addition, the maximum cable length is determined by the Ethernet specification. Table 6 provides connector pin assignments and mapping.

The Ethernet interface provides a means for configuring and monitoring the POS LV and conforms to the Institute of Electrical and Electronics Engineers (IEEE) standard 802.3 that comprise the following types of ports:

- One control port - TCP/IP transmits configuration information to POS LV and operates in conjunction with the Display port described below
- One display port - UDP provides data at a 1 Hz rate for use by LV-POSView software
- Two data ports - TCP/IP provides the same data as the Display port, at rates up to 200 Hz - (asynchronous events at higher rates)

Note: Data output from the display port (above) is broadcast using UDP protocol and may be captured by any host on the physical Ethernet network (regardless of the IP address of the host).

Note: Network routers typically block UDP protocol data transmissions. In addition, other couplers can only receive UDP data if they are in the same subnet (i.e. class B or class C). The subnet class (B or C) is determined by the choice of Ethernet address.

Output Data Format

The data available on the Ethernet connection (for both Display and Data ports) is organized into a group and message structure. Each port is configured independently in terms of the groups that are output and only those groups selected for a port are output on that port.

Refer to the Data Logging - Ethernet description on page 12-5 for information on selecting data groups for output. Please refer to Applanix document *PUBS-ICD-003759* if the data are used with software other than LV-POSView.

Input Data Format

The data input to the POS LV on the control port is organized into a message structure. Refer to Applanix document *PUBS-ICD-003759* if control commands will be generated by software other than LV-POSView.

USB Connector

A USB A type connector is located on the rear of the PCS. This Host port supports the USB 2.0 standard and is intended for external sensor connections, however, at this time none are supported. PCS-92 does not have a USB connector.

DMI Connector

Two DMI digital ports are provided as interfaces for DMI sensors. DMI encoder information is used by the POS LV as another independent sensor to combine with the inertial and GNSS data to obtain the best possible navigation solution. It is of particular benefit in the absence of GNSS signals. Presently Only DMI 1 data is used in the real time navigation solution. The DMI 2 interface is provided for the time-tagging of additional wheel encoder data only.

Physical Interface

Ensure that the connectors at the cable ends are grounded through the respective connector housings. Table 8 and Figure 25 provide a connector pin assignment.

Table 8: DMI Connector Pin Assignment

PIN	Pin Description	Signal Type	Signal Direction
1	DMI 1 Input 1	3 – 50 V digital	Input
2	DMI 1 Input 1 Return		
3	DMI 1 Input 2	3 – 50 V digital	Input
4	DMI 1 Input 2 Return		
5	DMI 2 Input 1	3 – 50 V digital	Input
6	DMI 2 Input 1 Return		
7	DMI 2 Input 2	3 – 50 V digital	Input
8	DMI 2 Input 2 Return		
9	+12 V Power (200 mA max.)	Isolated supply	Power output
10	Power Ground		
11	Power Ground	Isolated supply	Power output
12	+12 V Power (200 mA max.)		

POS LV Receptacle:
Lemo HEP.2F.312.CLNP
12 pin female (shown)

Cable Plug:
Lemo FGP.2F.312.CLC

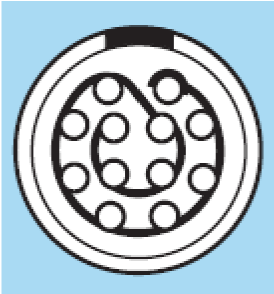


Figure 25: DMI Connector Pin Arrangement

Input Data Format

Two types of DMI encoders are available: pulse and direction, and quadrature. The PCS requires two signals from either of these encoders: a distance discrete and a direction discrete or two phases of a quadrature signal; refer to Table 9.

Table 9: DMI Input Data Format

Signal	Pulse and Direction	Quadrature
Input 1	Distance Pulses	Phase B
Input 2	Direction	Phase A

Both inputs accept signals in the 3 to 50 V input range and will draw a maximum of 10 mA current without the need for external current limiting resistors. Pulses must have a width >1 μs and a maximum rate of up to 500,000 pulses per second. Pulses are generated in both the forward and reverse directions of travel and each pulse represents an incremental rotation of the DMI Instrumented Wheel.

Pulse and Direction DMI

The default configuration for the direction signal is +5 Vdc (HIGH) when the vehicle is moving forward and 0 Vdc (LOW) when the vehicle is moving backward; this statement is true when the DMI is mounted on the drivers, left-side vehicle wheel. The default configuration may be changed in the LV-POSView software. Refer to the following descriptions for more information: the DMI Scale Factor Calculation on page 4-8, the Scale Factor Correction Pane on page 8-15 and the POS LV V5 DMI Sensor Interface Requirements on page I-1.

Quadrature DMI

Both DMI inputs, Phase A and Phase B, are pulse trains of approximately 50% duty cycle. Phase A measures the distance travelled. When the DMI is mounted on the left side of the vehicle, Phase B indicates forward movement by lagging Phase A, and backwards movement by leading Phase A. The reverse is true if the DMI is mounted on the right side. Refer to page 4-8 for the DMI scale factor calculation and page 8-15 for the scale factor correction input screen. Refer to page I-1 for the POS LV V5 DMI Sensor Interface Requirements.

ANT1 and ANT2 Connectors

Signals from the GNSS antennas are coupled to the GNSS receiver using the ANT1 (primary GNSS) and ANT2 (secondary GNSS) ports located on the rear panel of the PCS.

Physical Interface

The operating dc voltage for each antenna is coupled through the centre conductor of each cable and is supplied by the PCS; GNSS signals are routed through the same conductor to the receiver. If it is necessary to replace an antenna cable and RG-303 (50 ohm) coaxial cable is not available, RG-400 (50 ohm) may be used as an alternate. Both the GNSS antennas and the PCS ANT1 and ANT2 ports are female TNC connectors.

Refer to the Hardware Installation description on page 3-1 for the GNSS antenna installation and cable routing procedures.

SECTION 2

SOFTWARE INSTALLATION AND OPERATION

6.0 Install LV-POSView

LV-POSView System Requirements

The Personal Computer (PC) that LV-POSView is installed on must meet or exceed the hardware and software requirements outlined in Table 10.

Table 10: PC Configuration Requirements

Item	Minimum Requirements	Recording Directly to Hard Disk (via data port)
Processor	Intel Pentium® series or equivalent	Intel Pentium® series or equivalent
Speed	800 MHz	800 MHz
Memory	256 MB RAM	256 MB RAM
Operating System	Windows 7.1 SP1, Windows 7 Embedded, Windows 8, and Windows 10	Windows 7.1 SP1, Windows 7 Embedded, Windows 8, and Windows 10
Free Disk Space	2 GB	20 GB
Ethernet Card	10/100 Base-T Ethernet; IEEE 802.3 Standard	100 Base-T Ethernet; IEEE 802.3 Standard

Install LV-POSView

Windows® includes drivers for Ethernet support. Ensure that the Ethernet connection is working properly before proceeding.

The POS LV Installation Compact Disk (CD), supplied with POS LV system, contains the LV-POSView software. LV-POSView must be installed on a hard disk prior to use; it cannot be run from the Installation CD.

Installation

1. Insert LV-POSView Installation CD into CD drive of PC.
2. If set-up program starts, go to step 7.
3. If set-up program does not start, proceed to next step.
4. Select **Run** from **Start** menu.
5. Click **Browse** button and locate *set-up.exe* file on CD drive.
6. Click **OK** button or press **Enter** key.

7. Set-up program will guide you through install process. Follow all screen instructions. Use **Next>** button to continue from a screen or **<Back** button to go back to a previous screen and make changes.

Start LV-POSView

Double click the **LV-POSView** screen icon or select **Start, Programs, Applanix, LV-POSView** on the **Start** menu. Before using the POS LV system, ensure that the previously measured installation parameters, outlined under the Installation Parameters heading on page 4-1, are entered in LV-POSView program. Refer to chapters 7.0 and 8.0 for information on how to configure and use LV-POSView with the POS LV system.

Un-install LV-POSView

Select **Start, Control Panel, Settings, Add/Remove Programs** on the **Start** menu to un-install LV-POSView from the computer.

7.0 Configure POS LV Using LV-POSView

Configure POS LV

Prior to first time operation of the POS LV system, network configuration of the POS Computer System (PCS) and the installation of LV-POSView software are required.

Power-Up

Power-up the POS LV system by pressing the Power switch on the PCS front panel, refer Figure 26. The light, incorporated into the Power switch, illuminates when the PCS is operating. For PCS-92 applying power to the rear power connector will cause POS LV to automatically power-up.

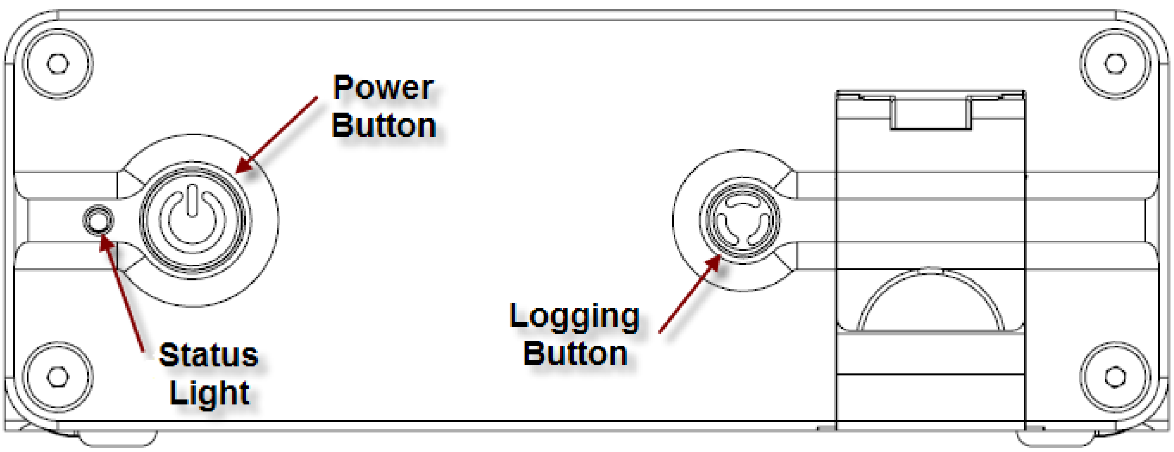


Figure 26: PCS Front Panel

Table 11 identifies the functions and status of the various PCS front panel lights.

Table 11: PCS Front Panel Lights

Status light - indicates current status of POS LV:	
Steady red:	POS LV failure - shows red when PCS is first powered-on. Changes to a valid condition when PCS internal program begins to run, but will turn red again if there is a fault in PCS. If a fault occurs, do not power-off PCS. Refer to **Fault Detection** window of controller program, see Data Integrity topic starting on page 11-1.
Steady amber:	Standby mode - POS LV is waiting for instructions.
Flashing amber:	Navigate mode - initialising and aligning attitude (coarse levelling).

Flashing green:	Navigate mode - degraded attitude performance. Attitude measurements are acceptable but do not meet user-set accuracy limits.
Steady green:	Navigate mode - normal system operation. System meets accuracy limits set by user for position, velocity, attitude and heading.
Logging light - indicates status of logging device, typically the removable device but the internal device for PCS-92.	
Steady green:	Removable logging device is active and recording data.
Steady amber:	Logging media is > 80% full.
Steady red:	Logging has failed – check that there is a USB flash drive in the logging bay and that the device is not full.
Power light - illuminates when the PCS is operating.	

Start LV-POSView

Double click the **LV-POSView** screen icon or select **Start, Programs, Applanix, LV-POSView** on the **Start** menu.

Change System IP Address

The PCS ships with a default Internet Protocol (IP) address of **192.168.53.100** (with a subnet mask of 255.255.255.0). Initially, to communicate with the PCS, the controlling Personal Computer (PC) IP address must be set to a unique address in the same subnet. Applanix recommends **192.168.53.1** as the unique address within the subnet, although any unique address (i.e. 192.168.xxx.xxx) may be used for the PC.

The PCS IP address and subnet mask may be changed to any value that suits the user's network and follows IP standards, except for addresses in the 155.155.xxx.xxx range.

To configure LV-POSView to operate with the network, refer to Figure 27:

1. Double-click LV-POSView screen icon.
2. On LV-POSView tool bar, ensure that PCS IP address (**192.168.53.100**) is selected.
3. On LV-POSView tool bar, click **Connect** icon or select **Tools, Connect**. LV-POSView connects to PCS and **Connected** is displayed on bottom status area.
4. On LV-POSView tool bar, select **Settings, Installation, POS IP Address**; POS Internet Address screen opens, see Figure 27.
5. Enter new IP address (one that is valid for your subnet), click **Apply** button (address takes effect immediately).

6. PCS disconnects, **Waiting** or **Monitor** is displayed in bottom status area of POSView.
7. Exit LV-POSView.
8. Restore PC's original IP address.

The PCS address is now set to match the local subnet and the PC's IP address is returned to its original setting.

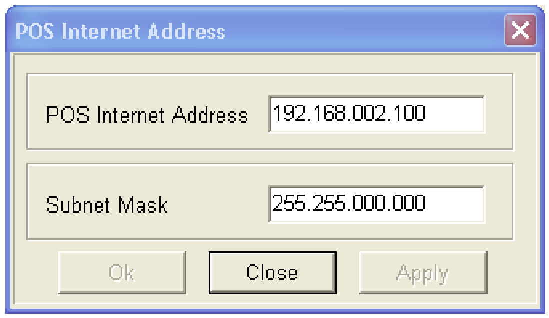


Figure 27: PCS IP Address Assignment Screen

The subnet must be chosen carefully if UDP unicast is selected as the network protocol for real-time data output (section 12-6). The user specified UDP unicast IP address must be within the same subnet as the POS IP address in order for network communication to be functional. If the UDP unicast IP address is outside the subnet, there will be no real-time output on the port that has UDP unicast selected.

A good rule of thumb is to keep the first three values of the POS and UDP unicast addresses the same unless you must set a custom subnet.

Connect to POS LV

To connect to the POS LV once the PCS and PC IP addresses are configured, perform one of the following:

- On the LV-POSView tool bar, select **Tools, Connect**
- On the LV-POSView tool bar, click the **Connect** icon

The LV-POSView program connects to the PCS and **Connected** is displayed in the bottom status area. In addition, the program screen provides status information that is updated once per second.

LV-POSView Modes of Operation

LV-POSView operates in one of two modes: **Monitor** or **Connected** (Control).

- **Monitor** mode: LV-POSView displays[1] all data that the POS LV outputs over the Ethernet display port, but changes are not permitted to the POS settings. This mode allows several users to monitor the POS data at the same time.
- **Connected** mode: POS LV settings can be changed and saved as required.

To toggle LV-POSView's mode of operation, select either the **Tools** menu bar or the appropriate tool bar icon.

[1] Only one PC or laptop running LV-POSView can be in the Control mode over a particular POS LV unit at any time. Only the data groups currently available on the display port can be monitored.

LV-POSView Main Screen Functions

Users can monitor or control the POS LV activities from the LV-POSView main screen, see Figure 28.

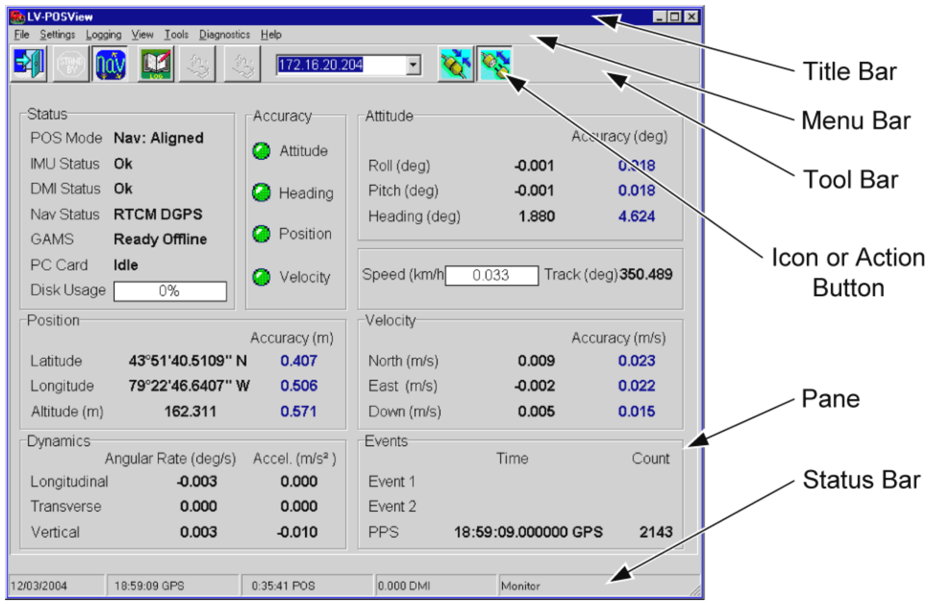


Figure 28: LV-POSView Main Screen

Tool Bar

The tool bar located near the top of the main screen, see Figure 29, permits quick access to commonly used features. From left to right:

- Exit button
- Standby button
- Navigate button
- Log button
- Base GNSS 1 modem
- Base GNSS 2 modem
- POS LV IP address field
- Connect button
- Monitor button

Figure 29: LV-POSView Tool Bar

Status Pane

The **Status** pane shown in Figure 30 displays information about the operational status of the major POS LV components. For a complete list of the possible status display messages, refer to the LV-POSView Status Pane Messages description on page D-1.

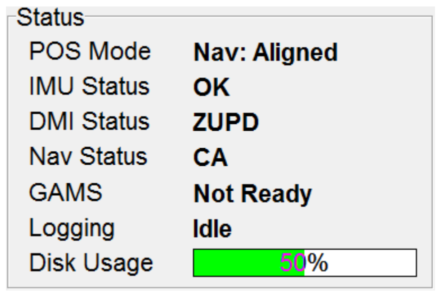


Figure 30: LV-POSView Status Pane

The following provides a brief description of the status elements:

- **POS Mode**: After a transition to navigate mode, the normal message sequence is from *Levelling Active* to *Nav: Degraded* to *Nav: Aligned* to *Nav: Full*.
- **IMU Status**: The IMU status indicates *OK***,** *Warning* or *Failure*. If the IMU status is not *OK,* it is recommended to immediately power-off the POS LV and arrange an examination of the IMU cable and cable connections.
- **DMI Status**: The DMI status indicates *OK, Offline,* and *ZUPD*.
- **Nav Status**: After power-up, the Navigator requires some time to initialize and align. During this initialization period, the Nav Status indicator displays *DR* or *GNSS Nav*. Afterwards, the indicator displays *CA, DGPS* or *RTK*, depending if differential corrections are used.
- **GAMS**: The GNSS Azimuth Measurement Subsystem (GAMS) displays the status of the GAMS.
- **Logging**: This displays the status of the primary logging device, either removable media (default) or internal drive (if PIL option enabled).
- **Disk Usage**: The bar indicates the percentage used (filled) of the removable media in the data logging drive.

Position, Dynamics, Attitude and Velocity Panels

The Position, Dynamics, Attitude and Velocity displays present sensor-derived orientation/motion data in three dimensions. The accuracy estimates for many of the values are displayed with their units; see Figure 31 for an example. The accuracies reflect confidence boundaries on the displayed parameters that vary based on the performance level of the POS LV system, the number of GNSS satellites tracked and whether or not GNSS differential corrections are received.

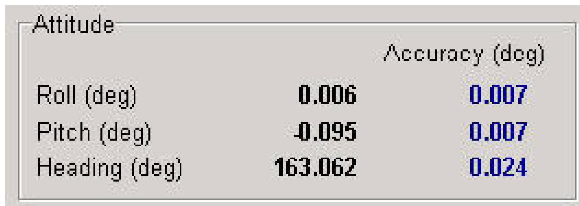


Figure 31: LV-POSView Attitude Pane

Accuracy Pane

The four indicators in the **Accuracy** pane are triggered on user-defined values. Below a user-defined threshold the indicator shows red, above the threshold the indicator shows green. The indicators provide a visual indication of an acceptable user-defined performance level. The threshold settings do not affect POS LV performance. Threshold levels are set by selecting **Settings, Installation, User Accuracy** from the LV-POSView menu bar, see Figure 32.

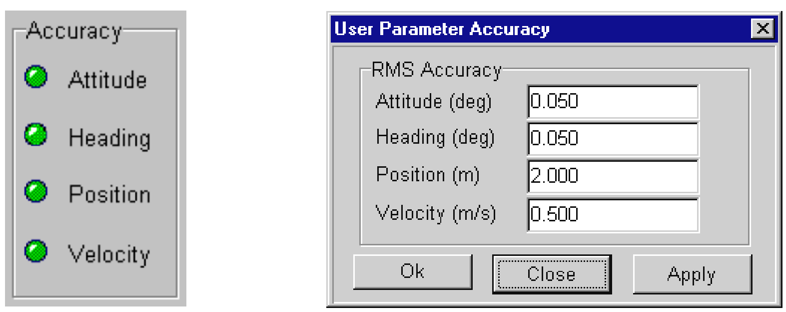


Figure 32: Accuracy Pane and User Parameter Accuracy Screen

Events Pane

The **Events** pane, see Figure 33, displays the Universal Time Coordinate (UTC) time of the most recent signals (known as events) from sources external to the Position and Orientation System (POS) system. In addition, the Pulse Per Second (PPS) displays the GPS time (in the **Time** field) of the most recent PPS pulse transmitted by the primary GNSS receiver. The **Count** field for PPS indicates the total number of signals recorded from the GNSS receiver, while the **Count** fields for Events 1 and 2 indicate the number of event pulses recorded. The PPS **Count** field increments once per second.

Figure 33: LV-POSView Events Pane

All event inputs can be seen by selecting **View, Event Data …** from the LV-POSView menu bar.

Speed Pane

Figure 34, **Speed** pane, shows the current speed in kilometres per hour and the direction of the velocity vector (Track) in degrees. When the vehicle is travelling in the forward direction, the direction should be similar to the Heading displayed in the **Attitude** pane.

Figure 34: LV-POSView Speed Pane

Status Bar

The status bar is located at the bottom of the LV-POSView screen, see Figure 35. The current date, TIME1 time tag (default GPS time), TIME2 time tag (default POS time), DMI distance tag (default DMI distance) indicating distance travelled in metres and the LV-POSView program connection status are shown.

Figure 35: LV-POSView Status Bar

Command Reply Screen

This screen provides the status of the POS LV messages and is useful for system debugging, see Figure 36. To view the **Command Reply** screen select **View, Command Reply** from the LV-POSView menu bar.

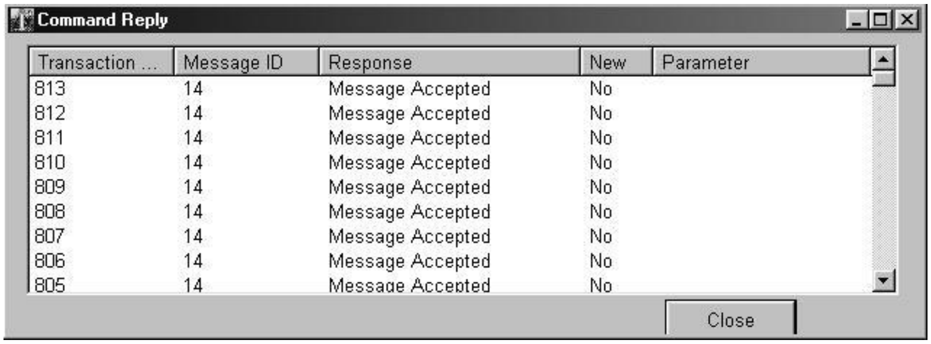


Figure 36: LV-POSView Command Reply Screen

8.0 POS LV Installation Parameter Set-up

POS LV system installation parameter set-up is performed using the LV-POSView software. Refer to the Configure POS LV Using LV-POSView description on page 7-1 for powering up the POS LV and starting the LV-POSView application. A description of the LV-POSView menu and tool bar functions, shown in Figure 37, is located in LV-POSView Main Screen Functions on page 7-5.

Figure 37: LV-POSView Title, Menu and Tool Bars

Input/Output Ports Set-up

The **Input/Output Ports Set-up** screen shown in Figure 38 is accessed from the LV-POSView menu bar by selecting **Settings, Input/Output Ports**. Configuration of each of the five serial COM ports and Ethernet input is performed on the screen tabs. The following lists the configuration choices:

- Selecting the input and output functionality for each port
- Setting the update rate for selected output data formats
- Setting the baud rate for the ports
- Setting the protocol and flow control for COM 1 and 2
- Selecting RS232 or RS422 interface for COM 3 and 4

COM Port Set-up

Select a tab for the COM port to be configured. All COM ports allow selection of **Baud Rate**. COM 1 and 2 allow selection of **Parity**, **Data Bits**, **Stop Bits** and **Flow Control** (Figure 38). COM 3 and 4 allow selection of the physical **Interface** (Figure 39). Settings that are not available on a particular COM port tab will be hidden or dim and not selectable.

Any input or output can be selected from the drop down menus for a given COM port (click on the down arrow). A context sensitive pane will appear once an input or output selection has been made, as described in the following sections.

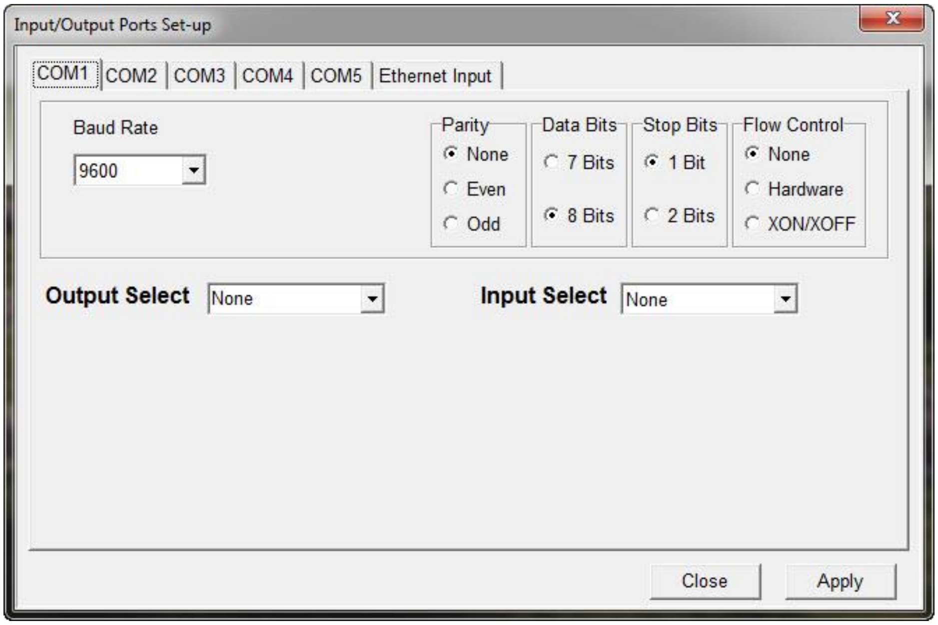


Figure 38: Input/Output Ports Set-up – COM1

Some interfaces require bi-directional communications, in which case a selection in either the Input or Output menu will result in the automatic assignment of the corresponding Output or Input for that COM port. For interfaces that require only uni-directional communications it is possible to assign an input and an output simultaneously on a COM port, but a ‘Y’ cable is required to split the transmit (Tx) and receive (Rx) lines to the two separate devices. A ‘Y’ cable is not included as part of the system.

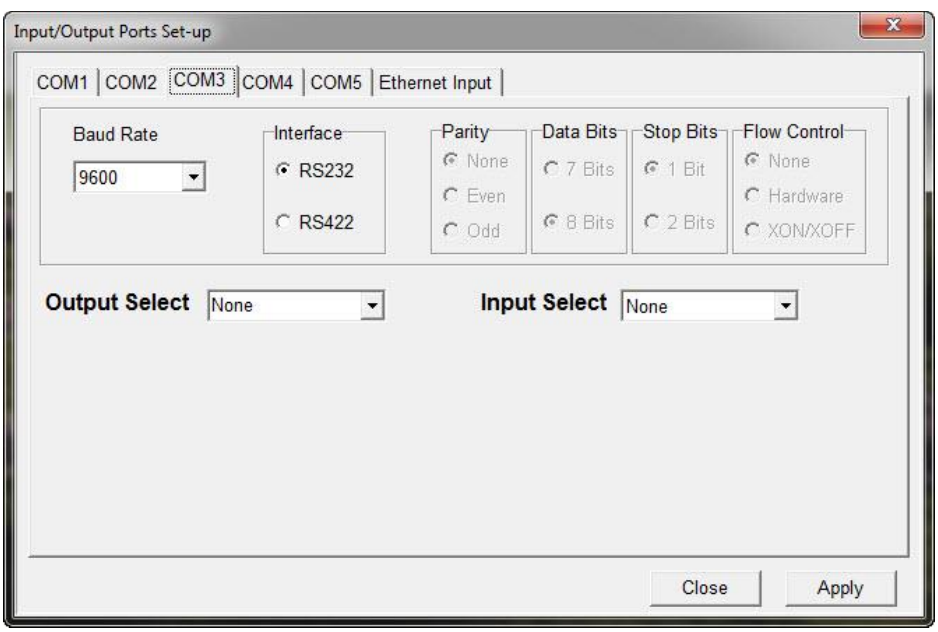


Figure 39: Input/Output Ports Set-up – COM3

To accept the screen parameters, click the **Apply** button. To abort any changes or to close the screen, click the **Close** button.

NMEA Output Data Format

The POS Computer System (PCS) outputs data on the selected COM port using the NMEA standard 0183 format. The supported NMEA message formats are listed in Table 12. POS LV has several different sentence formats available for output to third party equipment. Any or all of the sentences are available for output. Refer to the NMEA and Binary Message Formats starting on page F-1 for a description of the message sentences. In the **NMEA** pane, select values for the **Update Rate** and **Talker ID** for the NMEA output message (Figure 40).

Table 12: NMEA Output Messages

Message	Output
GST	Pseudo-range measurement noise statistics
GGA	Position
HDT	Heading
ZDA	Timing and date
$EVT1	Timed event #1 *
$EVT2	Timed event #2 *
VTG	Track and speed
PASHR	Attitude
GGA2	Position data, with GNSS fix, geoidal separation
PPS	PPS, UTC time, PPS time recovery
GGK	GNSS Fix
RMC	NMEA Recommended Minimum Specific Navigation Data

***** Not a NMEA 0183 message, but is compatible with the standard.

Note: Commas separate all fields and in instances where values have no set maximum, the value is listed as No Range Given (NRG). All real-time position and orientation message strings output to a selected port are with respect to the Reference Body Frame.

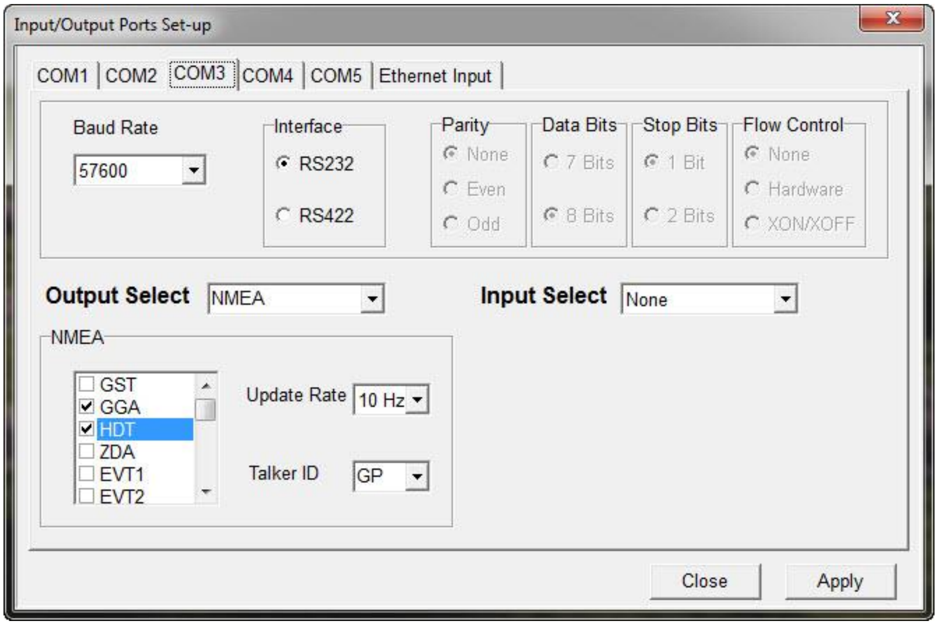


Figure 40: Input/Output Ports Set-up - NMEA Output

Binary Output Data Format

The PCS outputs real-time binary data on the selected COM port in any of several predefined formats. The format is selected from the Formula Select menu and the output frequency is set by selecting a value for the **Update Rate** field (Figure 41). The available message strings are listed in Table 13, and their formats are described in Appendix E - NMEA and Binary Message Formats starting on page F-1.

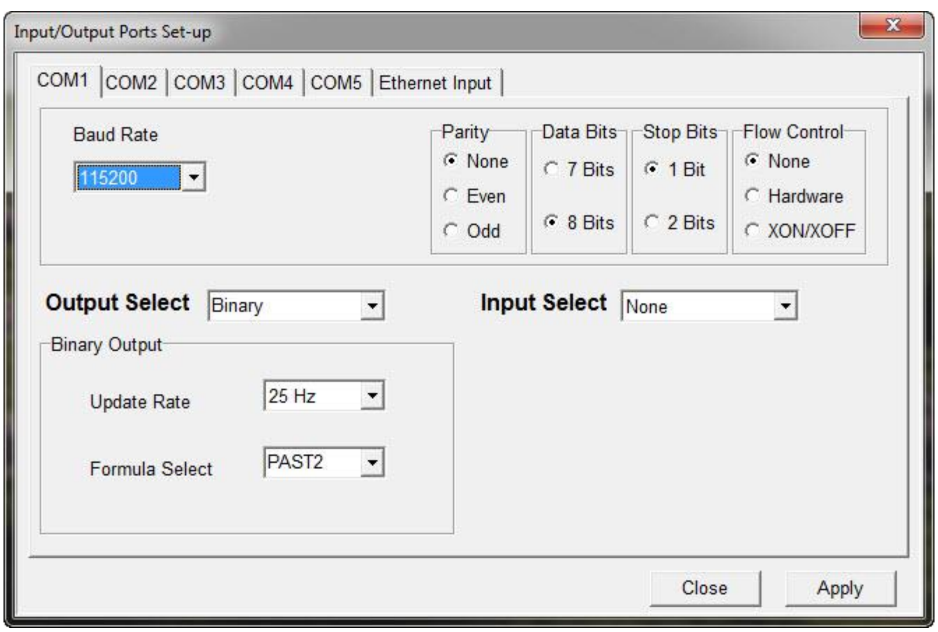


Figure 41: Input/Output Ports Set-up - Binary Output

Table 13: Binary Output Messages

Message	Output
0 None	No selection
RDR1	Position and Orientation for Land Radar Applications
PAST2	Position, Attitude, Speed, Track, Acceleration of Reference Frame; contains checksum
PPS	PPS – time, week, UTC offset
TM1B	PPS – week, seconds of week, UTC offset

Note: Only one message can be output at a time. All real-time position and orientation message strings output to a selected port are with respect to the Reference Body Frame.

Base 1/2 GNSS Output Data Format

The PCS outputs Base station data on the selected COM port when selected on the **Input/Output Ports Set-up** screen. This output feature is used to output a copy of all the data that appears on the corresponding Base 1/2 GNSS Input Port (described in the following text). This feature is useful where the real-time GNSS correction data are required by another external device. Note that this does not utilize the internal GNSS to generate base station data.

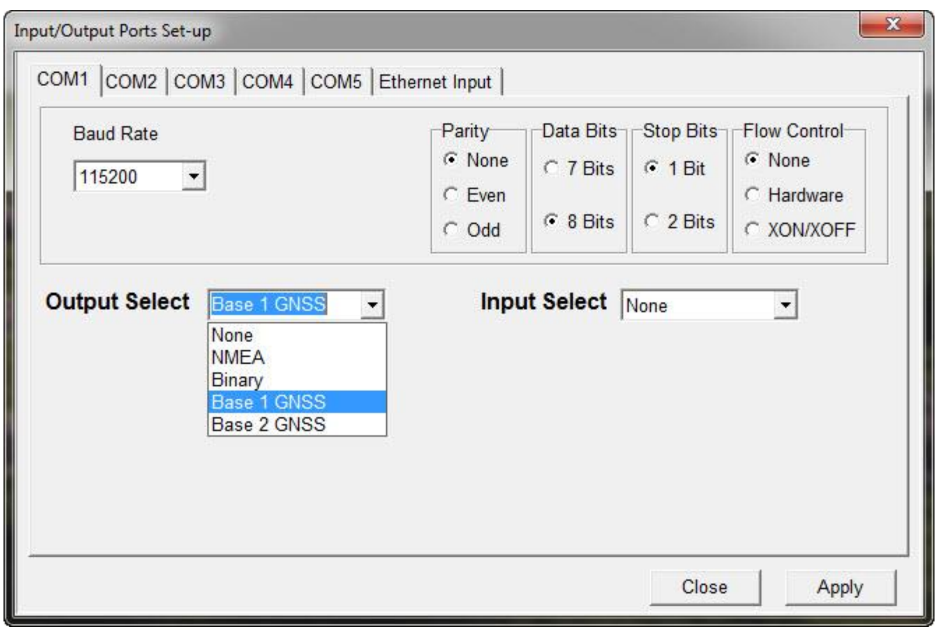


Figure 42: Input/Output Ports Set-up - Base 1 GNSS Output

Base 1/2 GNSS Input Data Format

The PCS accepts DGPS and RTK type differential correction inputs from up to two different GNSS Base Stations. Thus, a redundant communications link is provided. The PCS accepts the following messages:

- RCTM messages 1 and 9 to support DGPS operation
- RTCM messages 18 and 19
- CMR and CMR+ messages 0, 1, 2 and 94 to support RTK operation
- RTCM v3.x messages 20, 21, 23, 24 and 59 to support RTK operation

Note that the same message cannot be selected as input for both Base 1/2. If both inputs are available the PCS will use the higher quality corrections for navigation processing, but will automatically switch to the other Base input during outages or failure in the preferred source.

Base GNSS input can be configured for one of the COM ports or over Ethernet. The Ethernet connection can be used to feed only one Base GNSS input, but the second Base GNSS input may still be assigned to a COM port.

COM Port Input

Configure the input from the **Base GPS Input** pane by selecting the appropriate settings for the **Input Type** and **Line**. The **Line** pane is used to select the transmission medium of the input (Figure 43). For the RTCM 1 or 9 selection it is also necessary to select the appropriate **Datum** for the corrections, either WGS84 or NAD83 (Figure 44).

The transmission medium, over which the PCS can accept a variety of real-time GPS differential correction input messages, can be selected as **Serial** or **Modem**. This is incorporated to support the various radio modems and cell phone technologies available to transmit real-time GPS correction data.

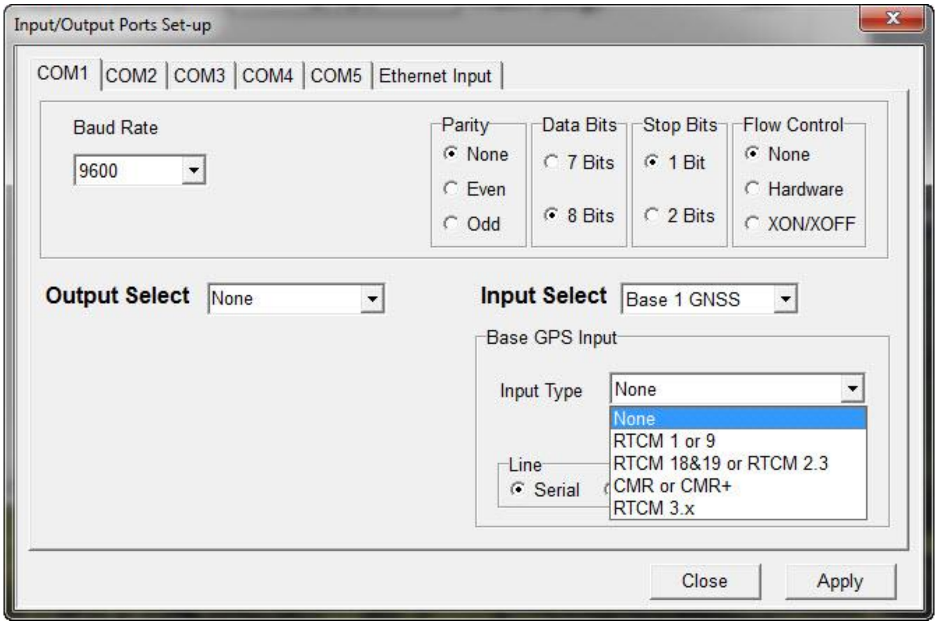


Figure 43: Input/Output Ports Set-up - Base 1 GNSS Input (Serial)

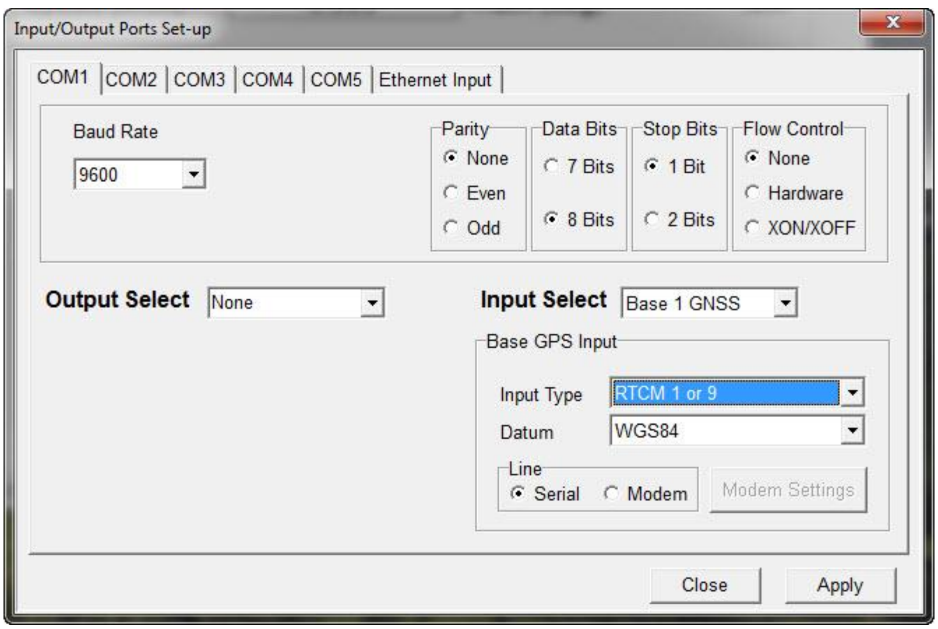


Figure 44: Input/Output Ports Set-up - Base 2 GNSS Input (Serial)

SERIAL INPUT SET-UP

Select the **Serial** option button located in the **Line** pane; see Figure 43 or 44. Selecting the serial input option permits the direct serial connection of a user supplied radio modem to the PCS. The radio modem must be properly configured to receive data before connecting it to the PCS.

MODEM INPUT SET-UP

Selecting the **Modem** option button in the **Line** pane of the **POS Port Configuration** screen enables the **Modem Settings** button; see Figure 45. Selecting the **Modem Settings** button displays the Modem Settings screen, which permits the connection of a Hayes compatible cell phone to the PCS.

The **Initialization String** field (**Modem Settings** screen) contains initialization parameters that are required to enable the modem when the option is selected from the **POS Port Configuration** screen.

The user must supply a valid telephone number, and values for maximum redial attempts and maximum data timeout. The maximum allowable redial attempts and data timeouts are typically restricted by the service provider or by the cell phone configuration. Some experimentation may be required to arrive at the correct settings.

Three modes of operation are selectable from the **Mode** pane:

- **Auto** option button - when selected along with the **Connect** option in the **Action** pane, the PCS initiates a phone call using the specified phone number. If the call succeeds, a connection is established. If the call fails, the PCS waits for a period of time (determined by the **Max. Data Timeout** field) before redialling. This process continues until a connection is established or the **Max. Redial Attempts** count is reached. The mode may be changed at any time or a hang-up action may be selected to terminate the call or dialling process. If the cell phone drops a connection, the automatic dialling sequence restarts to re-establish the connection. Click the **OK** command button to update the parameters.
- **Manual** option button - the user manually chooses when to connect or to hang-up. Redial and timeout is not in effect.

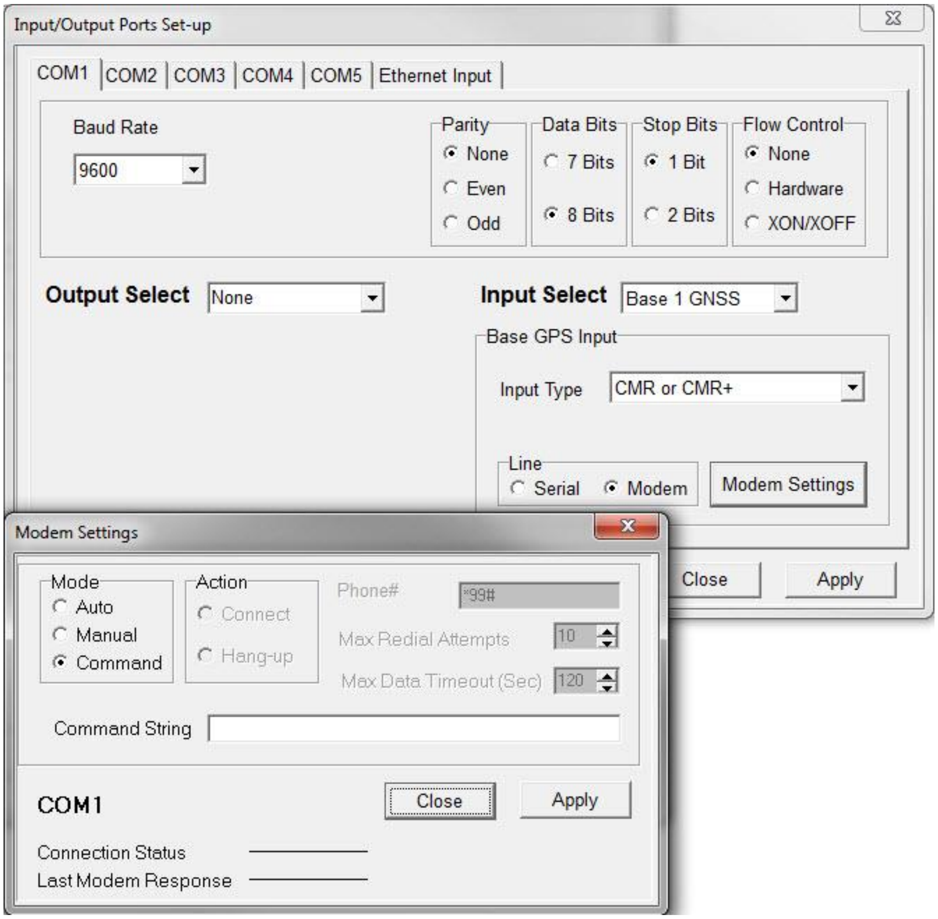


Figure 45: Input/Output Ports Set-up - Modem Settings

- **Command** option button: Uses the **Command String** field. This mode is useful for configuring the modem or for debugging modem problems. All dialup and hang-up commands must be entered manually.

  Use the Apply command button to prevent the screen from being dismissed.

Ethernet Input

The Ethernet Input tab on the Input/Output Ports Setup window is similar to the COM port setup except that only Base 1 & 2 inputs are available, and of course Ethernet parameters must be specified instead of COM port parameters as shown in Figure 46. A valid Internet Address, Port number must be entered and a Protocol selected or the Ethernet connection will not be established.

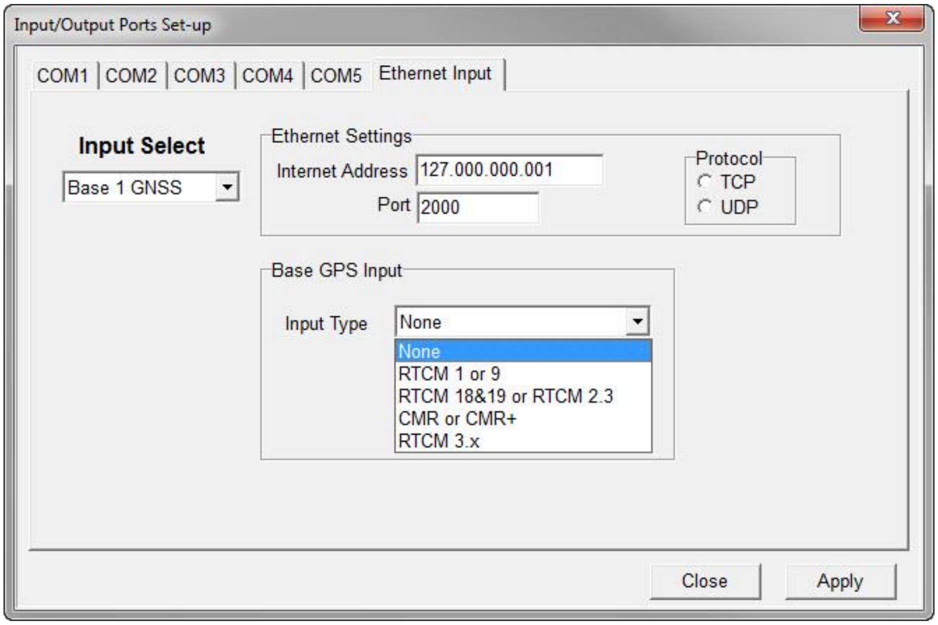


Figure 46: Input/Output Ports Set-up – Ethernet Input Settings

Corrections over NTRIP client

Differential corrections can also be received through the NTRIP client built into POSView. One must have access to an NTRIP server, or subscribe to a service that provides access to NTRIP server, in order to get differential corrections. To access the NTRIP client select **Tools** and then **NTRIP client**.

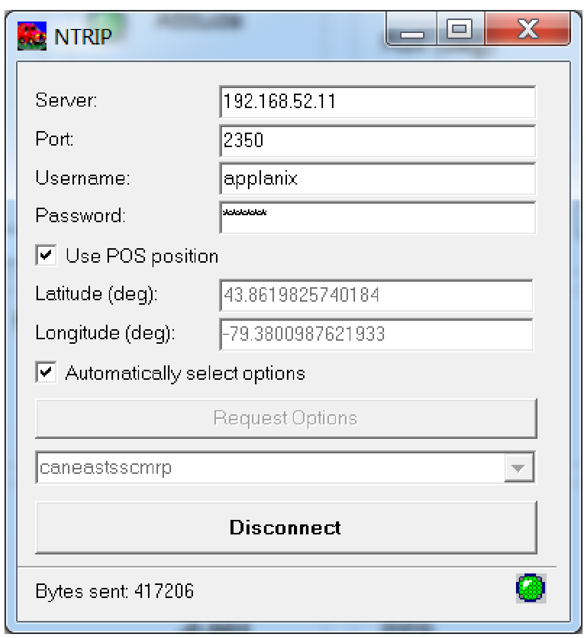


Figure 47: NTRIP Client User Interface

Enter the address information for **Server**, as well as **Port** and login credentials. The “User POS Position” option can be used if the NTRIP service requires GGA input to generate VBS near the position of the vehicle. If “User POS Position” is not selected – user can enter the position manually.

“Automatically select options” picks the first available corrections stream from the NTRIP service. To manually select a desired stream, deselect **“Automatically select options”** and then click **“Request Options”**. If the server credentials entered are correct, then a list of all available streams from the caster are displayed in the drop down menu below the **“Request Options”** button. Select the desired corrections stream and then hit the **“Connect”** button. The LED on the bottom right of the window indicate if the POS receives and decodes the corrections.

Aux 1/2 GNSS Input Data Format

The PCS inputs data on the selected COM port from an auxiliary GNSS receiver if the Aux1/2 GNSS is selected as input (Figure 48 and Figure 49). The auxiliary GNSS receiver must be configured to output specific NMEA strings (GGA, GST, GSV, GSA) on its COM port prior to connecting it to the PCS. If the auxiliary 1 or 2 GNSS inputs provide more accurate position information than the primary GNSS receiver, then the PCS will use the best auxiliary GNSS information. Note that the PCS still relies on the internal primary GNSS for timing information, therefore the system cannot run with only Aux GNSS input.

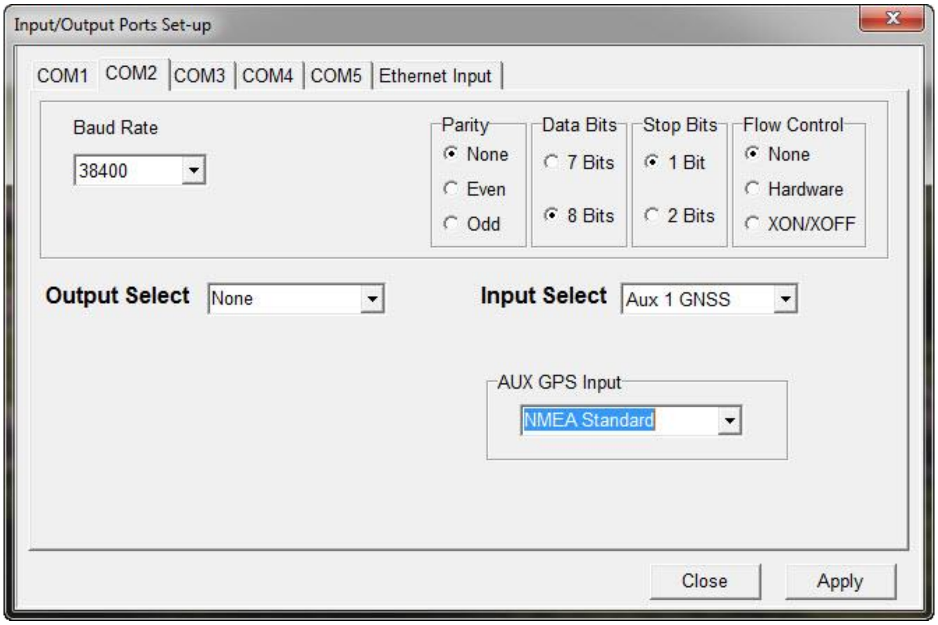


Figure 48: Input/Output Ports Set-up - Aux 1 GNSS Input

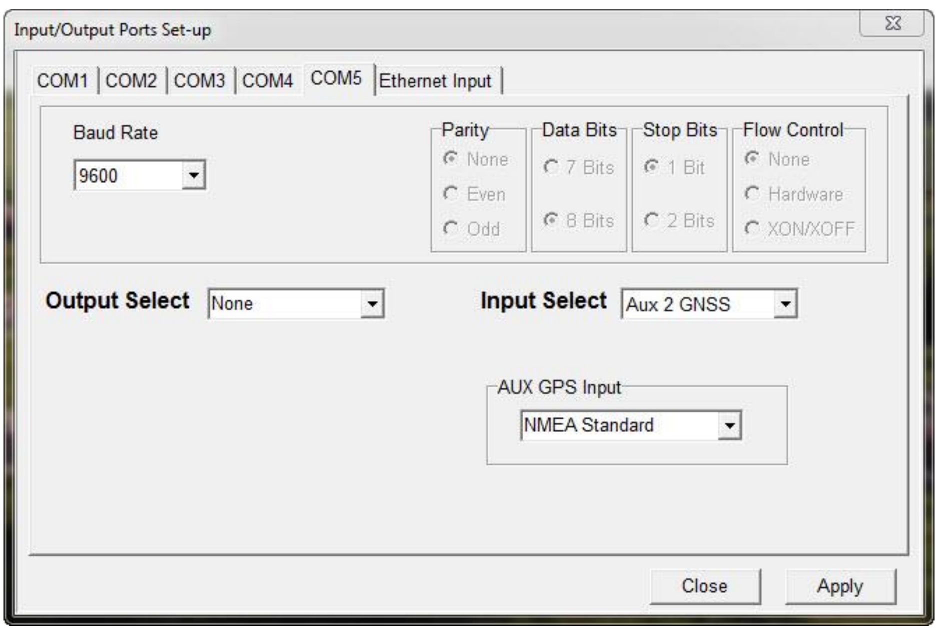


Figure 49: Input/Output Ports Set-up - Aux 2 GNSS Input

GNSS 1/2 Interface

The PCS provides a mechanism to connect directly to the internal GNSS receivers' COM ports through the external COM 3 and COM 4 ports. This is a bi-directional RS232 link so both input and output are automatically assigned when either one is selected. GNSS 1 is accessible through COM 3 (Figure 50) and GNSS 2 is accessible through COM 4 (Figure 51).

⚠ The purpose of this link is to allow field upgrades of the GNSS receiver firmware if necessary. This connection could also be used to output data directly from the GNSS if configured to do so. Applying a configuration to the internal GNSS via the COM port must be done with extreme care so as not to interfere with the PCS configuration. Contact Applanix customer support for assistance.

Note that PCS-86 provides a direct and dedicated connection to the COM port on the GNSS receiver through the DE9 connector labeled "COM5/GNSS" on cable 10005791 when this cable is plugged into the Sensor 2 connector on the PCS. This may be more convenient than assigning one of the other general purpose COM ports.

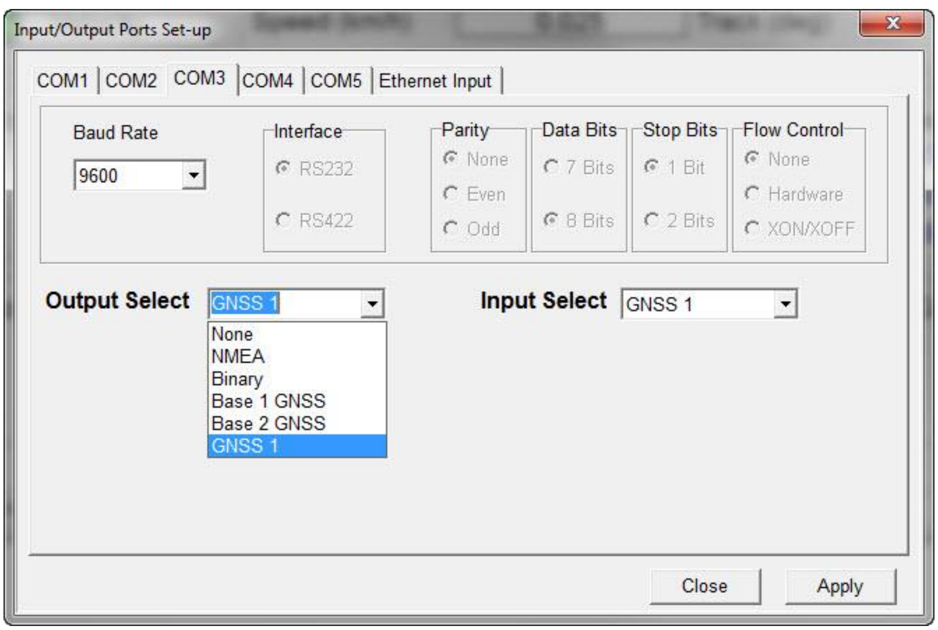


Figure 50: Input/Output Ports Set-up – GNSS 1 Interface

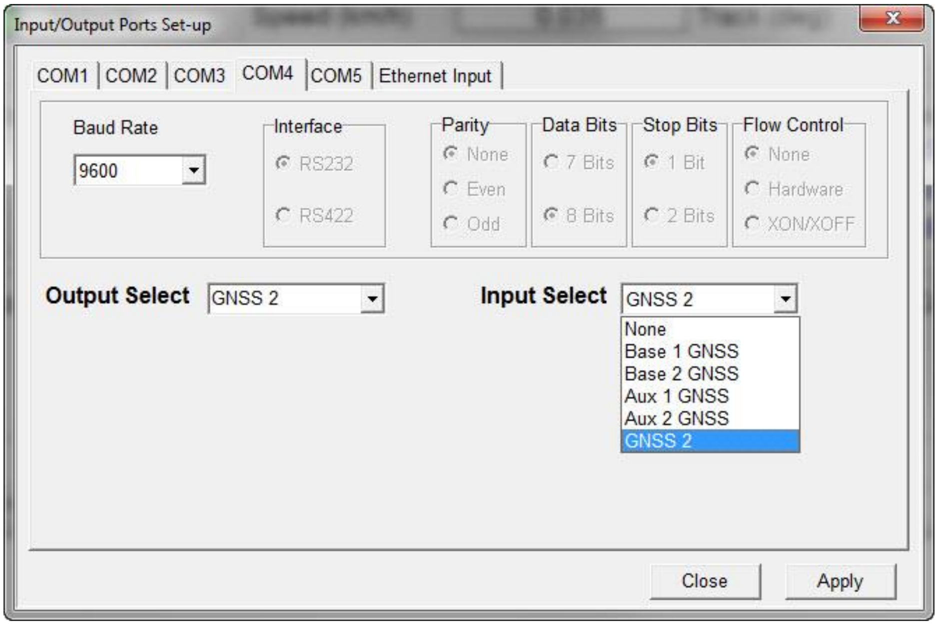


Figure 51: Input/Output Ports Set-up – GNSS 2 Interface

Lever Arms and Mounting Angles

The Lever Arm and alignment angles are measured during installation; refer to Chapter 4.0, Installation Parameters. Select **Settings, Installation, Lever Arms and Mounting** on the LV-POSView menu bar and then select the **Lever Arms and Mounting Angles** tab, see Figure 52.

As a minimum, accurate Lever Arm measurement between the Inertial Measurement Unit (IMU) and the Primary GNSS Antenna are entered before POS LV can compute and provide useful data in real-time. To accept the screen parameters and not close the screen, click the **Apply** button. To accept the screen parameters and close the screen, click the **OK** button.

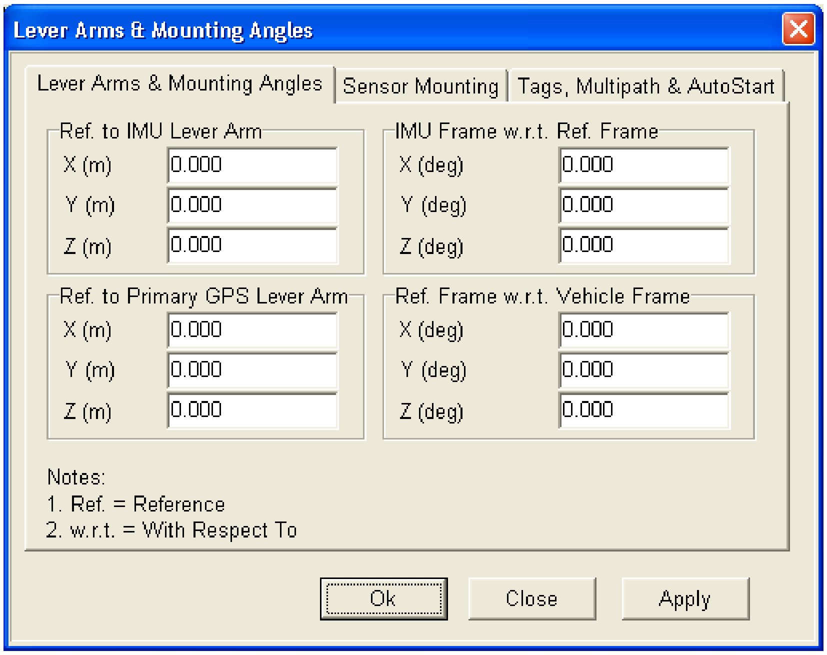


Figure 52: Lever Arm and Mounting Angles

DMI Sensor Mounting

Scale Factor Correction Pane

Prior to POS LV operation, an estimate for the Distance Measuring Indicator (DMI) scale factor should be entered into the PCS; refer to DMI Scale Factor Calculation on page 4-8 for assistance with estimating a DMI scale factor value. Enter the scale factor value by selecting **Settings, Installation, Lever Arms & Mounting Angles,** then select the **Sensor Mounting** tab**.**

Enter the scale factor value in the **DMI Scale Factor** field, see Figure 53. A positive value indicates that the DMI sensor is mounted on the driver's left side of the vehicle. A negative value indicates that the DMI sensor is mounted on the driver's right side of the vehicle.

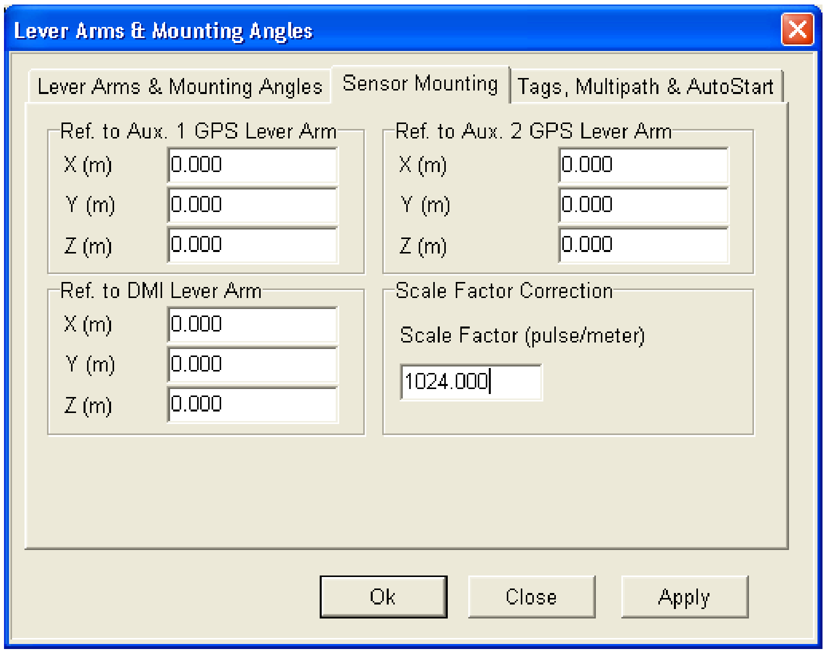


Figure 53: Lever Arms & Mounting Angles - Sensor Mounting

DMI Lever Arm Pane

The DMI Lever Arm is measured during installation, refer to Chapter 4.0, Installation Parameters. Select **Settings, Installation, Lever Arms & Mounting Angles,** then select the **Sensor Mounting** tab, see Figure 53. Enter the data into the **Ref. to DMI Lever Arm** pane fields.

Time and Distance Tags

Both time and distance tag settings are input in the **Tags, Multipath & AutoStart** tab, see Figure 54. Select **Settings, Installation, Lever Arms and Mounting** on the LV-POSView menu bar to display the tabs.

Note: Refer to POS-GPS Timing starting on page J-1 for further information.

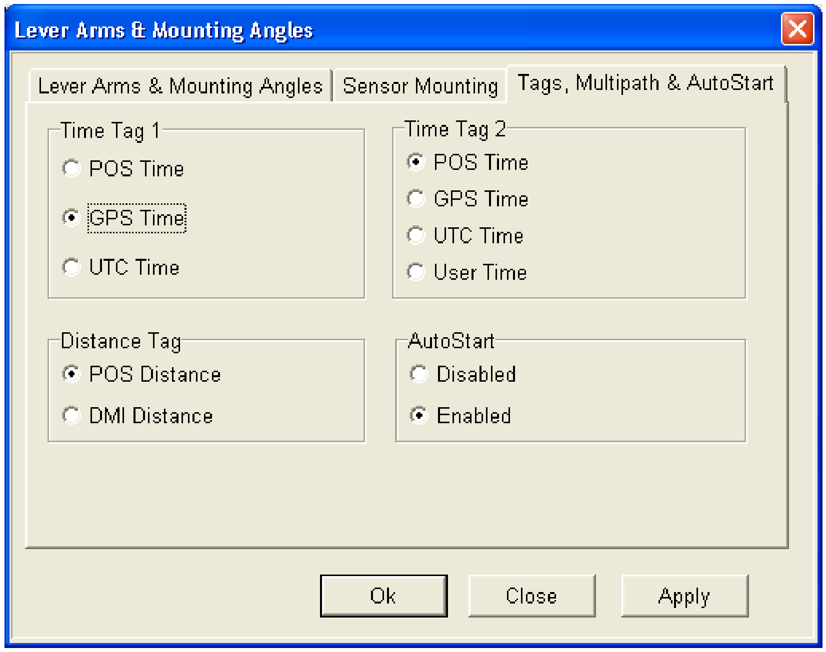


Figure 54: Tags, Multipath & AutoStart

Time Tag 1 and 2 Panes

All POS data are marked with two time tags. The time tags may be POS time, GPS time or UTC time. User Time is used when the user supplies ICD message 12 (Time Sync) in accordance with Applanix document *PUBS-ICD-003759*.

UTC and GPS times are not identical. Due to the occasional need to add a leap second to UTC, there is an integer second difference between UTC and GPS time. Transitions between seconds are precisely coincident between the two times.

POS time starts at zero each time POS LV is powered-up.

User Time is supplied to POS LV from other equipment, via ICD message 12. The User Time is slaved to POS LV's PPS output and is useful for time synchronizing data between POS LV and the user's auxiliary data logging equipment. The User Time appears in all of POS LV's data output on the data and logging ports.

POS data are only useful for post-processing using POSPac when Time Tag 1 is set to either GPS time or UTC time; GPS time is preferred.

Distance Tag Pane

POS data are further defined with a distance tag. The distance is either computed by POS (i.e. distance traveled by the Reference Point) or recorded by the DMI sensor. During forward motion, the distance tag will increase and during reverse motion the distance tag will decrease.

Auto Start Pane

If AutoStart is enabled, POS LV will automatically transition to Navigate Mode and start navigating as soon as possible after power-up. Otherwise, POS LV will remain in Standby mode.

GNSS Receiver Set-up

The **GNSS Receiver Configuration** screen, Figure 55, is accessed by selecting **Settings, Installation, GNSS Receiver** on the LV-POSView menu bar. The tabs for the primary and secondary GNSS receivers provide selection of the following parameters:

- **GNSS Output Rate** field: Selected using drop-down arrow. This setting determines the rate which GNSS raw observables are output to POS for logging.
- **Auto Configuration** pane: Enables or disables the automatic reconfiguration feature (POS LV is capable of detecting when the selected GNSS receiver is improperly configured and automatically reconfigures the receiver for use with POS - normally enabled).
- **GNSS 1/2 Port** pane: Configures the primary GNSS port **Baud Rate**, **Parity**, **Data Bits** and **Stop Bits**. This is the COM port accessible via the external COM connectors.

To accept the screen parameters and not close the screen, click the **Apply** button. To accept the screen parameters and close the screen, click the **OK** button.

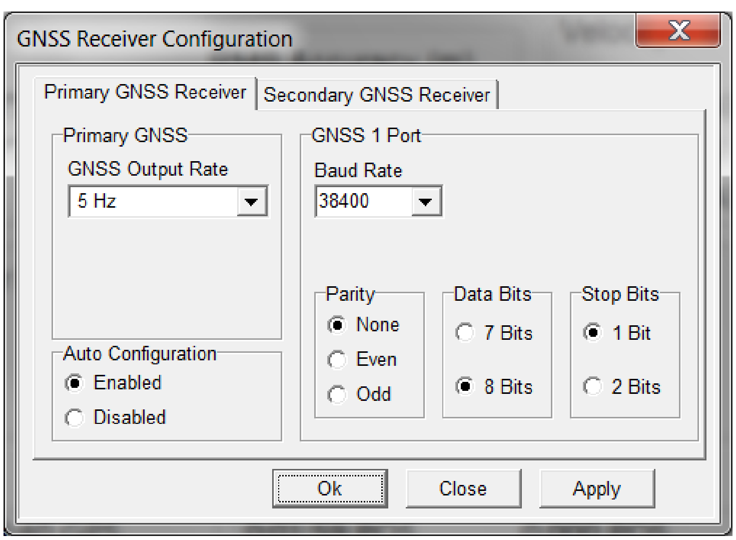


Figure 55: GNSS Receiver Configuration - Primary

Save Settings

Cycling power while saving may result in lost settings.

Save the POS LV parameters after any modification, otherwise changes will be lost when the POS LV power is cycled (power-down and power-up). Each time POS LV is powered up, the settings default to the stored values. To save the settings, select **Settings, Save Settings** from the LV-POSView menu bar. LV-POSView indicates when the settings are successfully saved (may take up to 30 seconds to save the settings).

Note: Multiple POS LV configurations can be managed by LV-POSView, refer to the Manage Multiple POS LV Configurations Using LV-POSView description on page 8-19.

Power-Down

Once configuration is complete and saved, reboot the POS LV to verify that all the changes are saved. Exit the LV-POSView and press the power button on the PCS front panel to turn the system off. Wait 10 seconds and press the button again to power-up the PCS. Finally, connect to the POS LV through LV-POSView and verify that all the parameters are correct.

For PCS-92 perform a clean shutdown by selecting the POSView **Tools, Shutdown** command. Once the power LED goes off remove the power from the rear power cable. After waiting a few seconds apply power to the chassis to power-up the PCS.

Make Changes

It is always possible to change the set-up and installation parameters of the POS LV system. All changes to parameters take effect immediately. To make changes permanent, save them by selecting **Settings, Save Settings** on the LV-POSView menu bar or by selecting **File, Save POS Config** as described below.

Manage Multiple POS LV Configurations Using LV-POSView

The controlling PC’s hard drive may be used to store multiple configurations. Select **File, Save POS Config** on the LV-POSView menu bar, specify a file name and save location, then click the **OK** button. Repeat this for each configuration.

To load a particular POS LV configuration from the PC’s hard disk, choose **File, Load POS Config**, highlight the file to load and click the **OK** button. POS LV is automatically configured with the settings contained in the configuration file.

Note: By default, POS LV boots to the last configuration saved in POS LV.

9.0 Calibrate Antenna Installation for GAMS

The Global Navigation Satellite System (GNSS) Azimuth Measurement Subsystem (GAMS) has the ability to resolve heading from the known placement of dual antennas.

For GAMS to operate the baseline vector from phase centre of the primary antenna to the phase centre of the secondary antenna (in the vehicle frame) must be known, along with the approximate accuracy of the measured baseline vector (Baseline Length Standard Deviation).

Accurate Baseline Measurement

If the baseline vector can be measured to an accuracy of 0.01m or better then the parameters can be entered into the GAMS Parameter Setup window in LV-POSView with the minimum standard deviation set (see figure Figure 56). In this case POS will not attempt to calibrate but will use the entered values after they are saved.

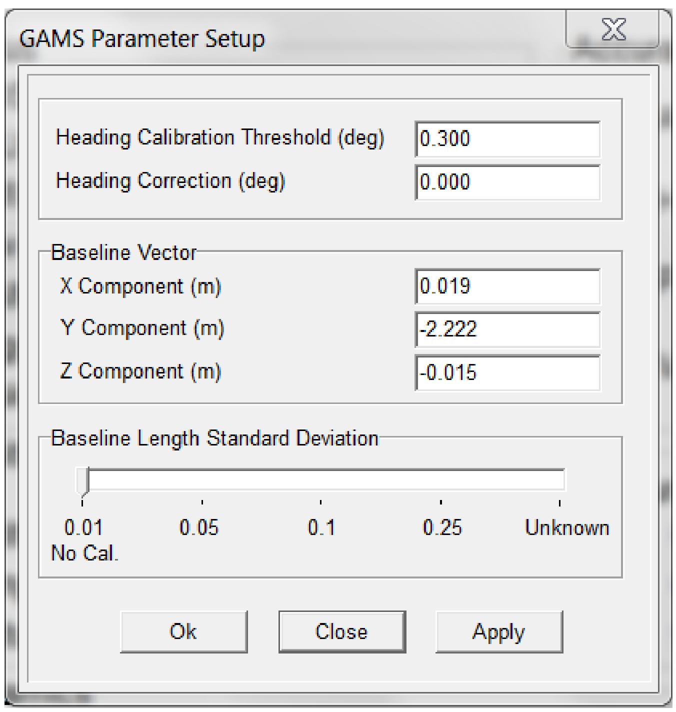


Figure 56: GAMS Parameter Setup

Save Settings

The user can save the GAMS parameter settings by:

1. Selecting **Settings, Save Settings** on the menu bar.
2. Click the **OK** button in response to the **Settings Saved** message.

Once the precise GAMS parameter settings have been saved the user can skip GAMS Calibration and proceed to section 10.0 - Operation with GAMS.

Preparation for GAMS Calibration

The Global Navigation Satellite System (GNSS) Azimuth Measurement Subsystem (GAMS) requires data from five or more satellites with a Positional Dilution of Precision (PDOP) of three, or less, to achieve a successful antenna installation calibration. Perform the antenna installation calibration at a time when there is good satellite geometry (i.e. low PDOP).

PDOP must be less than or equal to 3.0.

Perform the antenna installation calibration in an area where unrestricted manoeuvring is possible, such as a large, empty, paved parking area.

Familiarization with the LV-POSView main screen elements and an understanding of the displayed information is essential for successful completion of this chapter. If necessary, review the material beginning at the LV-POSView Main Screen Functions description on page 7-5.

Calibration Set-up

1. Select **Settings, Installation, GAMS Parameter Set-up** on menu bar to open **GAMS Parameter Set-up** screen, see Figure 57.
   - Enter value between 0.1 and 0.5 in **Heading Calibration Threshold** field.
   - Set to zero the remaining GAMS parameter fields including all **Baseline Vector** pane components.
   - Slide the **Baseline Length Standard Deviation** bar to “Unknown”.
   - Click **Apply** button then click **Ok** button.

For POS LV to function acceptably during GNSS outages, it is important that the **Heading Calibration Threshold** value is set as low as possible. Aggressive manoeuvring is required to bring the POS LV heading errors below this threshold. Fortunately, such manoeuvres are only required when GAMS is being calibrated. Calibration is only required if the GNSS antennas or Inertial Measurement Unit (IMU) are moved.

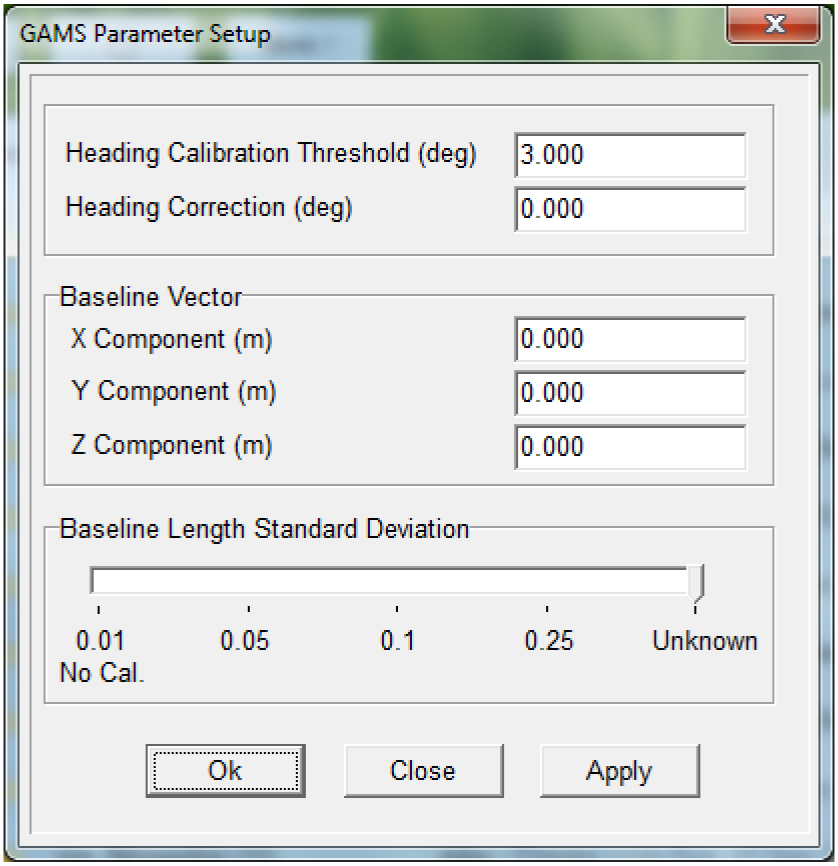


Figure 57: GAMS Parameter Set-up Screen

2. Switch POS LV to Navigate mode by selecting **Settings, Mode, Navigate** on menu bar or by selecting **Nav** icon on tool bar. This commands GAMS to begin execution of its ambiguity resolution algorithm.

   Note: When GAMS has resolved the carrier phase ambiguities, the GAMS status is displayed as **Ready Offline**. During this calibration set-up phase (GAMS is fixing its ambiguities) it is extremely important that there is no GNSS multipath. The status of GAMS should be confirmed by viewing the GAMS solution menu, select **View, GAMS Solution**. The solution status must indicate **Fixed**, see Figure 60 on page 10-1.

Calibration

Once the above set-up procedure is complete, proceed with the following calibration procedure.

3. Accelerate vehicle in a straight line as quickly as possible to a speed of at least 60 km/h (**GAMS Status** pane should display **Ready Offline**).

   - Once target speed is reached, apply vehicle brakes and come to full stop as quickly as possible.

- Turn vehicle around and repeat until **Heading Accuracy** values in **Attitude** pane (Figure 31, page 7-7) drop significantly below selected GAMS **Heading Calibration Threshold** (Figure 57, page 9-3).

  Note: Ensure there is no GNSS multipath present.

  It is important that the vehicle accelerations be performed in a straight line.

Note: Errors decrease as the vehicle is manoeuvred and should be minimum when the calibration is started.

4. Change the maneuver to perform a number of turns (e.g. circular or figure 8) in an area where there is no GNSS multipath.

- Before proceeding with calibration procedure, ensure that GAMS status (Figure 30, page 7-6) indicates **Ready Offline**.
- Select **Settings, GAMS Calibration Control, Start,** on LV-POSView menu bar, to start calibration procedure.
- GAMS status now indicates **Cal Requested**.

Note: The GAMS status display (Figure 30, page 7-6) transitions to **Cal In Progress**. When POS LV completes the calibration procedure, the GAMS status bar displays **Cal Completed** for five seconds and then transitions to **Online**.

- You may check the calibration progress in View, GAMS Solution, under heading of Calibration Status, see Figure 58.

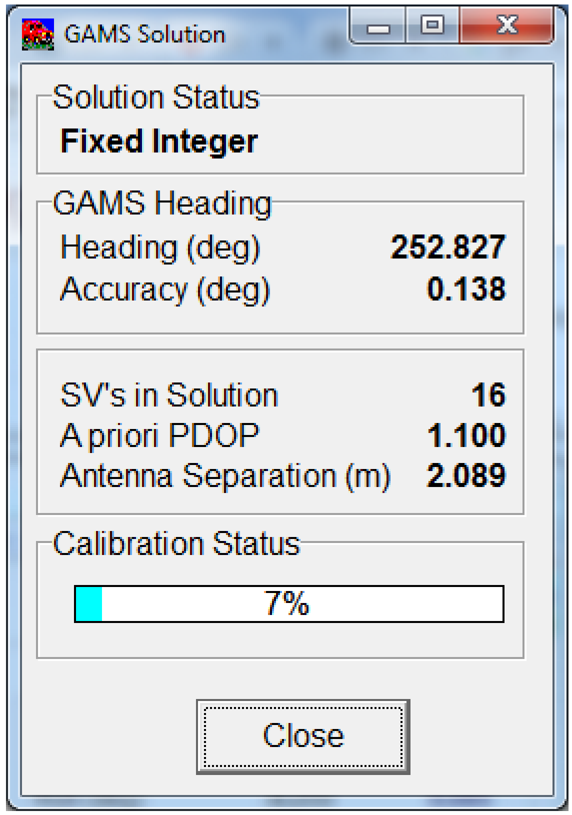


Figure 58: GAMS Calibration Status

Save Calibration

GAMS calibration is saved automatically upon conclusion, however the user can save the settings anytime by:

5. Selecting **Settings, Save Settings** on the menu bar.
6. Click the **OK** button in response to the **Settings Saved** message.
7. The GAMS installation may be examined by selecting **Settings, Installation, GAMS Installation**.

Successful Calibration

Monitor the POS LV using LV-POSView to observe the following indications of a successful calibration:

- **Online** is displayed after **GAMS** on the **Status** pane on the LV-POSView Main screen, see Figure 28 on page 7-5.

- **Heading Accuracy** values in the **Attitude** pane (see Figure 28 on page 7-5) decrease slowly to less than 0.15 degrees and eventually settle to a value between 0.020 and 0.015 degrees.

When the calibration is *not* successful, GAMS rejects the carrier phase ambiguities repeatedly and will eventually reject the installation parameters. If this occurs, repeat the calibration process. Ensure that the vehicle is away from structures that can cause GNSS multipath reception.

Record the displayed parameters on the **GAMS Parameter Set-up** screen for future reference by selecting **Settings, Installation, GAMS Parameter Set-up** on the LV-POSView menu bar. If the installation parameters become corrupted or altered, they can be re-entered manually.

GAMS Baseline Vector Correction

The surveyed antenna baseline vector may include the following errors:

- The length of the vector may be incorrect if large multipath errors occurred during the calibration process. This may affect the reliability of the GAMS ambiguity resolution during future POS LV initialization sequences.
- Azimuth errors, similar in size to the displayed **Heading Accuracy** values (Figure 28, page 7-5), that existed during the calibration process. This results in a constant offset in the displayed heading during normal operation of the POS LV with GAMS heading aiding.

The following is correction for surveyed antenna baseline vector errors:

- If the heading offset is known, enter the value in the **Heading Correction** field of the **GAMS Parameter Set-up** screen, then click the **Apply** button to install the new correction value.

Note: POS LV computes the new components of the surveyed antenna baseline vector using the corrected azimuth value.

Note: Remember to select **Settings, Save Settings** on the LV-POSView menu bar when configuration changes are made. The GAMS **Baseline Vector** values should not be altered (see Figure 57 on page 9-3).

10.0 Operation with GAMS

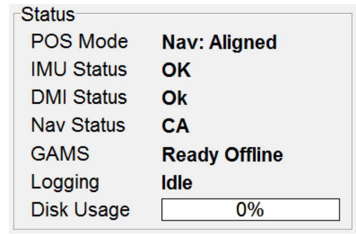


Figure 59: POSView Status Panel

The GNSS Azimuth Measurement Subsystem (GAMS) feature of POS LV increases and maintains heading accuracy using two GNSS antennas in heading determination. Once valid installation parameters for POS LV are inserted and saved (see the Calibrate Antenna Installation for GAMS description starting on page 9-1), POS LV is ready to operate with the GAMS heading enhancement.

Normal Operation

Power-on the POS LV and select **Navigate** mode, refer to Chapter 7.0 for assistance. Select **View, GAMS Solution** on the LV-POSView menu bar to monitor GAMS initialization. Figure 60 shows the **GAMS Solution** screen for a system with BD960/970.

For a BD960/970 system, in conjunction with the **GAMS Solution** screen, observe the LV-POSView **Status** pane (Figure 59) to view the GAMS initialization sequence.

1. Once POS LV completes the leveling routine, GAMS will start-up. The following appears:
   - Figure 59 - **GAMS Not Ready** is displayed in the **Status** pane; this indicates that GAMS has not resolved the carrier phase ambiguities.
   - Figure 60 - **GAMS Heading** pane, **SV's in Solution**, **A priori PDOP** and **Antenna Separation** fields initialise. The **SV** (Space Vehicle) column shows the identification numbers of the satellites being tracked - their order is not significant.
2. For BD960/970 system, if POS LV is successfully tracking fewer than five satellites or the indicated Positional Dilution of Precision (PDOP) is greater than 4.5, GAMS becomes dormant. GAMS continues to monitor the satellites in the dormant state, but does not process the data from the GNSS receivers. **GAMS Not Ready** (Figure 59) is displayed in the **Status** pane.
3. After successful completion of coarse leveling, POS LV transitions to **Nav: Degraded** (Figure 59). During this time, errors in the reported roll and pitch angles are larger than 0.05 degrees. If five or more satellites are tracked and the indicated PDOP is in the range of 4.0 to 4.5, GAMS begins its ambiguity

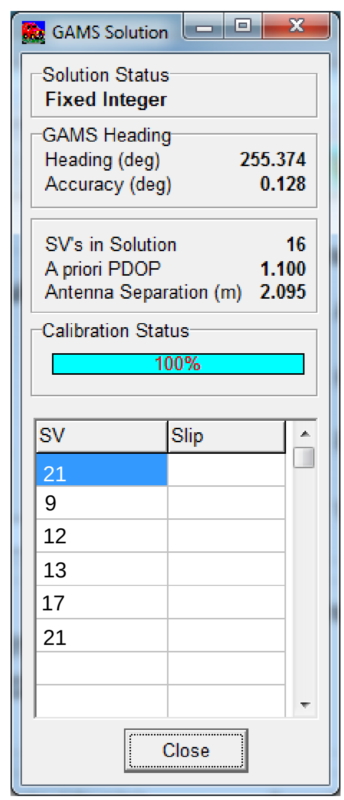


Figure 60: GAMS Solution Screen

search, using only the antenna separation distance to aid the search process. **GAMS Not Ready** is displayed in the **Status** pane.

4. When POS LV transitions to **Nav: Full** (Figure 59), the errors in the reported angles of roll and pitch are less than 0.075 degrees Root Mean Square (RMS). The heading error remains large (in the order of 10 to 15 degrees RMS) unless the vehicle performs dynamic maneuvers, in which case the heading error should fall to below one degree.

   The computed angles of roll and pitch are now sufficiently accurate for use by GAMS in its ambiguity search process using the antenna separation distance. The availability of this data shortens the time required to fix ambiguities to as little as two minutes, depending on satellite geometry.

5. Once GAMS has resolved the carrier phase ambiguities, the **Solution Status** pane (Figure 60) indicates **Fixed Integer**. **GAMS Ready Online** (Figure 59) is displayed in the **Status** pane to indicate that the GAMS is ready to provide heading aiding data to the POS LV.

   This status may exist for up to ten seconds. If it extends beyond 20 seconds, the GAMS heading aiding data may have been rejected.

6. The **Status** pane (Figure 59) changes to **GAMS Online** when the POS LV begins to process GAMS heading. The heading errors should fall to 0.25 degrees RMS within 30 seconds, and to between 0.020 and 0.015 degrees RMS within two minutes.

For a BD982 system, in conjunction with the **GAMS Solution** screen, observe the LV-POSView **Status** pane (Figure 59) to view the GAMS initialization sequence.

7. Once POS LV completes the leveling routine, GAMS will start-up. The following appears:
   - Figure 59 - **GAMS Not Ready** is displayed in the **Status** pane; this indicates that GAMS has not resolved the carrier phase ambiguities.
   - Figure 60: GAMS Solution Screen - **GAMS Heading** pane, **SV's in Solution**, and **Antenna Separation** fields initialise.

8. For BD982 system, the GNSS receiver outputs the status of the GAMS. If the receiver does not have a fixed solution, **GAMS Not Ready** (Figure 59) is displayed in the **Status** pane.

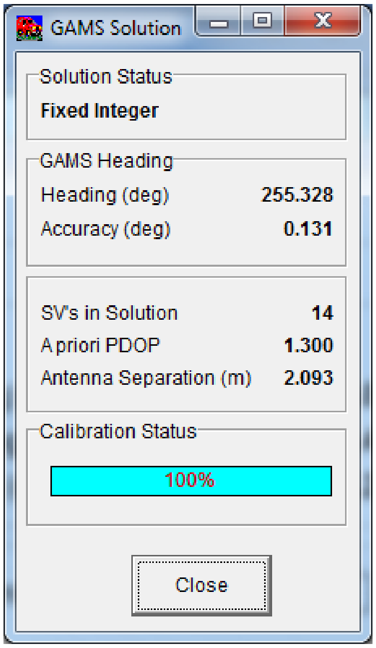


Figure 61: BD982 GAMS Solution Pane

9. After successful completion of coarse leveling, POS LV transitions to **Nav: Degraded** (Figure 59). During this time, errors in the reported roll and pitch angles are larger than 0.05

GAMS Status Changes

A change in **GAMS** status from **Online** to **Ready Online** indicates that POS LV has stopped processing GAMS heading aiding data. This condition occurs if:

- A one or two second GNSS data dropout occurs in one or both GNSS receivers - a data dropout occurs when phase observables are available from fewer than four satellites or the indicated PDOP is greater than 4.5, or both.
- The tracking Signal-To-Noise (S/N) ratio (for one or more satellites or GNSS receivers) drops below 32 Decibels (dB) - GAMS processes the observables for a satellite if the corresponding tracking S/N ratio in both receivers is at least 32 dB. POS LV rejects the computed GAMS heading aiding data.
- POS LV rejects the GAMS heading aiding data as being inconsistent with the inertial navigator heading - this occurs if a large multipath error causes GAMS to temporarily exhibit an unusually large heading error.

Note: The displayed **GAMS** status transitions to **Online** once the cause of heading aiding data rejection is cleared.

A change in **GAMS** status from **Online** to **Not Ready** indicates that GAMS has reset, abandoning the current fixed phase ambiguities and restarting its On-the-Fly (OTF) ambiguity search. This occurs if GAMS rejected the current fixed phase ambiguities (occurs if the carrier phase ambiguity for a recently acquired satellite is fixed to the wrong integer due to multipath errors or excessive phase noise).

Note: GAMS quickly resolves the carrier phase ambiguities and returns to **GAMS Online** status once the cause of the GAMS reset is cleared.

Abnormal GAMS Behaviour

Abnormal behaviour immediately following a period of normal operation is symptomatic of environmental anomalies such as multipath errors, GNSS signal masking or unknown changes in the IMU or GNSS antenna geometry. The following lists some common abnormal behaviour, along with their possible causes and suggested remedies.

Repeated Ambiguity Rejection

Symptom

GAMS repeatedly resolves the carrier phase ambiguities and then rejects them. The cycle may continue indefinitely, or eventually, POS LV flags the installation parameters as invalid.

Possible Causes and Remedies

1. **Cause**: The installation parameters are incorrect or have become incorrect. This can occur if one or both of the GNSS antennas has moved with respect to the IMU by more than a few millimetres, or if the IMU has moved with respect to the GNSS antennas by more than a few centimetres.

   Remedy: Ensure that the antennas and IMU are mounted rigidly with respect to each other and then allow GAMS to calibrate again.

2. **Cause**: The vehicle has entered a high multipath or GNSS signal-masking environment. A temporarily high multipath environment may occur if you move near a large reflective surface such as a building. S/N ratio degradation for low elevation satellites may occur in one or both GNSS receivers if trees, buildings or a bridge partially mask the satellite signal paths. For example, if the vehicle has moved to an urban location, then nearby vehicles and building surfaces can generate large multipath reflections, while large structures can mask the signal from some satellites.

   Remedy: Move away from the source of the high multipath environment. (GAMS recalibration is normally not necessary).

GAMS Status Remains Ready Offline Indefinitely

Symptom

The displayed GAMS status remains **Ready Offline** after several minutes despite the user activating GAMS by selecting **Tools, Configuration,** and un-checking the **GAMS, Disable GAMS Solution** box on the LV-POSView menu bar.

Possible Causes and Remedies

1. **Cause**: GAMS has identified the wrong ambiguities, and therefore has computed the wrong heading. POS LV continuously rejects the GAMS heading aiding data because it is inconsistent with the POS LV heading data derived without GAMS aiding.

   Remedy: Select **Tools, Reset GAMS** from the LV-POSView menu bar to transition POS LV to the Standby mode, then click on the **Navigate** button to return to Navigate mode. This re-initializes GAMS calibration.

2. **Cause**: POS LV has computed a heading that is incorrect in spite of the displayed heading accuracy. This may occur if POS LV processes highly inaccurate GNSS data during the heading alignment.

   Remedy: Click on the **Standby** button in the LV-POSView tool bar to transition POS LV to Standby mode, then click on the **Navigate** button to return to Navigate mode. This re-initializes GAMS calibration

3. **Cause**: GAMS uses one or more observables while tracking S/N ratios consistently below 32 dB from one or both GNSS receivers. This can be caused by:

   - Partial masking of a GNSS signal from a low elevation satellite by topographical features such as buildings, hills or mountains
   - Interference from nearby high voltage power lines
   - Very long antenna cables or cables built from coaxial cable having excessive losses at the L1 frequency (1575 MHz), resulting in high cable losses
   - GNSS receiver failure

   Remedy: The problem of partial masking or interference reduces as the vehicle moves away from the source of signal degradation. An antenna cable problem can be identified by substituting shorter low-loss cables. If a GNSS receiver failure is suspected, consult with an Applanix POS LV customer support representative.

Incorrect Heading

Symptom

The displayed GAMS status is **Online** and the displayed POS LV heading accuracy is less than 0.15 degrees. However, the displayed POS LV heading is clearly in error by several degrees.

Possible Causes and Remedies

Cause: GAMS has resolved the wrong carrier phase ambiguities and, as a result, computes the wrong heading. Furthermore, POS LV has accepted the wrong heading aiding data and the POS LV computed heading has aligned to the incorrect GAMS heading.

Remedy: Click on the **Standby** button in the LV-POSView tool bar to transition POS LV to Standby mode. Then click on the **Navigate** button to return to Navigate mode. This re-initializes POS LV and GAMS.

11.0 Data Integrity

Position Plot

The **Position Plot** screen, select **View, Position Plot** from the LV-POSView menu bar, shows the real-time position of the POS LV. This can be viewed as an X-Y plot or Latitude-Longitude plot of the real-time navigation solution, see Figure 62.

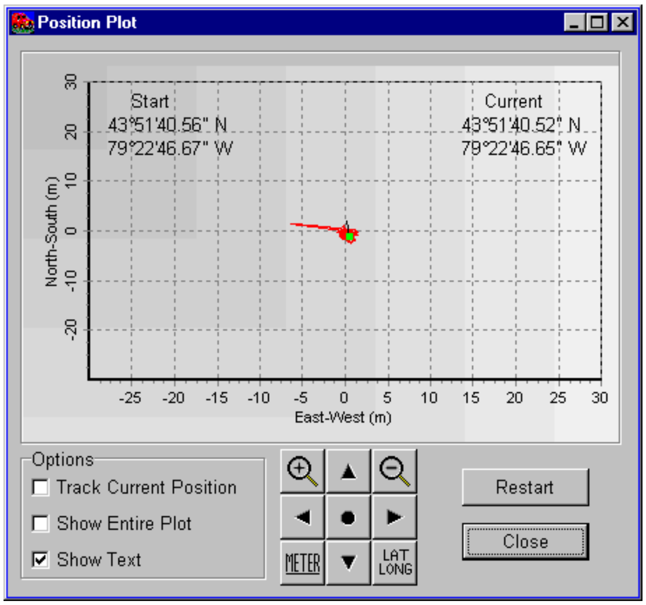


Figure 62: Position Plot

Fault Feedback

Fault Detection, Isolation and Reconfiguration (FDIR) allow the POS LV to combine sensor data in a manner that provides the best solution for the current data quality. Thus, the solution is always optimum at any point in time. POS LV monitors its sensors, determine which sensors show degraded performance and recombine the data as necessary to produce the best solution available.

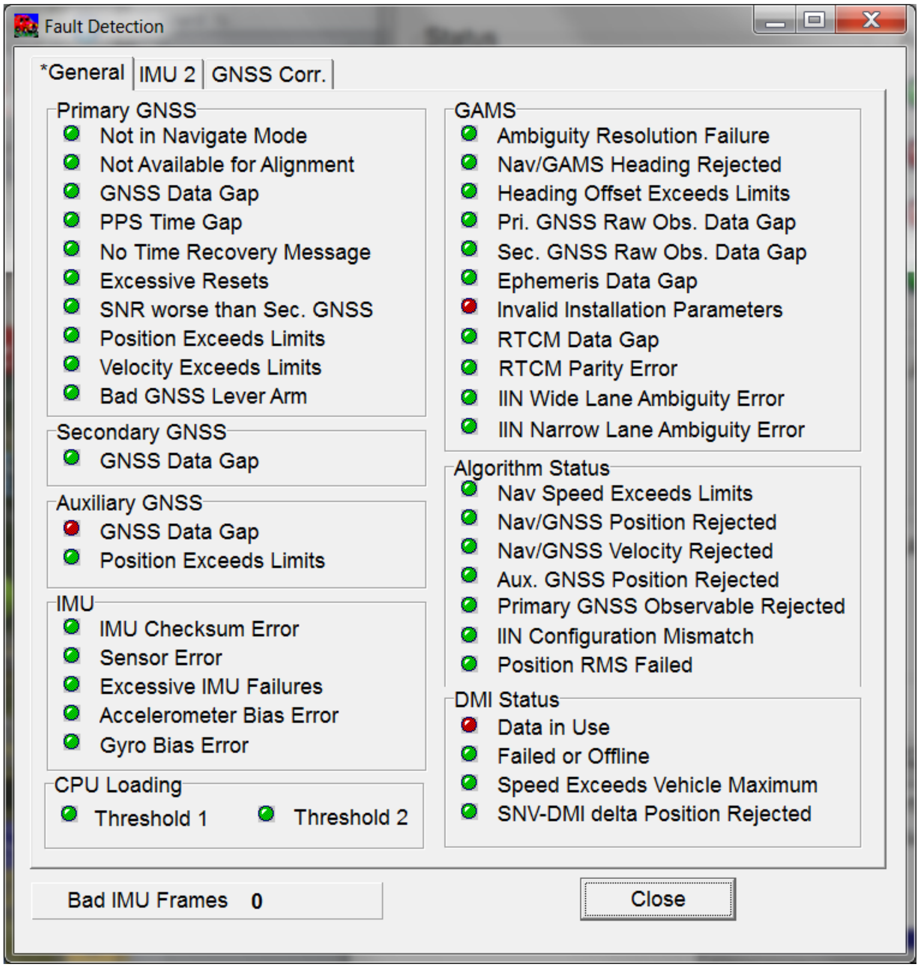


Figure 63: Fault Detection Screen

To display the **Fault Detection** screen (Figure 63), select **View, Faults** on the LV-POSView menu bar. A fault is present when the light button is red. Some faults remain once set, while others are transitory.

Message Log

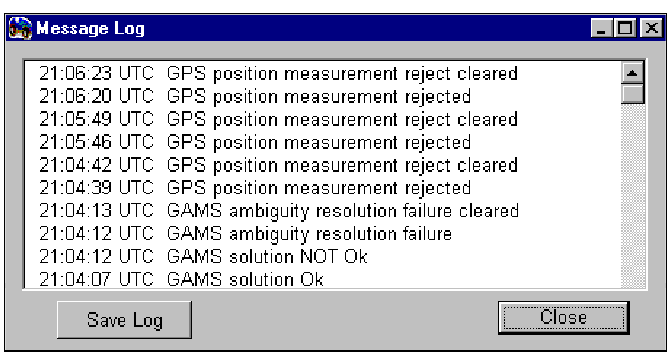


Figure 64: Message Log Screen

POS LV indicates the status and recent history of its sensor subsystems, see Figure 64. The status shown, indicates how POS LV is combining its sensor data. To display the general status messages, select **View, Message Log** on LV-POSView menu bar. Refer to the Message Log Definitions, starting on page B-1 for a list of messages and their descriptions.

GNSS Reset

The POS LV GNSS receiver may be reset from LV-POSView menu. To reset, select **Tools, Reset GNSS** on the LV-POSView menu bar. This action sends a reset command to the GNSS receiver. After a period of time (maximum of two minutes), the receiver locks on to the satellites and POS LV resumes using GNSS data.

The reset feature is a last resort measure used in the event that a GNSS receiver exhibits abnormal behaviour such as an inability to track satellites (indicated on LV-POSView Status screen and message log), failure to compute or failure to output a valid navigation solution for a prolonged period. Prior to using the reset feature, verify the serviceability of connections and cabling.

Base 1/ 2 Diagnostics

The Base diagnostic screens may provide a useful source of trouble shooting information. Figure 65 and Figure 66 show the diagnostic tabs for Base 1. The diagnostics for Base 2 are identical.

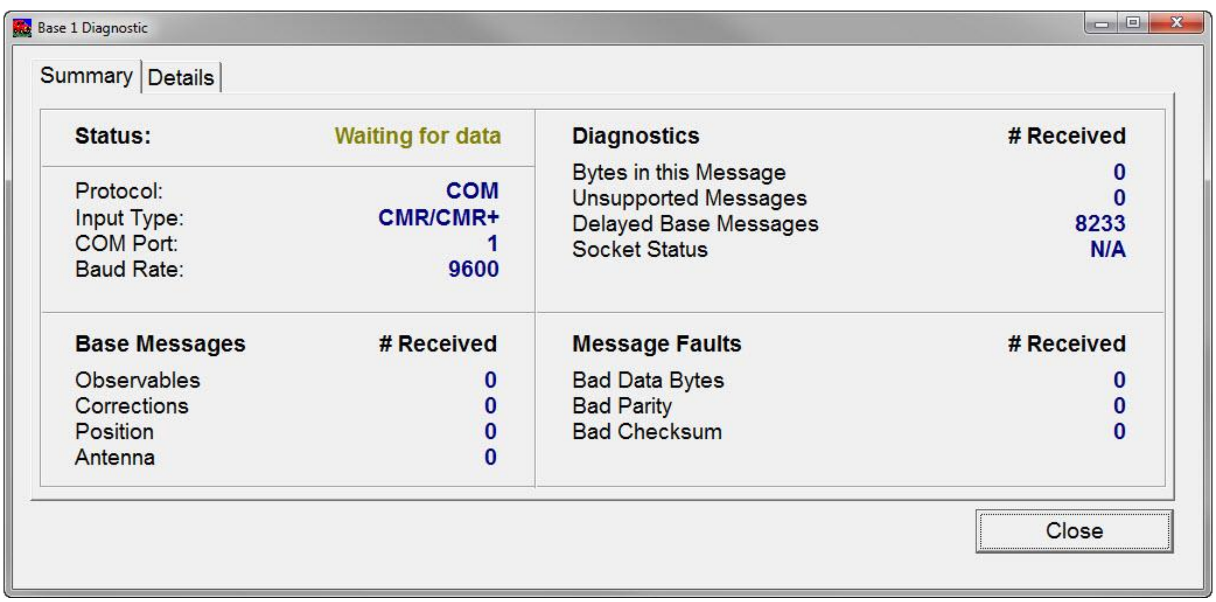


Figure 65: Base 1 Diagnostics - Summary

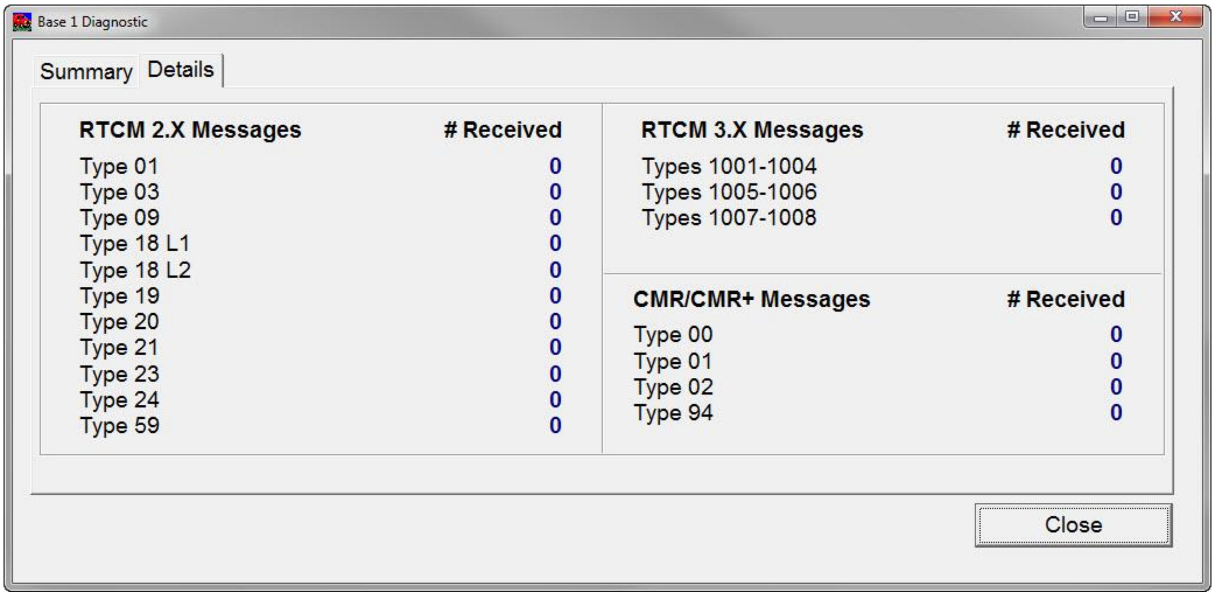


Figure 66: Base 1 Diagnostics - Detail

SECTION 3

SYSTEM OPERATION AND ADDITIONAL PROCEDURES

12.0 Data Logging

POS LV real-time and raw data may be recorded on storage media for post-processing. Typically, the data are recorded on removable media, a USB flash drive using the USB connector installed in the front of the POS Computer System (PCS). Alternately, the data may be transferred across the Ethernet Data Port to a disk file on an external PC. The USB flash drive is useable for post-processing in any PC with a USB connector. PCS-92 does not have removable USB media but instead logs data to an internal flash drive which is accessible via FTP.

Back-up logging is initiated when data are logged to the removable media and remains active, regardless of the removable media data logging activity, until the PCS is reset or powered-off.

For systems that do not have removable media the PCS is configured to log data internally to a flash drive. The file naming and group selection is performed the same as for removable media logging although backup logging will not be active. Data can be subsequently retrieved via FTP.

Note: Use of the removable or internal media interface is preferred due to the bandwidth limitations associated with some Ethernet installations.

PCS Configuration

The PCS contains a USB connector and an internal memory device, both dedicated to data logging. The system includes a 8GB industrial grade USB flash drive which is inserted into a USB connector on a shuttle behind a water tight door on the front of the PCS; see Figure 69, page 12-4 for its location.

A 4 GB internal memory device functions as a circular buffer and is used to back-up the last data logging file. Back-up logging is automatic and does not require any user maintenance. Once the user begins removable media logging, back-up logging will log the same data and continues to back-up the data until the system is reset or powered-off.

The first file of each back-up data file set begins with a *.000* extension. The file naming convention used by the PCS is *xxxxxxxxMMDD_HHMMSS.nnn* where *xxxxxxxx* is the filename specified for the removable media logging (up to 32 characters), *MMDD_HHMMSS* is the month, day, hour, minute and second in Universal Time Coordinated (UTC), and *nnn* is a unique counter value which is incremented with each new file.

Access the back-up drive or the internal data using an FTP client (e.g. CuteFTP, Filezilla) to connect to the POS LV system Internet Protocol (IP) address. Use *guest* (lowercase) for the username and *applanix* (lowercase) for the password.

LV-POSView Configuration

To access the logging configuration and control menus, select one of the following from the LV-POSView menu: **Logging, Ethernet Logging** or **Logging, Removable Media Logging**.

The logging screens (Figures 67 and 68) permit the selection of data groups to be recorded and define the logging rate for those data groups.

The Ethernet logging port is intended for data logging for a delayed processing application where data loss cannot be tolerated. This port implements a very large storage buffer to minimize the risk of data loss.

The logging method, Ethernet or Removable media, is changeable at any time, even if logging is in progress. To accept the screen parameters and not close the screen, click the **Apply** button. To accept the screen parameters and close the screen, click the **OK** button.

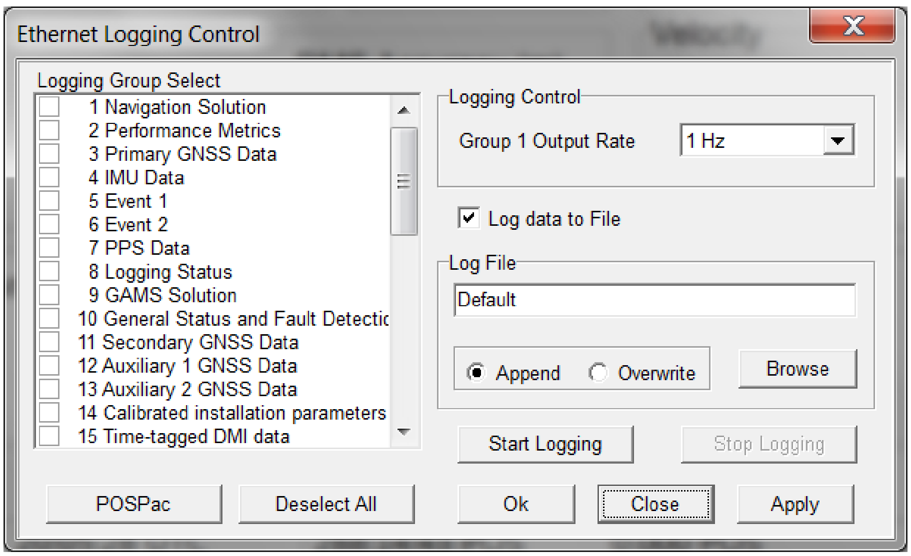


Figure 67: Ethernet Logging Control

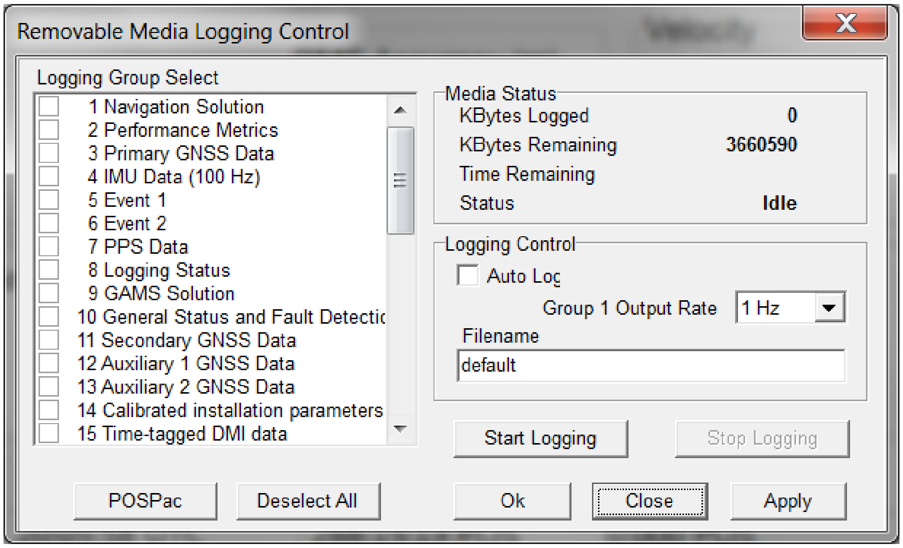


Figure 68: Removable Media Logging Control

Note: If the logged data are to be used with POSPac, click the **POSPac** button to select all the groups required for post-processing.

Data Logging – Removable Media

Insert a USB flash drive

The USB flash drive can be inserted into the USB shuttle bay at any time (i.e. with PCS power-on or off). The shuttle allows the USB flash drive to be entirely enclosed by the PCS housing. Insert the USB flash drive into the bay (Figure 69) ensuring that the card is facing up, Applanix logo showing. The shuttle mechanism will move back to its innermost position, at which point the USB flash drive must be pressed into the connector. The logging bay door should close without hitting the USB flash drive if it is properly seated in the connector.

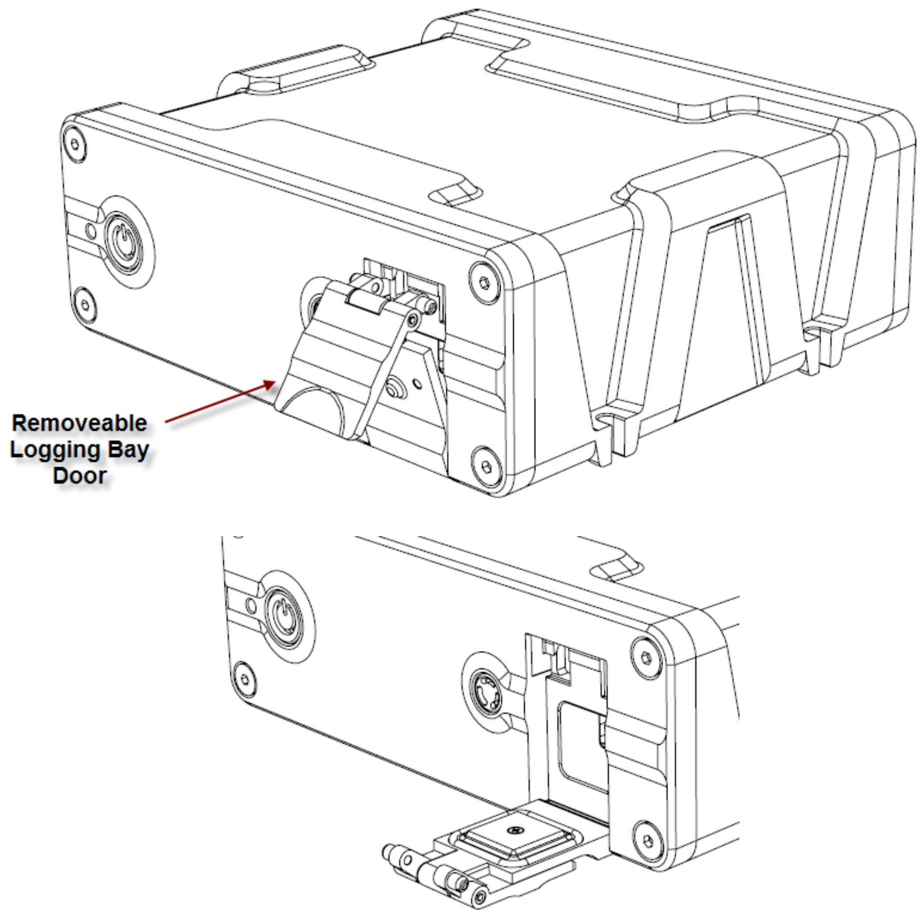


Figure 69: Removable Media Bay

Start Logging – Removable Media

AutoLog

If AutoLog is enabled (refer to AutoLog on page 13-1), logging starts automatically on PCS power-up. If AutoLog is enabled and there is no USB flash drive in the logging bay, the Logging light will turn red. If this occurs, insert a USB flash drive and force a start as described in the following paragraphs.

Manual Start

Press the Logging button on the PCS front panel and hold for at least 2 seconds to begin.

An alternate method to start logging is to click the LV-POSView **Start Logging** button on the PC Card Logging Control screen (Figure 68, page 12-3).

For a description of the logging status lights, refer to Table 14: PCS Front Panel Lights on page 13-3.

Stop Logging – Removable Media

Logging is stopped manually by pressing the Logging button on the PCS front panel and holding for at least 2 seconds. Logging stops after about six seconds.

An alternate method to stop logging is to click the LV-POSView **Stop Logging** button on the PC Card Logging Control (Figure 68, page 12-3) screen.

Logging data to the removable media may be stopped and restarted repeatedly. Restarting the logging process causes a new file to be opened with the same kernel name. If a new kernel name is assigned, the new file is viewed as a new mission.

Note: A data gap is treated as a new mission. The system can tolerate a 0.015 ms (maximum) IMU data gap.

Logged Data

Data are logged to the removable media in approximately 12-Megabyte (MB) files. If POS LV loses power while logging data to the USB flash drive, the amount of mission time lost will depend on how many groups were selected for output. The fewer the groups the less information recorded per minute, a longer time to fill a 12 MB file and the more mission time that may be lost.

Remove the USB flash drive

⚠ **Do not remove a USB flash drive from the logging bay when the logging light is on; the PCS may still be writing to the device. If the USB flash drive is removed when the logging light is on, there is a chance that all mission data will be lost.**

Stop logging before attempting to remove the USB flash drive from the logging bay. When the logging light is off, open the logging bay door, press in on the USB flash drive and then release. The shuttle mechanism will partly eject the stick to a point where it is possible to remove it from the connector (Figure 69, page 12-4).

Note: It may take several seconds after a request to stop logging for the PCS to stop recording to the USB flash drive and the logging light to extinguish.

Data Logging - Ethernet

Ethernet logging is intended to capture data for a delayed processing application where data loss cannot be tolerated. Data are output for Ethernet logging on the LAN data logging port. This port implements a very large storage buffer to minimize the risk of data loss due to delays in the Ethernet link.

Ethernet logging is performed using the LV-POSView software or other user supplied software. Any custom designed logging software’s interface must conform to the POS LV Ethernet ICD specifications. Please refer to Applanix document *PUBS-ICD-003759* for a description of the Ethernet data output format.

Note the following points regarding the Ethernet circuit:

- Requires at least a 100 Base T connection.
- Applanix recommends the use of the shielded Ethernet cables shipped with the POS LV system.
- Use of shielded Ethernet cables is a requirement of the European Union CE standard.

Note: Ethernet data logging cannot be started or stopped using the Logging button on the PCS front panel.

⚠ Ethernet data logging performed by LV POSView will be written to a single file and could be subject to loss or corruption depending on the stability of the PC on which it is being recorded.

Start logging - Ethernet Data Port

To start Ethernet data logging to a local PC, select **Logging** on the LV-POSView menu bar and **Ethernet Logging** on the drop-down menu. Next, select a file location and name using the **Browse** button, and finally, click the **Start Logging** button; refer to Figure 67 on page 12-2.

Stop logging - Ethernet Data Port

To stop Ethernet data logging, click the **Stop Logging** button on the **Ethernet Logging Control** screen (Figure 67, page 12-2).

Data Output – Ethernet

The Ethernet real-time data output ports are intended for real-time control applications where the most current position and orientation data are required. Real time data output on an Ethernet port is intended to provide data for a third-party application that is capable of decoding the POS LV Ethernet ICD format. Please refer to Applanix document *PUBS-ICD-003759* for a description of the Ethernet data output format. These ports implement small storage buffers which are flushed frequently to ensure timely delivery of the data.

Ethernet Real-Time is used for real-time control applications, whereas, **Ethernet Logging** has a large data buffer.

Start Output - Ethernet Realtime Data Port

To start Ethernet real-time data output, select **Settings** on the LV-POSView menu bar and **Ethernet**

Real-time Port on the drop-down menu. The window shown in Figure 70 appears.

Click on the tab for the port to be configured and then select the group or groups to be output by clicking on the check box next to the group in the **Logging Group Select** pane. Select an output rate for group 1 (navigation solution), select a protocol, and finally, click the **Start Logging** button.

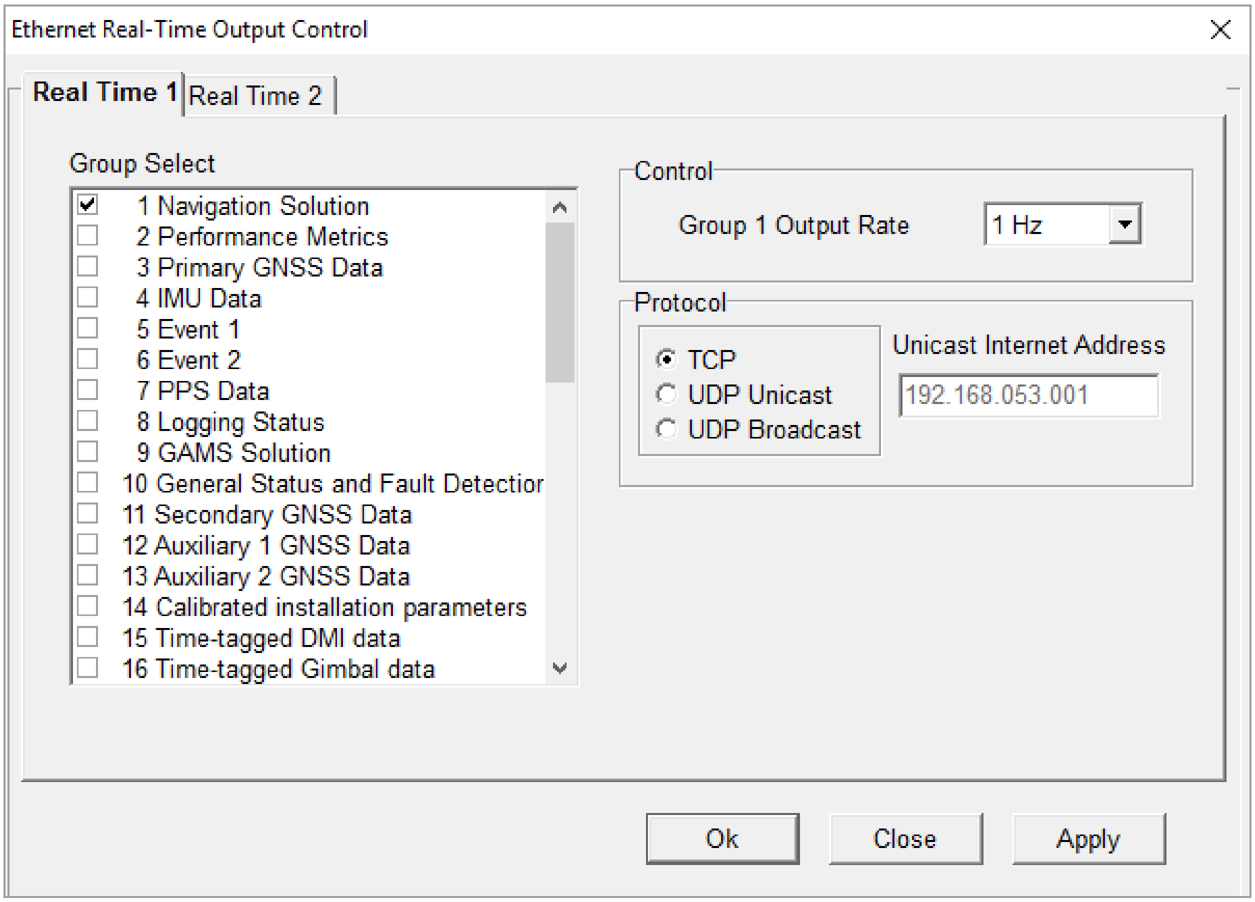


Figure 70: Ethernet Realtime Output Control.

13.0 Stand-Alone Operation

Stand-alone operation refers to using the POS LV without the LV-POSView software. After initial configuration and installation parameter set-up, the POS Computer System (PCS) can be instructed to transition to **Navigate** mode, and initiate data collection, without instructions from the LV-POSView software. This allows data to be collected without the POS LV being connected to a PC.

If the POS LV configuration is saved to non-volatile memory (refer to page 8-19, Save Settings) using the LV-POSView software, any output ports previously enabled are available in stand-alone operation. They will start outputting data when the Status light, located on the PCS front panel, begins flashing green. The Ethernet data output will begin as soon as the PCS has booted up, but Ethernet messages will contain only POS LV status and time information until the SYS light begins flashing green.

The POS LV status is determined from the Status light on the PCS front panel when the LV-POSView software is not monitoring the outputs.

AutoStart

When the AutoStart feature is enabled, POS LV automatically transitions to the **Navigate** mode during start-up. To enable the AutoStart mode, select **Settings, Installation, Tags, Multipath & AutoStart** on the LV-POSView menu bar and click the **Enabled** option in the **AutoStart** pane. Changes to the AutoStart status is saved by selecting **Settings, Save Settings** on the LV-POSView menu bar. The next time POS LV is powered-up, it automatically transitions to the **Navigate** mode. The user is not required to connect to the POS LV again.

If AutoStart is not enabled, POS LV stays in the **Standby** mode and the user is required to connect to the POS LV using the LV-POSView software. Select the **Navigate** mode option from the LV-POSView **Settings, Mode** menu bar.

AutoLog

Data logging to the removable media may be turned on without using the LV-POSView software. To enable AutoLog, select the **AutoLog** option in the **PC Card Logging Control** screen. Save the settings (described in the Save Settings description on page 8-19) prior to PCS power-down. AutoStart must be active for AutoLog to function and AutoLog is only available for removable media logging.

During the next PCS power-up, the PCS automatically transitions to the **Navigate** mode. At this time, POS LV begins logging data to the USB flash drive.

To stop data logging, press and hold the Logging switch for at least 2 seconds (located on the PCS front panel). Alternatively, click the **Stop Logging** button in the **PC Card Logging Control** screen. Data logging also stops automatically when the USB flash drive is full.

Manual Logging

Start

Logging is started manually by pressing and holding the Logging button for at least 2 seconds (PCS front panel), refer to Figure 71. Pressing the button for less than 2 seconds causes the button press to be ignored.

Stop

Logging is stopped manually by pressing and holding the Logging button for at least 2 seconds (PCS front panel). Logging stops after six seconds. If the Logging switch is pressed for less than 2 seconds the button press will be ignored.

PCS Switches and Indicators

Front Panel Switches

The PCS has two switches: Power and Logging (Figure 71). The Power switch controls the application of operating power to the PCS and illuminates the power button light when enabled. The Logging switch is used to start and stop removable media logging.

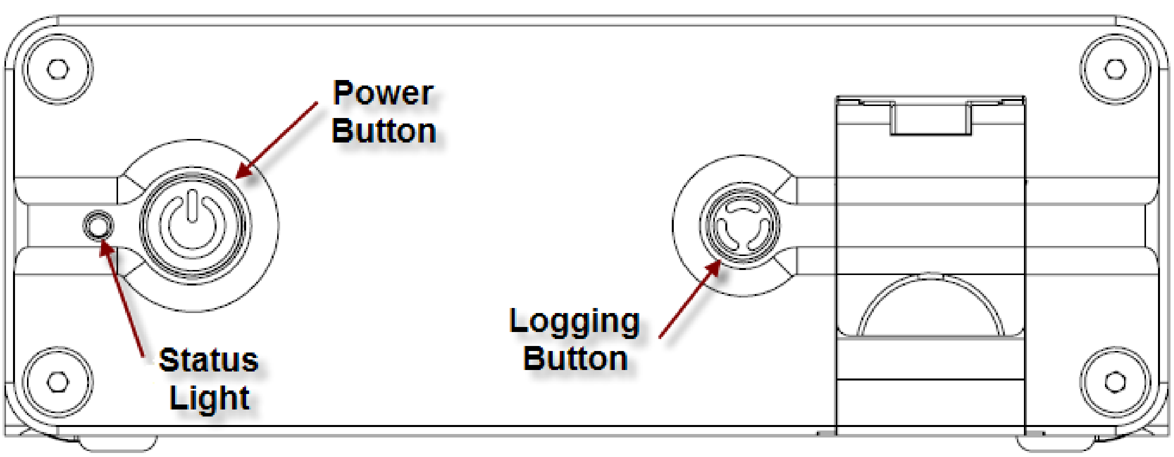


Figure 71: PCS Switches and Indicators

Front Panel Indicators

The front panel Status and Logging indicators have three different colours (red, amber and green) and three states (flashing, steady-on and steady-off). This provides multiple light patterns to indicate the status. The following list identifies the front panel indicators (Figure 71) and their indicated status.

Table 14: PCS Front Panel Lights

Status light - indicates current status of POS LV:	
Steady red:	POS LV failure - shows red when PCS is first powered-on. Changes to a valid condition when PCS internal program begins to run, but will turn red again if there is a fault in PCS. If a fault occurs, do not power-off PCS. Refer to **Fault Detection** window of controller program, see Data Integrity topic starting on page 11-1.
Steady amber:	Standby mode - POS LV is waiting for instructions.
Flashing amber:	Navigate mode - initialising and aligning attitude (coarse levelling).
Flashing green:	Navigate mode - degraded attitude performance. Attitude measurements are acceptable but do not meet user-set accuracy limits.
Steady green:	Navigate mode - normal system operation. System meets accuracy limits set by user for position, velocity, attitude and heading.
Logging light - indicates status of removable or internal media logging:	
Off:	Logging inactive
Steady green:	Logging active, media is <80% full
Steady amber:	Logging active, media is >80% full
Steady red:	Error writing to storage media
Power light - illuminates white when the PCS is operating.	

Power-Down

Power-down the POS LV by pressing and holding the Power switch on the front panel of the PCS for at least 2 seconds. The power light will begin to flash when the shutdown sequence has started. The power light will go off when the PCS has shutdown even though there may still be power applied to the PCS power cable.

For PCS-92 perform a clean shutdown by selecting the POSView **Tools, Shutdown** command. Once the power LED goes off remove the power from the rear power cable. After waiting a few seconds apply power to the chassis to power-up the PCS.

14.0 Maintenance

Voltages present in the POS LV system are sufficient to cause serious injury or death.

Important:

1. Equipment shall be serviced only by qualified personnel.
2. The PCS shall be grounded via the safety ground stud.
3. Power to the POS system should be protected by a user-supplied, resettable circuit breaker

GNSS Antennas

Do not place metallized labels on the radome. Signal attenuation will result.

Keep the weatherable polymer antenna domes clean and free of decals. Once a year inspect the antennas for damaged surfaces and check the cables for loose connectors or frayed insulation. Replace any damaged components. No further maintenance is required.

Inertial Measurement Unit

Handle the IMU with care. The POS LV IMU contains components that may be damaged by shock. Do not drop or bump the IMU. Check the shock indicator, affixed to the IMU housing, to ensure that it has not turned 'red'.

The IMU is a sealed unit and requires no maintenance. The Status light on the POS Computer System (PCS) front panel will be red or amber if the IMU has had a catastrophic failure. Connect to the PCS with LV POSView and check the **Faults** and **IMU Data** under **View** on the POSView tool bar item and **IMU** under the **Diagnostics** tool bar item. In case of failure inspect the IMU cable for damage. Contact Applanix Customer Support for assistance.

Distance Measuring Indicator

Clean the DMI regularly by spraying with water and wiping with a soft cloth to prevent dirt build-up. Regularly check the following:

- Security of the collet bolts - maximum torque value is 25 pound-force-inch (2.83 Newton metres) for ¼-20 bolts and 50 pound-force-inch (5.66 Newton metres) for $^{5}/_{16}$-18 bolts.
- Security of all DMI mounting brackets and screws.
- DMI shaft bearings for wear by attempting to move/twist the DMI body - excessive movement indicates bearing wear and possible replacement may be necessary.

Note: Contact Applanix Corporation for advice, refer to Technical Support and Service on page A-1 for procedures.

To check on DMI operation, connect to the PCS with LV POSView and check the **Faults** window under **View** on the POSView tool bar and **Time & Pulses** under the **Diagnostics** tool bar. In case of failure inspect the DMI cable and cable connectors for damage. Contact Applanix customer support for assistance.

POS Computer System

The PCS requires minimal maintenance. Ideally, the PCS should be mounted in a vibration isolated location. If not, the PCS should be examined for vibration stress (such as loosened screws). Tighten all screws and connectors. Inspect all cables for wear or damage. Inspect cable tie-downs to ensure that cables are secured and out of the way.

APPENDICES

Appendix A

Technical Support and Service

Contact Applanix

Applanix Corporation

85 Leek Crescent

Richmond Hill, ON, Canada

L4B 3B3

Tel: (905) 709-4600

Fax: (905) 709-6027

Web site: http://www.applanix.com/

How to Reach Technical Support

For technical support on POS regarding installation or operation, contact Applanix customer support at the numbers listed on our Web site. On the home page, select **Support**. If voice communication is required, select the **Contact Support** link. For general inquiries, please visit our Web site or call (905) 709-4600.

Returns

In the event that it becomes necessary to return any component of the POS system for repair, please follow the procedure below.

1. Call your Applanix Corporation Customer Support Representative and request an Return Material Authorization (RMA) number and shipping instructions
   OR
   Request an RMA number on-line by visiting www.applanix.com and going to the Support menu. A Customer Support Representative will email an RMA number and shipping instructions.
2. Carefully disconnect and remove the part(s) to be returned.
3. Pack the part(s) to be returned in their original packing containers. If the original containers are not available, make sure the part(s) are packed in hard cases with shock and vibration protection, or request shipping containers from Applanix. Applanix will not be responsible for damage to the parts during shipment.
4. Address shipping containers to the address specified with the RMA.

Please DO NOT ship any POS components to Applanix without an RMA number.

Appendix B

Message Log Definitions

The **Message Log** screen is accessed from the LV-POSView main screen by selecting ***View, Message Log*** on the menu bar. The following is a list of valid messages.

Message	Definition
Auxiliary GPS data gap cleared	Gap discontinued
Auxiliary GPS data gap detected	Gap in GPS data; this is normal if it occurs for short periods
Auxiliary GPS mode: differential	The attached auxiliary GPS receiver is operating in differential mode
Auxiliary GPS mode: Float RTK	The attached auxiliary GPS receiver is operating in float RTK mode
Auxiliary GPS mode: Narrow Lane RTK	The attached auxiliary GPS receiver is operating in narrow lane RTK mode
Auxiliary GPS mode: P-Code	The attached auxiliary GPS receiver is operating in P-Code mode
Auxiliary GPS mode: Wide Lane RTK	The attached auxiliary GPS receiver is operating in wide lane RTK mode
Auxiliary GPS position failure cleared	Flag reset
Auxiliary GPS position failure	Auxiliary GPS reports horizontal position error >1000 m; problem will eventually correct itself
Auxiliary GPS position measurement rejected	Position reported between IMU and GPS is inconsistent; GPS Lever Arms are likely incorrect in installation data
Auxiliary GPS position measurement reject cleared	Flag reset
Auxiliary GPS solution in use	Data from the auxiliary GPS receiver is being used by the PCS
Auxiliary GPS solution NOT in use	Data from the auxiliary GPS receiver is not being used by the PCS
Bad GPS Lever Arm error cleared	Flag reset
Bad GPS Lever Arm error	Primary GPS antenna Lever Arm values is invalid
Coarse levelling active	Used to indicate when POS LV is in its Coarse levelling routine, this is used to find an estimate of local level; this routine is executed upon entering Navigate mode

Message	Definition
Coarse levelling complete	Successful completion of coarse levelling routine
Coarse levelling fail cleared	Flag reset
Coarse levelling failed	Indicates that the routine was unable to find a solution due to excessive vehicle motion
Degraded navigation cleared	Flag reset
Degraded navigation set	Indicates that POS LV is estimating heading; attitude performance is OK but not optimal
DMI in use	DMI connected to POS LV
DMI not in use	DMI not connected to POS LV
DMI position measurement reject cleared	Flag reset
DMI position measurement rejected	DMI data rejected by PCS
DMI speed out of range failure cleared	Flag reset
DMI speed out of range failure	DMI rotation speed has surpassed the allowable maximum
Ephemeris data gap cleared	Flag reset
Ephemeris data gap detected	One or more expected ephemeris lists not received by the GPS receivers
Fine align active	POS LV begins accurate algorithm to estimate vehicle heading
Full navigation cleared	Flag reset
Full navigation set	Indicates everything OK, user set accuracy thresholds are met
GAMS ambiguity resolution failure	GAMS is unable to resolve carrier phase ambiguities
GAMS ambiguity resolution failure cleared	Flag reset
GAMS calibration complete	GNSS Antenna calibration for use with GAMS complete
GAMS calibration in progress	GNSS Antenna calibration for use with GAMS ongoing
GAMS calibration requested	Calibration AutoStart waiting for RMS heading error to drop below threshold
GAMS estimated offset error cleared	Flag reset

Message	Definition
GAMS estimated offset out of range	Gross error detected in GAMS Baseline Vector
GAMS heading reject cleared	Flag reset
GAMS heading rejected	GAMS heading rejected by the Kalman Filter
GAMS installation parameters NOT valid	GAMS parameters rejected by GAMS
GAMS installation parameters valid	GAMS parameters accepted by GAMS
GAMS solution in use	GAMS heading being used by Kalman Filter
GAMS solution NOT in use	GAMS heading not being used by Kalman Filter
GAMS solution not OK	Flag reset
GAMS solution OK	GPS Azimuth Measurement Subsystem is active and generating valid heading information for POS LV
GPS available for alignment	Flag reset
GPS data gap cleared	Gap discontinued
GPS data gap detected	Gap in GNSS data; this is normal if it occurs for short periods
GPS Datum parameters corrected	GNSS Datum parameters corrected
GPS Datum parameters incorrect	GNSS Datum parameters incorrect
GPS excess resets	GNSS excess resets
GPS excess resets cleared	Flag reset
GPS in navigate mode	Receiver in Nav mode
GPS Not available for alignment	POS LV failed to receive GNSS data for >60 s
GPS Not in navigate mode	GNSS receiver has not entered Navigate mode; still searching for satellites
GPS position failure cleared	Flag reset
GPS position failure	GNSS reports horizontal position error >1000 m
GPS position measurement reject cleared	Flag reset
GPS position measurement rejected	Position reported between IMU and GNSS are inconsistent; likely GNSS Lever Arms are incorrect in installation data

Message	Definition
GPS SNR worse	GNSS SNR worse
GPS SNR worse cleared	Flag reset
GPS tracking elevation limit corrected	Flag reset
GPS tracking elevation limit incorrect	GNSS receiver is not configured
GPS velocity failure cleared	Flag reset
GPS velocity failure	GNSS reports speed >35 m/s
GPS velocity measurement reject cleared	Flag reset
GPS velocity measurement rejected	Velocity reported between IMU and GNSS are inconsistent; likely GNSS Lever Arms are incorrect in installation data
IIN CA GPS mode in use	IIN CA GPS mode in use
IIN CA GPS mode not in use	IIN CA GPS mode not in use
IIN CODE DGPS mode in use	IIN CODE DGPS mode in use
IIN CODE DGPS mode not in use	IIN CODE DGPS mode not in use
IIN configuration mismatch	IIN configuration mismatch
IIN configuration mismatch cleared	Flag reset
IIN DR mode in use	IIN DR mode in use
IIN DR mode not in use	IIN DR mode not in use
IIN float RTK mode in use	IIN float RTK mode in use
IIN float RTK mode not in use	IIN float RTK mode not in use
IIN loosely coupled mode in use	IIN loosely coupled mode in use
IIN loosely coupled mode not in use	IIN loosely coupled mode not in use
IIN narrow lane RTK in use	IIN narrow lane RTK in use
IIN narrow lane RTK not in use	IIN narrow lane RTK not in use
IIN RTCM DGPS mode in use	IIN RTCM DGPS mode in use
IIN RTCM DGPS mode not in use	IIN RTCM DGPS mode not in use
IIN Wide Lane Ambiguity Error	IIN Wide Lane Ambiguity Error
IIN Wide Lane Ambiguity Error cleared	Flag reset
IIN Wide Lane Error	IIN Wide Lane Error
IIN Wide Lane Error cleared	Flag reset
IIN Wide Lane RTK mode in use	IIN Wide Lane RTK mode in use

Message	Definition
IIN Wide Lane RTK mode not in use	IIN Wide Lane RTK mode not in use
IMU failure	IMU status test failure set by IMU sensor
IMU failure cleared	Flag reset
IMU/POS checksum error	Error in data checksum between POS LV and IMU
IMU/POS checksum error cleared	Flag reset
Incorrect SV selection parameters	Incorrect SV selection parameters
Incorrect SV selection parameters cleared	Flag reset
Initial position invalid	Geographic position supplied by GNSS is invalid
Initial position valid	Geographic position supplied by GNSS is valid
Invalid mode	PCS error transitioning between Standby and Navigate modes
Message Log	Display of the POS messages
Multiple consecutive IMU failures	Communications problem between IMU and PCS; check cable
Multiple consecutive IMU failures cleared	Flag reset
Navigate mode	POS LV operating in Navigate mode
Navigator alignment active	Indicates that the algorithm used to obtain a rough estimate of the vehicle's heading is active; if GNSS is not available for more than five seconds, POS LV will return to Coarse levelling
Navigator alignment cleared	Flag reset
No Primary GPS data	The PCS is not receiving data from the primary GNSS receiver
NVM read fail cleared	Flag reset
NVM read fail set	NVM fail; parameters cannot be saved
NVM write fail	NVM write failed, try again
NVM write successful	RAM parameters successfully saved to NVM
PC Card logging device full	PC Card full
PC Card logging disabled	PC Card logging disabled
PC Card logging enabled	PC Card logging enabled

Message	Definition
PC Card logging file closed	PC Card logging stopped
PC Card logging file open	PC Card logging started
PC Card logging file write error	Error logging to PC Card
PC Card logging file write error cleared	Flag reset
POS Controller out of resources	Message log cleared
POS fix in use	POS fix in use
POS fix not in use	POS fix not in use
Position/Velocity fix error	Position/Velocity fix error
Position/Velocity fix error cleared	Flag reset
PPS time gap	Gap in PPS signal; this is normal if it occurs for shot periods
PPS time gap cleared	Gap discontinued
Pri-Aux GPS differential of position error cleared	Flag reset
Pri-Aux GPS differential of position exceeds limits	GNSS receiver position data difference exceeds tolerance
Primary GPS configuration file sent	File to configure GNSS receiver for POS LV use was sent to receiver
Primary GPS Initialization Failed Cleared	Flag reset
Primary GPS Initialization Failed	POS LV failed to receive initialization data from GNSS
Primary GPS L1 phase cleared	Flag reset
Primary GPS L1 phase set	Primary GPS L1 phase set
Primary GPS mode: C/A	GNSS receiver in standalone operation - no differential corrections are being processed
Primary GPS mode: differential	Primary GNSS receiver is in differential mode
Primary GPS mode: Float RTK	Primary GNSS receiver is in float RTK mode
Primary GPS mode: Narrow Lane RTK	Primary GNSS receiver is in narrow lane RTK mode
Primary GPS mode: Wide Lane RTK	Primary GNSS receiver is in wide lane RTK mode
Primary GPS NOT configured	Receiver did not respond to configuration message
Primary GPS precise L1 cleared	Flag reset

Message	Definition
Primary GPS precise L1 set	Primary GNSS precise L1 set
Primary GPS precise wide lane cleared	Flag reset
Primary GPS precise wide lane set	Primary GNSS precise wide lane set
Primary GPS Pseudorange cleared	Flag reset
Primary GPS Pseudorange set	Primary GNSS Pseudorange set
Primary GPS range rate cleared	Flag reset
Primary GPS range rate set	Primary GNSS range rate set
Primary GPS raw observable data gap cleared	Flag reset
Primary GPS raw observable data gap detected	Primary GNSS receiver data gap
Primary GPS reset	GNSS reset message sent to receiver to clear receiver problem
Primary GPS reset cleared	Flag reset
Primary GPS solution in use	Primary GNSS data are in use by the PCS
Primary GPS solution in use for GAMS	Primary GNSS data are in use for GAMS
Primary GPS solution NOT in use	Primary GNSS data are not in use
Primary GPS solution NOT in use for GAMS	Primary GNSS data are not in use for GAMS
Primary GPS wide lane IF phase cleared	Flag reset
Primary GPS wide lane IF phase set	Primary GNSS wide lane IF phase solved
Quadrant resolved	POS LV has determined the heading of the vehicle to within one quadrant (i.e. 90 degrees)
Quadrant resolved cleared	Flag reset
RTCM correction in use	RTCM in use
RTCM correction Not in use	RTCM NOT in use
RTCM data gap	RTCM messages late
RTCM data gap cleared	Flag reset
RTCM parity error	RTCM message error
RTCM parity error cleared	Flag reset
Secondary GPS data gap cleared	Gap discontinued

Message	Definition
Secondary GPS data gap detected	Gap in GNSS data; this is normal if it occurs for short periods
Secondary GPS raw observable data gap cleared	Flag reset
Secondary GPS raw observable data gap detected	Data gap detected in secondary GNSS receiver
Secondary GPS solution in use	Secondary GNSS data in use
Secondary GPS solution NOT in use	Secondary GNSS data not in use
Simulate Mode	Inertial Data from simulator
Speed out of range fault	Navigation algorithm speed is out of range (speed >35 m/s); algorithm will eventually reset itself
Speed out of range fault cleared	Flag reset
Standby mode	POS LV operating in Standby mode
Strap down navigator initialized	POS LV completes Coarse levelling & Navigator begins running
Strap down navigator initialized status cleared	Flag reset
Time Recovery message NOT received	UTC time of next PPS not received
Time Recovery message received	UTC time of next PPS received
User attitude RMS performance cleared	Attitude accuracy threshold reset
User attitude RMS performance set	Attitude accuracy threshold set
User heading RMS performance cleared	Heading accuracy threshold reset
User heading RMS performance set	Heading accuracy threshold set
User position RMS performance cleared	Position accuracy threshold reset
User position RMS performance set	Position accuracy threshold set
User velocity RMS performance cleared	Velocity accuracy threshold reset
User velocity RMS performance set	Velocity accuracy threshold set
X Accelerometer bias estimate error cleared	Flag reset

Message	Definition
X Accelerometer bias estimate out of range	The Kalman Filter's estimate of the X Accelerometer Bias is outside the allowable range of 4000 micro-gravity
X Gyro bias estimate error cleared	Flag Rest
X Gyro bias estimate out of range	The Kalman Filter's estimate of the X Gyro Bias is outside the allowable range of 20 deg/hr
Y Accelerometer bias estimate error cleared	Flag reset
Y Accelerometer bias estimate out of range	The Kalman Filter's estimate of the Y Accelerometer Bias is outside the allowable range of 4000 micro-gravity
Y Gyro bias estimate error cleared	Flag reset
Y Gyro bias estimate out of range	The Kalman Filter's estimate of the Y Gyro Bias is outside the allowable range of 20 deg/hr
Z Accelerometer bias estimate error cleared	Flag reset
Z Accelerometer bias estimate out of range	The Kalman Filter's estimate of the Z Accelerometer Bias is outside the allowable range of 4000 micro-gravity
Z Gyro bias estimate error cleared	Flag reset
Z Gyro bias estimate out of range	The Kalman Filter's estimate of the Z Gyro Bias is outside the allowable range of 20 deg/hr
ZUPD enabled	ZUPD on
ZUPD not enabled	ZUPD off
ZUPD in use	ZUPD on and in use
ZUPD not in use	ZUPD on but NOT in use

Appendix C

LV-POSView Main Menu Options

Table 15: File Menu

Menu Selection	Submenu Selection	Description
Load POS Config		Loads the IP address, installation settings and logging parameters for POS LV from the computer running LV-POSView.
Save POS Config		Saves the IP address, installation settings and logging parameters for POS LV to the computer running LV-POSView.
Save Message Log		Saves the Message Log file.
Exit (Alt + F4)		Exits LV-POSView; pressing Alt+F4 or clicking on the Screens close button on the top right corner of the screen will also exit LV-POSView.

Table 16: Settings Menu

Menu Selection	Submenu Selection	Description
Input/Output Ports		Selection of input and output stream setting for COM ports.
Events		Sets trigger edge for event marking and configures PPS output pulse.
Events Output		Configures the time or distance based event output pulse.
Initialize without GNSS		Sets the initial time, date, position and mode for POS when no GNSS signal is available.
GAMS Calibration Control	Start	Begins GAMS calibration process.
Ethernet Real-time Port		Enable output data groups on Real-time TCP/IP port.
SBAS Settings		Selects input type of SBAS.

Table 16: Settings Menu

Menu Selection	Submenu Selection	Description
Installation	Lever Arms & Mounting	Provides input screen for measured Lever Arms and mounting angle values; provides access to **Lever Arms & Mounting Angles, Sensor Mounting** and **Tags, Multipath & AutoStart** tabs.
	GNSS Receiver	GNSS receiver settings.
	GAMS Parameter Set-up	GAMS set-up parameters.
	Tags, Multipath & AutoStart	Provides access to Time and Distance Tag settings and whether AutoStart feature is enabled or disabled.
	User Accuracy	Accuracy threshold settings used for Main Screen accuracy indicators and system light on PCS.
	POS IP Address	IP Address setting.
Save Settings		Saves installation settings to the PCS.
Restore Settings	User Settings	Allows restoration of previously saved settings.
	Factory Default	Allows restoration of the factory default settings.

Table 17: Logging Menu

Menu Selection	Submenu Selection	Description
Ethernet Logging		Configure and control Ethernet logging; buffered port for data logging.
Removable Logging Media		Configure and control logging to removable media (USB flash drive).

⚠ **Logging high rate data to both an Ethernet port and a USB flash drive simultaneously can overload POS LV and result in a loss of data.**

Table 18: View Menu

Menu Selection	Submenu Selection	Description
Message Log		Displays the Message Log file.
GNSS Data		Displays status of GNSS satellites tracked.
IIN Solution		Displays status of the blended navigation solution.
GAMS Solution		Displays status of GAMS ambiguity resolution.
IMU Data		Displays IMU data.
Event Data		Displays event counts for all events.
Faults		Displays POS LV faults.
Statistics		Displays system information such as serial numbers, soft ware versions and run time.
User Time Data		Displays diagnostics regarding USER time synchronization.
Position Plot		Displays the current position of POS LV.
Modem State	Base 1	Displays the Base 1 modem connection status.
	Base 2	Displays the Base 2 modem connection status.
Integrated DGNSS		Displays integrated DGNSS status.
Command Reply		Displays log of confirmations or rejections of commands received by POS LV from LV-POSView (Transaction number, message ID, Response, New, Parameter).

Table 19: Tools Menu.

Submenu Selection	Submenu Options	Description
Options		User preferences.
Configuration		Allows manual configuration of the navigation data integration.
Configure GNSS		Sends commands to configure the receiver.
Reset GNSS		Sends commands to reset the receiver.

Table 19: Tools Menu.

Submenu Selection	Submenu Options	Description
Reset		Reset is equivalent to cycling the PCS power, with the exception that GNSS, IMU and DMI data are available immediately after reset; do not use unless POS LV exhibits inexplicable behaviour and all other options have been exhausted (e.g. Cables and Connectors checked for shorts or failures).
Shutdown		File systems are synchronized; Prepares POS LV for power-off.
Delete Files		Allows the internally logging data files to be deleted without having to FTP.
Zero Velocity Update		Configures when and how Zero Velocity Updates are detected and applied.

Table 20: Diagnostic Menu

Menu Selection	Submenu Selection	Description
Primary GNSS		Displays connectivity status of the Primary GNSS.
Secondary GNSS		Displays connectivity status of the Secondary GNSS.
Base GNSS	Base 1	Displays statistics on incoming Base 1 GNSS corrections data.
	Base 2	Displays statistics on incoming Base 2 GNSS corrections data.
Aux GNSS		Displays connectivity status of the auxiliary GNSS receivers.
Control Port		Displays statistics on the Ethernet control port.
Display, Data and NVM		Displays statistics on the Ethernet Display, Data Port 1 (real-time) and Data Port 2 (buffered) ports and on the Non-Volatile memory (NVM).
Time & Pulses		Displays statistics on POS timing, discrete data and DMI pulses.
IMU		Displays statistics on raw IMU data.

Table 20: Diagnostic Menu

Menu Selection	Submenu Selection	Description
NMEA & Binary Output		Displays statistics on COM port facilities.
Other		Displays statistics on other system functions.

Table 21: Help Menu

Menu Selection	Submenu Selection	Description
About		Lists information about LV-POSView.

Appendix D

LV-POSView Status Pane Messages

Table 22: POS Mode

Message	Description
Standby	The system is ready to output the real-time solution once the user presses the Navigate button.
Levelling Active	POS LV is in the process of determining vehicle orientation.
Nav: Degraded	POS LV is operating in degraded navigation mode. Roll and pitch errors are greater than 0.05 degree.
Nav: Full	POS LV is operating in full navigation mode. When all navigation accuracy falls to or below user setting (see Accuracy Pane under section 7)
Nav: Aligned	POS LV is operating in heading aligned mode. Heading error is below 10 degree and being continuously improved.
Navigate	POS LV is operating in Navigate mode.

Table 23: IMU Status

Message	Description
Failure	IMU not functioning properly. Power-down, disconnect IMU and contact Applanix Customer Support.
Warning	IMU not functioning properly. Power-down, disconnect IMU and contact Applanix Customer Support.
OK	IMU functioning correctly.

Table 24: DMI Status

Message	Description
Offline	DMI not functioning properly. Power-down, disconnect DMI and contact Applanix Customer Support.
OK	DMI functioning correctly.

Table 25: Nav Status

Message	Description
DR	The system provides a navigate solution without GNSS aiding.

Table 25: Nav Status

Message	Description
C/A	The GNSS receivers are providing positional data without differential correction.
RTCM DGPS	The GNSS receivers are providing positional data enhanced by real-time differential correction.
CODE DGPS	The GNSS receivers are providing positional data enhanced by real-time differential correction.
FLOAT RTK	Real-time positional data are being generated with float ambiguity resolution.
FIXED RTK	Real-time positional data are being generated with fixed ambiguity resolution.
Aux. NL RTK	The auxiliary GNSS receiver is providing real-time positional data using narrow lane ambiguity resolution.
Aux. WL RTK	The auxiliary GNSS receiver is providing real-time positional data using wide lane ambiguity resolution.
Aux. Float RTK	The auxiliary GNSS receiver is providing real-time positional data using float ambiguity resolution.
Aux. DGPS	The auxiliary GNSS receiver is providing positional data enhanced by a differential correction signal.
Aux. C/A	The auxiliary GNSS receiver is providing positional data without differential correction.

Table 26: GAMS

Message	Description
CAL In Progress	The PCS is calibrating GAMS against IMU data. The calibration must finish before GAMS can be used for navigation.
CAL Requested	POS LV is waiting for RMS heading error to fall below the user-defined value before calibration AutoStart. Perform an aggressive manoeuvre and then stop, and wait.
CAL Complete	The GAMS calibration is complete. POS LV will now be able to provide more accurate heading data.
Online	GAMS heading aiding data are available and being processed by the Kalman Filter.
Ready Online	GAMS heading-aiding data are available, but not being processed by the Kalman Filter.
Ready Offline	GAMS has resolved carrier ambiguities. (Perform a GAMS calibration for heading data to be available to the PCS).
Not Ready	GAMS is not ready for calibration or operation.

Table 27: Logging

Message	Description
Idle	Logging is not currently in progress.
Buffering	The PCS is buffering data in preparation for writing data to the USB flash device.
Writing	Data are being logged to the USB flash device.
Device Full	The media is full.
Write Error	An error occurred while attempting to write to the media. Ensure that the USB flash device has been correctly and fully inserted into the drive, and that the disk is not full. This message may also appear if the disk is damaged.
Invalid	Disk in logging device is not compatible.

Appendix E

Tait-Bryan Sequence

Locate the X1, Y1 and Z1 axis and the XY, YZ, ZX planes of the IMU reference frame. Locate the reference frame axis X2, Y2, Z2 (Figure 72). To bring the IMU into alignment with the reference frame, rotate the reference frame about its Z2 axis until the Y2 axis is in the YZ plane of the IMU. Rotate the reference frame about its Y2 axis (already once rotated), until the X2 axis direction is parallel to the X1 axis direction. Rotate the reference frame about its X2 axis (already twice rotated) until the Y2 axis is parallel to the Y1 axis.

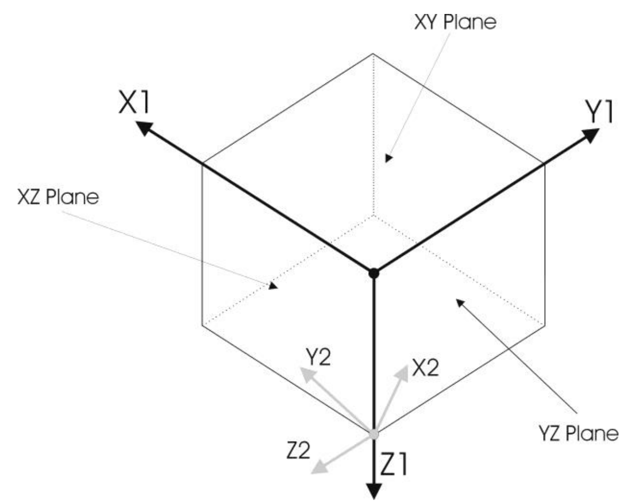
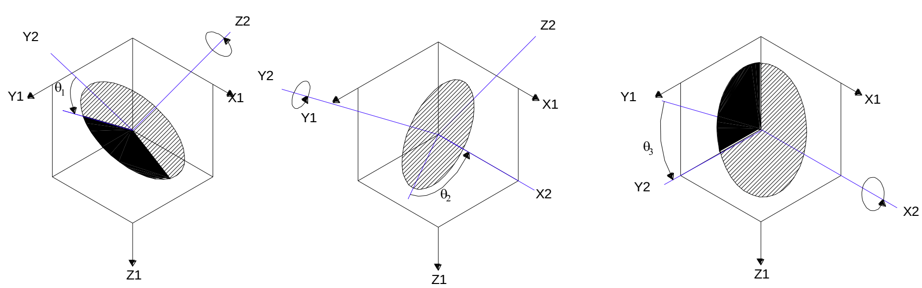


Figure 72: Tait-Bryan Planes and Axis



This indicates the area of the circle defined by the angle θ that is in front of the 3D matrix.

This indicates the area of the circle defined by the angle θ that is behind the 3D matrix.

Figure 73: Tait-Bryan Rotations Diagram

Yaw is the angle θ_1 from the first rotation. Pitch is the angle θ_2 from the second rotation and Roll is the third rotation angle θ_3, shown in the diagram above.

Appendix F

NMEA and Binary Message Formats

Note: Multiple NMEA messages can be output simultaneously on a given COM port, but only one Binary message can be output at a time on a given COM port.

NMEA Checksum Field

The checksum field is transmitted in all sentences, is the last field in a sentence and follows the checksum delimiter character '*****'. It is the 8-bit exclusive OR (no start or stop bits) of all the characters in a sentence, including the '**,**' delimiters, between but not including the '$' and the '*****' delimiters. The hexadecimal value of the most significant and the least significant 4 bits of the result is converted to two ASCII characters (0-9, A-F) for transmission; the most significant character is transmitted first.

NMEA Port GST Message Format

The GST pseudo range measurement noise statistics data are translated in the position domain in order to give statistical measures of quality of the position solution.

It is output in the following ASCII NMEA format:

Table 28: NMEA GST Message Format

$ttGST,hhmmss.sss,,ssss.s,,ssss.s,ooo.o,l.l,y.y,a.a*hh<CR><LF>

Item	Definition	Value	Units
$ttGST	Header with talker ID	$ttGST	tt = IN or GP
hhmmss.sss	UTC time of position	NRG	hours / minutes / seconds. decimal seconds
Null	Not supported	Null	N/A
ssss.s (-ssss.s)	Standard deviation of semi- major axis of error ellipse	NRG	metres
ssss.s (-ssss.s)	Standard deviation of semi-minor axis of error ellipse	NRG	metres
ooo.o	Orientation of semi-major axis of error ellipse	0 to 359.9	degrees from True North
l.l (-llll.l)	Standard deviation of latitude	NRG	metres
y.y (-yyyy.y)	Standard deviation of longitude	NRG	metres

Table 28: NMEA GST Message Format

$ttGST,hhmmss.sss,,ssss.s,,ssss.s,ooo.o,l.l,y.y,a.a*hh<CR><LF>

Item	Definition	Value	Units
a.a (-aaa.a)	Standard deviation of altitude	NRG	metres
*hh	Checksum	Hexadecimal value (NRG)	N/A
<CR><LF>	Carriage return & line feed	<CR><LF>	N/A

NRG stands for No Range Given.

Note: In the case of the all fields except Orientation, Checksum and UTC time of position, leading digits are added as required (i.e. if the value exceeds 9.9).

NMEA Port GGA Message Format

The GGA position data are output in the following ASCII NMEA format:

Table 29: NMEA GGA Message Format

$ttGGA,hhmmss.sss,llll.lllll,a,yyyyy.yyyyy,b,t,nn,v.v,x.x,M,,,cc.c,rrrr*hh<CR><LF>

Item	Definition	Value	Units
$ttGGA	Header with talker ID	$ttGGA	tt = IN or GP
hhmmss.sss	UTC time of position	NRG	hours / minutes / seconds. decimal sec
llll.lllll	Latitude	0° to +90°	degrees / minutes. decimal min
a	N (North) or S (South)	N or S	N/A
yyyyy.yyyyy	Longitude	0° to +180°	degrees / minutes. decimal min
b	E (East) or W (West)	E or W	N/A
t	GPS Quality Indicator	0 to 8 (see Table 30)	N/A
nn	Number of Satellites used in the fix	0 to 32	N/A
v.v	HDOP	NRG	N/A
xxxx.xx	Altitude of the IMU above or below mean sea level; a leading "-" indicates below	NRG	metres
M	Units of Measure = metres	M	N/A

Table 29: NMEA GGA Message Format

$ttGGA,hhmmss.sss,llll.lllll,a,yyyyy.yyyyy,b,t,nn,v.v,x.x,M,,,cc.c,rrrr*hh<CR><LF>

Item	Definition	Value	Units
null	Geoidal Separation = (WGS-84 Earth ellipsoid- mean sea level); a leading "-" indicates below	NRG	metres
null	Units of Measure = metres	M	N/A
cc.c (null if not DGPS mode)	Age of differential corrections in seconds since last RTCM-104 message.	0 to 99.9	seconds
rrrr (null if not DGPS mode)	DGPS reference station ID	0000 to 1023	N/A
*hh	Checksum	Hexadecimal value (NRG)	N/A
<CR><LF>	Carriage return & line feed	<CR><LF>	N/A

NRG stands for No Range Given.

Note: In the case of the HDOP and IMU Altitude, leading digits are added as required (i.e. if the value exceeds 9.9).

Table 30: GPS Quality Indicator Values

Value	GPS Mode
0	Fix not available or invalid
1	GPS SPS mode, fix available
2	Differential GPS, SPS mode fix valid
3	GPS PPS mode, fix valid (not supported)
4	RTK Satellite system used in RTK mode with Fixed integers
5	Float RTK satellite system used in RTK mode with floating integers
6	Estimated (dead reckoning) mode
7	Manual Input mode (Not Supported)
8	Simulated mode (Not Supported)

NMEA Port HDT Message Format

The HDT heading data are output in the following ASCII NMEA format:

Table 31: NMEA HDT Message Format

$ttHDT,xxx.x,T*hh<CR><LF>

Item	Definition	Value	Units
$ttHDT	Header with talker ID	$ttHDT	tt = IN or GP
xxx.x	True vehicle heading	0 to 359.9	degrees. decimal degrees
T	True	T	N/A
*hh	Checksum	Hexadecimal value (NRG)	N/A
<CR><LF>	Carriage return & line feed	<CR><LF>	N/A

NRG stands for No Range Given.

NMEA Port ZDA Message Format

The ZDA provides time and date information. It is output in the following ASCII NMEA format:

Table 32: NMEA ZDA Message Format

$ttZDA,hhmmss.sss,dd,mm,yyyy,,*hh<CR><LF>

Item	Definition	Value	Units
$ttZDA	Header with talker ID	$ttZDA	tt = IN or GP
hhmmss.sss	UTC time of data string	NRG	Hours / minutes / seconds. decimal sec
dd	Day of the month	01 to 31	N/A
mm	Month of the year	01 to 12	N/A
yyyy	Year	1993 to 9999	N/A
Null	Local time zone hours		Hours (not supported)
Null	Local time zone minutes		Minutes (not supported)
*hh	Checksum	Hexadecimal value (NRG)	N/A
<CR><LF>	Carriage return and line feed	<CR><LF>	N/A

NRG stands for No Range Given.

NMEA Port $EVT1 and $EVT2 Message Format

$EVT1 and $EVT2 provides event timing. Although not NMEA 0183 messages, each event time message is compatible with the standard. The following identifies their output ASCII format:

Table 33: $EVT1 Message Format

$EVT1,ssssss.ssssss,t,xxxxxxxx,*hh<CR><LF>

Item	Definition	Value	Units
$EVT1	Header	$EVT1	N/A
ssssss. ssssss	UTC time of data string	N/A	seconds. decimal seconds of the week (variable length)
t	Time tag	G or U	GPS or UTC time
xxxxxxxx	Event counter	0 to 999999	N/A
*hh	Checksum	Hexadecimal value (NRG)	N/A
<CR><LF>	Carriage return and line feed	<CR><LF>	N/A

Table 34: $EVT2 Message Format

$EVT2,ssssss.ssssss,t,xxxxxxxx,*hh<CR><LF>

Item	Definition	Value	Units
$EVT2	Header	$EVT2	N/A
ssssss. ssssss	UTC time of data string	N/A	seconds. decimal seconds of the week (variable length)
t	Time tag	G or U	GPS or UTC time
xxxxxxxx	Event counter	0 to 999999	N/A
*hh	Checksum	Hexadecimal value (NRG)	N/A
<CR><LF>	Carriage return and line feed	<CR><LF>	N/A

NMEA Port VTG Message Format

The VTG track and speed data are output in the following ASCII NMEA format:

Table 35: NMEA VTG Message Format

$ttVTG,xxx.x,T,,M,n.n,N,k.k,K*hh<CR><LF>

Item	Definition	Value	Units
$ttVTG	Header with talker ID	$ttVTG	tt = IN or GP
xxx.x	True vehicle track	0 to 359.9	degrees. decimal degrees
T	True	T	N/A
Null	Not supported	Null	N/A
M		M	N/A
n.n (-nnnn.n)	Speed	NRG	knots
N	Knots	N	N/A
k.k (-kkkk.k)	Speed	NRG	km/hr
K	Kilometres	K	N/A
*hh	Checksum	N/A	N/A
<CR><LF>	Carriage return & line feed	<CR><LF>	N/A

NRG stands for No Range Given.

Note: In the case of the speed fields, leading digits are added as required (i.e. if the value exceeds 9.9 or is negative).

NMEA $PASHR Message Format

The $PASHR provides attitude data. It is output in the following ASCII NMEA format:

Table 36: NMEA $PASHR Message Format

$PASHR,hhmmss.sss,xxx.xx,T,RRR.RR,PPP.PP,HHH.HH,
a.aaa,b.bbb,c.ccc,d,e,*hh<CR><LF>

Item	Definition	Value	Units
$PASHR	Header	$PASHR	N/A
hhmmss.sss	UTC time of data string	N/A	Hours / minutes / seconds. decimal sec
xxx.xx	True Heading	0 to 359.99	degrees. decimal degrees
T	True	T	N/A
RRR.RR	Roll	-90.00 to +90.00	degrees

Table 36: NMEA $PASHR Message Format

$PASHR,hhmmss.sss,xxx.xx,T,RRR.RR,PPP.PP,HHH.HH,
a.aaa,b.bbb,c.ccc,d,e,*hh<CR><LF>

Item	Definition	Value	Units
PPP.PP	Pitch	-90.00 to +90.00	degrees
HHH.HH	Heading (Not supported)	0 to 359.99	degrees
a.aaa	Roll accuracy	0 to 9.999	degrees
b.bbb	Pitch accuracy	0 to 9.999	degrees
c.ccc	Heading accuracy	0 to 9.999	degrees
d	Flag: GPS quality	0, 1 or 2	0 = no aiding 1 = GPS aiding 2 = GPS & GAMS aiding
e	Flag: IMU state	0 or 1	0 = IMU bad 1 = IMU ok
*hh	Checksum	Hexadecimal value (NRG)	N/A
<CR><LF>	Carriage return and line feed	<CR><LF>	N/A

NRG stands for No Range Given.

NMEA PORT GGA2 Message Format

The GGA2 position data are output in the following ASCII NMEA format:

Table 37: NMEA GGA2 Message Format

$ttGGA,hhmmss.ss,llll.llll,a,yyyyy.yyyy,b,t,nn,v.v,xxxx.x,m,
gggg.g,m,ccc,rrrr*hh<CR><LF>

Items	Definition	Values	Units
$ttGGA2	Header with talker ID	$ttGGA	tt = IN or GP
hhmmss.ss	UTC Time of position	NRG	hours / minutes / seconds. decimal sec
llll.llll	Latitude	0º to 90º	degrees / minutes. decimal min
a	N (North) or S (South)	N or S	N/A
yyyyy.yyyy	Longitude	0º to 180º	degrees / minutes. decimal min

Table 37: NMEA GGA2 Message Format

$ttGGA,hhmmss.ss,llll.llll,a,yyyyy.yyyy,b,t,nn,v.v,xxxx.x,m,
gggg.g,m,ccc,rrrr*hh<CR><LF>

Items	Definition	Values	Units
b	E (East) or W (West)	E or W	N/A
t	GPS Quality Indicator	0 to 8 (see Table 32)	N/A
nn	Number of Satellites used in the fix	0 to 32	N/A
v.v	HDOP	NRG	N/A
xxxx.x	Altitude of IMU above or below mean sea level; a leading “-“ indicates below	NRG	metres
m	Units of Measure = metres	M	N/A
gggg.g	Geoidal Separation = (WGS-84 Earth Ellipsoid-mean sea level); a leading “-“ indicates below	NRG	metres
m	Units of Measure = metres	M	N/A
ccc (null if not DGPS mode)	Age of differential corrections in second since last RTCM-104 message	0 to 999	seconds
rrrr (null if not DGPS mode)	DGPS reference station ID	0000 to 1023	N/A
*hh	Checksum	Hexadecimal value (NRG)	N/A
<CR><LF>	Carriage return & Line feed	<CR><LF>	N/A

NRG stands for No Range Given.

Note: In the case of the HDOP and IMU Altitude, leading digits are added as required (i.e. if the value exceeds 9.9).

NMEA Port PPS Message Format

The PPS data are output in the following ASCII NMEA format:

Table 38: NMEA PPS Message Format

$ttPPS,hhmmss.ss,dddddd,wwwwww,fff.ff,pppppp,*hh<CR><LF>

Items	Definition	Values	Units
$ttPPS	Header with talker ID	$ttPPS	tt = IN or GP
hhmmss.ss	UTC time of PPS	NRG	hours / minutes / seconds. decimal sec
dddddd	Day offset	NRG	days
wwwwww	GPS week	NRG	weeks
fff.ff	UTC time offset	NRG	seconds
pppppp	PPS count	NRG	N/A
*hh	Checksum	Hexadecimal value (NRG)	N/A
<CR><LF>	Carriage return & Line feed	<CR><LF>	N/A

NRG stands for No Range Given.

NMEA Port GGK Message Format

The GGK position data are output in the following ASCII NMEA format:

Table 39: NMEA GGK Message Format

$ttGGK,hhmmss.sss,ddmmyy,llll.lllll,a,yyyyy.yyyy,b,t,nn,v.v,
EHTxxxx.xx,m*hh<CR><LF>

Items	Definition	Values	Units
$ttGGK	Header with talker ID	$ttGGK	tt = IN or GP
hhmmss.sss	UTC time	NRG	hours / minutes / seconds. decimal sec
ddmmyy	UTC Date	NRG	day / month / year
llll.lllll	Latitude	0º to 90º	degrees / minutes. decimal min
a	N (North) or S (South)	N or S	N/A
yyyyy.yyyy	Longitude	0º to 180º	degrees / minutes. decimal min

Table 39: NMEA GGK Message Format

$ttGGK,hhmmss.sss,ddmmyy,llll.lllll,a,yyyyy.yyyy,b,t,nn,v.v,
EHTxxxx.xx,m*hh<CR><LF>

Items	Definition	Values	Units
b	E (East) or W (West)	E or W	N/A
t	GPS Quality Indicator	0 to 8 (See Table 32)	N/A
nn	Number of Satellites used in fix	0 to 32	N/A
v.v	PDOP	NRG	N/A
EHTxxxx.xxx	Ellipsoidal height	EHTxxxx.xxx	metres
m	Units of measure = metres	M	N/A
*hh	Checksum	*hh	N/A
<CR><LF>	Carriage return & Line feed	<CR><LF>	N/A

NRG stands for No Range Given

NMEA Port RMC Message Format

The RMC navigation data are output in the following ASCII NMEA format. Note the 2 fields describing the magnetic variation are not included and are therefore left null.

Table 40: NMEA RMC Message Format

$ttRMC,hhmmss.ssss,v,llll.lllll,a,yyyyy.yyyyy,b,sssss.s,
hhh.h,ddmmyy,,,c*hh<CR><LF>

Items	Definition	Values	Units
$ttRMC	Header with talker ID	$ttRMC	tt = IN or GP
hhmmss.ssss	UTC time of navigation data	NRG	hours / minutes / seconds. decimal sec
v	A (Valid) or V (Not valid)	A or V	N/A
llll.lllll	Latitude	0^{o} to 90^{o}	degrees / minutes. decimal min
a	N (North) or S (South)	N or S	N/A
yyyyy.yyyyy	Longitude	0^{o} to 180^{o}	degrees / minutes. decimal min

Table 40: NMEA RMC Message Format

$ttRMC,hhmmss.ssss,v,llll.lllll,a,yyyyy.yyyyy,b,sssss.s,
hhh.h,ddmmyy,,,c*hh<CR><LF>

Items	Definition	Values	Units
b	E (East) or W (West)	E or W	N/A
sssss.s	Speed in knots	NRG	knots
hhh.h	Heading	0^o to 359.9^o	degrees
ddmmyy	Date of navigation data	NRG	days/ months/ year
c	Mode indicator	See Table 43	N/A
*hh	Checksum	Hexadecimal value	N/A
<CR><LF>	Carriage return & Line feed	<CR><LF>	N/A

NRG stands for No Range Given.

Table 41: RMC Mode Indicator Values

Value	777777RMC Mode
a	Autonomous
d	Differential
e	Dead reckoning
n	Not valid

Binary Output Port Position, Attitude, Speed, Track and Acceleration Output: PAST2 Message Format

PAST2 is a 40-byte message containing time, position, attitude, speed, track and acceleration of the Reference Frame. Unlike some of the other COM (2) messages, it also contains a checksum.

A description of the output message is given in the following table:

Table 42: PAST2 Message Format

Item	Byte	Format	Value	Units
Header LSB	0	Byte	0x00	N/A
Header MSB	1	Byte	0x96	N/A

Table 42: PAST2 Message Format

Item	Byte	Format	Value	Units
Time of Validity	2-9	Double	UTC seconds of the week or elapsed seconds if GPS not available	seconds
Roll LSB	10	Byte	LSB: 0.01° Range: ± 180°	degree/bit
Roll MSB	11	Byte		
Pitch LSB	12	Byte	LSB: 0.01° Range: ± 180°	degree/bit
Pitch MSB	13	Byte		
Heading LSB	14	Byte	LSB: 0.01° Range: 0° to 359.99°	degree/bit
Heading MSB	15	Byte		
Latitude	16-19	Long	LSB: 0.001 arcsec Range: -90° to + 90°	arcsec/bit
Longitude	20-23	Long	LSB: 0.001 arcsec -180° to + 180°	arcsec/bit
Altitude	24-27	Long	LSB: 0.01m Range: -1000.0 m to 20000 m	m/bit
Speed LSB	28	Byte	LSB: 0.01m/s Range: 0 to 300 m/s	m/s/bit
Speed MSB	29	Byte		
Track LSB	30	Byte	LSB: 0.01° Range: 0° to 359.99°	deg/bit
Track MSB	31	Byte		
Long Accel LSB	32	Byte	LSB: 0.0005 m/s^2	m/s^2/bit
Long Accel MSB	33	Byte		
Tran Accel LSB	34	Byte	LSB: 0.0005 m/s^2/bit	m/s^2/bit
Tran Accel MSB	35	Byte		
Down Accel LSB	36	Byte	LSB: 0.0005 m/s^2	m/s^2/bit
Down Accel MSB	37	Byte		
Checksum LSB	38	Byte	N/A	N/A
Checksum MSB	39	Byte		

Checksum calculation: Bytes 0 & 1 are ignored. Bytes 2 to 37 are added. Bytes 38 & 39 contain the checksum.

Binary Output Port RDR1 Message Format

The RDR message outputs sensor position and orientation for Land Radar applications.

Table 43: RDR1 Message Format

Item	Byte	Format	Value	Units
Header LSB	0	Byte	0x55	N/A
Header MSB	1	Byte	0xBB	N/A
Byte Count	2-3	Short	46	N/A
SIDC	4	Byte	0x03	N/A
SIDC	5	Byte	IP Address	N/A
MIDC – LSB	6	Byte	0x00	N/A
MIDC - MSB	7	Byte	0x8B	N/A
Date – Day	8	Byte		N/A
Date – Month	9	Byte		N/A
Date - Year	10-11	Short		N/A
Time	12-19	Double		seconds
Roll - MSB	20	Byte	LSB: 0.005495	deg/bit
Roll – LSB	21	Byte	LSB: 0.005495	deg/bit
Pitch – MSB	22	Byte	LSB: 0.005495	deg/bit
Pitch – LSB	23	Byte	LSB: 0.005495	deg/bit
Heading – MSB	24	Byte	LSB: 0.005495	deg/bit
Heading - LSB	25	Byte	LSB: 0.005495	deg/bit
Latitude	26-29	Long	LSB: 0.00035	arcsec/bit
Longitude	30-33	Long	LSB: 0.00035	arcsec/bit
Altitude	34-37	Long	LSB: 0.01	m/bit
Status A	38-41	Bits	As per ICD – general status A	
Status B	42-45	Bits	As per ICD – general status B	
CRC	46-47	Short		N/A

CRC calculation: Bytes 0 & 1 are ignored. Bytes 2 to 45 are added. Bytes 46 (MSB) & 47 (LSB) contain the CRC.

Binary Output PPS Message Format

PPS is a 24-byte message containing time, UTC offset, week number and PPS count.

A description of the output message is given in the following table:

Table 44: PPS Message Format

Item	Byte	Format	Value	Units
Header LSB	0	Byte	0x00	N/A
Header MSB	1	Byte	0x99	N/A
PPS Time	2-9	Double	GPS seconds of the week or elapsed seconds if GPS not available	seconds
Week	10-13	Int		N/A
UTC offset	14-17	Float		seconds
PPS hits	18-21	Int		N/A
Checksum	22-23	Short		N/A

Checksum calculation: Bytes 0 & 1 are ignored. Bytes 2 to 23 are added. Bytes 22 & 23 contain the checksum.

Binary Output TM1B Message Format

TM1B is a 52-byte message containing week number, seconds of the week, and UTC offset.

A description of the output message is given in the following table:

Table 45: TM1B Message Format

Item	Byte	Format	Value	Units
Header 1	0	Byte	0xAA	N/A
Header 2	1	Byte	0x44	N/A
Header 3	2	Byte	0x11	N/A
Checksum	3	Byte		N/A
ID	4-7	Int	3	N/A
Length	8-11	Int	52	N/A
Week	12-15	Int		N/A
Seconds of week	16-23	Double	GPS seconds of the week or elapsed seconds if GPS not available	seconds
Clock offset	24-31	Double	Clock offset error reported by GNSS	seconds

Table 45: TM1B Message Format

Item	Byte	Format	Value	Units
Clock offset standard deviation	32-39	Double		N/A
UTC offset	40-47	Double		seconds
Clock model status	48-51	Int	0 (not supported)	N/A

Checksum calculation: Bytes 0 & 1 are ignored. Bytes 2 to 23 are added. Bytes 22 & 23 contain the checksum.

Appendix G

GNSS Receiver and OmniSTAR Corrections - POS LV

POS LV contains a GNSS receiver which is used to track and apply Differential GNSS corrections from OmniSTAR. The GNSS receiver type is ascertained from selections made from an operating LV POSView controller and its local network. Select **View, Statistics** from the main menu of the controller to display Figure 74.

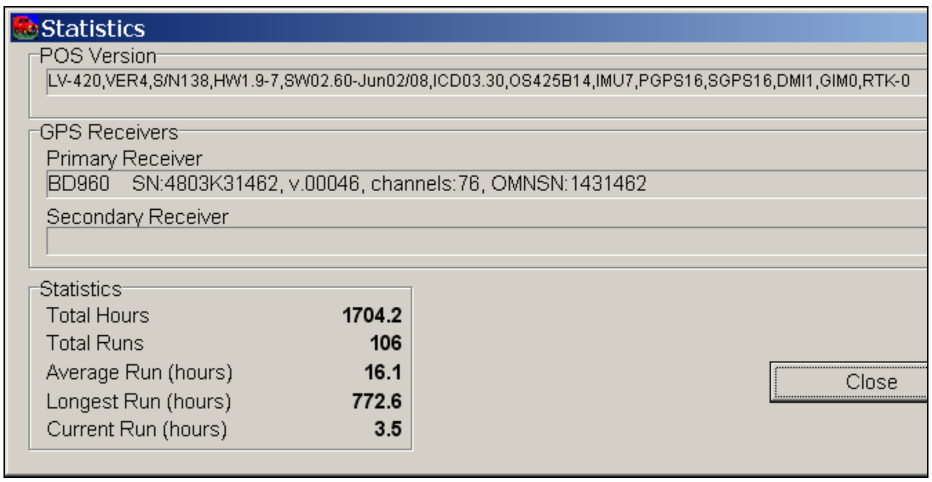


Figure 74: Statistics Window

Receiver type, serial number, firmware version, number of available tracking channels and the OmniSTAR serial number are displayed under the **Primary Receiver** in the **GNSS Receivers** pane.

OmniSTAR provides a subscription service for the enhancement of GNSS position accuracy. Corrections to the GNSS observables are broadcast via satellite and are applied automatically by the POS LV for improved performance. Subscriptions are obtained directly from OmniSTAR. For contact and pricing information in your region, consult the OmniSTAR website at www.omnistar.com or call 1-800-338-9178. For system information, OmniSTAR will require the OmniSTAR serial number from the Statistics screen illustrated above. If the receiver type is a BD960 but the OmniSTAR serial number is not available, it can be determined from the receiver's serial number by taking the last five digits and adding the prefix "14" (e.g. the receiver serial number is "480314**31462**". The OmniSTAR serial number is "14**31462**".

Antennas

OmniSTAR corrections are broadcast by satellite in geosynchronous orbit. For the GNSS receiver to utilize this broadcast, a Trimble 'Zephyr Model 2 GNSS' antenna or Trimble 'AT1675 GNSS' antenna is required. This antenna type is included with all complete POS LV systems.

Navigation Mode

When OmniSTAR corrections are in use, the POS LV will display this in the **Nav Status** field of the main view of LV POSView. Three levels of OmniSTAR service are displayed as:

- **Pri. VBS** (for OmniSTAR VBS)
- **Pri. XP** (for OmniSTAR XP)
- **Pri. HP** (for OmniSTAR HP)

Important

Applanix Corp. is not responsible for the quality or accuracy of any services supplied by OmniSTAR Inc.

Appendix H

POS LV Mission Checklist

This appendix outlines the typical mission procedure.

Mission Preparation

	Step
	Bring several Applanix USB flash drives and store them appropriately until use.
	Check laptop PC battery before starting mission. Have an extra battery available in case the laptop’s battery discharges completely during data collection.
	Enter all appropriate mission data in a POS LV Mission Profile Form (found on page H-4). This information will be required if Applanix Technical Support is asked to troubleshoot logged data.
	Check that all cables are connected and secured neatly out of the way. If you will be using Event inputs, check that an appropriate Event cable is connected to the IO port.
	Power-on all equipment and verify that there are no errors and that no warning lights are lit.
	Park the vehicle away from buildings and other obstructions to reduce GNSS multipath reception.
	Switch POS LV to Navigate mode. Wait for coarse levelling to finish and for Nav status display to read CA, DGPS or RTK (this can take a few minutes).
	Insert a USB flash drive into the logging bay (refer to Data Logging on page 12-1 for details on using the removable media).
	Select PC Card Logging from the Settings pull-down menu in the LV-POSView Main Screen and verify that the required data groups are selected. Click Start Logging and check that the internal drive is writing to the USB flash drive. Refer to the **Media Status** pane in the **PC Card Logging Control** window of POSView or the PCS front panel Logging status light (Table 14).
	If you are using the event tagging function of POS LV, trigger the sensor several times and verify the increasing event count in the LV-POSView Main Screen.
	Ensure that the GNSS Differential Corrections Base Station is on, and receiving and transmitting data.
	Log 2-5 minutes of GNSS data to resolve ambiguities before departure.
	Allow GAMS to come online.

	Step
	Start the mission. The POS status light should change from flashing green to solid green within 5 minutes of departure.

During Mission Procedures

Stand Alone Mode

	Step
	Monitor POS LV using the PCS status lights.
	Use the Logging button on the front of the PCS to start and stop data logging to the removable media.

Controller Monitor Mode

	Step
	Monitor the Position, Speed, Heading and Attitude displays, and compare them to the vehicle’s motion.
	Monitor the LV-POSView Faults Screen for error flags.
	Monitor the Event counts on the Controller main screen and compare them to the sensor’s activity.

During Mission Restart

If power is interrupted during the mission, restart the mission using the following procedure.

⚠ **Do not remove a USB flash drive from the logging bay when the Logging light is on; the drive may still be writing. If the USB flash drive is removed when the Logging light is on, there is a chance that all mission data will be lost.**

	Step
	Stop logging data. The USB flash drive does not need to be removed. Switch the PCS power-off, wait 10 seconds, then re-power the PCS.
	Drive for 2-3 minutes until the PCS system light flashes green or the POS mode display indicates that the system is Nav: Aligned. Then park the vehicle and log 2-5 minutes of data. This step orients the system with respect to the down direction.
	Allow GAMS to start.
	POS is ready when the PCS system light is solid green and/or the POS mode is displayed as Nav: Aligned in the LV-POSView Main Screen. This step takes approximately 1-2 minutes.

Post Mission Checklist

	Step
	Stop the vehicle away from buildings to minimize GNSS multipath reception.
	Continue logging data for 2-5 minutes.
	Stop logging data and remove the USB flash drive from the logging bay (refer to the Data Logging description on page 12-1 for more detailed instructions).
	Power-off all POS LV equipment.

Notes:

POS LV Mission Profile Form

Operator Name:____

Mission Information

DMI:____

Date:____

DMI Scale Factor:____

Location:____

Datum:____

Lever Arms

Lever Arm	Ref to IMU	Ref to GNSS	Ref to DMI
X			
Y			
Z			

Notes:

Misalignment Angles

Mounting Angle	IMU wrt Reference	Reference wrt Vehicle
X		
Y		
Z		

GAMS Parameters

Two Antenna Separation (m):____

Heading Calibration (deg):____

Heading Correction (deg):____

Baseline Vector - X Component (m):__________________________________

Baseline Vector - Y Component (m):__________________________________

Baseline Vector - Z Component (m):__________________________________

Notes:

Base Stations

Operator Name:_________________
Station number:_______
Latitude:_____________N / S
Longitude:___________W / E
Altitude:_____________metres
__ Geoidal or __ Ellipsoidal
Antenna Height:_______metres

Operator Name:_________________
Station number:_______
Latitude:_____________N / S
Longitude:___________W / E
Altitude:_____________metres
__ Geoidal or __ Ellipsoidal
Antenna Height:_______metre

Operator Name:_________________
Station number:_______
Latitude:_____________N / S
Longitude:___________W / E
Altitude:_____________metres
__ Geoidal or __ Ellipsoidal
Antenna Height:_______metres

Operator Name:_________________
Station number:_______
Latitude:_____________N / S
Longitude:___________W / E
Altitude:_____________metres
__ Geoidal or __ Ellipsoidal
Antenna Height:_______metres

Operator Name:_________________
Station number:_______
Latitude:_____________N / S
Longitude:___________W / E
Altitude:_____________metres
__ Geoidal or __ Ellipsoidal
Antenna Height:_______metres

Operator Name:_________________
Station number:_______
Latitude:_____________N / S
Longitude:___________W / E
Altitude:_____________metres
__ Geoidal or __ Ellipsoidal
Antenna Height:_______metres

Notes:

Appendix I

POS LV V5 DMI Sensor Interface Requirements

Voltages present in the POS LV system are sufficient to cause serious injury or death.

Important:

1. Equipment shall be serviced only by qualified personnel.
2. The PCS shall be grounded via the safety ground stud.
3. Power to the POS system should be protected by a user-supplied, resettable circuit breaker

This appendix defines the requirements for a user supplied Distance Measuring Indicator (DMI) sensor with the Position and Orientation System for Land Vehicles (POS LV). Additional connector information is available in the DMI Connector description on page 5-12.

DMI Data Cable Requirements

- The data cable connectors and backshells shall be waterproof to prevent any electrical short circuits.
- The data cable outer jacket should be Teflon material and waterproof.
- The data cable shall use #24 AWG foil shielded twisted pair (signal + signal GND) with overall metal braid.
- The data cable braid and foil shield shall be connected to the connector housing at the POS LV end.
- The DMI sensor hardware shall only be grounded through the data cable braid and foil shield if a single-point ground path, via this cable, is guaranteed. Otherwise, the DMI sensor hardware shall be grounded to the vehicle frame or body and the DMI sensor hardware shall not be connected to the data cable braid and foil shield.
- The braid and foil shield shall not be connected to any signal ground wire in the DMI data cable.
- The data cable shall have (full coverage) 360 degree Radio Frequency (RF) shielding at both connector ends and for the full length of the cable.
- The data cable shall have a mechanical strain relief at both ends.
- The user-supplied data cable connector at the POS LV end is a Lemo FGP.2F.312.CLC and shall have a full, shielded backshell connected to the braid shield.

- The DMI data connector on the back of the POS LV system is a HEP.2F.312.CLNP.

Note: The high degree of electrical shielding is required to avoid problems related to Electromagnetic Interference (EMI) in the vehicle environment. Not following the above recommendations could lead to unreliable DMI data and quality problems.

DMI Connector Pin-Outs

The HEP.2F.312.CLNP connector pin assignments are summarized in the following table.

Table 46: DMI Connector Pin-Outs

PIN	Pin Description		Signal Type	Signal Direction
	DMI Type 1	DMI Type 2		
1	Distance Pulses	Phase B	3-50 V digital	Input
2	Pulse Return			
3	Direction	Phase A	3-50 V digital	Input
4	Direction Return			
5	Distance Pulses	Phase B	3-50 V digital	Input
6	Pulse Return			
7	Direction	Phase A	3-50 V digital	Input
8	Direction Return			
9	+12 Vdc power (max 200 mA)		Isolated supply	Power output
10	12 Vdc return			
11	12 Vdc return		Isolated supply	Power output
12	+12 Vdc power (max 200 mA)			

General DMI Electrical Interface Requirements

- The DMI electrical signals input to POS LV must be within 3 to 50 V dc.
- No external current limiting on the signal inputs is required.
- The DMI connector pins 2 and 4 may be joined together and used as the common return for the two DMI inputs (on pin 1 and pin 3).
- The DMI sensing device, connected to the POS LV PCS, shall source at least 1 mA of current. This is the minimum current required to register a DMI input to the POS LV.
- The DMI sensing device may draw a maximum 200 mA from the 12Vdc power supply.

DMI Type 1 Interface Requirements

- Two signals shall be input to POS LV:
  a) The Direction signal shall indicate the vehicle direction of travel. This signal is either high or low, depending on the direction of travel. The user may choose the direction sense since it is programmable in the POS LV by changing the sign on the DMI Scale Factor entered in LV-POSView.
  b) The Distance Pulse signal shall indicate the vehicle distance traveled, where each pulse corresponds to a fixed distance increment (either forward or reverse).
- The Distance Pulse input shall have a maximum frequency of 100 kHz without waveform distortion, 50% duty cycle and a 1 μs rise and fall time (typical).
- For every metre of distance traveled, approximately 500 evenly spaced pulses should be provided. Pulse counts in the range 4 to 4000 are acceptable. Note that this pulse range will have to be adjusted to take into account the POS LV performance (lower range limit) and maximum vehicle speed and/or tire diameter (high range limit).
- The DMI Distance pulse accuracy shall correspond to 0.1% of the distance traveled or better. An accuracy corresponding to at least 0.05% of the distance traveled is desirable.

DMI Type 2 Interface Requirements

- Two signals shall be input to POS LV: Phase A and Phase B. These two inputs represent a quadrature signal where the relative phase angle between the Phase A and Phase B input is fixed at 90 degrees. The vehicle direction of travel (forward or reverse) is determined by examining the phase relationship (leading or lagging) of the Phase A input relative to the Phase B input. The vehicle distance is derived from considering both the rising and falling edges of both the Phase A and Phase B inputs (four edges). Thus, the POS LV DMI Type 2 interface multiplies the sensor resolution by a factor of four.
- The user may choose the Direction sense (depending on the DMI sensor used and which phase input is connected to pin 1 and pin 3 on the POS LV DMI connector) since it is programmable in POS LV by changing the sign on the DMI Scale Factor entered in LV-POSView.
- The effective pulse rate (and hence the DMI scale factor entered into LV-POSView) shall be equal to the pulse rate of either DMI sensor phase input multiplied by four (owing to the fact that the POS LV DMI Type 2 interface performs full quadrature decoding). The effective quadrature distance pulse shall indicate the vehicle distance traveled, where each quadrature-decoded pulse corresponds to a fixed distance increment (either forward or reverse).

- Each phase input shall have a maximum frequency of 100 kHz without waveform distortion, 50% duty cycle and a 1 μs rise and fall time (typical).
- For every metre of distance traveled, approximately 125 evenly spaced pulses should be provided at each phase input. Pulse counts in the range 1 to 1000 at each phase input are acceptable. Note that this pulse range will have to be adjusted to take into account the POS LV performance (lower range limit) and maximum vehicle speed and/or tire diameter (high range limit).
- The DMI Distance pulse accuracy shall correspond to 0.1% of distance traveled or better. An accuracy corresponding to at least 0.05% of distance traveled is desirable.

DMI Type 3 Interface Requirements

- POS LV DMI Type 3 is provided so that users may differentiate low-resolution DMI inputs from a standard DMI source. The interface is identical to DMI Type 1; refer to DMI Type 1 for interface characteristics.
- DMI Type 3 provides a pulse interval of two centimetres (50 ppm) and are configured using POSConfig. For a smaller pulse interval, use DMI Type 1.
- Systems regularly operating in RTK mode should not use a DMI Type 3. If the pulse interval is five millimetres or greater, use the DMI Type 3.

Appendix J

POS-GPS Timing

Background

Global Positioning System (GPS) time is a continuous measurement of time from an epoch started on January 6, 1980 at midnight (0 hours 0 minutes 0 seconds) Universal Time Coordinated (UTC). GPS time is often stated in a number of weeks and seconds from this GPS time epoch. GPS time does not introduce leap seconds and therefore, is ahead of UTC by a number of seconds.

The GPS Master Control Station, located at Schriever AFB in Colorado, steers GPS time to within one microsecond (less leap seconds) of UTC. Navigation messages transmitted by the Space Vehicles (SVs) contains parameters that permit users to compute an estimate of the current GPS/UTC sub-microsecond difference as well as the number of leap seconds introduced into UTC since the GPS epoch. GPS time is derived from the GPS Composite Clock (CC), consisting of the atomic clocks at each Monitor Station and all of the GPS SV frequency standards.

The following identify a few of the many time standards:

- Local time is the date/time reported by your PC (as seen by your web browser). Local time differs from UTC by the number of hours for your time zone (plus local PC clock errors).
- UTC, Coordinated Universal Time, popularly known as GMT (Greenwich Mean Time), or Zulu time.
- GPS, Global Positioning System time, is the atomic time scale implemented by the atomic clocks in the GPS ground control stations and the GPS satellites.
- TAI, Temps Atomique International, is the international atomic time scale based on a continuous counting of the International System of Units (SI) second.

Because GPS and TAI time do not have leap seconds, they will change by one second with respect to UTC whenever a leap second is inserted. GPS and UTC time scales were aligned when GPS time began on January 6, 1980. TAI and UTC time scales were aligned when TAI time began on January 1, 1958.

Table 47: GPS, TAI and UTC Times

Date	GPS to UTC Offset (sec)	Date	TAI to UTC Offset (sec)
Jan 6, 1980	0	Jan 1, 1980	19
Jul 1, 1981	1	Jul 1, 1981	20

Date	GPS to UTC Offset (sec)	Date	TAI to UTC Offset (sec)
Jul 1, 1982	2	Jul 1, 1982	21
Jul 1, 1983	3	Jul 1, 1983	22
Jul 1, 1985	4	Jul 1, 1985	23
Jan 1, 1988	5	Jan 1, 1988	24
Jan 1, 1990	6	Jan 1, 1990	25
Jan 1, 1991	7	Jan 1, 1991	26
Jul 1, 1992	8	Jul 1, 1992	27
Jul 1, 1993	9	Jul 1, 1993	28
Jul 1, 1994	10	Jul 1, 1994	29
Jan 1, 1996	11	Jan 1, 1996	30
Jul 1, 1997	12	Jul 1, 1997	31
Jan 1, 1999	13	Jan 1, 1999	32
Jan 1, 2006	14	Jan 1, 2006	33
Dec 31, 2008	15	Dec 31, 2008	34
Jul 1, 2012	16	Jul 1, 2012	35
Jul 1, 2015	17	Jul 1, 2015	36
Dec 31, 2016	18	Dec 31, 2016	37

Notes:

1. GPS and TAI are ahead of UTC time, see Figure 75.

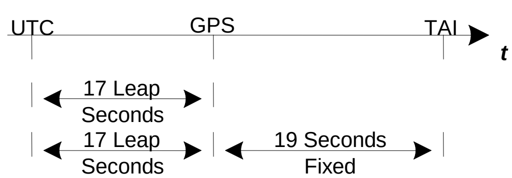


Figure 75: GPS, TAI and UTC Times

2. Consult the International Earth Rotation Service (IERS) web pages for more quantitative information.

GPS Timing Basics

<u>One Pulse Per Second</u>

The basis for all time and frequency functions is the One Pulse Per Second (1PPS) signal supplied by the GPS receiver. This signal is typically a short logic pulse, one edge of which is adjusted by the receiver to be ‘on time’ with respect to the one second epoch of UTC. In order to do this, the GPS receiver needs to know its position.

If the position is unknown, the receiver can find its own position and solve for time by tracking four or more GPS satellites. This is called the dynamic mode, and is the mode used in moving platform applications.

Alternatively, timing receivers can be told to use a known fixed position, in which case the receiver can solve for time by tracking a minimum of one satellite. This is called the static mode, and it is used in applications where the position is fixed.

Timing Accuracy

Errors in the time of occurrence of the 1PPS pulses from the GPS receiver consist of three parts:

- Bias - a fixed offset due to uncompensated delay errors in the receiver/antenna system
- Drift - variations in timing over long periods due primarily to differences in satellites tracked over time
- Jitter - short-term variations in timing from pulse to pulse

These error sources are inherent in the both the GPS system and the GPS receiver. The sum of these errors can be as low as a few tenths of a microsecond or up to a few microseconds. This high level of accuracy is possible because the timekeeping maintained within the GPS system is continuously adjusted to null out timing errors.

Output Characteristics

The 1PPS signal is usually in the form of a pulse of whose duration varies between microseconds and milliseconds, at Transistor-Transistor Logic (TTL) or RS-232 signal levels.

Time Message

The 1PPS signal provides an accurate time mark, but is ambiguous unless coupled with a time stamp. Most timing systems specify a time message that is transmitted (usually over a serial data port) that gives the date and time of day for each occurrence of the 1PPS signal. This time message is sent in between the 1PPS signals and may be specified to time-tag either the 1PPS that has just occurred, or the one that is just about to happen.

POS System Timing

There are a number of aspects to POS system timing; there is the internal timing of sensor data and the navigation solution, there is the ability to synchronize external equipment to POS, or POS can be synchronized to external equipment time, all ICD data output from POS includes time tags, and the user can generate event pulses which are time tagged by POS and then made available for output or logging. Each of these items are described in the following sections.

Internal POS Timing

POS uses its internal clock to keep track of *POS time*, which starts from 0 when the system is powered up and continually increases. POS time never resets the way GPS and UTC seconds of the week do. POS uses the 1PPS pulse and the corresponding time message from the Primary GNSS receiver to 1) set an internal GPS and UTC offset with respect to POS time and 2) correct the drift in the internal clock.

The Primary GNSS receiver must has sufficient satellites visible when POS is started so that it will generate the 1PPS and time message. Without this data POS will not be able to synchronize its internal clock and navigation will not proceed. Once the internal clock is synchronized there can be gaps in the Primary GNSS output of 1PPS and time message without adversely affecting POS performance.

The **Events** pane on the main POSView window, see Figure 33, displays the Universal Time, Coordinated (UTC) time of the most recent PPS pulse transmitted by the primary GNSS receiver. The Count field for PPS indicates the total number of signals recorded from the GNSS receiver.

Synchronizing External Equipment to POS

To synchronize external equipment time with POS, the external equipment must read and record the 1PPS signal and one of the corresponding time messages from POS. With this information the external device can adjust its internal timing to match POS timing using either GPS or UTC as the time base. Any data recorded by the external device can then be time stamped with a time synchronized to POS so that the data can later be merged with POS data using a common time base.

Processing the time differential for each new 1PPS pulse and time message allows the user to compensate for drift in the external device clock.

The PPS pulse is present at the rear panel IO connectors and is configurable for pulse width and polarity from the POSView **Settings** – **Events** window. Figure 76 shows the parameters of the 1PPS signal.

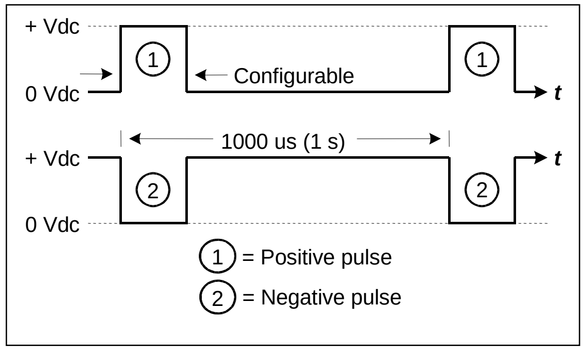


Figure 76: 1PPS Signal Characteristics

The time messages corresponding to PPS can be configured to be output on any COM port. The various 1PPS time message outputs provide the time of the previous 1PPS signal. PPS time is available from POS in either a NMEA message (ZDA or PPS) or Binary output message (PPS or TM1B). Refer to Appendix A for message format details.

Synchronizing POS to External Equipment

POS maintains a *User time* offset in addition to the GPS and UTC offsets with respect to its internal POS time. This provides the user with the option of supplying POS with an external time message that will be used to set the User time offset. Once set, the User time can be used as a time tag for ICD output data groups.

To synchronize POS with external equipment time (User Time), the external equipment must read and record the 1PPS signal from POS and transmit its User Time to POS on the Ethernet port. Refer to the description of the Ethernet Connector on page 5-10.

'Message 55 - User Time Recovery' (Table 48) is extracted from Applanix document *PUBS-ICD-003759*. This message specifies the time of the last PPS in User Time to the POS. It directs POS to synchronize its User Time with the time specified in the User PPS Time field. POS accepts this message at anytime at a maximum rate of once per second.

To establish User Time synchronization, the user must send the User Time of last PPS to POS with this message after the PPS has occurred. The resolution of time synchronization is one microsecond.

Table 48: Message 55 - User Time Recovery

Item	Bytes	Format	Value	Units
Message start	4	Char	$MSG	N/A
Message ID	2	Ushort	55	N/A
Byte count	2	Ushort	24	N/A

Table 48: Message 55 - User Time Recovery

Item	Bytes	Format	Value	Units
Transaction number	2	Ushort	<u>Input</u>: Transaction number <u>Output</u>: [65533, 65535]	N/A
User PPS time	8	Double	[0,) default = 0.0	seconds
User Time conversion factor	8	Double	[0,) default = 1.0	•/seconds
Pad	2	Short	0	N/A
Checksum	2	Ushort	N/A	N/A
Message end	2	Char	$#	N/A

This message must be sent by a user application that connects to the POS TCP/IP socket interface (Control Port) to accommodate both the User Timing input and the substitute controller communication.

<u>Time Tagging of Output Data</u>

POS formats data into ICD groups as described in *PUBS-MAN-003759*. The ICD groups are output in real-time on the Display Port and Data Port and are logged on the removable media and internal flash drive. Which groups are output on which port are under user control.

All ICD groups have the same basic structure as shown in Table 49 (extracted from Applanix document *PUBS-ICD-003759*). The selections of the time and distance types are made from the POSView **Settings** – **Installation** – **Tags, Multipath & Autostart** window. To ensure the POS data are useful for post-processing using POSPac, set Time Tag 1 to GPS time.

Table 49: Common ICD Group Structure

Item	Bytes	Format	Value	Units
Group start	4	Char	$GRP	N/A
Group ID	2	Ushort	Group specific	N/A
Byte count	2	Ushort	Group specific	bytes
Time 1	8	Double	N/A	sec
Time 2	8	Double	N/A	sec
Distance tag	8	Double	N/A	m

Table 49: Common ICD Group Structure

Item	Bytes	Format	Value	Units
Time types	1	Byte	Time 1 Select — Value: bits 0-3 Time 1: POS time 0 Time 1: GPS time 1 (default) Time 1: UTC time 2 Time 2 Select — Value: bits 4-7 Time 2: POS time 0 (default) Time 2: GPS time 1 Time 2: UTC time 2 Time 2: User Time 3	
Distance type	1	Byte	Distance select — Value N/A 0 POS distance 1 (default) DMI distance 2	
Group specific data fields				
Pad	0-3	Byte	0	N/A
Checksum	2	Ushort	N/A	N/A
Group end	2	Char	$#	N/A

The navigation solution, sensor data and user event groups are time tagged with the Time of Validity of the data. Other low rate (1 Hz) status type groups are time tagged with the time when the group was processed.

POS outputs data in NMEA and Binary formats in addition to the ICD format described. Not all formats have a time field, the assumption being that they are output with minimal latency with respect to their Time of Validity. For those formats that do incorporate a time field, POS will insert the Time of Validity of the data in the appropriate time base.

Event Time Tagging

Event inputs can be used to capture any external event whose time or distance when the event occurred is important for processing the mission data. The user must arrange for the external equipment to generate a digital pulse as described in Event Interface on page 5-9. POS is configured to detect the event pulse from the POSView **Settings** – **Events** window. Upon detecting an event input pulse, POS will record the time and distance into an ICD Event group, within 1 µs of the pulse edge. The time and distance types will be the same as configured for all other ICD groups. These Event ICD groups can be output or logged in the same manner as other ICD groups.

The Events pane of the POSView main window displays the last times and counts for events 1 and 2. To view all the events, open the POSView **View** – **Event Data** window.

ICD groups 5, 6, 30 and 31 correspond to Events 1, 2, 3 and 4.

NMEA EVENT MESSAGE FORMAT

$EVT1 and $EVT2 messages provide event timing. Although not NMEA 0183 messages, each event time message is compatible with the standard. Refer to page F-5 for further message details.

POSPac uses Group 5 and Group 6 messages to derive geographic coordinates for each event. The user is responsible to resolve the solution at event time.

Appendix K

GNSS Reference Station

Overview

The Global Navigation Satellite System (GNSS) permits users to determine their location on land, sea or in the air. It does this by using satellites and receivers. There are many satellites in orbit, operated by authorities in various countries, that provide worldwide coverage 24 hours a day, seven days a week.

Simplistically, the Global Navigation Satellite System (GNSS) system operates by the satellites sending information to receivers. This satellite information includes time, position and signal strength, among other things. The receivers pick up this information and use it to determine their location. Receiving signals from a minimum of four satellites permits a receiver to calculate its latitude, longitude, elevation and time. Some receivers are capable of converting latitude and longitude into other coordinate system values. The receiver determines its position by:

- Calculating its distance (pseudorange) from several simultaneously observed satellites
- Determining where each satellite was when the measurement coded signal was transmitted (broadcast ephemeris)
- Matching its own clock to GNSS time to determine the time difference between the instant the signal was transmitted and the instant it was received

Position accuracy varies with GNSS receiver configuration (receiver and antenna), location (geographic latitude), surrounding objects, satellite constellation status and ionosphere conditions. Simply stated, the following determines the receiver accuracy:

- Satellites are not where they say they are
- Transmitted signals are delayed
- Timing corrections are faulty
- Receiver has excessive measurement noise
- Available satellites are in a poor configuration

Precision versus Accuracy

Precision and accuracy are deemed by most of us as being interchangeable, but in reality, they are not.

Precision is considered as a relative term. A very precise set of GNSS data in relation to itself may exist (e.g. nice straight roads, poles aligned evenly and neatly along the curb), but there is no real way of telling how well these positions overlay in reality.

Accuracy is an absolute term. For example, 'this GNSS position is accurate to within one metre', implies knowledge of the true real-world position, and the term is often used when referring to permanently mounted reference stations.

Converting ‘precise’ data to ‘accurate’ data are performed by recording the location of some known points during the data collection session. By comparing these GNSS points with their published equivalents, it is possible to determine how accurate the data really is, and even adjust it if necessary. In fact, the term "network adjustment" used by surveyors is exactly this; adjusting a network of precise GNSS positions to accurately fit an existing control network. Figure 77 illustrates the difference between precise and accurate.

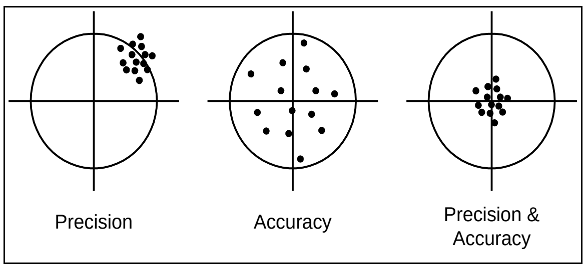


Figure 77: Precision Versus Accuracy

Reducing Errors

Accurate positioning using Differential GNSS (DGNSS), Real-time Kinematic (RTK) or phase measurements remove most of the errors (identified in the ‘Position accuracy’ paragraph on page K-1) to produce sub-metre to millimetre level fixes. Figure 78 shows three typical signal modulation methods.

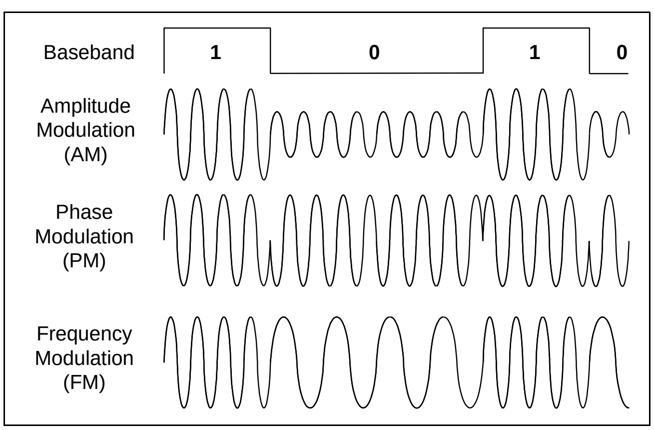


Figure 78: Examples of Signal Modulation

Differential GNSS

DGNSS employs position corrections to attain greater accuracy by using a reference station, see Figure 79. The reference station (base station) may be a ground based facility or a geosynchronous satellite; in either case it is a station whose position is a known point. When a station knows it's precise location, it can compare that position with the signals from the GNSS satellites. These corrections are transmitted to mobile GNSS receivers (DGNSS). Typical accuracies are in the one to five metre ranges.

Real-time Kinematic

RTK is a process where GNSS signal corrections are transmitted in real-time from a reference receiver at a known location to one or more remote rover receivers, see Figure 79. The use of an RTK capable GNSS system can compensate for atmospheric delay, orbital errors and other variables in GNSS geometry, increasing positioning accuracy up to two centimetres. RTK is used, not only as a precision positioning instrument, but also as a core for navigation systems or automatic machine guidance, in applications such as civil engineering and dredging.

Phase

Using the code phase of GNSS signals, as well as the carrier phase, which delivers the most accurate GNSS information, RTK provides differential corrections to produce the most precise GNSS positioning.

Bi-Phase Shift Key Modulation (BPSK) is the technique used to add a binary signal to a sine wave carrier. This amounts to causing a 180° phase shift in the carrier at a distinct wave ‘trough’ or ‘crest’ each time the binary sequence undergoes a transition from ‘0’ to ‘1’, or ‘1’ to ‘0’. This is illustrated in Figure 78. The modified P code (P code plus Navigation Message) is used to modulate both the L1 and L2 carriers, and the modified Coarse Acquisition (C/A) code (C/A code plus Navigation Message) is only used to modulate the L1 carrier. This creates a spread spectrum ranging signal.

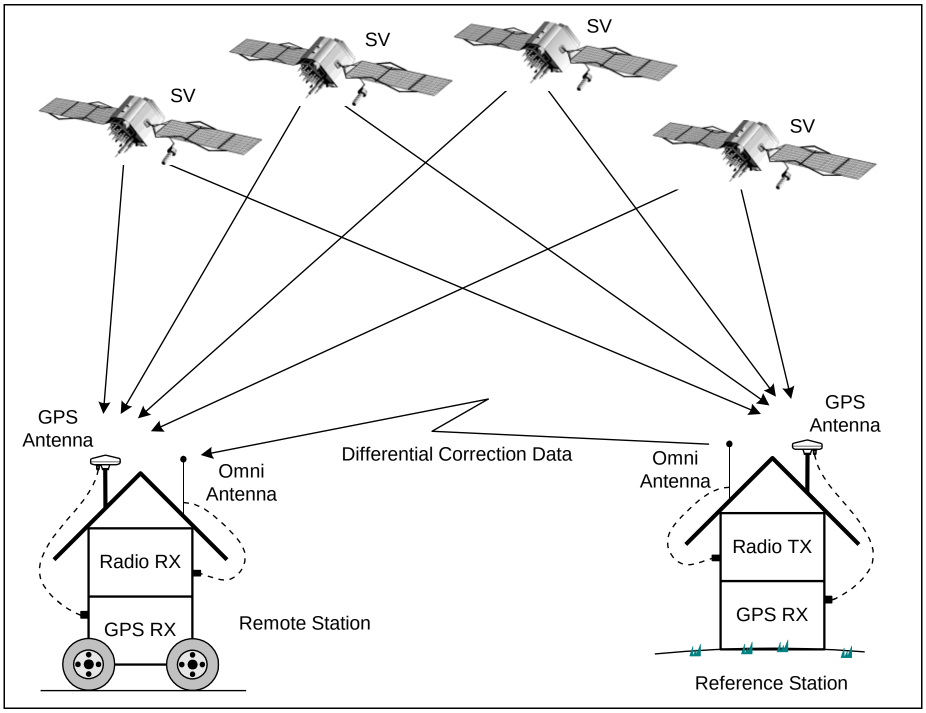


Figure 79: Reference and Remote Station Configuration

DIFFERENCES BETWEEN DGPS & RTK

Distinguishing between RTK and DGNSS may be difficult; the following list identifies the major differences:

- Accuracy - RTK has an accuracy of a few centimetres (in all three dimensions). DGNSS can achieve sub-metre accuracies of 0.5 to 0.9 Metres (m).
- Initializing - RTK requires a minimum of five satellites. After that, it can operate with four. DGNSS requires a minimum of four for sub-metre accuracy.
- Initializing - RTK requires the POS LV navigator alignment to complete. DGNSS corrections can be used immediately without waiting for alignment.
- Receivers - RTK needs a dual frequency GNSS receiver whereas a single frequency receiver is sufficient for DGNSS.
- Corrections - GNSS corrections for RTK requires a user provided station that is within forty kilometres of the field of operation. GNSS corrections for DGNSS can be obtained from a user provided reference station, a correction service provider or a free radio beacon broadcast. DGNSS accuracy decreases with distance from the reference station.

Typical Reference Station

Differential Global Navigation Satellite System (DGNSS) is a method of providing differential corrections to a Global Navigation Satellite System (GNSS) receiver in order to improve the accuracy of the navigation solution. DGNSS corrections originate from a reference station at a known location. The receivers in these reference stations can estimate errors in the GNSS because they have an accurate knowledge of their position. As a result of applying DGNSS corrections, the horizontal accuracy of the system can be improved from 15 m (95% of the time) to better than 1 m (95% of the time).

Reference stations provide integrity monitoring, warning users to disregard a satellite which is operating outside of specification. With DGNSS, this warning happens within a few seconds of the satellite becoming 'unhealthy', compared to GNSS warnings where some hours can elapse.

Real-time kinematic is a GNSS differential mode of operation using carrier phase measurements and is a technique which makes use of the most accurate information delivered by the GNSS system. Figure 80 shows a configuration for a typical reference station.

In an RTK system, the reference station is located on a known, surveyed, point. In order to obtain optimum accuracy, the mobile receivers must operate within forty kilometres (~25 miles) of the reference station. The reference station determines its geographic position based on the received Space Vehicle (SV) signals and transmits corrections by radio modem or cell phone, which are received by mobile receivers operating in the POS LV system. The reference station then resolves the difference between the information received from the SVs and its surveyed point.

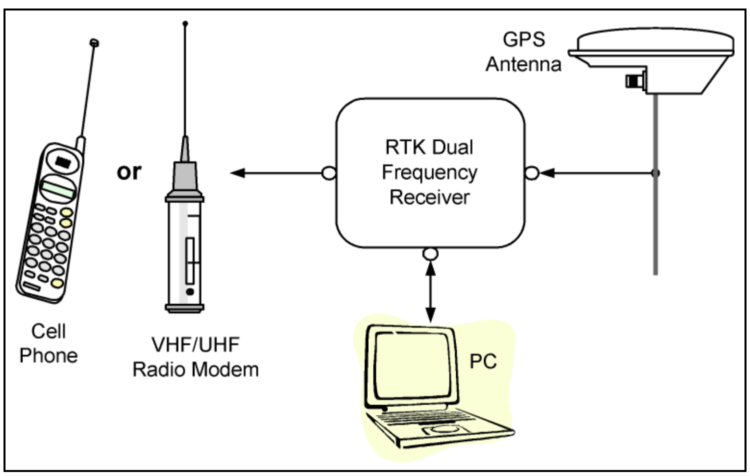


Figure 80: Reference Station Configuration

A typical radio link required for RTK is in the Very High Frequency (VHF), Ultra High Frequency (UHF) or spread spectrum radio band. Radios operate best within line of sight or with a repeater. Refer to section Base 1/2 GNSS Input Data Format for the types of correction data accepted by POS.

Appendix L

Notes and Tips

Important:

1. Equipment shall be installed and serviced only by qualified personnel.
2. The PCS shall be grounded via the safety ground stud.
3. Power to the POS system should be protected by a user-supplied, resettable circuit breaker

Install and Maintain

- Install the equipment as per Hardware Installation, starting on page 3.0
- Maintain the equipment as per Maintenance, starting on page 14.0

Accuracy of POS LV Installation Parameters

- Related to position accuracy: CA, RTCM DGPS, Code DGPS, IARTK
- For CA, RTCM DGPS, Code DGPS: use of a measuring tape is usually accurate enough (depends on vehicle size)
- For IARTK: accurate installation parameters are critical; erroneous installation parameters will result in incorrect system operation; accuracy will affect GAMS calibration; at least one centimetre accuracy is required for Lever Arms
- POSPac can be used to validate the POS LV installation parameters; contact Applanix Customer Support for assistance

Base GNSS Configuration

- Refer to Appendix K, GNSS Reference Station
- Does not apply to CA mode
- Correct base configuration is critical to POS LV operation, especially in IARTK mode
- Do not alter the Base GNSS configuration (in anyway) while POS LV is operating, especially the Base GNSS coordinates
- POS LV may be used with an RTK virtual reference network, DGPS correction service, coastguard beacon or private GNSS base station

Base GNSS Message Latency

- Does not apply to CA mode
- The choice of radio transmission medium typically affects the GNSS correction message latency
- For short baselines, UHF radio modems work well (5 to 10 km range)
- For longer baselines, cell phone modems are a better choice if service is available in the mapping area (range depends upon cell coverage)
- Any transmission device should support at least 19200 baud (compressed), ensure cell phones compress data
- Data transmission interruptions and latencies do occur - this may affect the POS LV performance:
    - RTCM DGPS, Code DGPS age of corrections is five minutes
    - IARTK age of corrections is nominally one second; up to three seconds of occasional jitter can be tolerated

GAMS Calibration

- Refer to the Calibrate Antenna Installation for GAMS description starting on page 9.0
- Correct POS LV installation parameters are essential for GAMS calibration
- GAMS may fail to calibrate if install parameters are out-of-tolerance
- Calibrate GAMS when GNSS DOP is low - GAMS will not calibrate above a PDOP = 3
- Be patient, calibration will occur faster if the POS LV is well aligned
- Calibrate GAMS only under ideal GNSS conditions, away from multipath obstructions
- Repeat GAMS calibration two or more times (clear parameters to factory defaults between each calibration):
    - The GAMS calibration is good if successive calibrations return parameters within five millimetres of each other
    - Accelerate vehicle in a straight line
- Only GNSS antennas and cables recommended by Applanix should be used with POS LV
- If GAMS calibration is not successful or takes very long:

- Set all parameters to 'zero' - except heading calibration where threshold is 0.5 or lower (**Settings, Installation, GAMS Parameter Set-up** screen), refer to Figure 57 on page 9-3

  Note: Setting all the fields to zero causes POS LV to select the appropriate settings, above all, if the user inserts values, then accuracy is paramount.

- Save settings (**Settings, Save Settings** menu item)
- Reset GAMS (**Tools, Reset GAMS** menu item)

POS LV Configuration

- Use a configuration that is close to the factory default settings; do not unnecessarily change settings
- Save POS LV settings so that they will be available next time POS LV is powered-on
- Save settings to the PC's hard drive (refer to Save Settings on page 8-19) in a secure location; useful for supporting multiple configurations

Monitoring POS LV

- Set the user accuracy threshold and observe the system lights to graphically determine POS LV performance
- Use LV-POSView

Data Logging

- In LV-POSView, select the **Logging, Removable Media Logging** screen and click the **POSPac** command button to process data - it is not necessary to log other data

Troubleshooting

If the navigation solution errors seem unreasonably large or the GAMS cannot be calibrated or the Navigator resets, it is prudent to check the quality of the raw sensor data input to Navigator

GNSS

- Check L1/L2 signal-to-noise ratio
- Check DOP
- Check that the GNSS receiver is properly configured
- Check the faults screen, all tabs

IMU

- Check the faults screen
- Check IMU faults (**View, IMU data**)

DMI

- Check the DMI light (vehicle moving)
- Check the forward/reverse function (**Diagnostics, Time & Pulses** screen)

Navigator

- Check system timing (e.g. PPS at 1 Hz, IMU TOV connect rate)
- Check cell phone connection to verify messages are arriving on time
- Check GNSS correction faults (**View, Faults, GNSS Corr** screen)
- Check Base 1/2 Diagnostic screens (**Diagnostics, Base GNSS, Base1/Base 2**)

Tips-Inertial Measurement Unit

- Simplify the installation parameter measurements by mounting the IMU with its base plate horizontal and orient either the X or Y-axis towards the front of the vehicle; the sensing axis are labelled on the IMU case

Tips-Antennas

- Use the following procedure to verify that an L1/L2 antenna is connected to a dual frequency primary GNSS receiver:
  - In LV-POSView, select **View, GNSS Data, Primary** tab
  - The L2 signal-to-noise ratio should be a reasonably stable value
  - If the L2 signal-to-noise ratio varies randomly, then an L1 only GNSS antenna is connected at the ANT1 port - replace with an L1/L2 antenna
- Only GNSS antennas and cables recommended by Applanix should be used with POS LV

Tips-Post-Processing

- Ensure the POS data are useful for post-processing (using POSPac) by setting Time Tag 1 to either GPS time or UTC time - GPS time is preferred; in LV-POSView, select **Settings, Installation, Tags, Multipath & AutoStart** screen
- Spend sufficient time when aligning the POS LV and allow the POS LV Navigator to estimate the sensor errors; good GNSS coverage is important

Tips-Radio Modems

- Antenna positioning is critical to good performance. VHF and UHF radio signals are line-of-sight transmissions; as such, they cannot penetrate through the Earth. Place the base antenna as high as possible to provide the best line-of-site condition. A telescoping tripod antenna mast is useful in positioning the antenna for best performance. Ensure that the antenna is tuned to the frequency in use.
- Keep the equipment in good condition. Field failures are most often caused by broken cables and connectors. Inspect cables and connectors frequently. Replace worn cables and damaged antennas before they fail in the field and always carry spares.
- Avoid radio interference by monitoring the available frequencies prior to using the radio modem. A simple radio scanner may be used to monitor the frequencies.

Tips-General

- For POS LV to function acceptably during GNSS outages, it is important that the GAMS Heading Calibration Threshold value is set as low as possible. Aggressive manoeuvring is required to bring the POS LV heading errors below this threshold. Fortunately, such manoeuvres are only required when GAMS is being calibrated. Calibration is only required if the GNSS antennas are moved.
- To obtain optimal performance from POS LV, Applanix recommends setting the GAMS multipath setting to low. Only initialize GAMS in an area where there is excellent GNSS reception.

Appendix M

Drawings

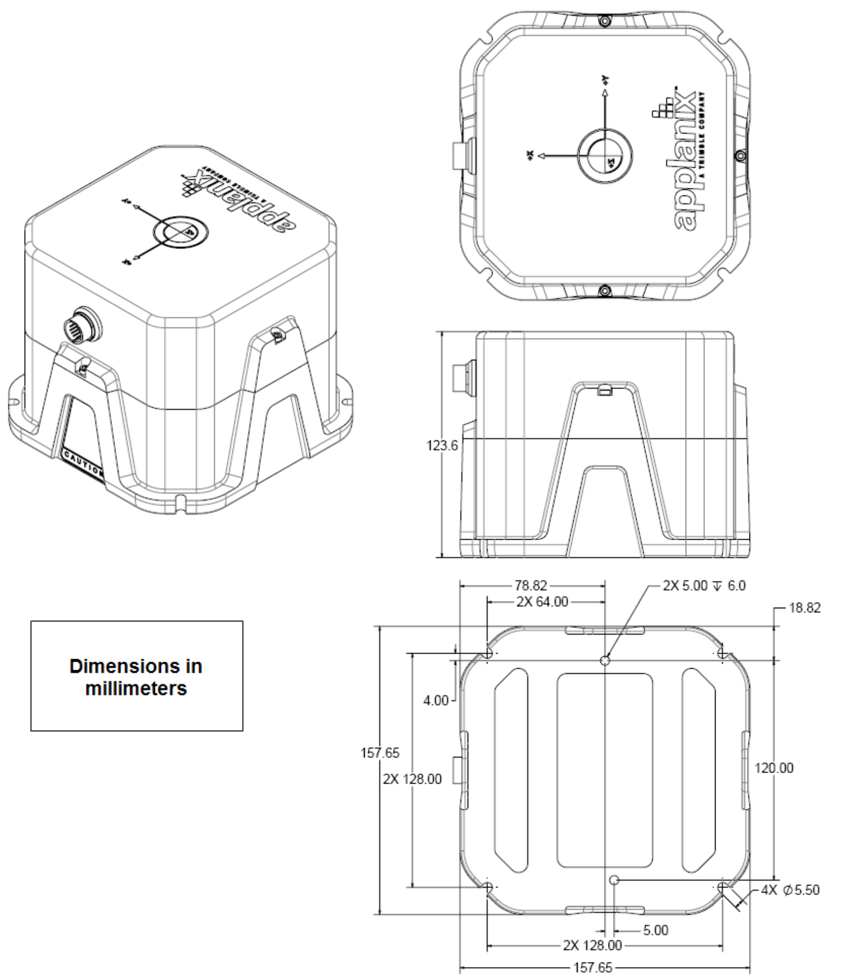


Figure 81: IMU Type 7, 17 & 42 Outline - Top, Side and Bottom Views

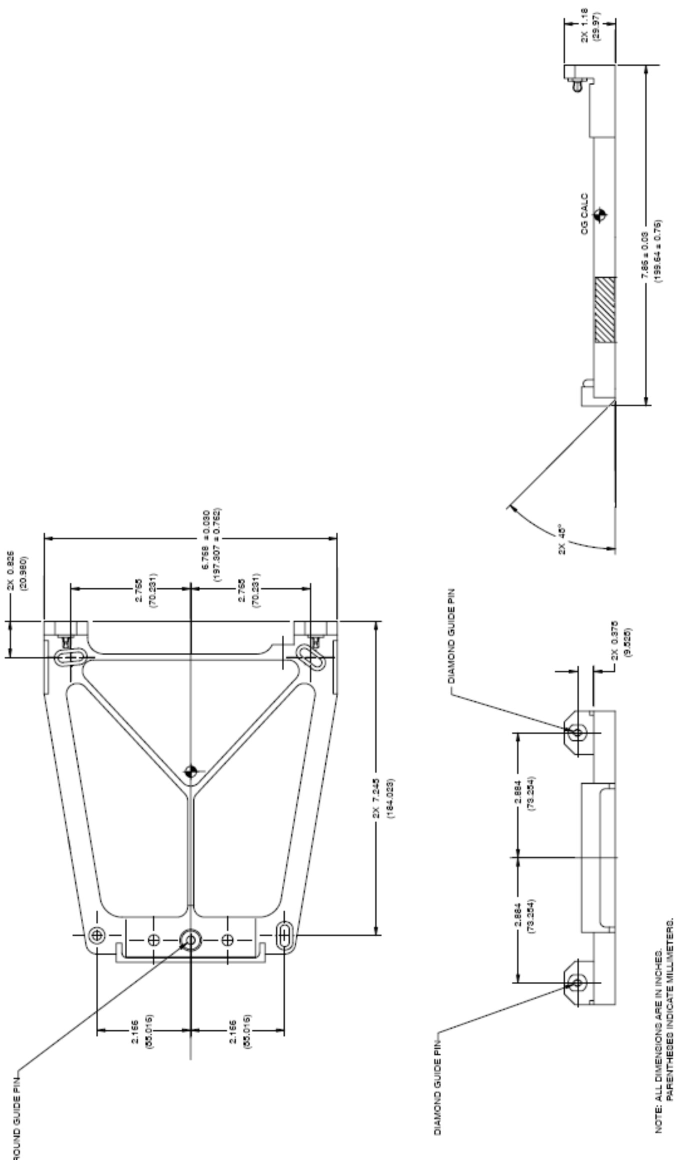


Figure 82: IMU Type 21 Mounting Tray Outline

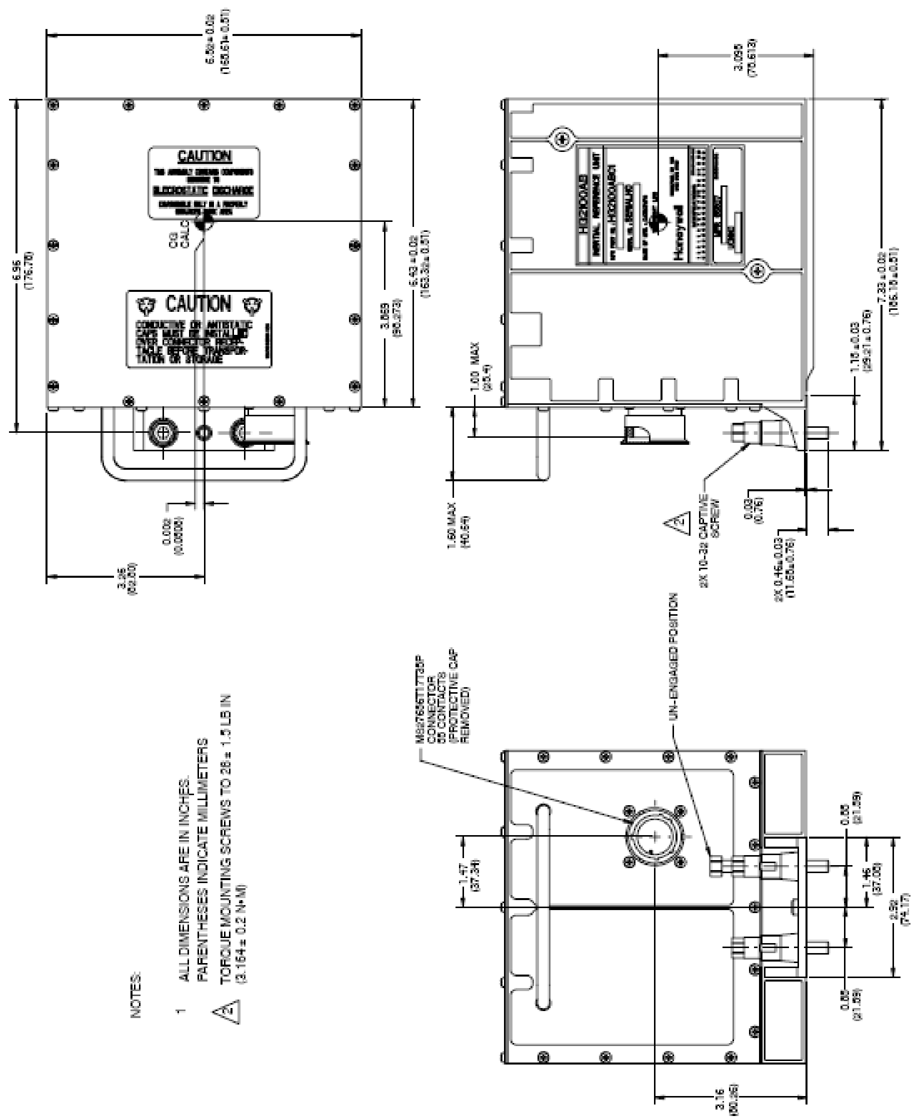


Figure 83: (1 of 4) IMU Type 21 Outline - Top, Side and Front Views

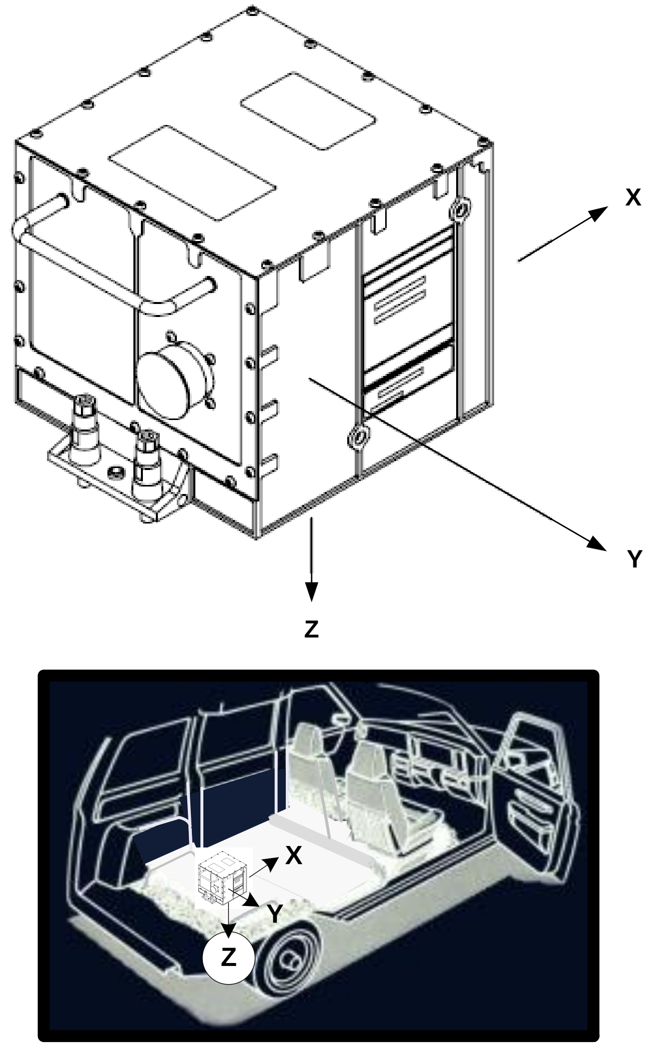


Figure 84: (2 of 4) IMU Type 21 Outline - Rear View

The sensing centre is displayed on IMU type 21 and is located at a height of 3.095 in (78.613 mm) above the mounting plate.

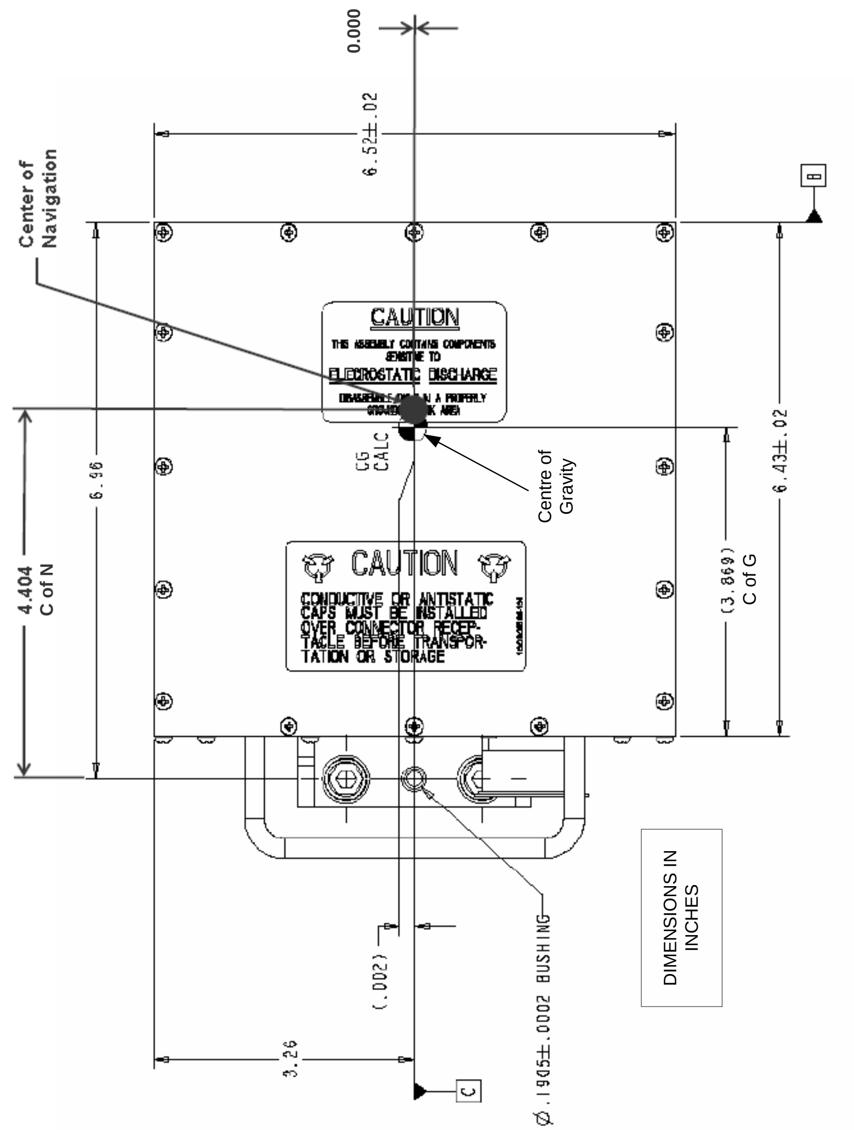


Figure 85: (3 of 4) IMU Type 21 Sensing Centre Diagram

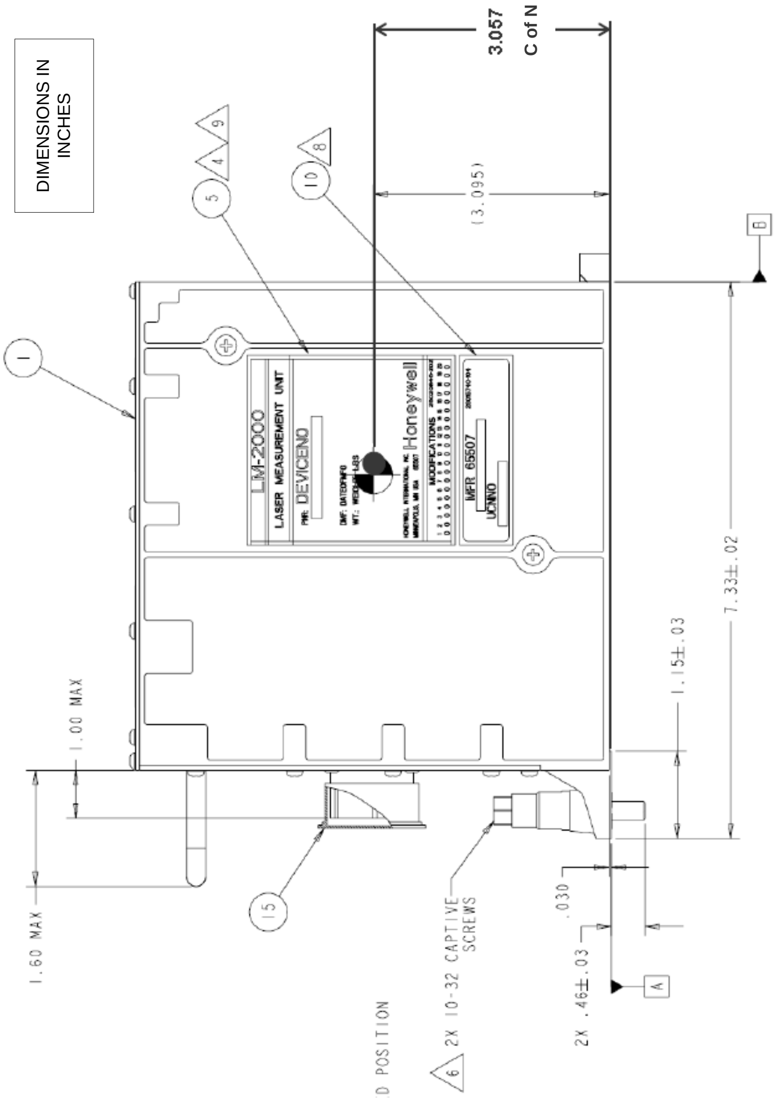


Figure 86: (4 of 4) IMU Type 21 Sensing Centre Diagram

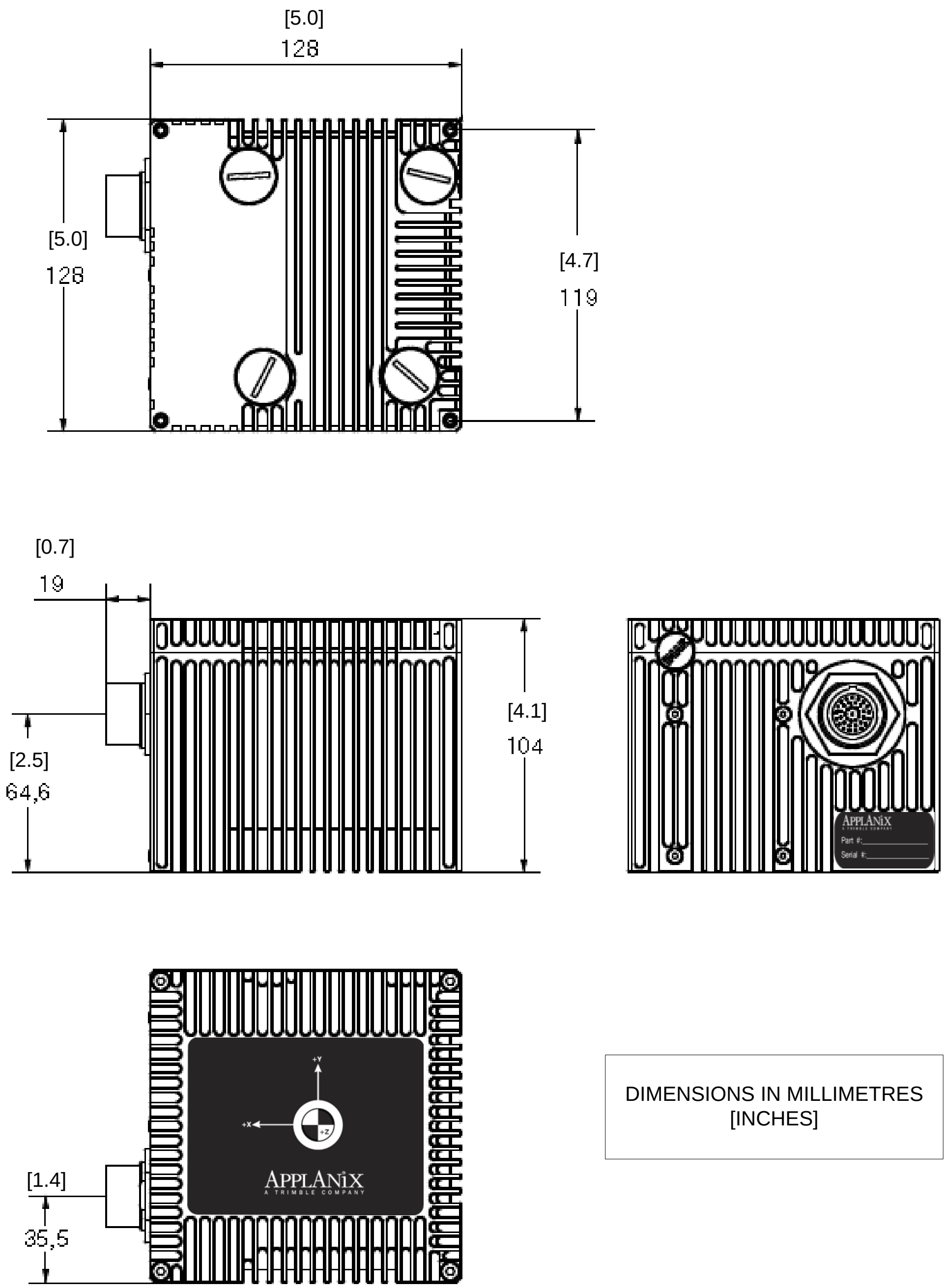


Figure 87: (1 of 4) IMU Type 26 Outline Diagram

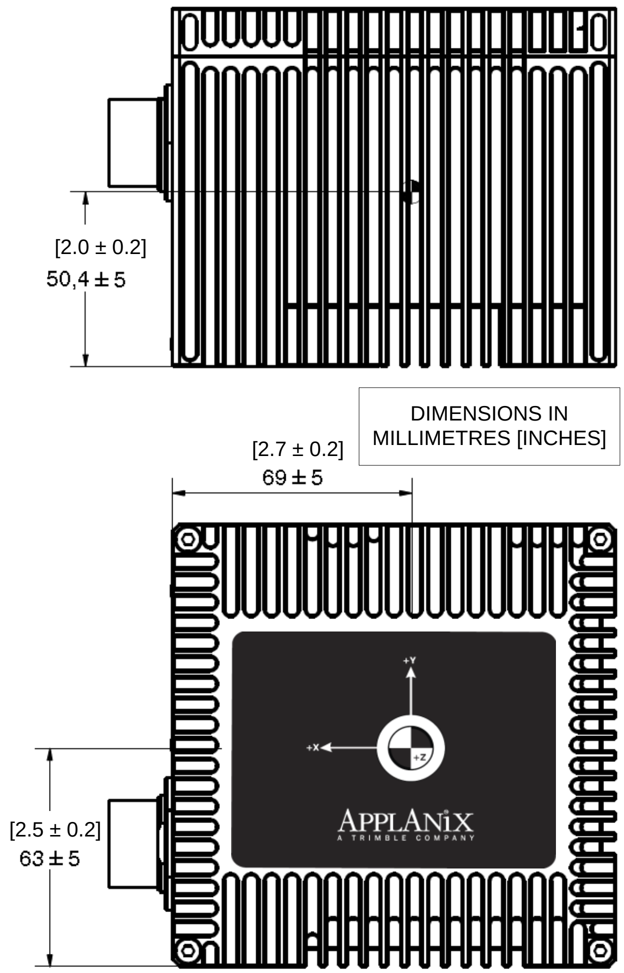


Figure 88: (2 of 4) IMU Type 26 Sensing Centre Diagram

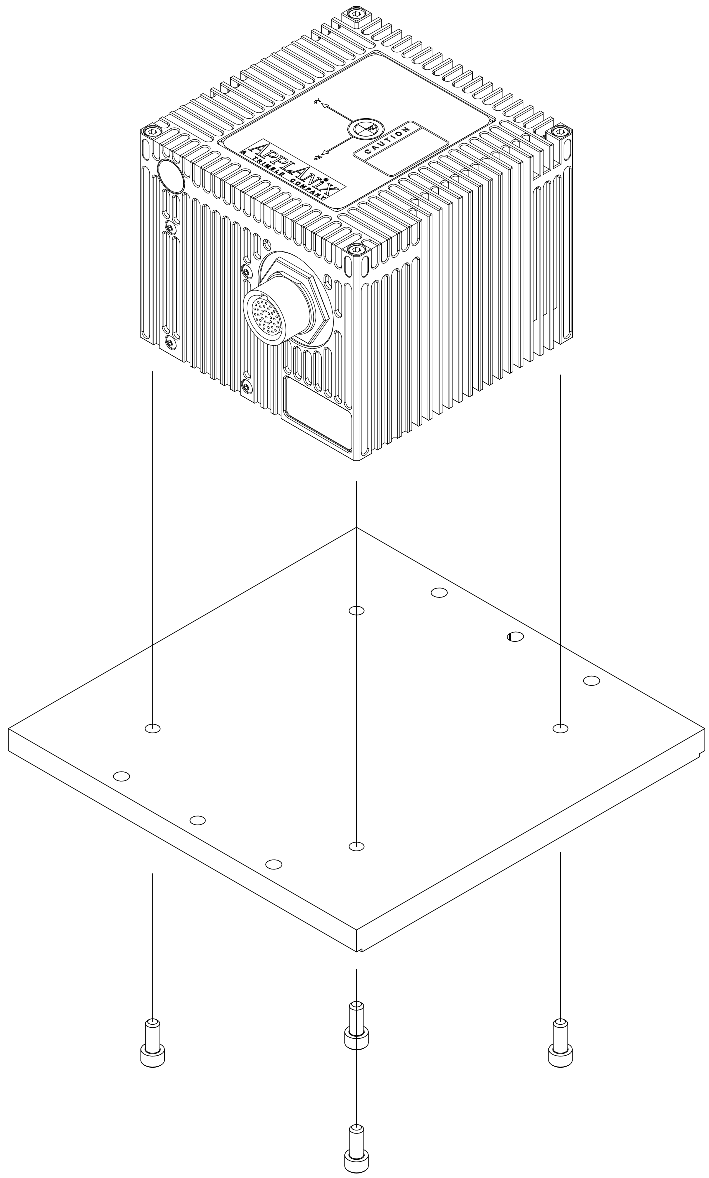


Figure 89: (3 of 4) IMU Type 26 Adapter Plate

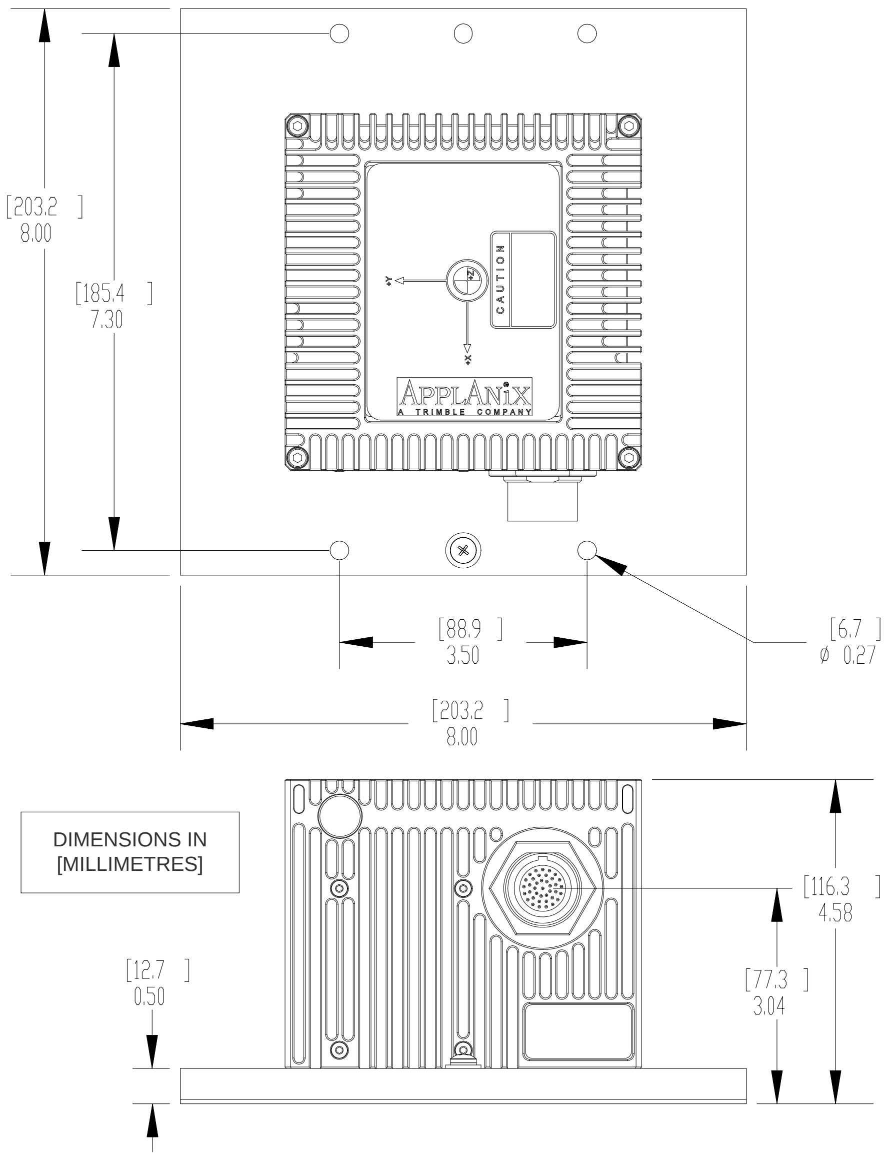
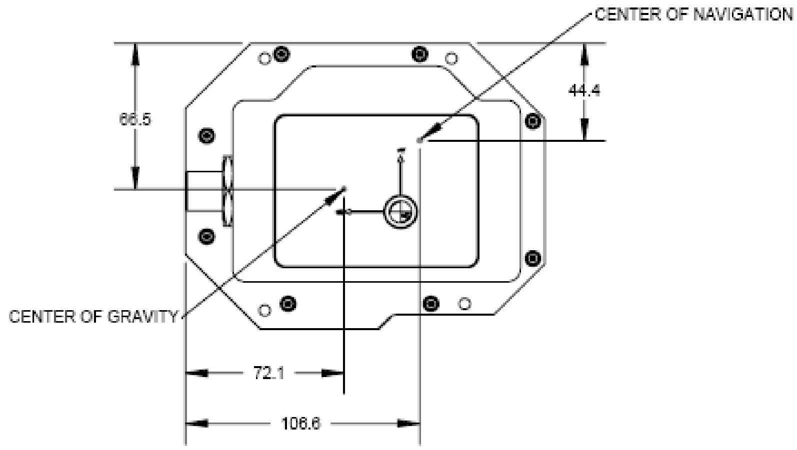


Figure 90: (4 of 4) IMU Type 26 Dimensions



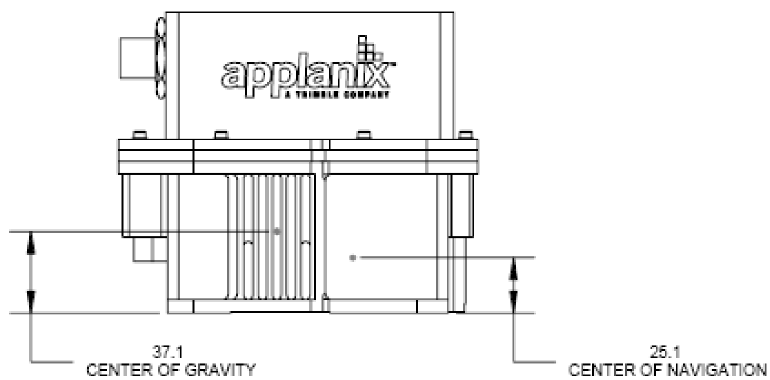


Figure 91: (1 of 4) IMU Type 31 & 40 Sensing Centre Diagram

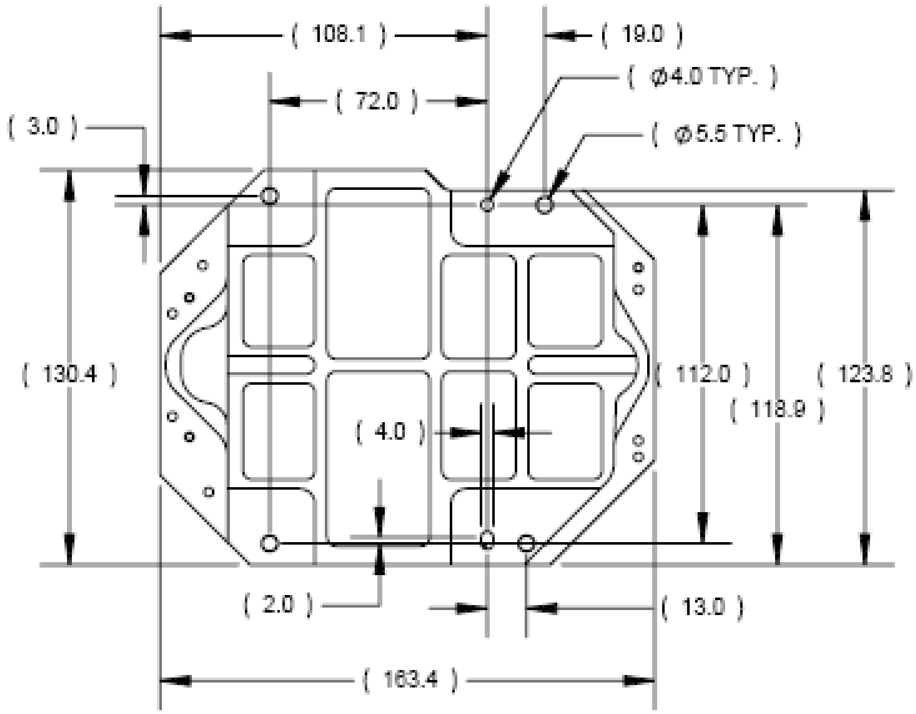


Figure 92: (2 of 4) IMU Type 31 & 40 Mounting Detail

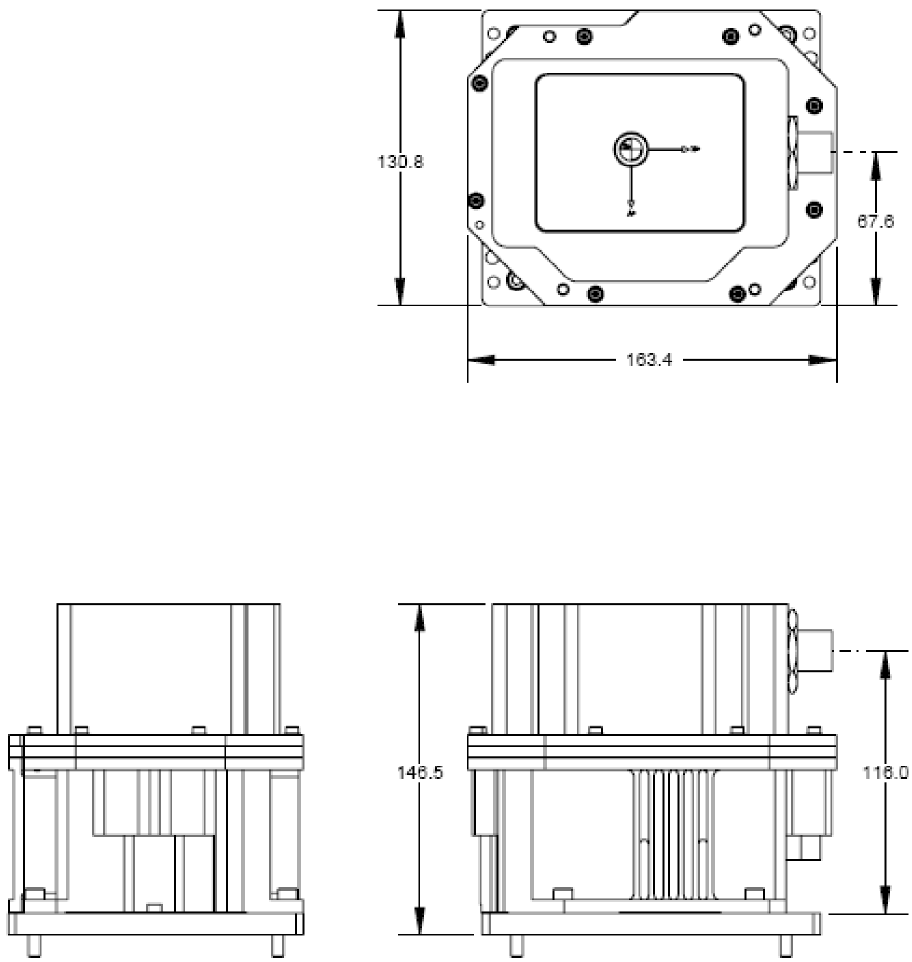


Figure 93: (3 of 4) IMU Type 31 & 40 Oveview Diagram with Adaptor Plate

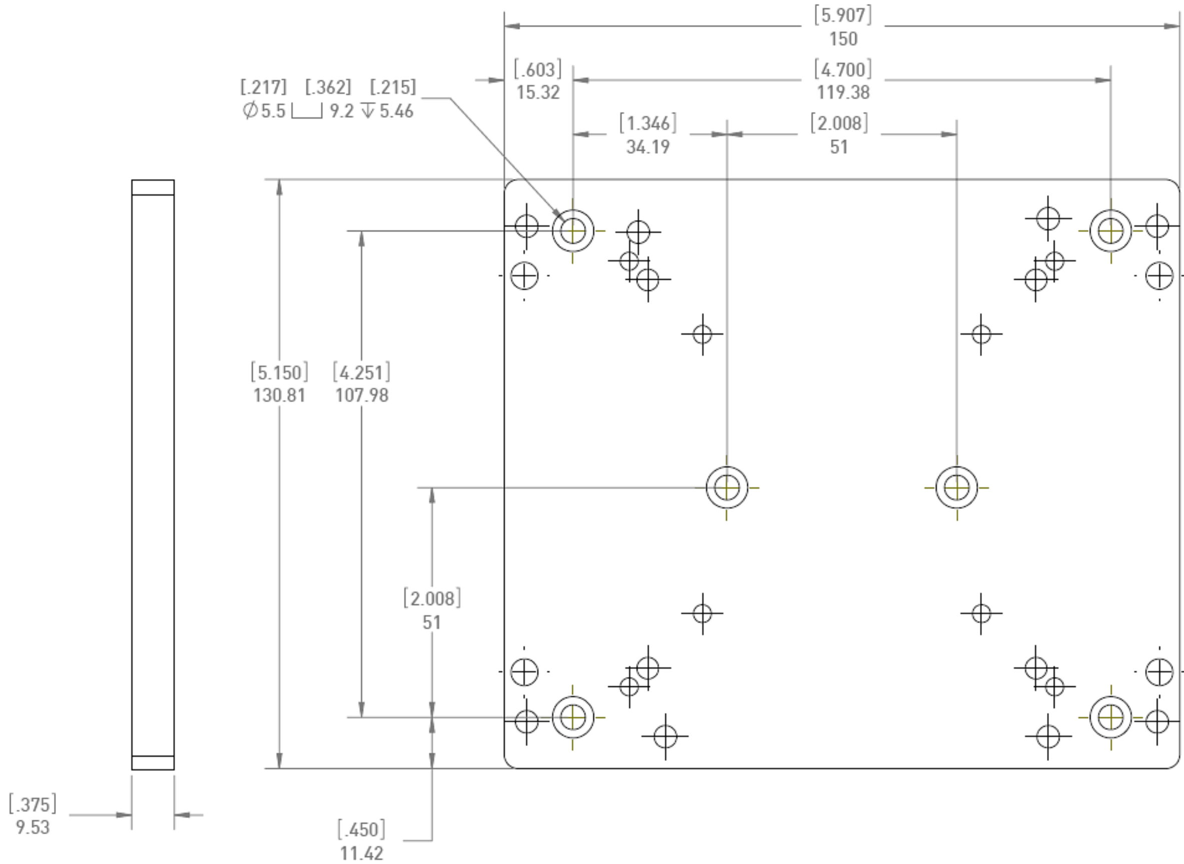


Figure 94: (4 of 4) IMU Type 31 & 40 Adaptor Plate

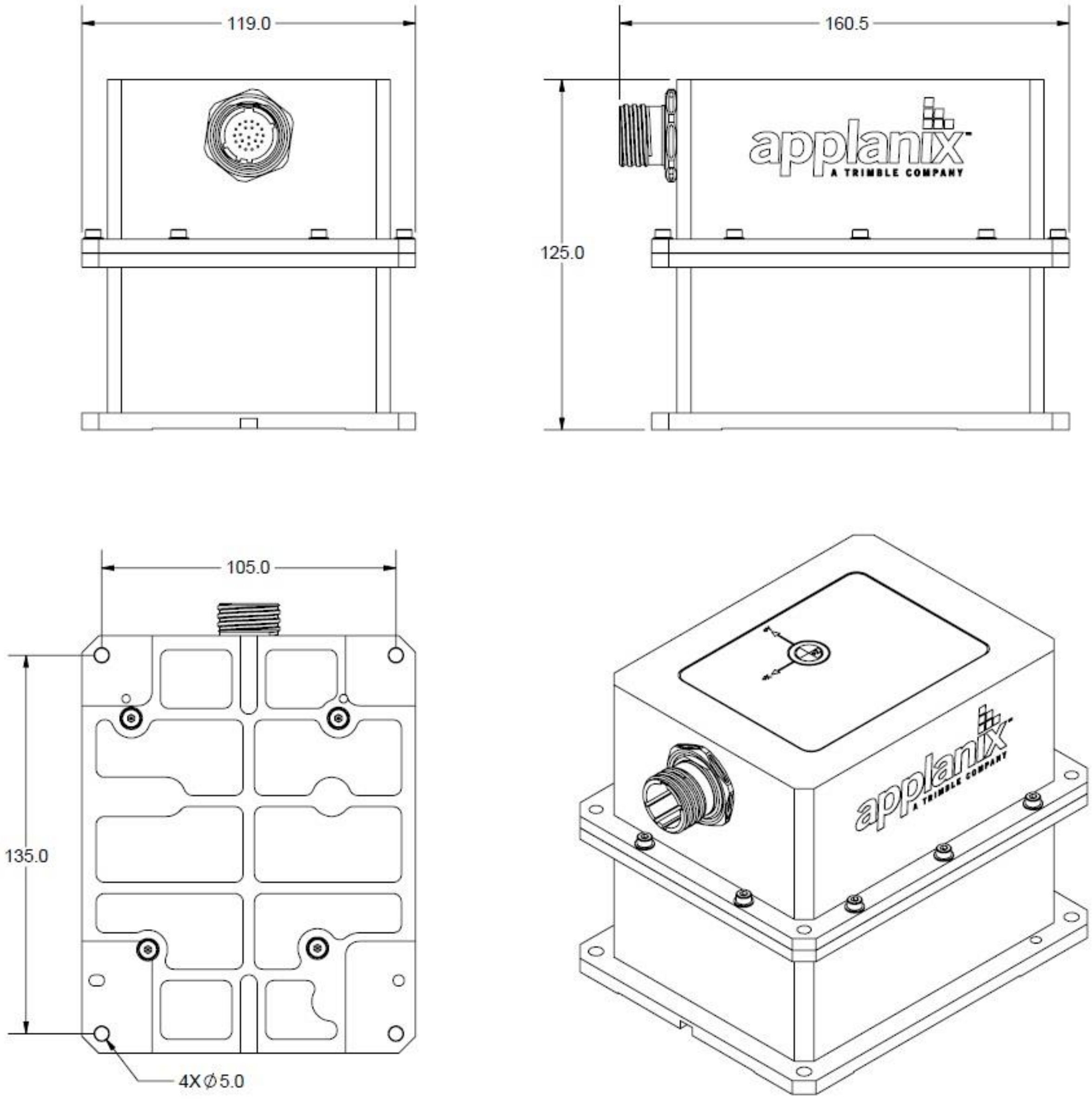


Figure 95: IMU Type 46 and 80 Outline and Mounting Diagram

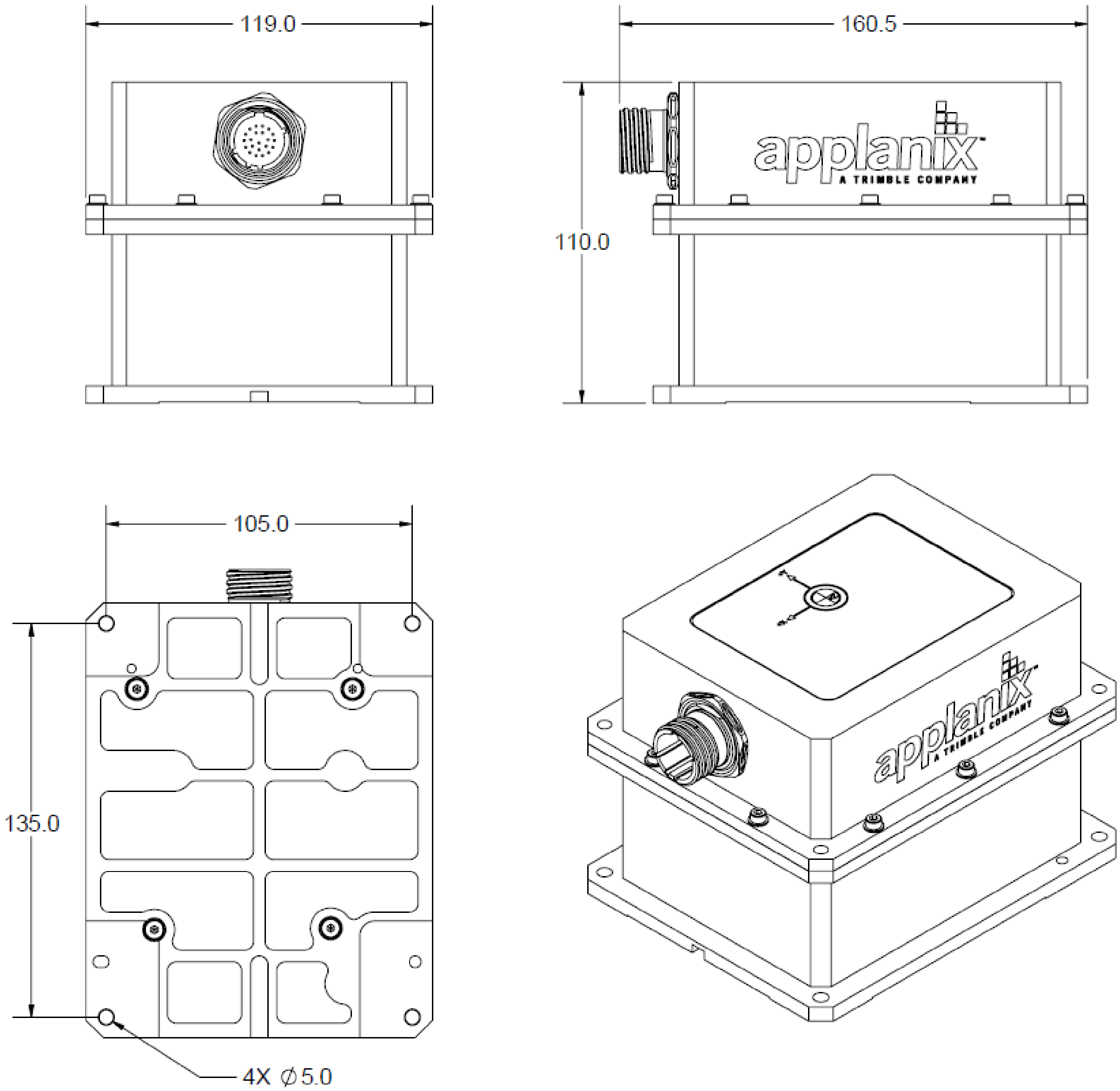


Figure 96: IMU Type 52 Outline and Mounting Diagram

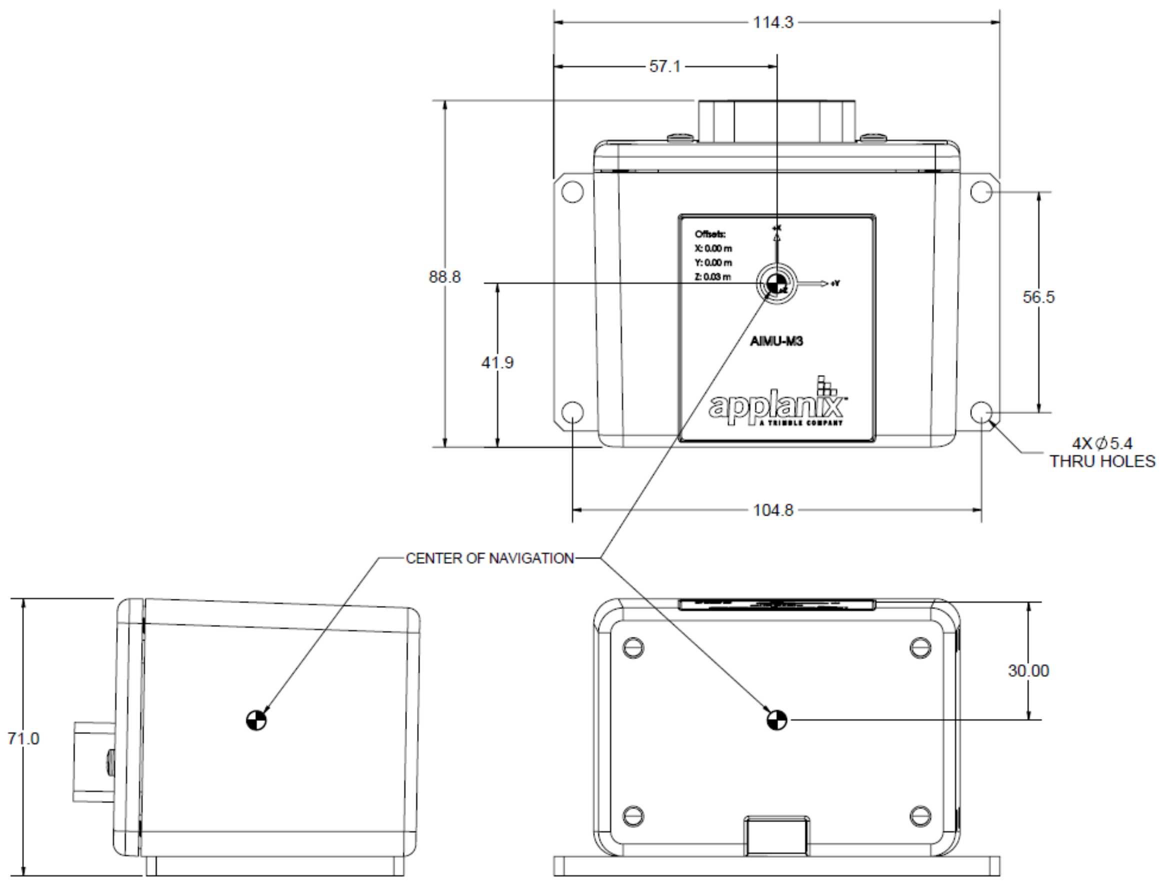


Figure 97: IMU Type 55 & 56 Outline, Mounting and Sensing Centre Diagram

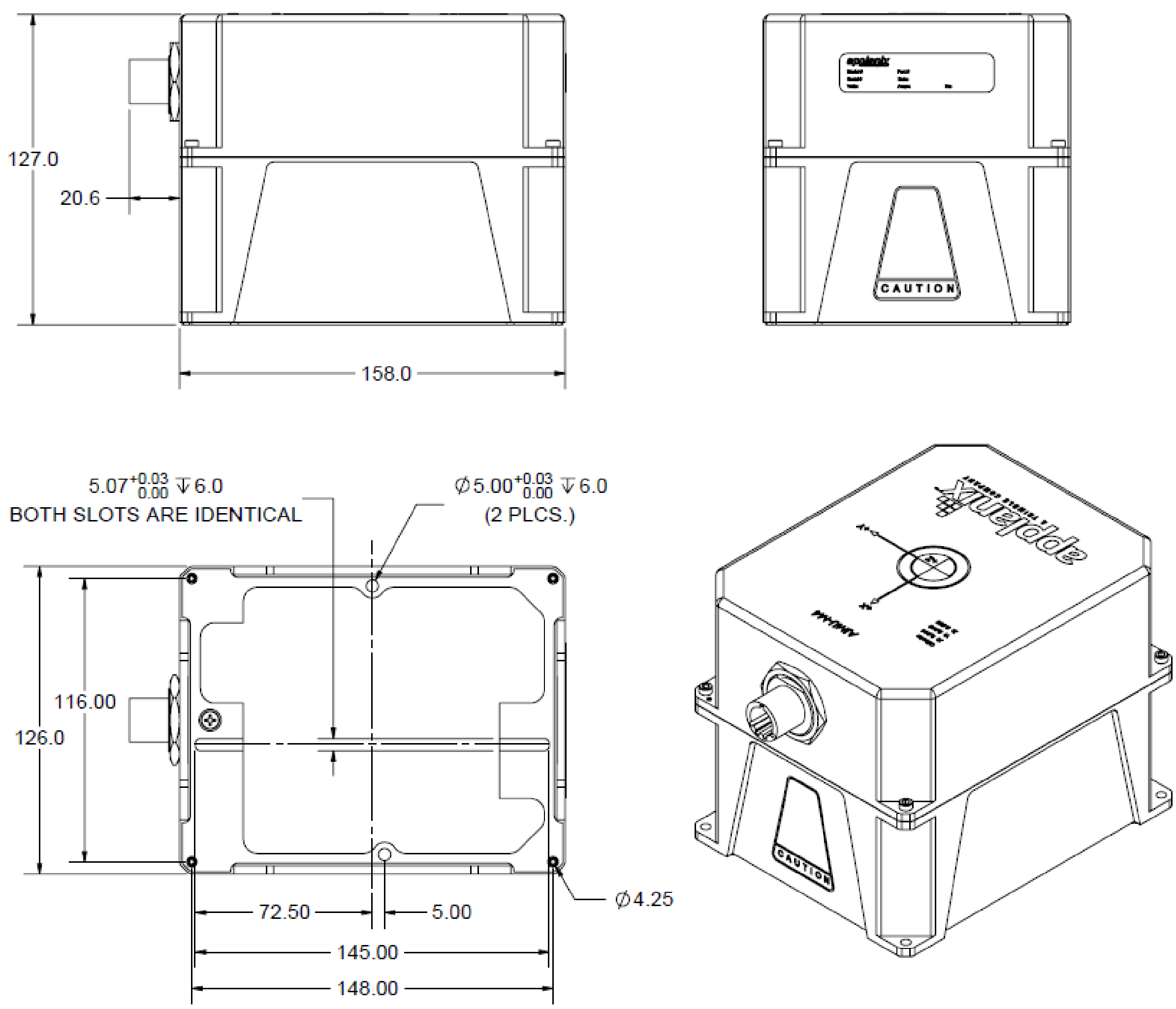


Figure 98: IMU Type 57 Outline and Mounting Diagram

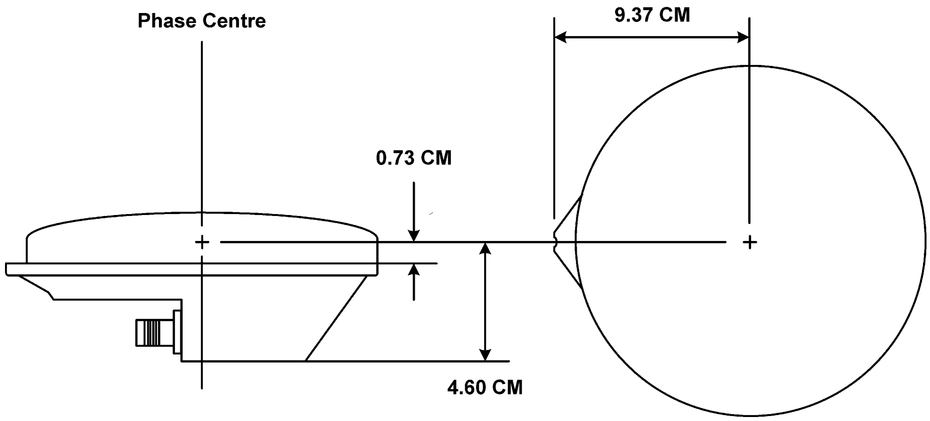


Figure 99: Trimble Zephyr GNSS Antenna Foot Print

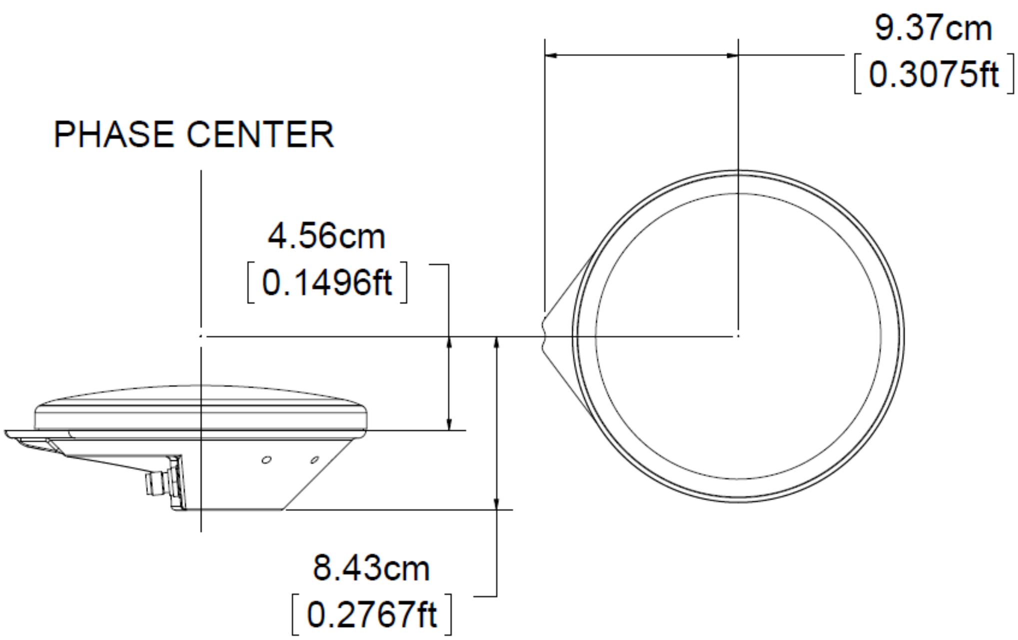
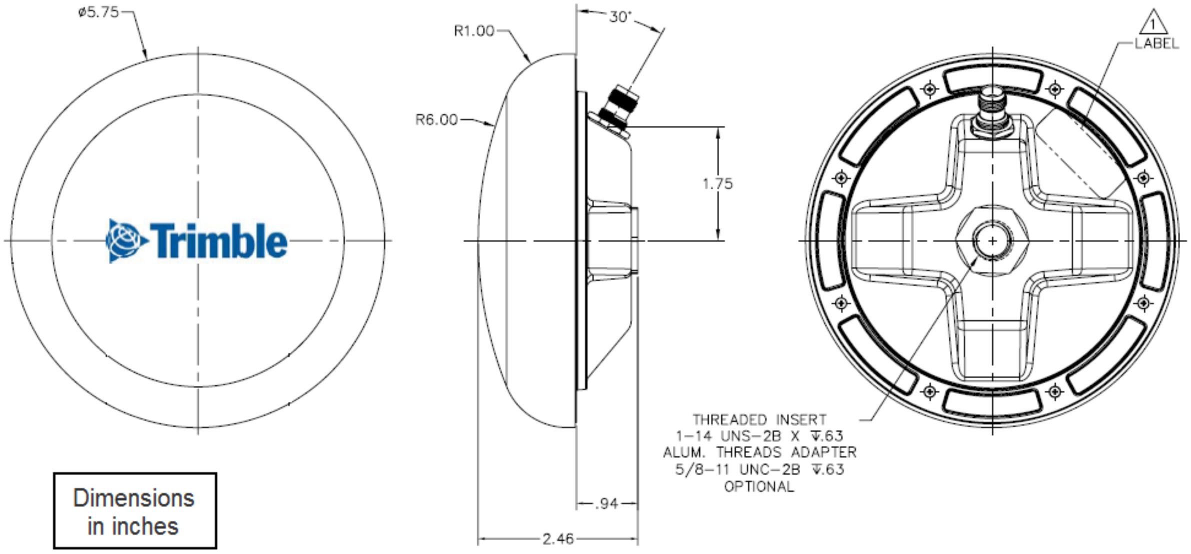
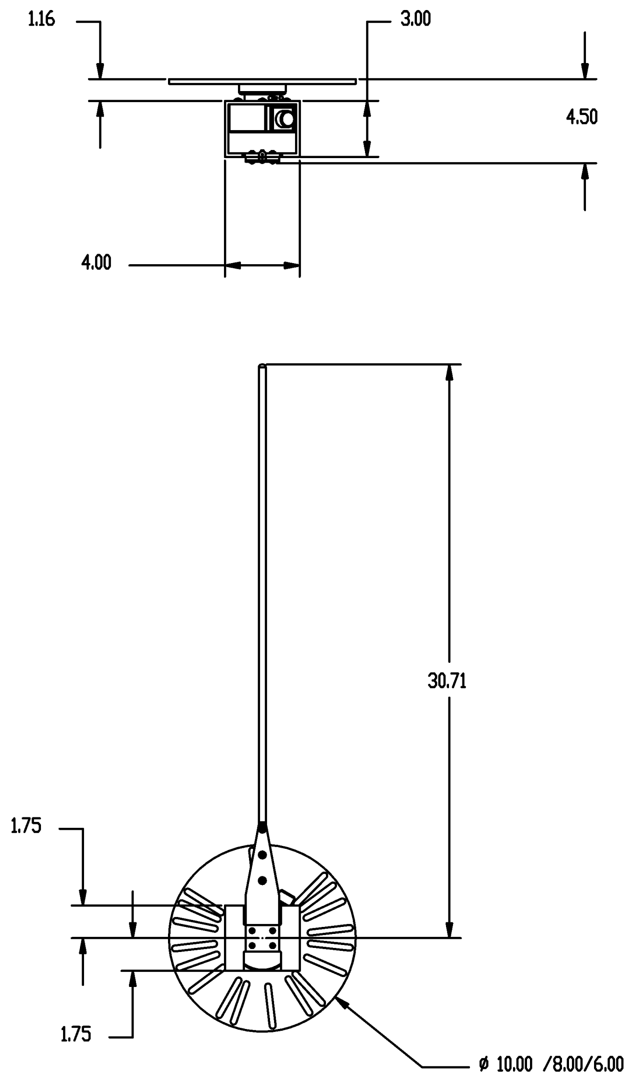


Figure 100: Trimble Zephyr Model 2 GNSS Antenna Foot Print



Phase centre is 66 mm above bottom of mounting thread.

Figure 101: Trimble 382AP GNSS Antenna Footprint



DIMENSIONS IN INCHES

Figure 102: DMI Foot Print

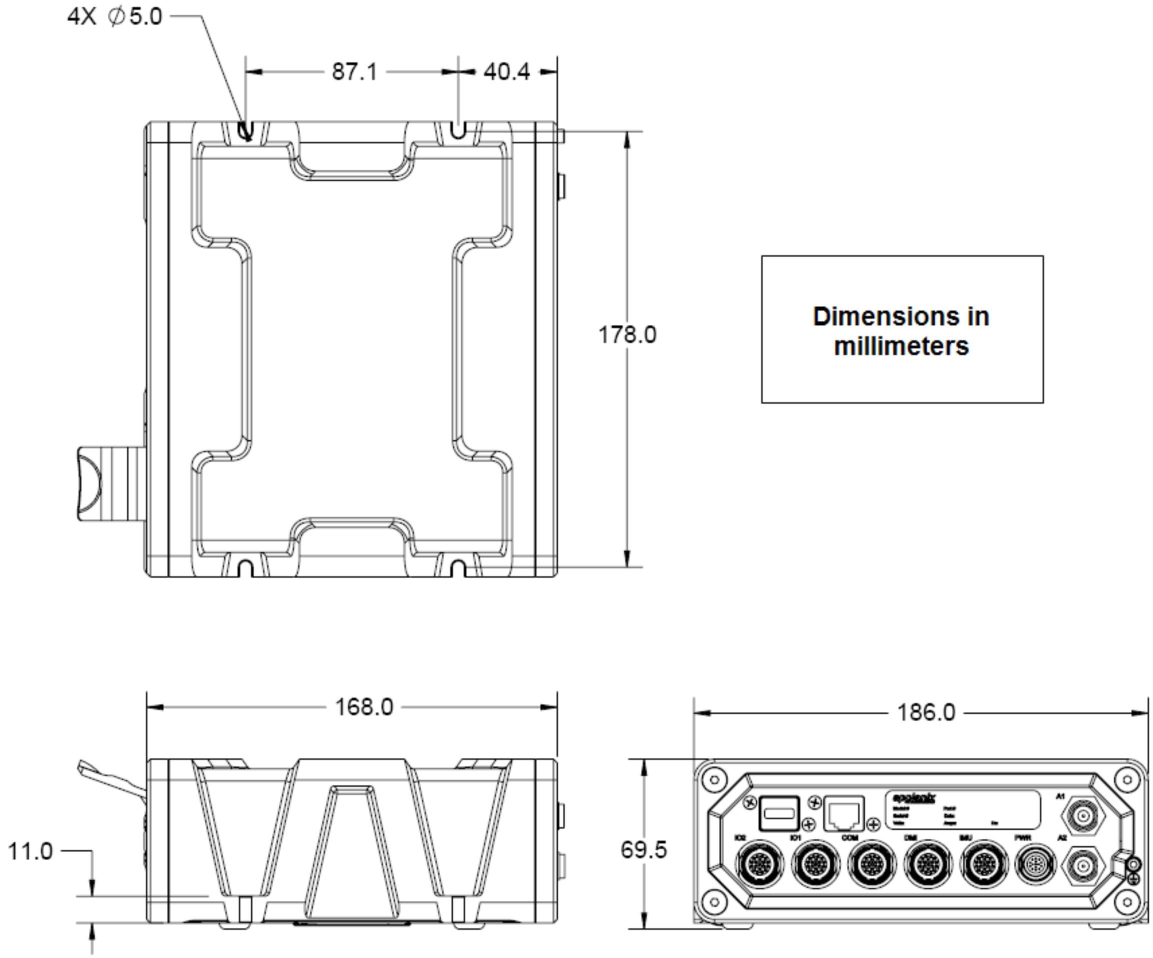


Figure 103: PCS-86 Foot Print

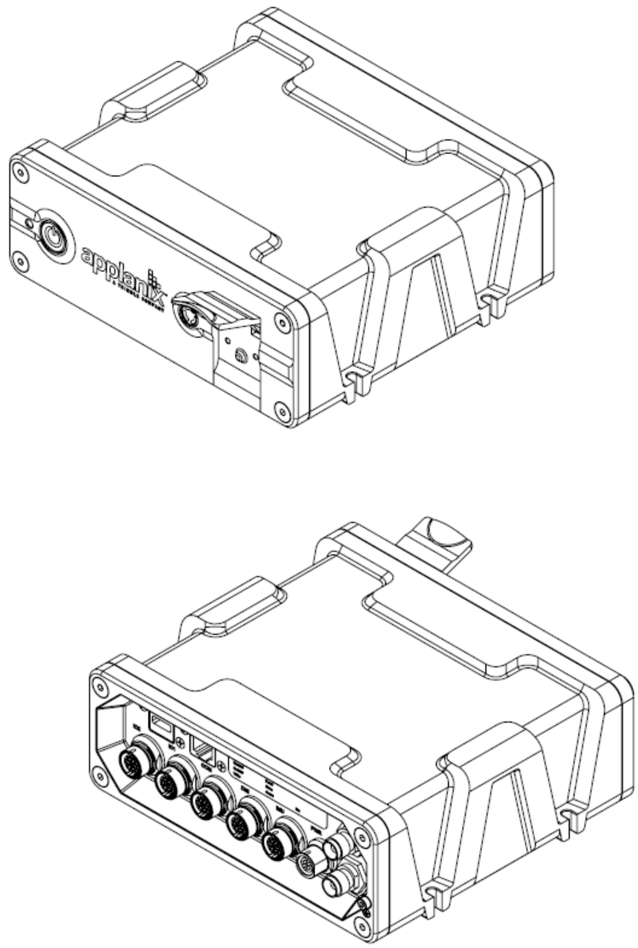
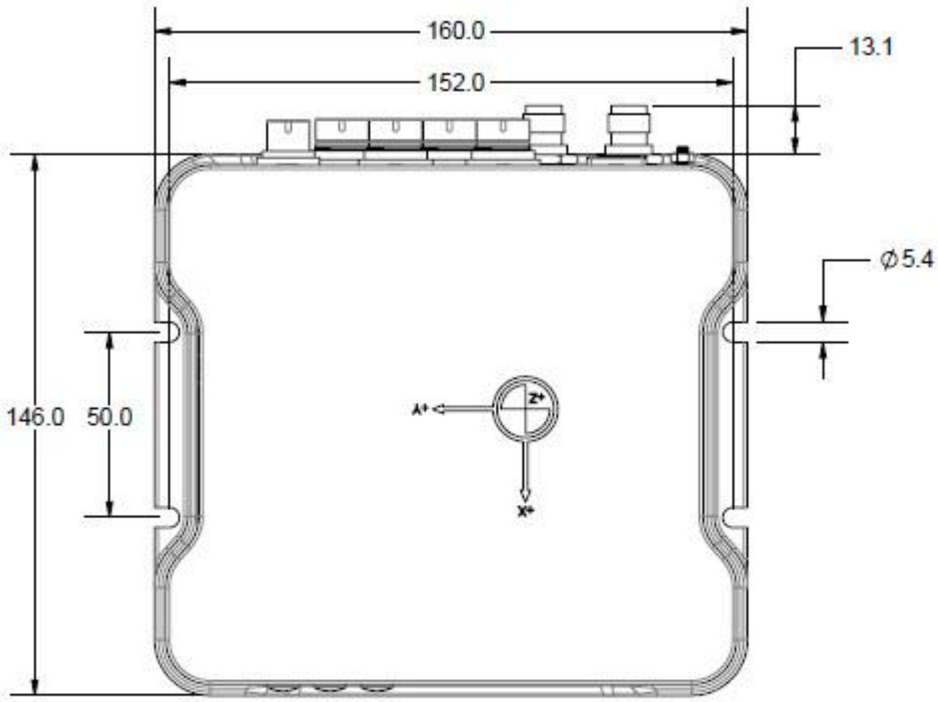


Figure 104: PCS-86 3D View



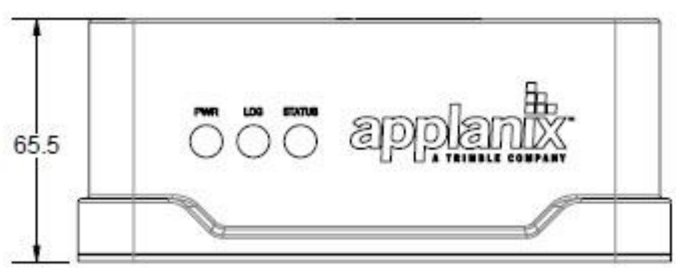


Figure 105: PCS-92 Foot Print

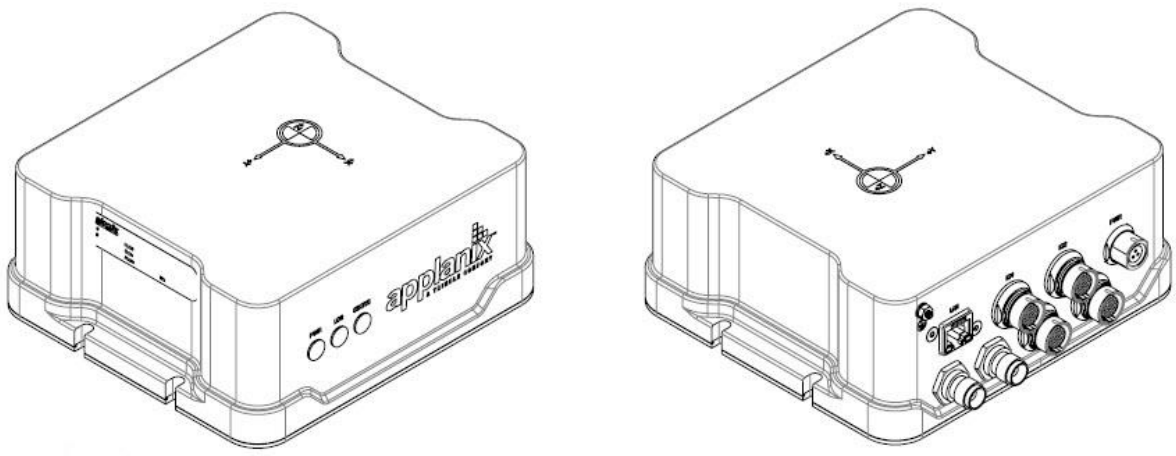


Figure 106: PCS-92 3D View

Glossary

Acceleration of Gravity

Acceleration of Gravity (g), not to be confused with the force of gravity (F_{grav}), is the acceleration experienced by an object when the only force acting upon it is the force of gravity. On and near the Earth's surface, the value for the acceleration of gravity is approximately 9.8 m/s/s. It is the same acceleration value for all objects, regardless of their mass (and assuming that the only significant force is gravity).

Angular Rate

Defines how quickly an angle is changing. The faster the angle changes, the higher the angular rate. Can be expressed as:

$$\frac{\textit{change in angle}}{\textit{duration of angle change}}.$$

ASCII

American Standard Code for Information Interchange. A code in which each alphanumeric character is represented as a number from 0 to 127, translated into a 7-bit binary code for the computer.

Attitude

Attitude determination is the process of estimating the orientation of a vehicle (space, air, marine or land) by using known reference points and vehicle attitude. Vehicle attitude sensors supply roll, pitch, and yaw data to a computer for processing with navigational data (reference points).

Baseline Vector

X, Y and Z components of the displacement from the Primary to Secondary GNSS antenna phase centre. The baseline vector is resolved in the Vehicle body frame.

Baud Rate

Baud Rate, in computer science, is commonly a reference to the speed at which a modem can transmit data. Often incorrectly assumed to indicate the number of bits per second (bps) transmitted, baud rate actually measures the number of events, or signal changes, that occur in one second. Because one event can actually encode more than one bit in high-speed digital communications, baud rate and bits per second are not always synonymous, and the latter is the more accurate term to apply to modems. For example, a so-called 9600-baud modem that encodes four bits per event actually operates at 2400 baud but transmits 9600 bits per second (2400 events times 4 bits per event) and thus should be called a 9600 bps modem.

Bit

The smallest element of computer storage, the bit is a single digit in a binary number (0 or 1). Groups of bits make up storage units in the computer, called "characters," "bytes," or "words," which are manipulated as a group. The most common is the byte, made up of eight bits and equivalent to one alphanumeric character.

Bits are widely used as a measurement for transmission. Ten megabits (Mb) per second means that ten million pulses are transmitted every second. Measurements for storage devices such as disks, files and databases are given in bytes rather than bits.

Byte

The common unit of computer storage from micro to mainframe, the byte is made up of eight binary digits (bits). A ninth bit may be used in the memory circuits as a parity bit for error checking. The term was originally coined to mean the smallest addressable group of bits in a computer (has not always been eight).

C/A

The coarse/acquisition or clear/acquisition code modulated onto the GPS L1 signal. This code is a sequence of 1023 pseudorandom binary bi-phase modulations on the GPS carrier at a chipping rate of 1.023 MHz, thus having a code repetition period of one millisecond. The code was selected to provide good acquisition properties. Also known as the "civilian code".

Choke Ring

An optional ring mounted around a GNSS antenna, designed to minimize multipath signal reception.

Control Port

Accessed via the LAN connector, the Control Port is designed to receive and acknowledge set-up and control commands from LV-POSView. The Control port is not a physical port. Rather, it is a subset of the Ethernet Interface.

Data Ports

Accessed via the LAN connector, the Data Ports are designed for high rate navigation and raw sensor data. Data ports are not physical ports. Rather, they are a subset of the Ethernet Interface.

DGPS

Differential GPS. A technique used to improve positioning or navigation accuracy by determining the positioning error at a known location and subsequently incorporating a corrective factor (by real-time transmission of corrections or by post-processing) into the position calculations of another receiver operating in the same area and simultaneously tracking the same satellites.

Dilution of Precision

Dilution of Precision (DOP) is a dimensionless number that accounts for the purely geometric contribution of the position of the satellites to the uncertainty in a position fix. Standard terms for the GNSS application are: GDOP-Geometric Dilution of Precision (three position coordinates plus clock offset in the solution); PDOP-Position Dilution of Precision (three coordinates); HDOP-Horizontal Dilution of Precision (two horizontal coordinates); VDOP-Vertical Dilution of Precision (height only); TDOP-Time Dilution of Precision (clock offset only); RDOP-Relative Dilution of Precision (normalized to 60 seconds).

Direction Signal

A TTL level signal from the DMI that indicates the direction for wheel rotation to the PCS.

Display Port

Accessed via the LAN connector, the Display Port is designed to broadcast low rate (once per second) data and status information for display by LV-POSView. The Display Port is not a physical port; it is a subset of the Ethernet Interface.

Distance Pulse

A TTL level signal generated by the DMI that represents a fractional revolution of the Instrumented Wheel.

Dropout

Loss of signal.

Ephemeris

The predictions of current satellite positions transmitted to the user in the data message. A list of accurate positions or locations of a celestial object as a function of time. Available as "broadcast ephemeris" or as post-processed "precise ephemeris."

Force of Gravity

Gravity is a force that exists between the Earth and objects which near it. All objects on Earth experience this force and is represented it by the symbol F_{grav}.

GPS

Global Positioning System. A constellation of 24 satellites that allows precise determination of position by analysis of satellite signals.

GPS Time

Highly accurate time system with units of Weeks and Seconds. GPS time is offset from UTC time by an integer number of seconds.

Instrumented Wheel

The Instrumented Wheel is the wheel to which the DMI is mounted. .

IP Address

An Internet Protocol Address is a series of numbers that identifies a specific computer.

Kalman Filter

A Kalman Filter is an algorithm that refines imprecise data to provide a more accurate estimate of a system's current state.

Kinematics

A branch of dynamic theory that deals with aspects of motion apart from mass and force. Technically speaking, real-time kinematics is a GPS differential mode of operation using carrier phase measurements, as such it is a technique, which makes use of the most accurate information delivered by the GPS system. The actual phase observations taken require a preliminary ambiguity resolution before they can be made use of. This ambiguity resolution is a crucial aspect of any kinematics system, especially in real-time where the mobiles velocity should not degrade either the achievable positional performance or the systems overall reliability.

NMEA

National Marin**e** Electronics Association. NMEA is a standard for interfacing electronic devices. This standard includes the definition of specific message formats.

Point of Validity

The Point of Validity defines the geographical location to which a particular set of data applies.

Post-Processing

Non real-time navigation solution computation from previously collected and recorded raw sensor data.

PPS Mode

Precise Positioning Service capable GPS receivers have higher accuracy than C/A code receivers, but are currently only available for military use.

PPS Strobe

The Pulse per Second Strobe is a TTL-level signal; generated once per second, whose falling edge is coincident with the GPS second.

Pseudo-range

A GPS distance measurement that has not been corrected for differences in synchronization between the satellite and receiver clocks.

Rutbar

An extendible bar mounted on the front of a vehicle bumper that contains ultrasonic transducers (typically spaced at 100 mm centres). The transducers measure the distance to the road surface. These measurements are combined with the output from a roll gyroscope to give a transverse profile of the surface from which rut depth is computed.

TCP/IP

TCP/IP is a routable protocol, and the TCP part provides transport functions, which ensures that the total amount of bytes sent is received correctly at the other end. It is widely used for real-time voice and video transmissions where erroneous packets are not retransmitted.

The IP part of TCP/IP provides the routing capability. In a routable protocol, all messages contain not only the address of the destination station, but the address of a destination network. This allows TCP/IP messages to be sent to multiple networks within an organization or around the world, hence its use in the worldwide Internet. Every client and server in a TCP/IP network requires an IP address that is either permanently assigned or dynamically assigned at start-up.

Time of Validity

Time of Validity defines the exact time at which a particular set of data are current.

TTL Level Signal

TTL Level Signals are DC signals interpreted in a discrete fashion. A signal below 0.8V is interpreted as a LOW, and a signal above 3.3V is interpreted as a HIGH. TTL signals can be likened to a binary system, where LOW is equivalent to 0, and HIGH is equivalent to 1.

UDP

UDP is a collection of protocols similar to TCP/IP. Most notable among the differences is that data broadcast in UDP can be read by any computer on the network. In contrast, TCP/IP messages are directed at particular computer.

USB

Universal Serial Bus is a specification to establish communication between devices and a host controller.

USB flash drive

A USB flash drive consists of a flash memory data storage device integrated with a USB interface. USB flash drives are typically removable and rewritable.

UTC

Universal Time Coordinated time is a precise atomic time system, offset from GPS time by an integer number of seconds. Also known as Greenwich Mean Time (GMT).

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