POS LV V4 Installation and Operation Guide

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POS LV V4 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-000048

Revision 5

General Notice

This manual describes the POS LV V4™ in detail and contains full installation and operating instructions.

Read chapters 3 and 4 thoroughly before beginning your installation.

The manual is an important part of the system. It should remain with the system for use by those who will operate and maintain it.

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.

Applanix reserves the right to change the specifications and information in this document without notice.

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, GPS antennas, GPS antenna cables, Ethernet cable, IMU, IMU cable and RS-232 serial cables.

DECLARATION OF CONFORMITY

Manufacturer's Name:	APPLANIX A TRIMBLE COMPANY
Manufacturer's Address:	85 Leek Crescent
	Richmond Hill, Ontario, Canada L4B 3B3
EC Representative's Name:	Nemko Canada Inc.
EC Representative's Address:	303 River Road, RR#5
	Ottawa, Ontario, Canada K1V 1H2
Equipment Model Designation:	POS LV V4
Equipment Description:	POS LV V4 is a fully integrated, turnkey position and orientation system for land vehicles.

Application of Council Directive: 73/23/EEC on the harmonization of the laws related to Member States relating to electrical equipment designed for use within certain voltage limits, as amended by: Council Directive 93/68/EEC and Council Directive 89/336/EEC on the approximation of the laws related to Member States relating to electromagnetic compatibility, as amended by: Council Directive 93/68/EEC.

Referenced Safety Standards:

EN 60950-1

Referenced EMC Standards:

EN 55022:98 with Amendments A1:2000 and A2:2003
EN 55024:98 with Amendments A1:2001 and A2:2003

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 has been tested and found to comply with the limits for a Class A 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. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Industry Canada

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

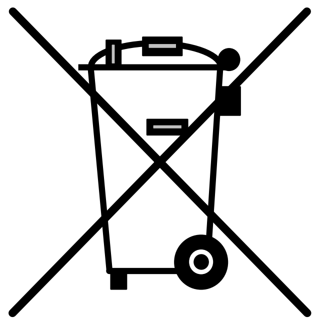
VCCI

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Ａ情報技術装置です。この装置を家庭環境で使用すると電波妨害を引き起こすことがあります。この場合には使用者が適切な対策を講ずるよう要求されることがあります。

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take corrective actions.

For Our European Union Customers
A New 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-000048, Revision 5, dated 11 June 2008.

This document describes all TNG POS LV mPOS hardware versions. For information on all other POS LV hardware versions, including VME, please consult the appropriate document or contact Applanix Customer Support for assistance.

References

PUBS-MAN-000055, AgGPS 132/AgGPS 332 System Manual

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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 Direct
CD	Compact Disk
CD-ROM	Compact Disk – Read Only Memory
cm	Centimetre
CMR	Compact Measurement Record
CPU	Central Processing Unit
ctr	Centre

CTS	Clear To Send
dB	Decibel
dBm	Decibel (referenced to 1 milliwatt)
dc	Direct Current
DCD	Data Carrier Detect
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)
dpi	Dots Per Inch
DSR	Data Set Ready
DTR	Data Terminal Ready
EMI	Electromagnetic Interference
ERR	Error
ESD	Electrostatic Discharge
FAX	Facsimile
FDIR	Fault Detection, Isolation, and Reconfiguration
ft	Foot
FTP	File Transfer Protocol
g	Gravity (acceleration due to gravity)
GAMS	GPS Azimuth Measurement Subsystem

GB	Gigabyte
GIS	Geographic Information System
gnd	Ground
GMT	Greenwich Mean Time
GND	Signal Ground
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
hr	Hour
Hz	Hertz
I/O	Input/Output
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
ISA	Industry Standard Architecture
kb	Kilobit
kB	Kilobyte
kbps	Kilobits Per Second
kHz	Kilohertz
lat	Latitude
LCD	Liquid Crystal Display
LOF	List of Figures

long	Longitude
LSB	Least Significant Bit
m	Metre
mA	Milliampere
Mb	Megabit
MB	Megabyte
MHz	Megahertz
min	Minute (time interval)
mm	Millimetre
mPOS	Mini-Position and Orientation System
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
PCI	Peripheral Component Interconnect
PCMCIA	Personal Computer Memory Card International Association
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
RI	Ring Indicator
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
SDRAM	Synchronous Dynamic Random Access Memory
SI	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
TR	Terminal Ready
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)
UTP	Unshielded Twisted Pair
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

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 Positioning System (GPS) 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 GPS 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 GPS 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 GPS 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 GPS 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 GPS 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 GPS receivers - heading aiding provided by a direct measurement of vehicle heading supplements inertial heading, significantly increasing heading accuracy.
- Tightly coupled integration - raw GPS 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 GPS.
- DMI aiding - wheel rotation data constrains drift, especially during vehicle stoppages in areas of intermittent GPS 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 Positioning System (GPS) 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 GPS 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 four sensors: an IMU, a DMI, and two GPS antennas. The PCS uses data from the four 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 GPS 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 PC Card. 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 GPS 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 GPS dropouts.

Models 420 and 220 house two GPS receivers inside the PCS, where as, the model 200 only has an external GPS receiver that is connected to the PCS as the primary GPS receiver. POS LV model 200 supports the Trimble AgGPS 132, AgGPS 332, 5700 and MS750 external GPS receivers. Please contact Applanix for the latest support list, see Appendix A1.

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 GPS receiver, GPS Azimuth Measurement Subsystem (GAMS) and the DMI, estimating the inertial navigation errors. A tightly coupled ambiguity resolution algorithm is in use when real-time GPS 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 GPS 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.

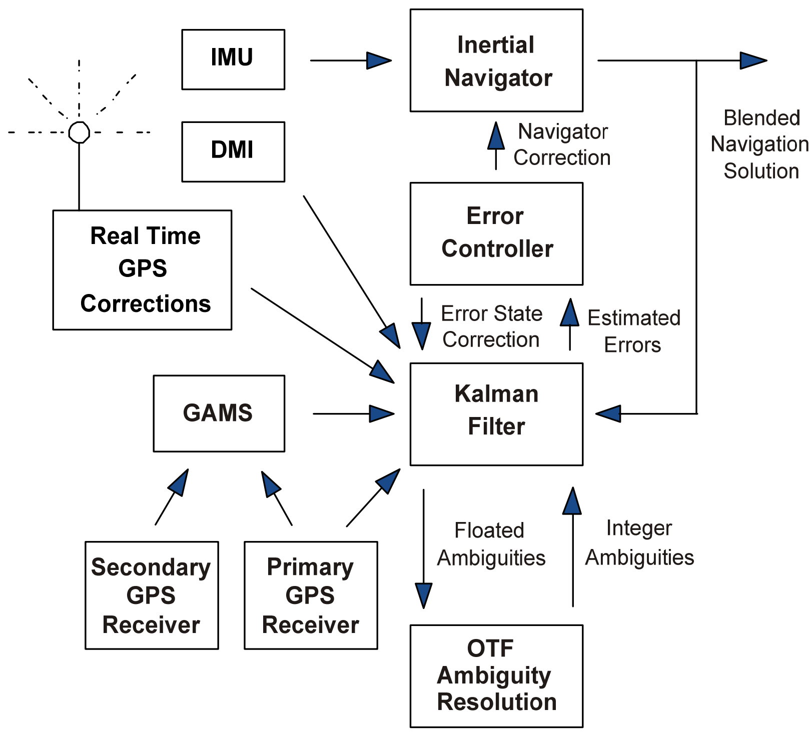


Figure 2: POS LV Aided Inertial Navigation Processing

Major Components

POS LV consists of the following components.

Basic Components

- POS Computer System (PCS)
- Data logging device (part of the PCS)
- GPS receivers (installed inside the PCS)
- Inertial Measurement Unit (IMU)

- Distance Measuring Indicator (DMI)
- GPS antennas
- LV-POSView software
- Interconnect cables

Optional Components

- POSPac post-processing software

POS Computer System

The PCS is a mini-computer contained in a painted aluminium housing. It contains all the data acquisition and processing hardware, two GPS receivers and power supplies for the IMU, DMI and GPS 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.

PC Card Data Logging

A PC Card is used to record the mission data and can be directly transferred to any computer with a PC Card slot. The data logging device writes to removable media (PC Cards).

Back-up Data Logging

When the PC Card logging is active, the same data are written to an internal one-gigabyte storage device within the PCS.

GPS Receivers - Primary and Secondary

Models 420 and 220 house two GPS receivers inside the PCS; one single frequency unit (secondary receiver) and one single or dual frequency unit (primary receiver). The secondary and primary receivers provide raw GPS satellite observable information to POS LV.

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

Model 200 only has an external GPS receiver that is connected to the PCS as the primary GPS receiver. POS LV model 200 supports the Trimble AgGPS 132, AgGPS 332, 5700 and MS750 external GPS receivers. Please contact Applanix for the latest support list, see Appendix A1.

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.

GPS Antennas

The GPS antennas are external components that require mounting on the roof of the vehicle. The antennas provide signals to the GPS receivers 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 (PC Card and back-up logging)
- AutoStart (automatically transitions from Standby mode to Navigate mode on power-up)

- AutoLog (automatically starts PC Card 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.

PC Card Data Logging

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

Back-up Data Logging

When the PC Card logging is active, the same data are written to an internal storage device within the PCS. In the event that PC Card logging fails, anonymous File Transfer Protocol (FTP) may be used to recover the mission data.

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 PC Card 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 K-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 Transistor-Transistor Logic (TTL) signal is input into POS LV. The rising or falling edge corresponds to the exact time and distance of the event. The TTL signal is connected to an event line of the I/O connector, described in the Events Connector topic on page 5-12.

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 K-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, GPS and DMI data to the PC Card 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 V4) shall be grounded via the safety ground screw.
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. As with any computer, handle the PCS with care to avoid damage. Locate the PCS in a mount that provides isolation from both shock and vibration. Avoid areas of excessive dust and humidity; the PCS is not a sealed unit.

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.

AgGPS-332, GPS Antennas, PCS, IMU and DMI

Figure 3: (1 of 2) POS LV Components

DMI, Restraint Rod, Cable and Hub Adapter

Figure 4: (2 of 2) POS LV Components

GPS Antennas

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

Two Global Positioning System (GPS) antennas are included with the system, one for each of the internal GPS receivers, see Figure 3. Handle the antennas with care to avoid scratching or otherwise damaging their weatherable 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 -20 °C or above +60 °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

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

Power requirements for the PCS are:

Nominal voltage and current:		12 Vdc at 6.0 A
	or	24 Vdc at 2.5A
Voltage range:	for	12 Vdc is 10 to 20 Vdc
	for	24 Vdc is 20 to 34 Vdc

The PCS input voltage is not switchable. Operating power for the IMU, DMI, and the GPS antennas is supplied by the PCS.

Environmental Requirements

POS Computer System

Do not expose the PCS to water, excessive dust or heat. It has a rear mounted exhaust fan and requires approximately six inches (15 centimetres) of clearance behind the rear panel to accommodate proper cooling and cable clearance. Do not restrict the airflow intake or exhaust located on the top and rear of the chassis.

The following are environmental limits for the PCS:

Operating temperature:	0 °C to +50 °C
Storage temperature:	-20 °C to +60 °C
Relative humidity:	5% to 95% non-condensing

Inertial Measurement Unit

The IMU is enclosed in a fully sealed housing made of powder-coated aluminium. It can withstand water, oil and gas spray, but it is not designed for immersion in a liquid. Even though it is a sealed unit, 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 the IMU:

Temperature:	-40 °C to +60 °C
Relative humidity:	0 to 100%
Shock:	~50 g (~490 m/s^2)

Distance Measuring Indicator

The DMI is mounted on one of the vehicle's wheels, as described in the Distance Measuring Indicator description on page 3-4. 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 +85 °C
Storage temperature:	-40 °C to +85 °C
Relative humidity:	0 to 100%, condensing

GPS 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 GPS antenna connection may cause weak signal reception, damage the internal GPS antenna circuitry or the GPS receiver in the PCS.

Wrap the connectors between the GPS antenna cables and the antennas with self-fusing tape (supplied) to prevent moisture intrusion into the connection, see page 3-2 for application instructions.

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

GPS Antenna

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

GPS 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 2-2 for more information.

Important:

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

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 2-5 to 2-6.

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 humidity, dust or heat. It has a rear mounted exhaust fan and requires approximately six inches (15 centimetres) of clearance behind the rear panel to accommodate proper cooling and cable clearance. Do not restrict the airflow intake or exhaust located on the top and rear of the chassis.

Internal Measurement Unit

IMPORTANT

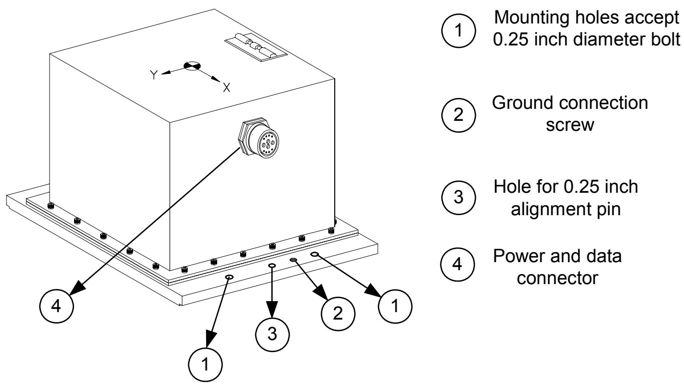
Rigidly mount the IMU to the vehicle frame. Select a structurally sound location that is not prone to flexation (bending motion of the vehicle chassis).

If the POS LV is intended to motion-compensate data from a particular sensor, then mount the Internal 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.

Two holes (see note on Figure 5) are predrilled in the IMU base plate to accept ¼ in (0.250 in) diameter alignment pins. These holes (diameter = 0.252 +0.002, -0.000 in; length = 0.275 ±0.005 in) maintain IMU alignment when the unit is replaced. One of the two holes is slightly elongated to allow for keying.



Note: Item 3 - standard for POS LV models 200 and 220, optional for model 420.

Figure 5: IMU Mounting Features

Four ¼ in (0.250 in diameter) or M6 (6.000 mm diameter) bolts secure the IMU base plate to the vehicle. Tighten the bolts in a uniform manner, exercising care not to over torque them. Attach a ground strap between the IMU ground connection screw and the vehicle chassis to ensure adequate electrical noise protection.

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.

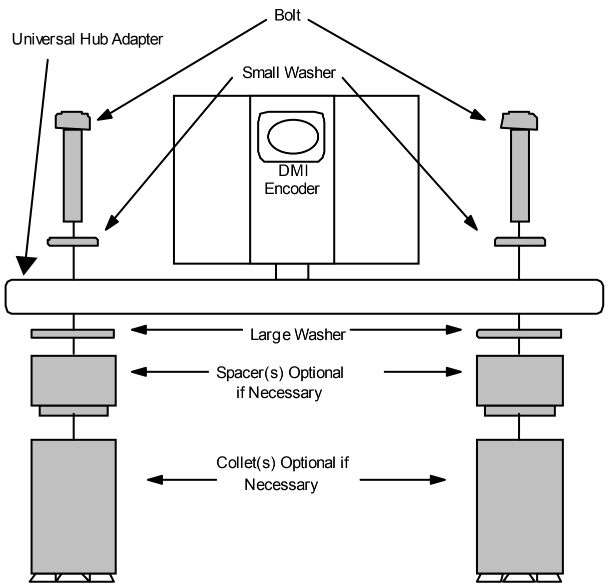


Figure 6: DMI Collet Mounting Guide

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:

1. Slip collets over wheel nuts (Figure 8).
2. 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.

3. 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.

4. 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.

5. Slip (permanent or temporary) restraint bracket over restraint rod and position rod perpendicular to road (Figure 9).

6. Attach DMI restraint bracket:

   - Permanent - attach bracket using predrilled holes in rear fender lip using metal screws (refer to Mounting Brackets on page 3-5 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 3-2 for application instructions.

To install the DMI cable perform the following (Figure 11):

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

GPS Antennas

To ensure system performance, Applanix recommends a configuration that incorporates the GPS 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 GPS antenna. Each GPS antenna, associated coaxial cable and receiver is configured for optimum performance.

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

- GPS antennas require line-of-sight signals from the GPS 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 GPS Azimuth Measurement Subsystem (GAMS) at resolving vehicle heading. The minimum antenna separation is ~59 in (1.5 m); however, Applanix recommends 78 ¾ in (2.0 m) or more, up to a distance of five metres.
- Wrap the GPS antenna connector connection with the supplied self-fusing tape to prevent moisture intrusion, see page 3-2 for application instructions. Moisture intrusion will cause signal degradation and may damage the GPS antenna or receiver.
- The three components of the Lever Arm between the primary GPS antenna and the IMU must be measured with centimetre accuracy, refer to the Installation Parameters description on page 4-1. Select a GPS antenna location that does not restrict these measurements.

After GPS antenna installation, connect the primary GPS antenna to the ANT1 port and the secondary GPS 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 GPS antenna cable will provide strain relief.

Note: If the primary GPS 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 GPS receiver by using the LV-POSView software program. Select **View, GPS 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 GPS 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 Positioning System (GPS) 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 (object frames)
- 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 Frame to IMU Frame

- Lever Arm - Reference Frame to DMI Frame
- Lever Arm - Reference Frame to GPS Frame
- Mounting Angles - Reference Frame with Respect to Vehicle Frame
- Mounting Angles - IMU Frame With Respect to Reference Frame
- DMI scale factor
- GPS two antenna separation (GPS Azimuth Measurement Subsystem [GAMS])

Other parameters:

- Lever Arm - Reference Frame to Auxiliary GPS 1 Frame
- Lever Arm - Reference Frame to Auxiliary GPS 2 Frame

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. Such an error may manifest itself as a Lever Arm error.

Lever Arms and Mounting Angles for the IMU, as well as the Lever Arms for the primary GPS 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 misaligned angles between the various frames (IMU, reference and sensor) have to be determined by using a bore sighting procedure.

To boresight the POS LV to a vehicle, compare the POS LV orientation solution to its direction of travel derived from the POS LV velocity vector. Average the difference over long periods (of time) using only the dynamic data to cancel out the vehicle suspension travel and other drift factors. Enter the observed angular errors as either a “Reference Frame with respect to Vehicle Frame” rotation or an “IMU Frame with respect to Reference Frame” depending on how you want your reference frame to be defined. See “Mounting Angles” on page 4-9.

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. The purpose of the Vehicle Frame is to provide an orientation reference for the Reference Frame.

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 axis 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 (label on the case), serve to locate the IMU Frame origin.

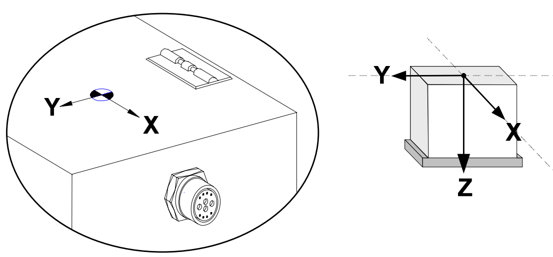


Figure 13: IMU Body Frame

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 axis 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.

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.

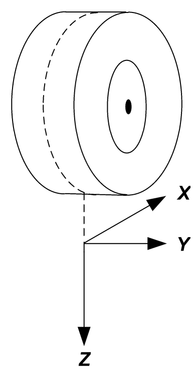


Figure 14: DMI Body Frame

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 x, y and z sensing centre offsets, specified on the IMU case, are then added to these measured values. The resulting distance from the user-defined Reference Frame origin to the IMU sensing centre is resolved in the Reference Frame; 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), 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 is measured with respect to the user-defined Reference Frame.

Lever Distances are measured from the user-defined 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.

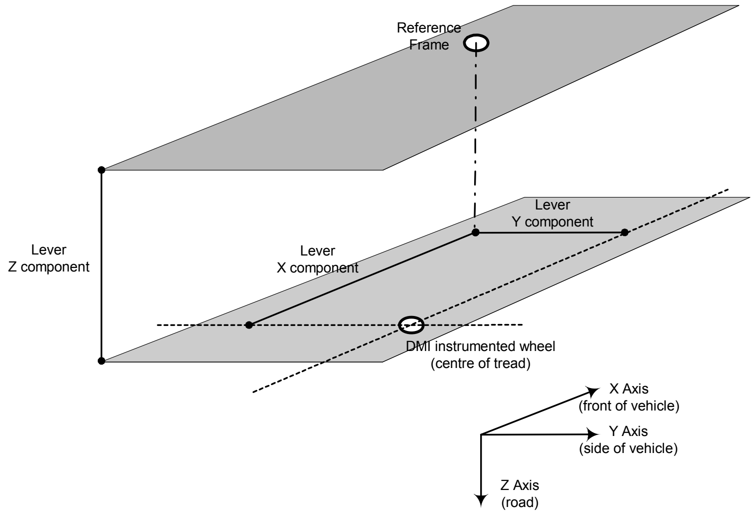


Figure 15: Three Dimensional Vector Lever Arm

Reference to Primary GPS Antenna Lever Arm

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

Distances are measured from the user-defined Reference Frame origin to the phase centre of the primary GPS antenna, with respect to the Reference Frame, see Figure 16. Typically, a vertical offset is specified on the GPS 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).

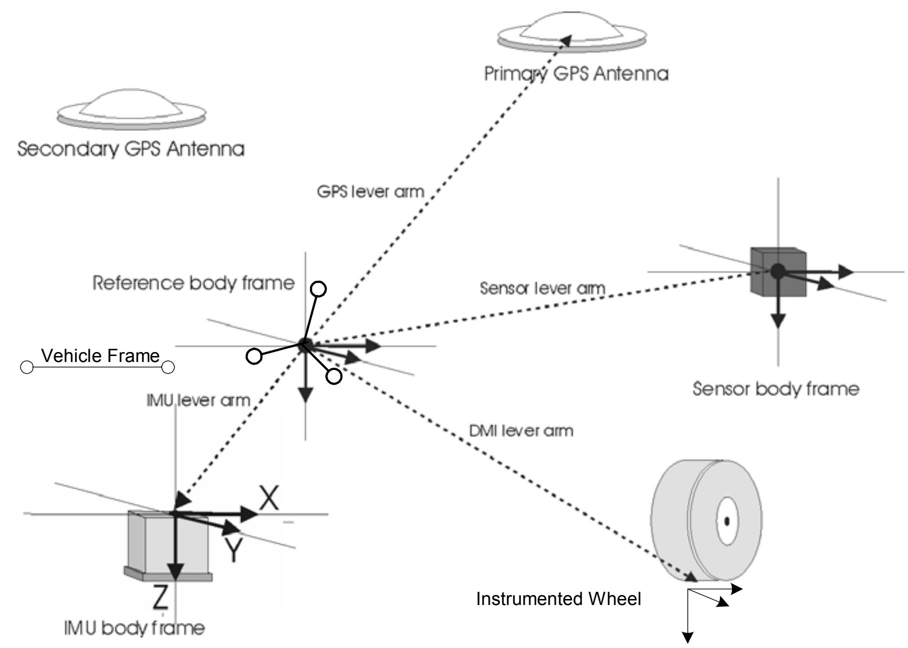


Figure 16: Lever Arms

Reference to Auxiliary GPS Lever Arms

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

The measurement method is analogous to the measurements for the Reference to primary GPS 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, IMU,* and DMI Body Frame definitions).

These angles define the Tate-Bryant 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. Refer to Tate-Bryant Sequence on page E-1 for a more detailed explanation of the Tate-Bryant sequence.

Make note of all measured mounting angles for later input into the POS LV and store the measurements in a secure place for future reference.

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.

The Euler sequence of rotations defines angles that bring the Vehicle Frame into alignment with the Reference frame. The angles follow the Tate-Bryant sequence of rotation given as follows: right-hand screw 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 axis are fixed to the IMU and are labelled on the IMU case.

The Euler sequence of rotations defines angles that bring the Reference Frame into alignment with the IMU body frame. The angles follow the Tate-Bryant sequence of rotation given as follows: right-hand screw 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 is showing the bottom view of the IMU body.

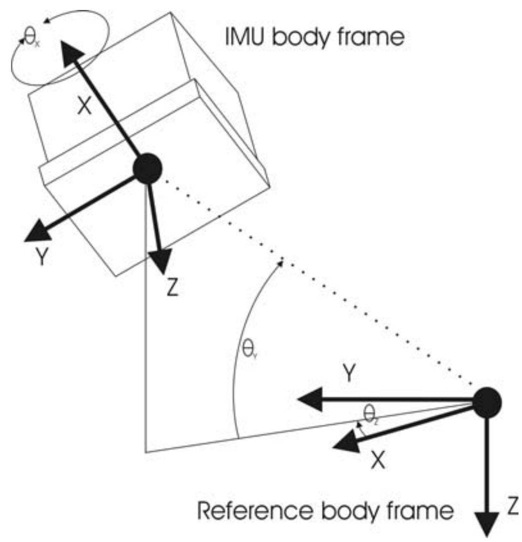


Figure 17: IMU with respect to Reference Frame Mounting Angles

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 factors:

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

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

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 1024 pulses per revolution
- $s = \frac{1024}{d\pi} = \frac{1024}{0.5 \times 3.14} \cong 652 \text{ pulses/m}$

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.

GPS Antenna Separation

GPS antenna separation (between two antennas) is the distance between the phase centres of the two GPS antennas used by POS LV. This distance is used by the GPS Azimuth Measurement Subsystem (GAMS) for heading aiding.

Measure the length of the straight line joining the two GPS antenna phase centres; measurement is critical to within five millimetres.

5.0 Cable Characteristics

Important:

1. Equipment shall be serviced only by qualified personnel.
2. The PCS shall be grounded via the safety ground screw.
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 six 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 connector, which supports a multi-connector breakout cable. Table 1 provides a summary of the connectors used in the POS LV configuration.

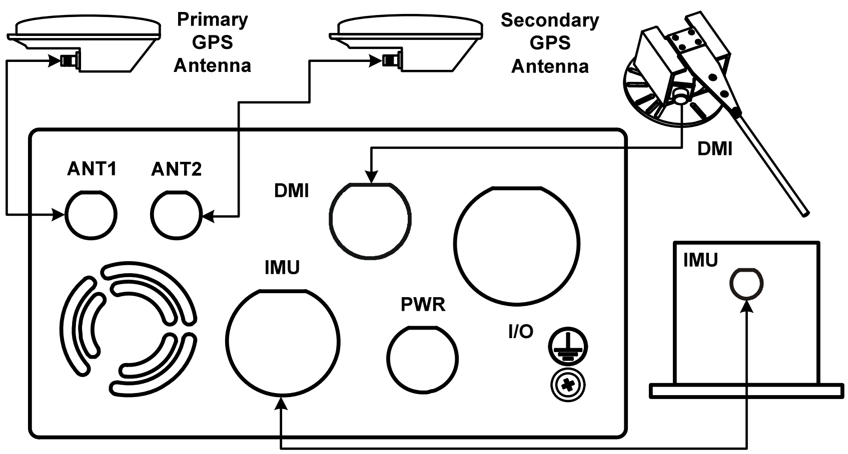


Figure 18: PCS Rear Panel Configuration

Table 1: Connector and Port Summary

Connector	Port	Description
PWR		12 Vdc at 6.0 A configuration: connects to a 10 to 20 Vdc customer source
		24 Vdc at 2.5A configuration: connects to a 20 to 34 Vdc customer source
IMU		• RS-422 serial I/O port • Supplies dc power and data to/from IMU
I/O	COM (1)	RS-232 Serial I/O port (digital)
	COM (2)	RS-232 Serial I/O port (digital)
	COM (3)	RS-232 Serial I/O port (digital)
	COM (4)	RS-232 Serial I/O port (digital)
	COM (5)	RS-232 Serial I/O port (digital)
	GPS 1 (primary)	• RS-232 Serial I/O port (digital) • Primary GPS receiver software upgrade - contact Applanix Customer Support for details • O/P GPS time (synchronization) message
	GPS 2 (secondary)	• RS-232 Serial I/P port (digital) • Secondary GPS receiver software upgrade - contact Applanix Customer Support for details
	DIO - Event 1	• Optically isolated digital input • Event 1 tagging
	DIO - Event 2	• Optically isolated digital input • Event 2 tagging
	DIO - Event 3 (not supported)	• Optically isolated digital input • Event 3 tagging
	DIO - Event 4 (not supported)	• Optically isolated digital input • Event 4 tagging
	Ethernet	Ethernet port - communication between POS LV and LV-POSView, 10/100 Base-T

Table 1: Connector and Port Summary

Connector	Port	Description
	PPS Out	O/P BNC connector - one pulse per second for synchronization with GPS time, TTL signal level
	PPS In	• I/P BNC connector - one pulse per second for synchronization with GPS time, TTL signal level • Optically isolated digital input • Only effective if external GPS option is enabled through POSConfig
DMI		• Digital I/O port • I/P TTL data from DMI • O/P 5 Vdc to DMI
ANT1		I/O TNC connector - supplies dc power and receives signal from primary GPS antenna
ANT2		I/O TNC connector - supplies dc power and receives signal from secondary GPS antenna

Power Connector

Two configurations are available: 12 and 24 Vdc power. The PCS is configured at Applanix prior to delivery. Table 2 and Figure 19 identify the pin assignments for the two configurations.

Table 2: PWR Connector Pin Assignment

PIN	Pin Description 12 Vdc Configuration	Pin Description 24 Vdc Configuration
A	10 to 20 Vdc	20 to 34 Vdc
B	Return	Return
C	N/C	N/C

12 Vdc Configuration	24 Vdc Configuration
POS LV Receptacle: JD38999/24FA98PB	POS LV Receptacle: JD38999/24FA98PN
Cable Plug: JD38999/26FA98SB	Cable Plug: JD38999/26FA98SN

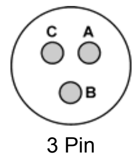


Figure 19: PWR Connector Pin Arrangement

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.

Physical Interface

A double-shielded cable connects the IMU to the PCS. Ensure the cable is secure by locking the connector shell to the base. Table 3 and Figure 20 provide the connector pin assignment.

Table 3: IMU Connector Pin Assignment

PIN	Pin Description	Signal Type	Signal Direction
1	Serial Data +	RS422	Input
2	Serial Data -	RS422	Input
3	Serial Data Clock Receive +	RS422	Input
4	Serial Data Clock Receive -	RS422	Input
5	TOV +	RS422	Input
6	TOV -	RS422	Input
7	Serial Data Transmit +	RS422	Output
8	Serial Data Transmit -	RS422	Output

Table 3: IMU Connector Pin Assignment

PIN	Pin Description	Signal Type	Signal Direction
9	Serial Data Clock Transmit +	RS422	Output
10	Serial Data Clock Transmit -	RS422	Output
11, 12	Chassis GND	N/A	N/A
17 to 19	5 Vdc Return 1	N/A	N/A
20	5 Vdc Return 1 Sense	N/A	N/A
21	+5 Vdc 1 Sense	N/A	N/A
22 to 24	+5 Vdc 1	N/A	N/A
25	5 Vdc Return 2	N/A	N/A
26	+5 Vdc 2	N/A	N/A
27, 28	15 Vdc Return 1	N/A	N/A
29, 30	+15 Vdc 1	N/A	N/A
31, 31	15 Vdc Return 2	N/A	N/A
33, 34	+15 Vdc 2	N/A	N/A
13 to 16; 35 to 37	N/C	N/A	N/A

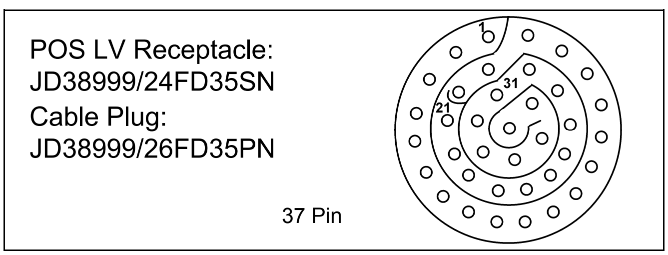


Figure 20: IMU Connector Pin Arrangement

I/O Connector

The I/O connector supports a multi-connector breakout cable (I/O cable) that permits access to the following signals:

- Two ports (one input and one output) for the One Pulse Per Second (PPS) signal
- Five multi-function COM ports
- Two (primary and secondary) GPS receiver ports for software updates
- One Ethernet port
- Two Event input ports

Table 4 and Figure 21 provide the pin assignment for the I/O connector and pin mapping of the I/O cable.

Table 4: I/O Connector Pin Assignment

I/O Pin	Pin Description	I/O Cable Mapping		Signal Type	Signal Direction
		PIN	Connector		
1	PPS Out	Ctr	BNC (female) PPS Out	5 V TTL	Output
5	GND	Shell		N/A	N/A
6	External PPS In	Ctr	BNC (female) PPS In	**see notes	**see notes
7	External PPS In Return	Shell		**see notes	**see notes
8	Event 1 In	2	DB-9S (female) DIO	**see notes	**see notes
9	Event 1 In Return	7		**see notes	**see notes
10	Event 2 In	3		**see notes	**see notes
11	Event 2 In Return	8		**see notes	**see notes
12	Reserved	1		N/A	Input

Table 4: I/O Connector Pin Assignment

I/O Pin	Pin Description	I/O Cable Mapping PIN	I/O Cable Mapping Connector	Signal Type	Signal Direction
13	Reserved	6		N/A	N/A
14	Reserved	4		N/A	Input
15	Reserved	9		N/A	N/A
18	COM 5 TX	3	DB-9P (male) COM 5 Pin 5 = GND	RS-232	Output
19	COM 5 RX	2		RS-232	Input
20	COM 5 RTS *	7		RS-232	Output
21	COM 5 CTS	8		RS-232	Input
22	COM 1 TX	3	DB-9P (male) COM 1 Pin 5 = GND	RS-232	Output
23	COM 1 RX	2		RS-232	Input
24	COM 1 RTS *	7		RS-232	Output
25	COM 1 CTS	8		RS-232	Input
26	GND	N/A		N/A	N/A
27	COM 2 TX	3	DB-9P (male) COM 2 Pin 5 = GND	RS-232	Output
28	COM 2 RX	2		RS-232	Input
29	COM 2 RTS *	7		RS-232	Output
30	COM 2 CTS	8		RS-232	Input
31	GND	N/A		N/A	N/A
32	COM 3 TX	3	DB-9P (male) COM 3 Pin 5 = GND	RS-232	Output
33	COM 3 RX	2		RS-232	Input
34	COM 3 RTS *	7		RS-232	Output
35	COM 3 CTS	8		RS-232	Input
36	GND	N/A		N/A	N/A
37	COM 4 TX	3	DB-9P	RS-232	Output

Table 4: I/O Connector Pin Assignment

I/O Pin	Pin Description	I/O Cable Mapping		Signal Type	Signal Direction
		PIN	Connector		
38	COM 4 RX	2	(male) COM 4 Pin 5 = GND	RS-232	Input
39	COM 4 RTS *	7		RS-232	Output
40	COM 4 CTS	8		RS-232	Input
41	GND	N/A		N/A	N/A
42	GPS 1 TX	2	DB-9P (male) Pin 5 = GND	RS-232	Output
43	GPS 1 RX	3		RS-232	Input
44	GPS 2 TX	8		RS-232	Output
45	GPS 2 RX	9		RS-232	Input
46	Ethernet TX+	1	RJ-45 (Socket) Ethernet	N/A	Output
47	Ethernet TX-	2		N/A	Output
48	Ethernet RX+	3		N/A	Input
49	Ethernet RX-	6		N/A	Input
2 to 4; 16, 17; 50 to 55	Reserved	N/A		N/A	N/A

* May be used for the TOV pulse output depending on the function assigned to the port.
** Event 1 In and Event 2 In are optically isolated digital inputs.
** Inputs (and their return lines) are not referenced and are independent of internal mPOS power supplies and GND.
** Inputs can be controlled from an external 5V TTL-level source capable of supplying a minimum of 7 mA of sourcing or sinking current.
** Examples of possible configurations of Event 1 and Event 2 inputs are shown below.

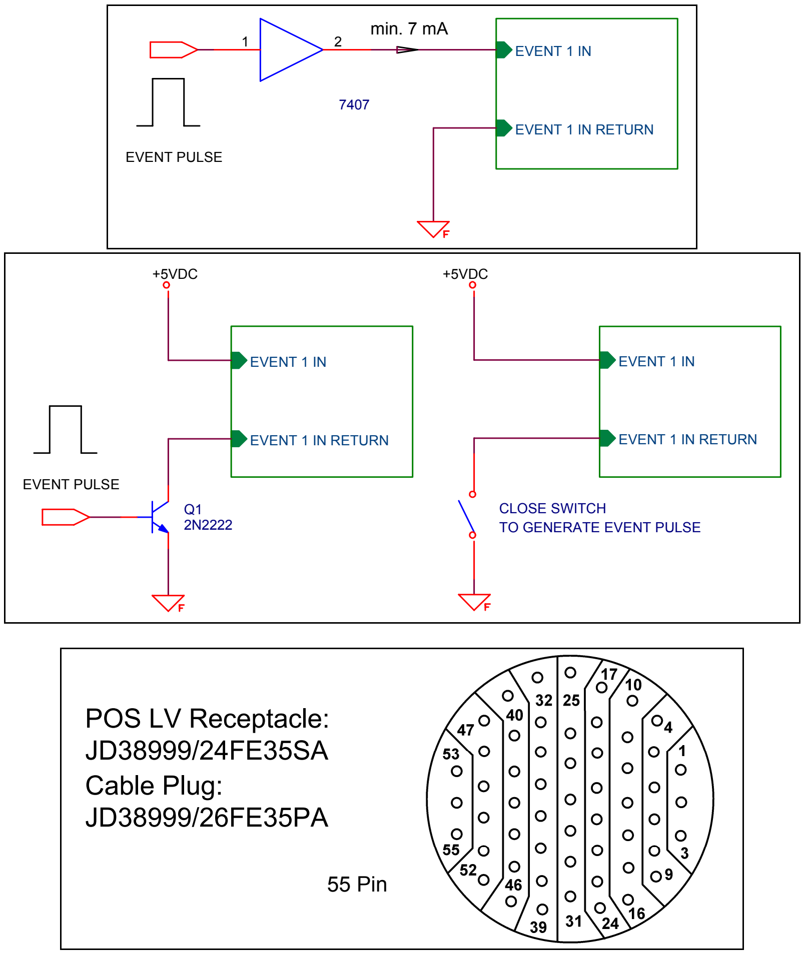


Figure 21: I/O Connector Pin Arrangement

COM (1) through COM (5) Connectors

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. Table 4 provides connector pin assignments and mapping.

Interface Configuration

Table 5 identifies the configuration for the COM ports.

Table 5: COM Port Configuration

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

GPS 1 and GPS 2 Connectors

The serial digital port for each GPS receiver provides access for receiver upgrading of its software. The GPS ports also serve as an output for the GPS time message that can be used for time synchronization.

Physical Interface

Table 4 provides connector pin assignments and mapping.

Output Data Format

The GPS time message output provides the time (Universal Time Coordinate [UTC]) corresponding to the next 1PPS signal available on the PPS port; refer to the PPS Connectors description on page 5-15 and the POS-GPS Timing description on page K-1 for more information. The RS-232 GPS port message format is described in detail on page H-1, GNSS Time Message Output.

To synchronize external equipment time (User Time) with GPS time, the external equipment must read and record the 1PPS signal in User Time and the GPS time message from the GPS port. With the time differential known, the external device can calculate the correct GPS time tag for the external data.

Interface Configuration

Table 6 identifies the port configuration for the GPS ports. These settings may be changed using the LV-POSView software; refer to the GPS Receiver Set-up description on page 8-17.

Table 6: GPS Port Configuration

Setting	Value
Baud Rate	2400 to 115200
Parity	None, Even, Odd
Data Bits	7, 8
Stop Bits	1, 2

Events Connector

The DIO Events digital port provides access to the POS LV event timing facility for events one and two.

Physical Interface

A cable that supports the two events is supplied with the system. Table 4 provides connector pin assignments and mapping.

Input Data Format

Refer to the Event Tagging description on page 1-14 for a detailed description.

Ethernet Connector

A 10/100Base-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

Two Ethernet cables are supplied with the POS LV system: a shielded straight through cable and a shielded crossover cable. Both cables are terminated with shielded RJ-45 connectors. Ensure that replacement cables meet the RJ-45 Cat5 standard 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 4 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 12-7 for information on selecting data groups for output. Please refer to Applanix document *PUBS-ICD-000036* 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-000036* if control commands will be generated by software other than LV-POSView.

PPS Connectors

The PCS requires the one Pulse Per Second (PPS) signal for internal timing requirements. This signal can be obtained from the primary GPS receiver or from an external GPS receiver. In addition, the PPS Out port will duplicate the 1PPS signal from the selected source. The input signal is only effective if the external GPS 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.

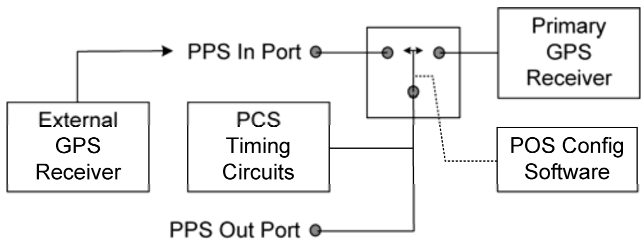


Figure 22: PPS Port Signal Sources - Functional Diagram

Physical Interface

A cable must be constructed and installed to couple the 1PPS signals; Table 4 provides connector pin assignments and mapping.

⚠ **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.**

Output Data Format

The 1PPS signal (input or output) is an active 'LOW' 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 GPS time message that specifies the UTC time of the 1PPS is output on the GPS 1 port; refer to the GPS 1 and

GPS 2 Connectors description on page 5-11 and to the GPS Timing Basics description starting on page K-3.

DMI Connector

Presently, a single DMI digital port is provided as an interface for a DMI sensor. DMI encoder information is used by the POS LV to: provide distance-travelled information; provide navigation by dead reckoning in the absence of GPS signals; and to determine when the vehicle has stopped so that a zero velocity update can be performed.

Physical Interface

Ensure that the connectors at the cable ends are grounded through the respective connector housings. Table 7 and Figure 23 provide a connector pin assignment.

Table 7: DMI Connector Pin Assignment

PIN	Pin Description	Signal Type	Signal Direction
1	Input 1	TTL	Input
2	Input 2	TTL	Input
3	Not supported	N/A	N/A
4	Common Return	N/A	N/A
5	+5 Vdc	N/A	N/A
6	5 Vdc Return	N/A	N/A
13	N/C	N/A	N/A
7 to 12	Reserved	N/A	N/A

POS LV Receptacle:
JD38999/24FB35SN
Cable Plug:
JD38999/26FB35PN

13 Pin

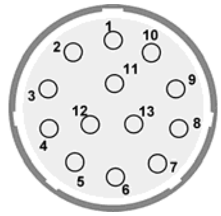


Figure 23: DMI Connector Pin Arrangement

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. Both discretes are Transistor-Transistor Logic (TTL) level signals; refer to Table 8.

Table 8: DMI Input Data Format

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

The TTL signal asserts a logical LOW when the signal is less than + 0.8 volts and a logical HIGH when the signal is greater than +3.3 volts. Signals are ambiguous in the range 0.8 to 3.3 volts. A pulse is sampled by the POS LV when the signal transitions from LOW to HIGH, or vice versa.

The distance pulse signal is a sequence of pulses with a pulse width >1 μs. Pulses are generated in both the forward and reverse directions of travel and each pulse represents an incremental rotation of the DMI Instrumented Wheel. The PCS can handle up to 100,000 pulses per second.

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 4-11, the Scale Factor Correction Pane on page 8-14 and the POS LV V4 DMI Sensor Interface Requirements on page J-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 4-11 for the DMI scale factor calculation and page 8-14 for the scale factor correction input screen. Refer to page J-1 for the POS LV V4 DMI Sensor Interface Requirements.

ANT1 and ANT2 Connectors

Signals from the GPS antennas are coupled to the GPS receivers using the ANT1 (primary GPS) and ANT2 (secondary GPS) 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; GPS signals are routed through the same conductor to the respective 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 GPS antennas and the PCS ANT1 and ANT2 ports are female TNC connectors.

Refer to the Hardware Installation description on page 3-1 for the GPS 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 9.

Table 9: 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	Microsoft Screens® 2000, NT 4 or XP	Microsoft Screens® 2000, NT 4 or XP
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 green Power switch on the PCS front panel, refer Figure 24. The light, located above the Power switch, illuminates when the PCS is operating.

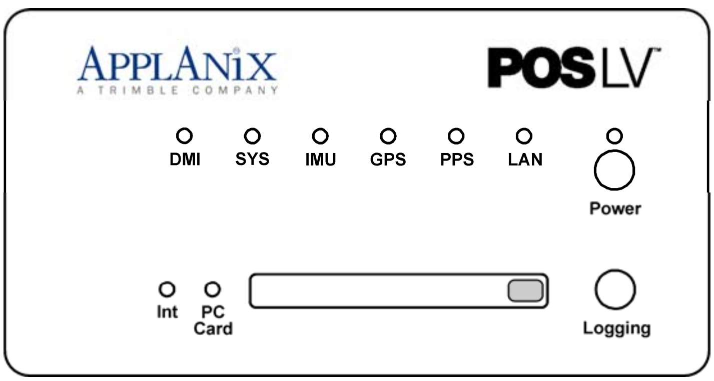


Figure 24: PCS Front Panel

Table 10 identifies the functions and status of the various PCS front panel lights.

Table 10: PCS Front Panel Lights

DMI light - indicates status of DMI:	
Steady green:	Navigate mode - DMI is ok.
Steady amber:	Navigate mode - DMI wheel slipping; once slipping stops light returns to green.
Steady red:	Navigate mode - DMI is defective.
Flashing green:	Navigate mode - DMI is ok; vehicle is starting (Zero Velocity Update [ZUPT]).
Steady *colour*:	Standby mode - assumes colour of last navigate mode (observe in conjunction with SYS light).
SYS 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. A solid red indication while all the other lights behave normally indicates 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. If light frequently shows red during operation, PCS may be receiving poor quality electrical power. Applanix recommends a UPS to power POS LV installation.
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.
IMU light - indicates status of IMU:	
Steady green:	Receiving IMU data and TOV.
Steady red:	IMU down, disconnected or an internal hardware failure.
GPS light - indicates GPS reception in loosely coupled mode or navigation status in tightly coupled mode:	
Steady red:	No GPS solution is available.
Steady amber:	GPS receiver is delivering a C/A or P-Code GPS solution.
Steady green:	GPS receiver is delivering a DGPS or RTK solution.
PPS light - flashes green once per second to indicate reception of GPS 1PPS signal.	
LAN light - indicates transmit and receive local area network activity:	
Flashing green:	Activity on Ethernet LAN.
Steady red:	A LAN fault (e.g. a break in Ethernet line).
Int light - steady green indicates internal data logging (back-up) is functioning, see Table 14 on page 13-6 for details.	
PC Card light - steady green indicates PC Card (external) data logging mode is selected, see Table 14 on page 13-6 for details.	
Power light - illuminates green 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 **129.100.0.231** (with a subnet mask of 255.255.0.0). Initially, to communicate with the PCS, the controlling Personal Computer (PC) IP address is set to a unique address in the same subnet. Applanix recommends **129.100.0.1** as the unique address within the subnet. Any unique address (i.e. 129.100) may be used.

To change the PC's address perform the following:

1. On **Start** menu select **Settings, Control Panel, Network and Dial-up Connections**:
   - In Windows NT® - highlight installed **TCP/IP** component and select its **Properties** under **Protocols** tab
   - In Windows 2000/XP® - select **Local Area Connection, General, Properties, Internet Protocols (TCP/IP), Properties**
2. Specify an appropriate IP address (e.g. **129.100.0.1**) in IP address field.
3. Click **OK** button.
4. Reboot PC for IP address change to take effect.

To configure LV-POSView to operate with the network, refer to Figure 25 and Figure 26:

1. Double-click LV-POSView screen icon.
2. On LV-POSView tool bar, ensure that PCS IP address (**129.100.0.231**) 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 25.
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.
7. Exit LV-POSView.
8. Restore original PC's IP address.
9. Reboot PC.

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

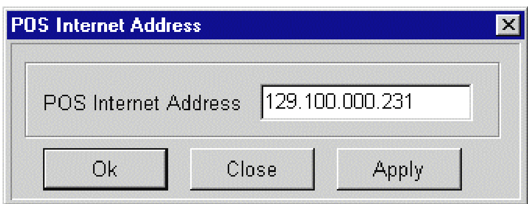


Figure 25: PCS IP Address Assignment Screen

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.

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[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 26.

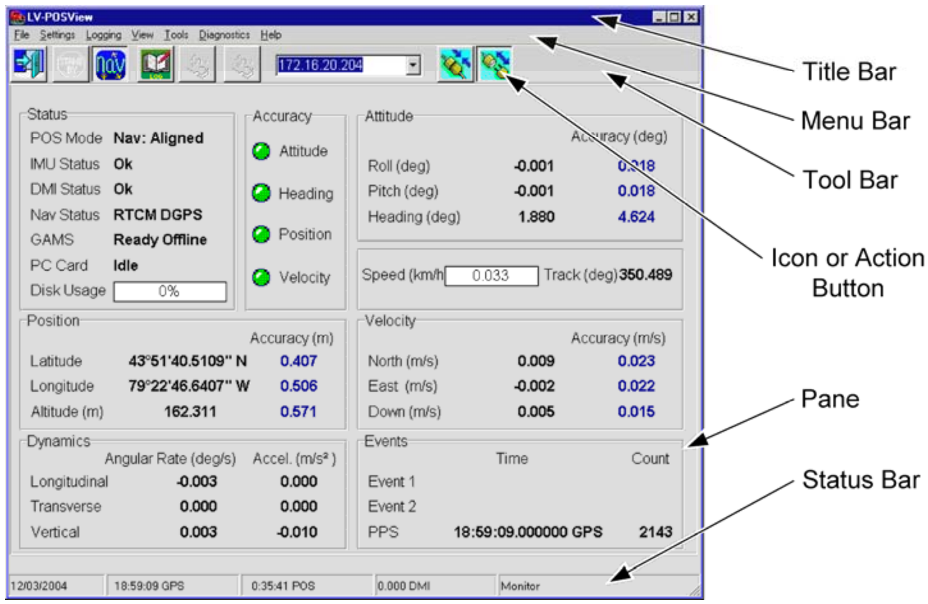


Figure 26: LV-POSView Main Screen

Tool Bar

The tool bar located near the top of the main screen, see Figure 27, permits quick access to commonly used features. From left to right:

- Exit button
- Standby button
- Navigate button

- Log button
- Base GPS 1 modem
- Base GPS 2 modem
- POS LV IP address field
- Connect button
- Monitor button

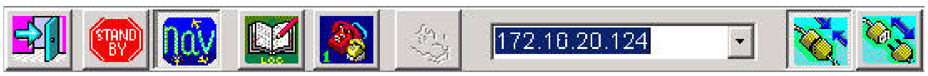


Figure 27: LV-POSView Tool Bar

Status Pane

The **Status** pane shown in Figure 28 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.

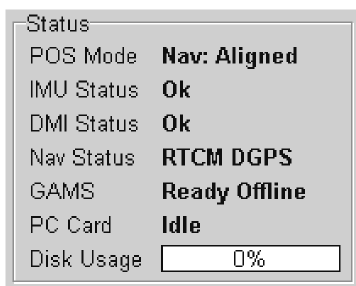


Figure 28: LV-POSView Status Pane

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* and *Offline*.
- **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 *GPS Nav*. Afterwards, the indicator displays *C/A, DGPS* or *RTK*, depending if differential corrections are used.
- **GAMS**: The GPS Azimuth Measurement Subsystem (GAMS) displays the status of the GAMS.
- **PC Card**: The PC Card displays the status of the data logging drive.
- **Disk Usage**: The bar indicates the percentage used (filled) of the PC Card 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 29 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 GPS satellites tracked and whether or not GPS differential corrections are received.

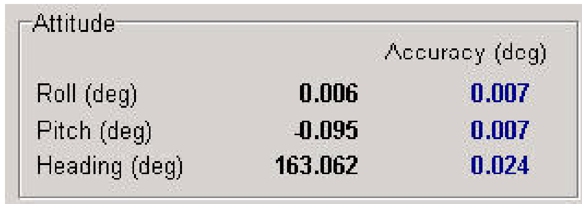


Figure 29: LV-POSView Attitude Pane

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 30.

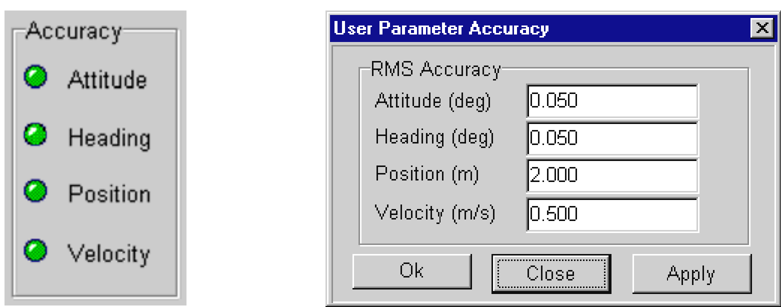


Figure 30: Accuracy Pane and User Parameter Accuracy Screen

Events Pane

The **Events** pane, see Figure 31, 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 GPS receiver. The **Count** field for PPS indicates the total number of signals recorded from the GPS 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.

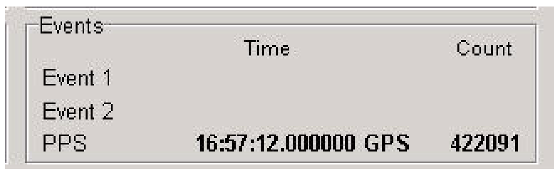


Figure 31: LV-POSView Events Pane

Speed Pane

Figure 32, **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.

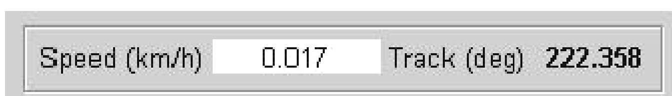


Figure 32: LV-POSView Speed Pane

Status Bar

The status bar is located at the bottom of the LV-POSView screen, see Figure 33. 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 33: 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 34. To view the **Command Reply** screen select **View, Command Reply** from the LV-POSView menu bar.

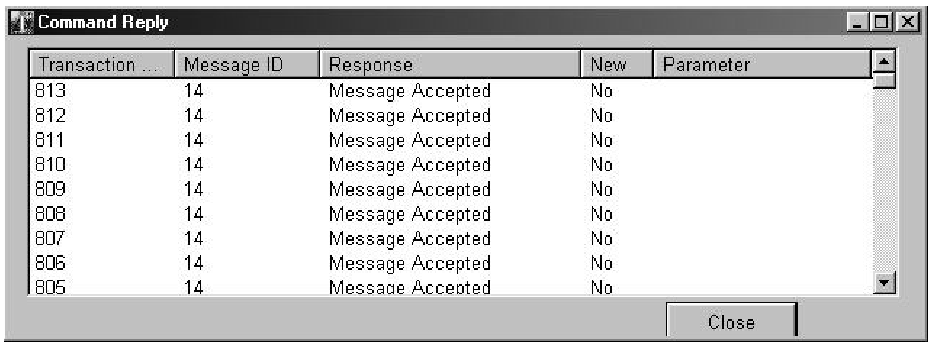


Figure 34: LV-POSView Command Reply Screen

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 35, is located in LV-POSView Main Screen Functions on page 7-7.

Figure 35: LV-POSView Title, Menu and Tool Bars

Input/Output Ports Set-up

The **Input/Output Ports Set-up** screen shown in Figure 36 is accessed from the LV-POSView menu bar by selecting **Settings, Input/Output Ports**. Configuration of each of the five serial COM ports is performed on the screen tabs. The following lists the configuration choices:

- Enabling/disabling the input and output ports
- Selecting the message formats for the input and output that may be assigned to a particular port
- National Marine Electronics Association (NMEA) and Binary Outputs can be assigned in multiples
- Setting the baud and update rates for the ports

NMEA Output Port Set-up

Select a tab to display the parameters screen (Figure 36). In the **Output Select** field, choose **NMEA**. Select the desired **Baud Rate**, **Parity**, **Data Bits**, **Stop Bits** and **Flow Control**.

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

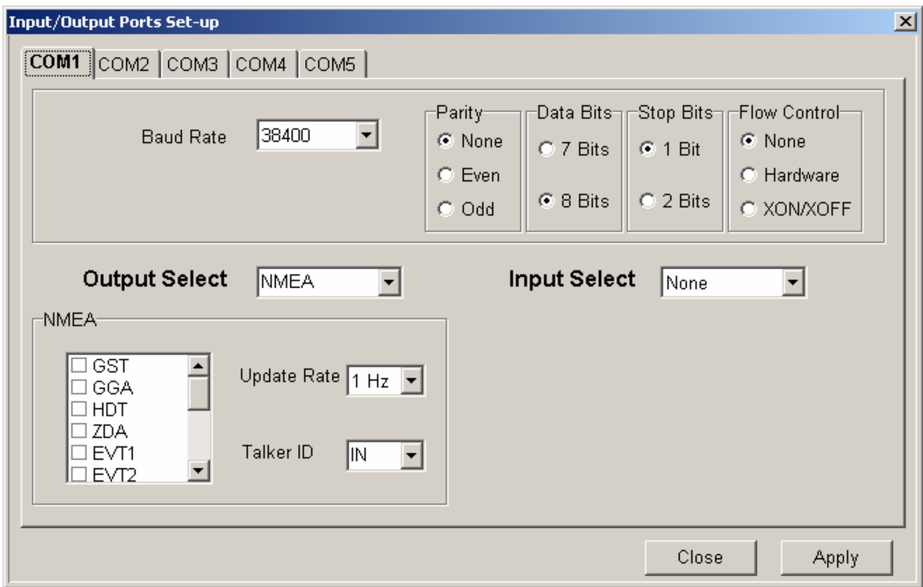


Figure 36: Input/Output Ports Set-up - NMEA Output

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 11. 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** or the NMEA output message.

Table 11: 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 GPS fix, geoidal separation
PPS	PPS, UTC time, PPS time recovery
GGK	GPS 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.

Binary Output Port Set-up

Select a tab to display the parameters screen (Figure 37). In the **Output Select** field, choose **Binary**. Select the desired **Baud Rate**, **Parity**, **Data Bits**, **Stop Bits** and **Flow Control**.

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

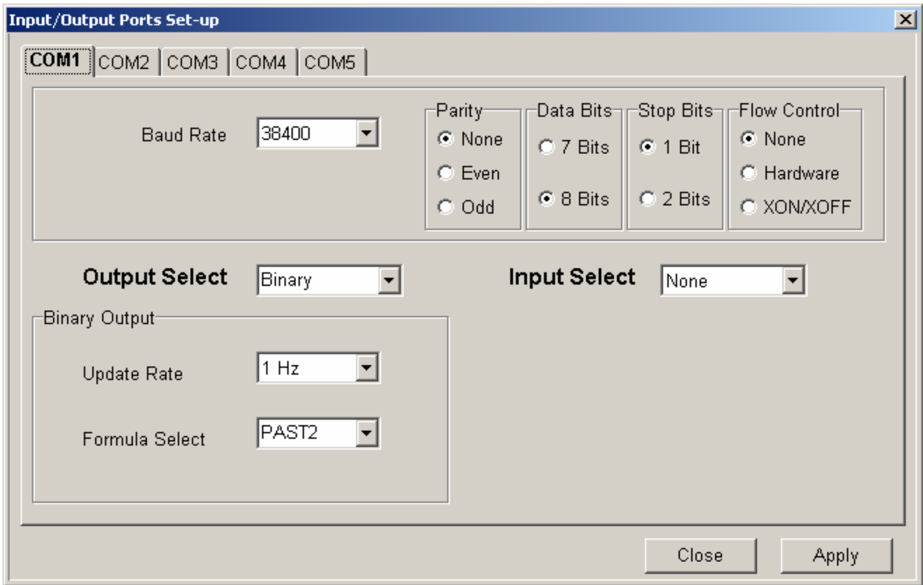


Figure 37: Input/Output Ports Set-up - Binary Output

Binary Output Data Format

The PCS outputs real-time binary data on the selected COM port in any of several predefined formats. The output frequency of the sentences is set by selecting a value for the **Update Rate** field (use the drop-down arrow). The available message strings are listed in Table 12, and their formats are described in NMEA and Binary Message Formats starting on page F-1.

Table 12: 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

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 GPS Output Port Set-up

Select a tab to display the parameters screen (Figures 38 and 39). In the **Output Select** field, choose **Base 1 GPS** or **Base 2 GPS**. Select the desired **Baud Rate**, **Parity**, **Data Bits**, **Stop Bits** and **Flow Control**.

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

Base 1/2 GPS Output Data Format

The PCS outputs data on the selected COM port according to the settings on the **Base 1/2 GPS Output Select** screens. The output feature is used to output a copy of all the data that appears on the applicable Base 1/2 GPS Input Port (described in the following text). This feature is useful where the real-time GPS correction data are required by another external device.

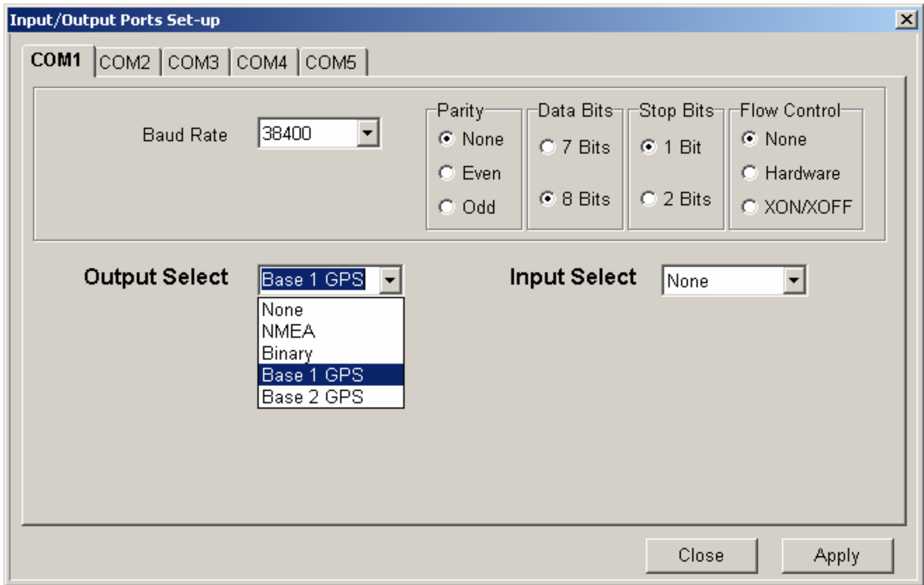


Figure 38: Input/Output Ports Set-up - Base 1 GPS Output

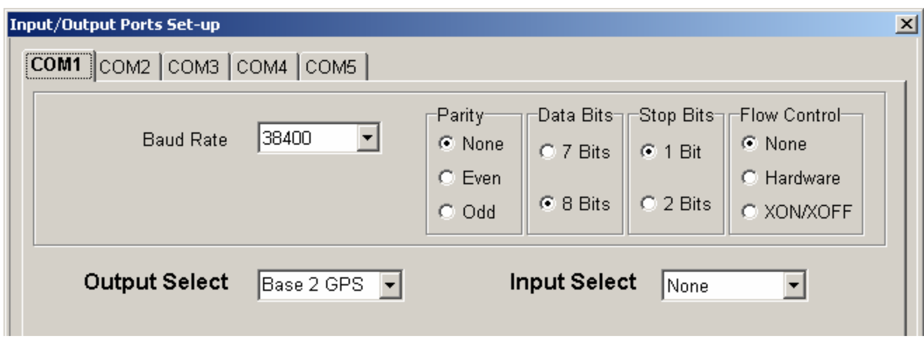


Figure 39: Input/Output Ports Set-up - Base 2 GPS Output

Base 1/2 GPS Input Port Set-up

Select a tab to display the parameters screen (Figures 40 and 41). In the **Input Select** field, choose **Base 1 GPS** or **Base 2 GPS**. Select the desired **Baud Rate**, **Parity**, **Data Bits**, **Stop Bits** and **Flow Control**.

In the **Base GPS Input** pane select the appropriate settings for the **Input Type** and **Line**. The **Line** pane is used to select the transmission medium of the input.

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

Base 1/2 GPS Input Data Format

The PCS accepts DGPS and RTK type differential correction inputs from up to two different GPS Base Stations. Thus, a redundant link is provided and in the event that one of the communication links should break down, the other is still available. The PCS accepts the following messages:

- RCTM messages 1 and 9 to support DGPS operation*****
- RTCM messages 18 and 19
- CMR and CMR+ messages to support RTK operation*****

Note: ***** Both Base 1/2 cannot select the same message.

Serial Line Input versus Modem Line Input

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.

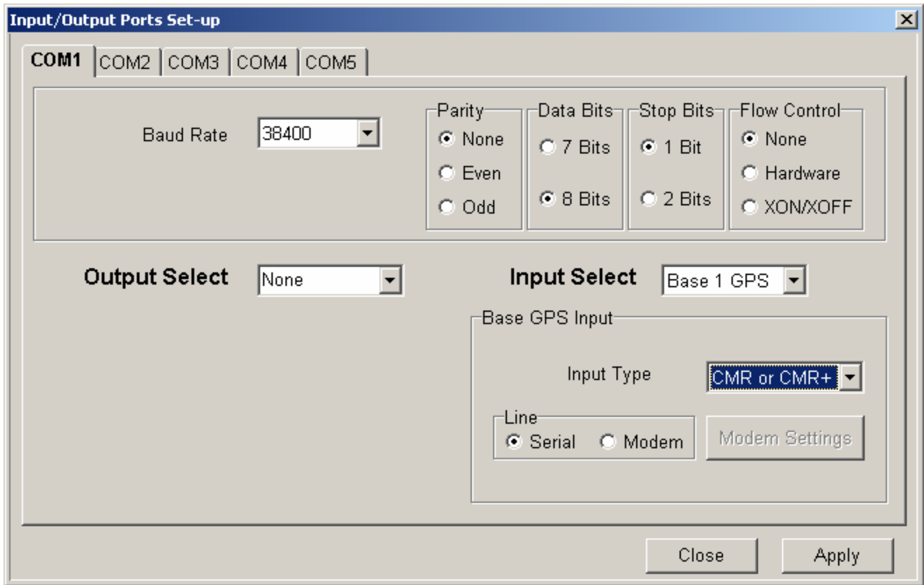


Figure 40: Input/Output Ports Set-up - Base 1 GPS Input (Serial)

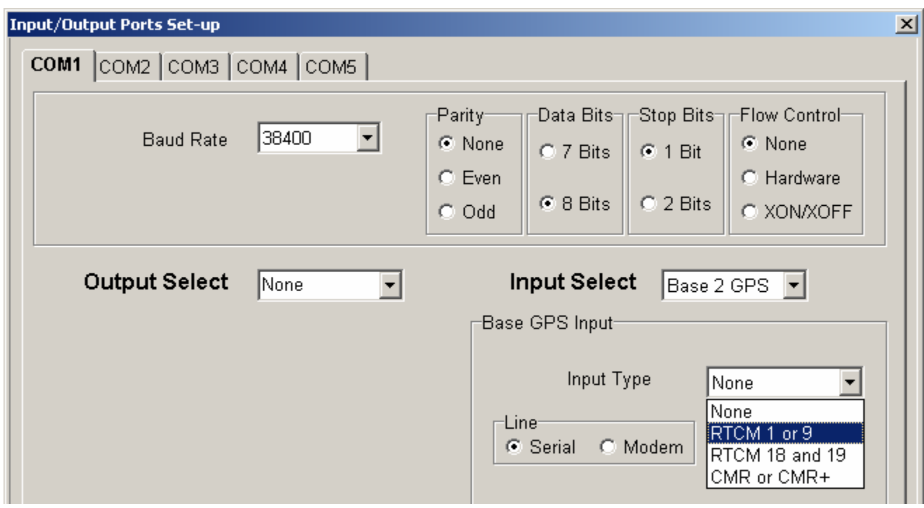


Figure 41: Input/Output Ports Set-up - Base 2 GPS Input (Serial)

SERIAL INPUT SET-UP

Select the **Serial** option button located in the **Line** pane; see Figure 40 or 41. 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. Click the **OK** command button to update the parameters.

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 42. 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.

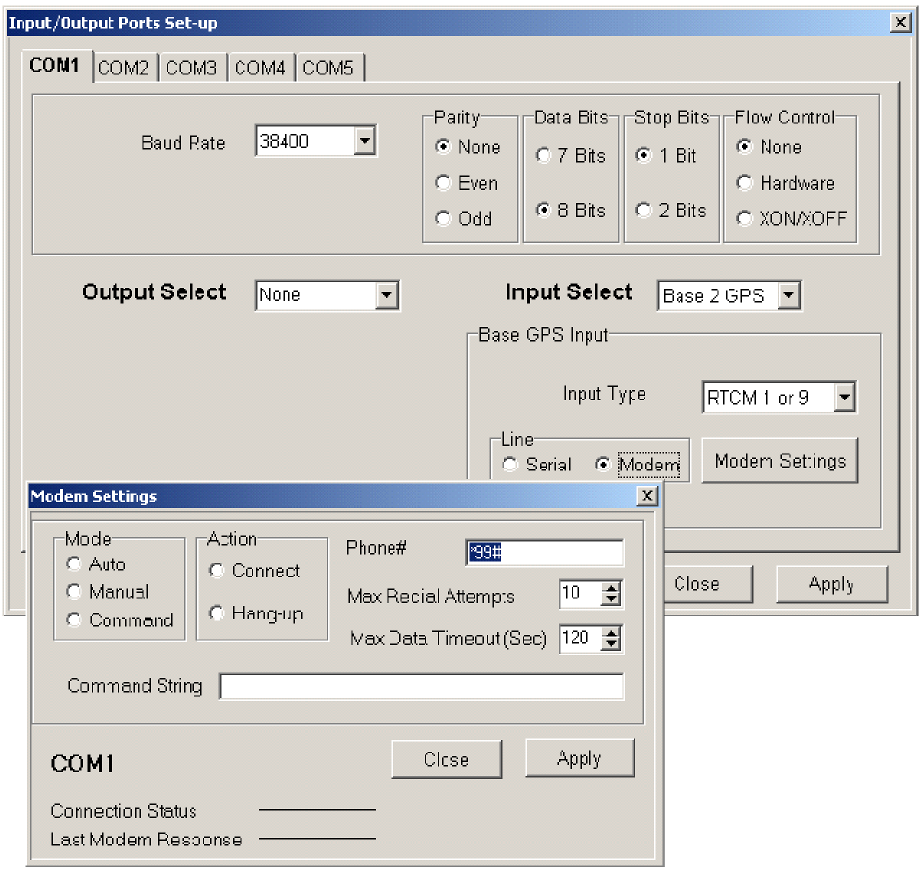


Figure 42: POS Port Configuration - Modem Settings

- **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.

Aux 1/2 GPS Input Port Set-up

Select a tab to display the parameters screen (Figures 43 and 44). In the **Input Select** field, choose **Aux 1 GPS** or **Aux 2 GPS**. Select the desired **Baud Rate**, **Parity**, **Data Bits**, **Stop Bits** and **Flow Control**.

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

Note: If the auxiliary 1 or 2 GPS inputs provide more accurate position information than the primary GPS receiver, then the PCS will use the auxiliary GPS information.

Aux 1/2 GPS Input Data Format

The PCS inputs data on the selected COM port according to the settings on the **Aux 1/2 GPS Input** tab. The input feature is used to input a copy of all the data that appears on the applicable Aux 1/2 GPS Input Port.

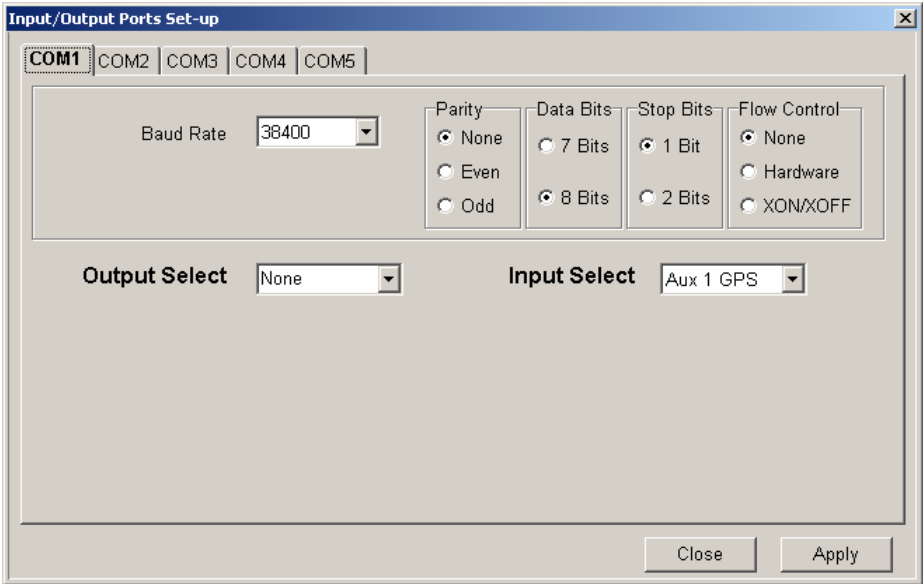


Figure 43: Input/Output Ports Set-up - Aux 1 GPS Input

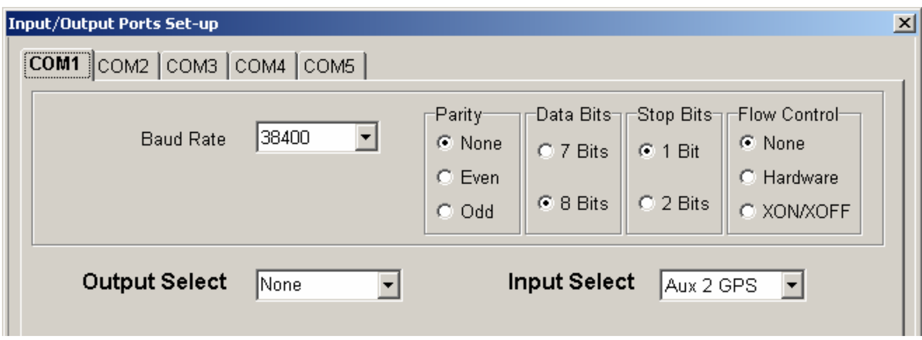


Figure 44: Input/Output Ports Set-up - Aux 2 GPS Input

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 45.

As a minimum, accurate Lever Arm measurement between the Inertial Measurement Unit (IMU) and the Primary GPS 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.

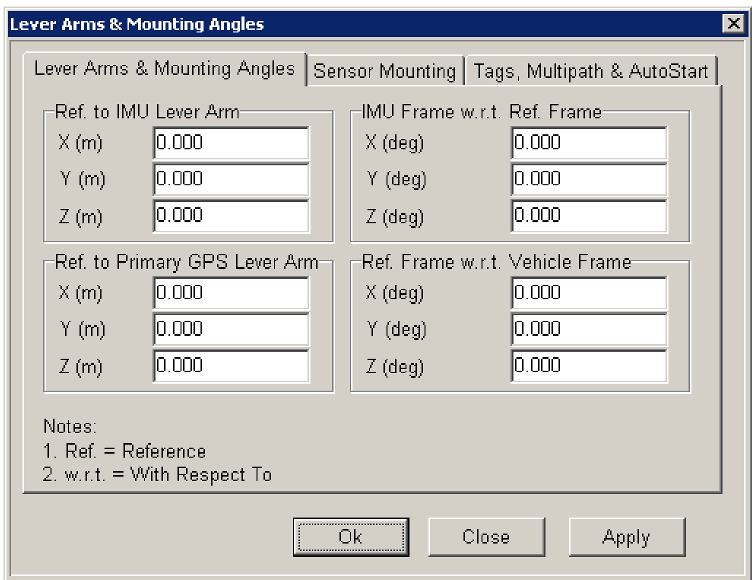


Figure 45: Lever Arm and Mounting Angles

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 4-11 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 46. 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.

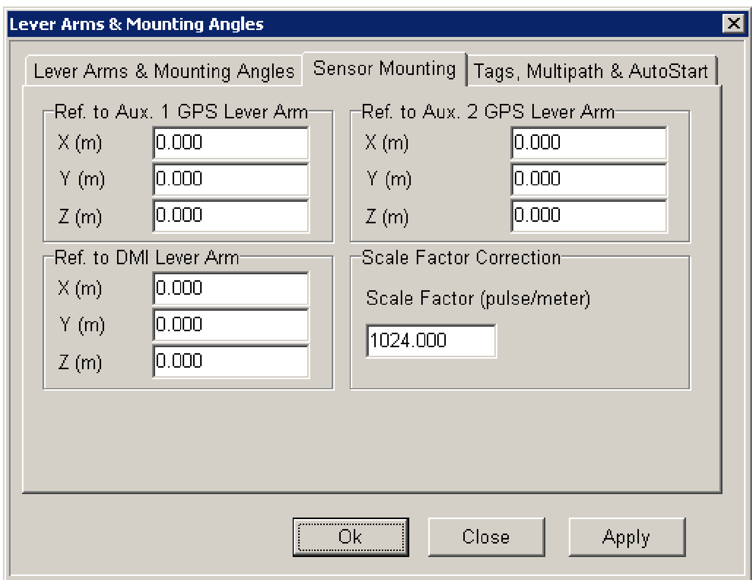


Figure 46: Lever Arms & Mounting Angles - Sensor Mounting

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 46. 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 47. 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 K-1 for further information.

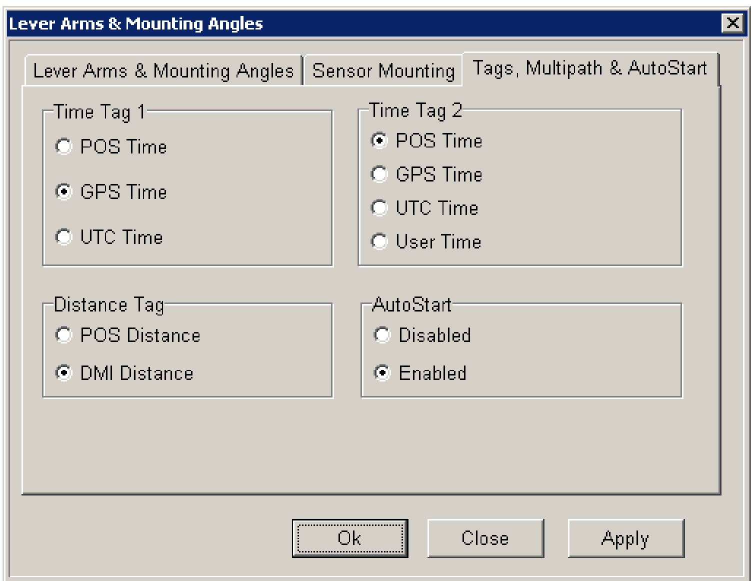


Figure 47: Tags, Multipath & AutoStart

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-000031*.

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.

GPS Receiver Set-up

The **GPS Receiver Configuration** screen, Figure 48, is accessed by selecting **Settings, Installation, GPS Receiver** on the LV-POSView menu bar. The tabs for the primary and secondary GPS receivers provide selection of the following parameters:

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

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.

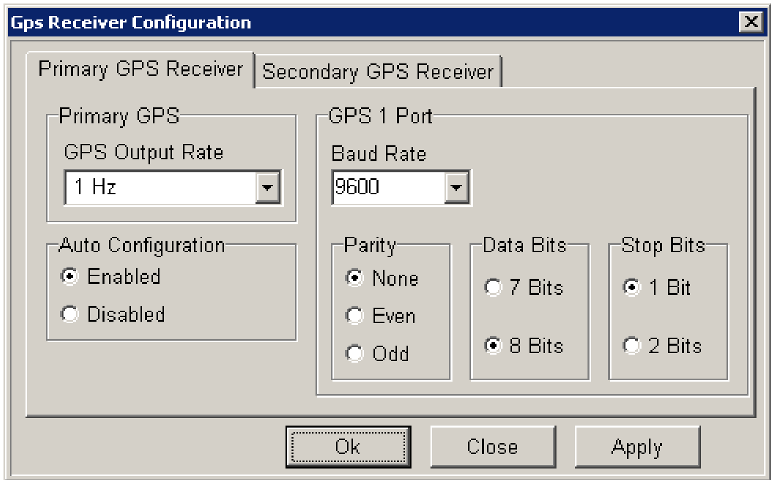


Figure 48: GPS Receiver Configuration - Primary

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 green power button on the PCS front panel to turn the system off. Wait 10 seconds and press the green button again to power-up the PCS. Finally, connect to the POS LV through LV-POSView and verify that all the parameters are correct.

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 the GPS Antenna Installation for GAMS

Note: The Global Positioning System (GPS) 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.

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

Note: 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 7-7.

Calibration Set-up

1. Select **Settings, Installation, GAMS Parameter Set-up** on menu bar to open **GAMS Parameter Set-up** screen, see Figure 49.
   - 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.
   - Click **Apply** button.

For POS LV to function acceptably during GPS 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 GPS antennas or Inertial Measurement Unit (IMU) are moved.

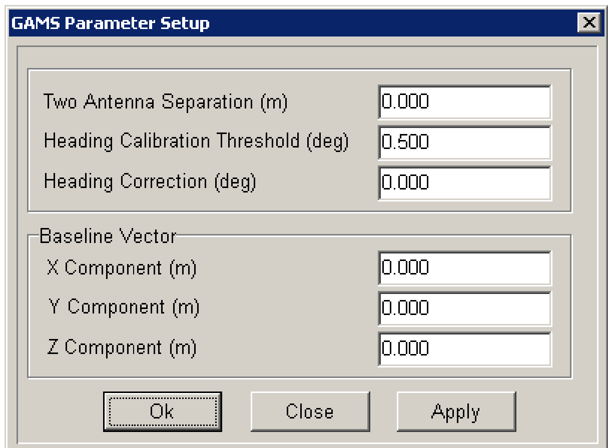


Figure 49: GAMS Parameter Set-up Screen

2. Next:
    - Enter GPS antenna separation (described in GPS Antenna Separation on page 4-12) in **Two Antenna Separation** field.
    - Click **Apply** button.
    - Value must be accurate to within ±5 mm.
    - If value is unknown or cannot be reliably measured, enter zero and click **Apply** button.

Note: Before Proceeding, ensure that the **GAMS Parameter Set-up** screen displays the values entered in steps 1 and 2.

3. 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**. Resolution may take several minutes and will take longer if a **Two Antenna Separation** of zero was entered. During this calibration set-up phase (GAMS is fixing its ambiguities) it is extremely important that there is no GPS 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 51 on page 10-2.

Calibration

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

1. 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 29, page 7-10) drop significantly below selected GAMS **Heading Calibration Threshold** (Figure 49, page 9-2).

     Note: Ensure there is no GPS 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.

2. Stop vehicle and remain stationary in an area where there is no GPS multipath.
   - Before proceeding with calibration procedure, ensure that GAMS status (Figure 28, page 7-8) 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 28, page 7-8) transitions to **Cal In Progress** for approximately one minute. When POS LV completes the calibration procedure, the GAMS status bar displays **Cal Completed** for five seconds and then transitions to **Online**.

Stop Calibration

Select **Settings, GAMS Calibration Control, Stop** on the LV-POSView menu bar. **Ready Offline** is displayed on the GAMS status screen (Figure 28, page 7-8) and the POS LV system aborts the partially completed calibration.

Save Calibration

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

1. Selecting **Settings, Save Settings** on the menu bar.

2. Click the **OK** button in response to the **Settings Saved** message.
3. 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 26 on page 7-7.
- **Heading Accuracy** values in the **Attitude** pane (see Figure 26 on page 7-7) 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 GPS 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 26, page 7-7), 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 are corrections for surveyed antenna baseline vector errors:

- If the **Two Antenna Separation** value (Figure 49, page 9-2) differs by more than 5 mm ($^{3}/_{16}$ in) with the value that was measured after the antenna installation:
    - Clear (set to zero values) the installation parameters and re-enter the measured separation distance in the **GAMS Parameter Set-up** screen, then click the **Apply** button to install the new antenna separation distance.
    - Perform a new calibration procedure; see the Calibration Set-up procedure starting on page 9-1.
- 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 **Two Antenna Separation** and **Baseline Vector** values should not be altered (see Figure 49 on page 9-2).

10.0 Operation with GAMS

The GPS Azimuth Measurement Subsystem (GAMS) feature of POS LV increases and maintains heading accuracy using two Global Positioning System (GPS) antennas and receivers in heading determination. Once valid installation parameters for POS LV are inserted and saved (see the Calibrate the GPS 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 51 shows the **GAMS Solution** screen.

In conjunction with the **GAMS Solution** screen, observe the LV-POSView **Status** pane (Figure 50) to view the GAMS initialization sequence.

1. Once POS LV completes the leveling routine, GAMS will start-up. The following appears:
   - Figure 50 - **GAMS Not Ready** is displayed in the **Status** pane; this indicates that GAMS has not resolved the carrier phase ambiguities.
   - Figure 51 - **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. 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 GPS receivers. **GAMS Not Ready** (Figure 50) is displayed in the **Status** pane.

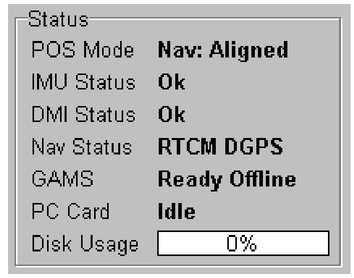


Figure 50: POSView Status Pane

3. After successful completion of coarse leveling, POS LV transitions to **Nav: Degraded** (Figure 50). 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 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 50), 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.

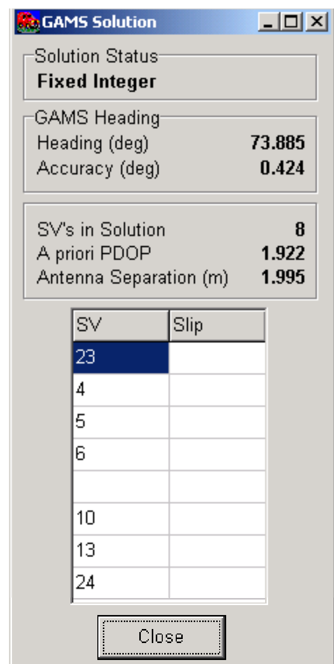


Figure 51: GAMS Solution Screen

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 51) indicates **Fixed Integer**. **GAMS Ready Online** (Figure 50) 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 50) 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.

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 GPS data dropout occurs in one or both GPS 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 GPS 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, GPS signal masking or unknown changes in the IMU or GPS 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 GPS antennas has moved with respect to the IMU by more than a few millimetres, or if the IMU has moved with respect to the GPS 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 GPS 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 GPS 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 GPS 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 GPS receivers. This can be caused by:

   - Partial masking of a GPS 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
   - GPS 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 GPS 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 52.

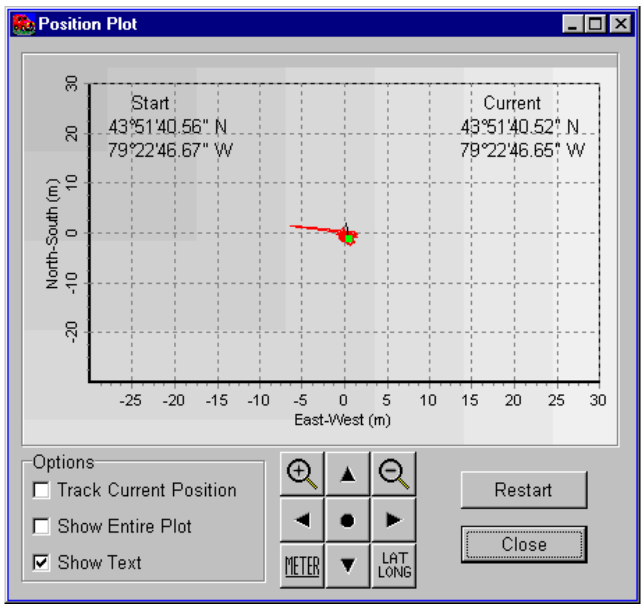


Figure 52: Position Plot

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.

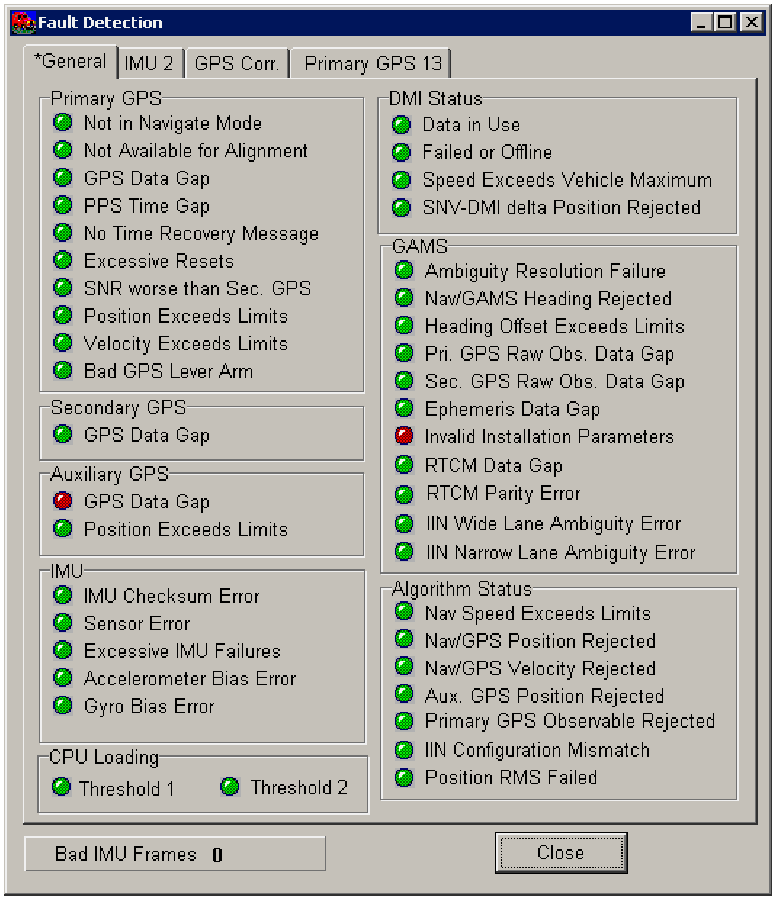


Figure 53: Fault Detection Screen

To display the **Fault Detection** screen (Figure 53), 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

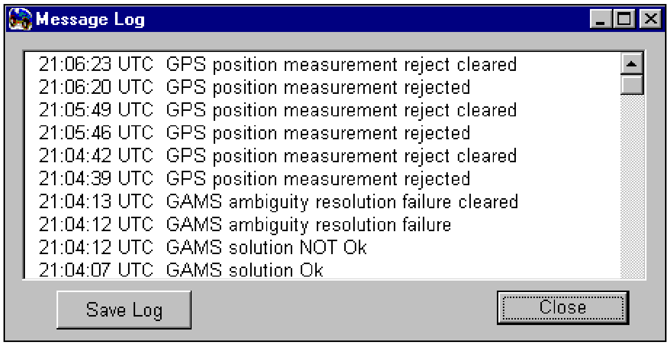


Figure 54: Message Log Screen

POS LV indicates the status and recent history of its sensor subsystems, see Figure 54. 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.

GPS Reset

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

The reset feature is a last resort measure used in the event that a GPS 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 and Port Status

The diagnostic screens when compared with the Port status screens may provide an invaluable source of trouble shooting information. Compare Figure 55 (Port status) with Figure 57-left (Diagnostics) or Figure 56 (Port status) with Figure 57-right (Diagnostics).

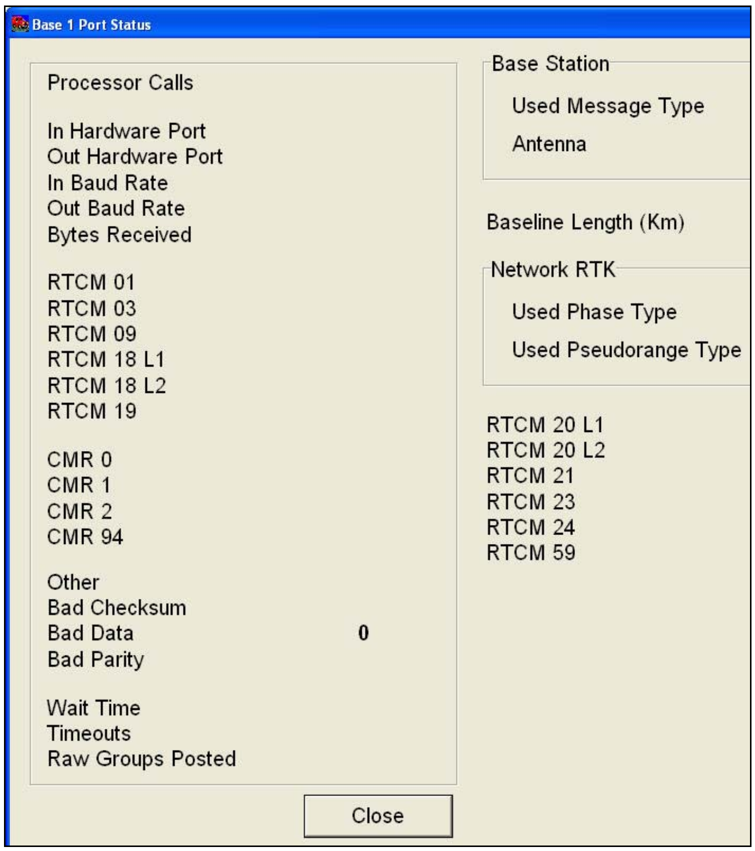


Figure 55: Base 1 Port Status

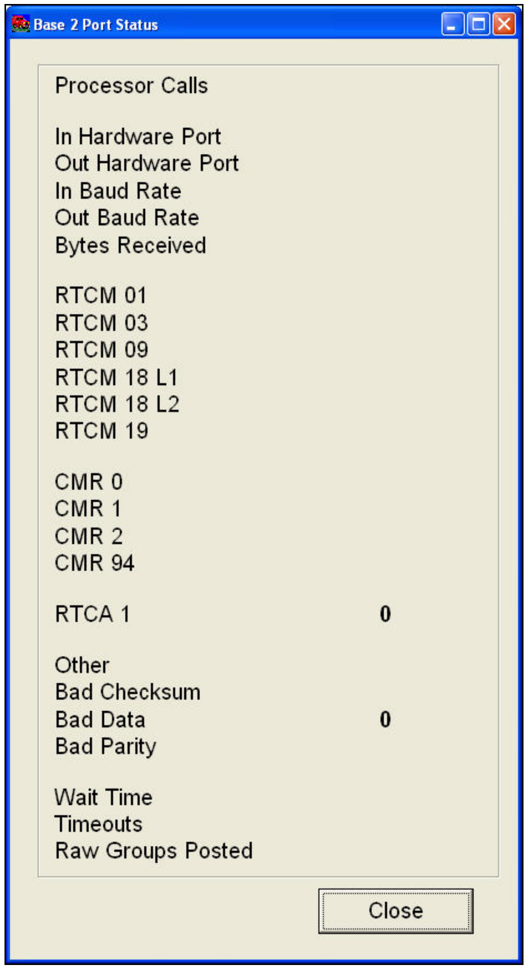


Figure 56: Base 2 Port Status

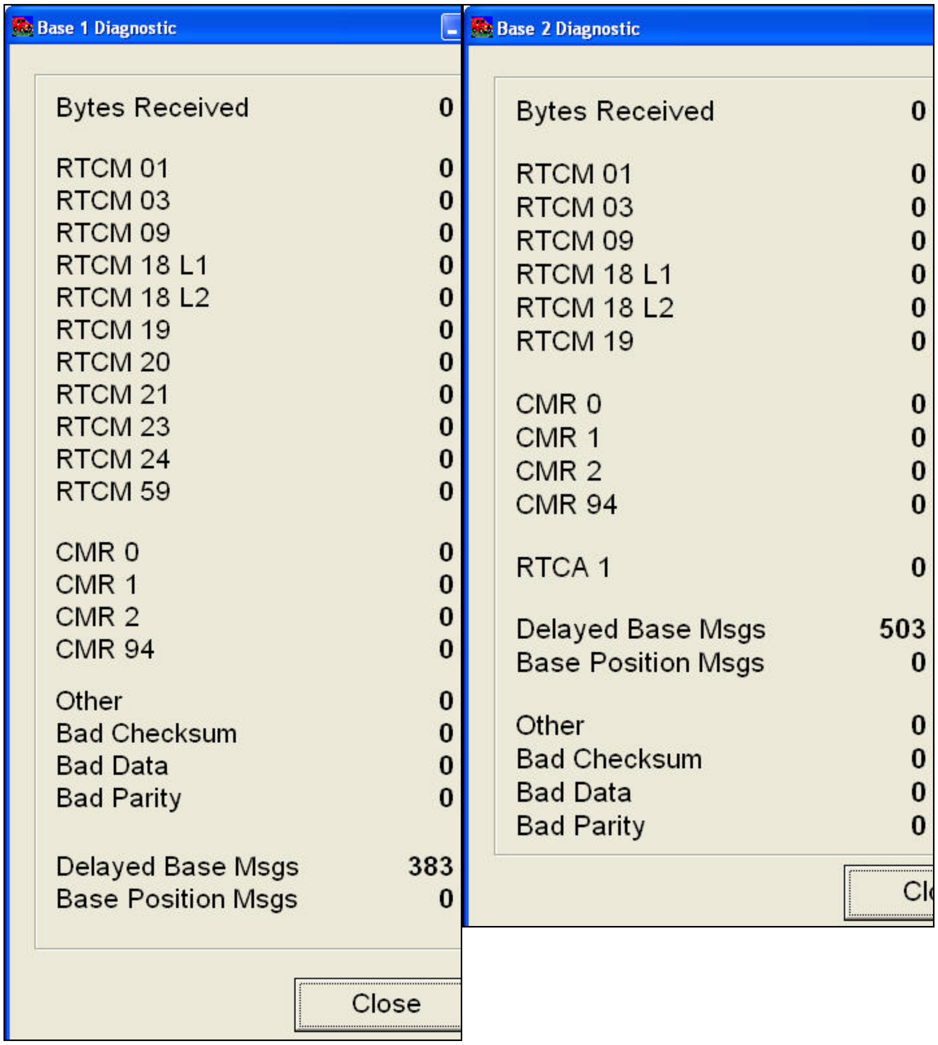


Figure 57: Base 1 and Base 2 Diagnostics

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 transferred to a Personal Computer (PC) Card using the PCMCIA (Personal Computer Memory Card International Association) drive installed in 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 PC Card is useable for post-processing in any PC with a PCMCIA drive.

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

Note: Use of the PC Card interface is preferred due to the bandwidth limitations associated with some Ethernet installations.

PCS Configuration

The PCS contains a PC Card and an internal memory device, both dedicated to data logging. The 1 GB PC Card uses a Personal Computer Memory Card International Association (PCMCIA) drive; see Figure 61, page 12-5 for its location. The PC Card is useable for post-processing in any PC with a PCMCIA drive.

A 1 GB internal memory device functions as a circle 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 PC Card logging, back-up logging will log the same data as the PC Card and continues to back-up the data until the system is reset or powered-off. Data logging back-up activity is shown by the Int light located to the left of the drive bay.

The first file of each back-up data file set begins with a *.000* extension. The file naming convention used by the PCS is *XXXXXXXXMMDDYYHHMMSS* where *XXXXXXXX* is the filename selected for the PC Card logging (up to 8 characters), and *MMDDYYHHMMSS* is the month, day, year, hour, minute and second in Universal Time Coordinated (UTC).

Access the back-up drive using an FTP client (e.g. CuteFTP) to connect to the POS AV system Internet Protocol (IP) address. Use *anonymous* (lowercase) for the username and press the Enter key when prompted for a 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**; **Logging, PC Card Logging**; **or Logging, Ethernet Real-Time**.

The logging screens (Figures 58, 59 and 60) permit the selection of data groups to be recorded and define the logging rate for those data groups.

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

Of the two Ethernet ports that are available, the first port, or the Ethernet real-time logging port, is intended for real-time control applications only where the most current Position and Orientation System for Land Vehicles (POS LV) data are required. The second port, or the Ethernet logging port, is intended for data logging or 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 PC Card, 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.

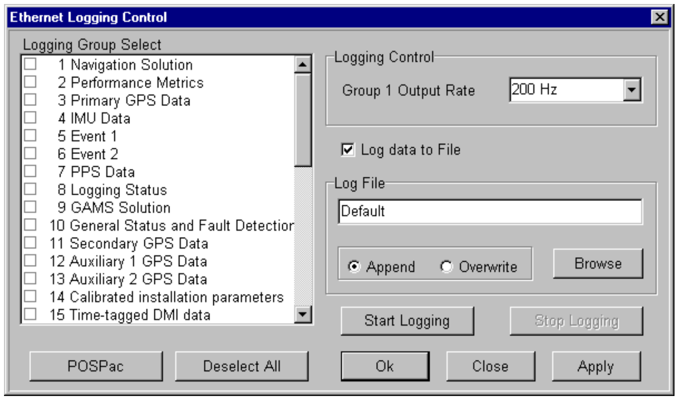


Figure 58: (1 of 3) PC Card and Ethernet Logging Screens

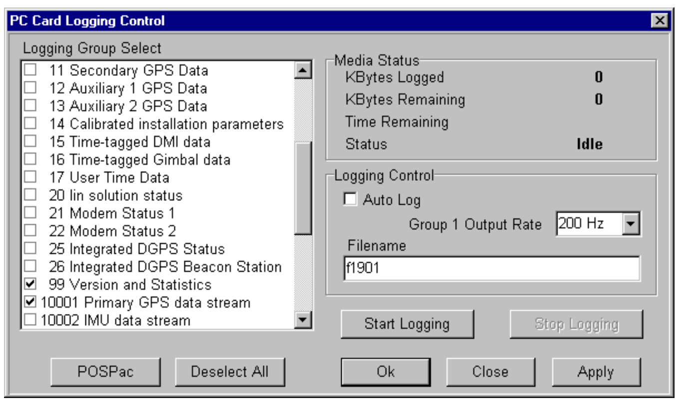


Figure 59: (2 of 3) PC Card and Ethernet Logging Screens

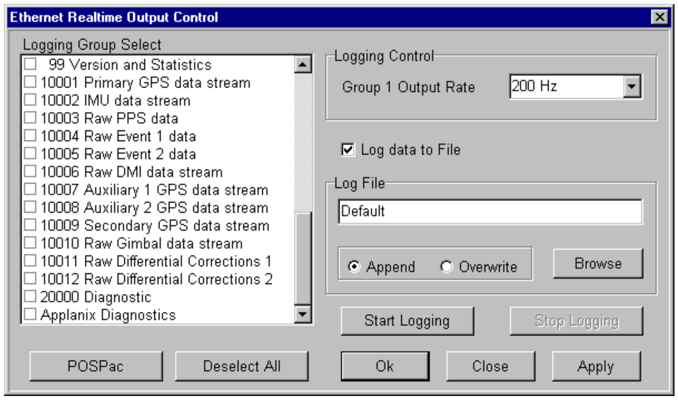


Figure 60: (3 of 3) PC Card and Ethernet Logging Screens

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 - PC Card

Insert a PC Card

Static electricity may temporarily interrupt the operation of the PC Card drive. Always touch the metal portion of the PCS case before inserting the PC Card.

PC Cards are sensitive to shock - do not drop. Store in a protective case when not installed in the PC Card drive.

The PC Card can be inserted into the PC Card bay at any time (i.e. with PCS power-on or off). Insert the PC Card into the drive bay (Figure 61) ensuring that the card is facing up and the printed arrow is pointing into the bay. The eject button is fully extended when the card is properly seated.

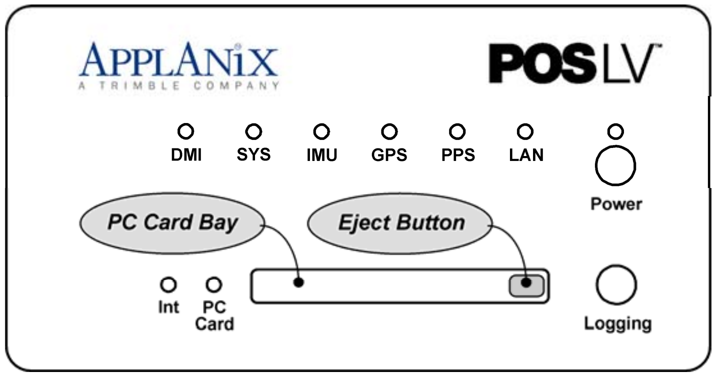


Figure 61: PC Card Drive Bay

Start Logging - PC Card

AutoLog

If AutoLog is enabled (refer to AutoLog on page 13-2), logging starts automatically on PCS power-up. If AutoLog is enabled and there is no disk in the PC Card drive, the PC Card light is red. If this occurs, insert a PC Card and force a start as described in the following paragraphs.

Manual Start

Press the Logging button on the PCS front panel twice to begin. If the button is pressed once, the PC Card light will flash, waiting for the second press. If it is not pressed a second time within a few seconds, the state will expire and the button will have to be pressed twice again.

An alternate method to start logging is to click the LV-POSView **Start Logging** button on the PC Card Logging Control screen (Figure 59, page 12-3).

For a description of the logging status lights, refer to Table 14 on page 13-6.

Stop Logging - PC Card

Logging is stopped manually by pressing the Logging button on the PCS front panel twice. Logging stops after about six seconds. If the Logging switch is only pressed once, the PC Card light will flash waiting for the second press. After a few seconds, the state will expire and logging will continue.

An alternate method to stop logging is to click the LV-POSView **Stop Logging** button on the PC Card Logging Control (Figure 59, page 12-3) screen.

Logging data to the PC Card 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 PC Card in 12-Megabyte (MB) files. If POS LV loses power while logging data to the PC Card, 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 PC Card

Static electricity may temporarily interrupt the operation of the PC Card drive. Always touch the metal portion of the PCS case before inserting the PC Card.

PC Cards are sensitive to shock - do not drop. Store in a protective case when not installed in the PC Card drive.

Do not remove a PC Card from the drive bay when the PC Card light is on; the drive may still be writing to the PC Card. If the PC Card is removed when the PC Card light is on, there is a chance that all mission data will be lost.

Stop logging before attempting to remove the PC Card from the drive bay. When the PC Card light is off, press the eject button (Figure 61, page 12-5) and remove the PC Card from the drive.

Note: It may take several seconds for the PC Card drive to stop recording to the PC Card and the PC Card light to extinguish.

Data Logging - Ethernet

Ethernet logging is performed using the LV-POSView software or other user supplied software. This custom designed software's interface must conform to the POS LV Ethernet ICD specifications. Data are output for Ethernet logging on one of the LAN data logging ports. Please refer to Applanix document *PUBS-ICD-000031* for a description of the Ethernet data output format.

Note the following points regarding the Ethernet circuit:

- Requires 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.

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 58 on page 12-3.

Stop logging - Ethernet Data Port

To stop Ethernet data logging, click the **Stop Logging** button on the **Ethernet Logging Control** screen (Figure 58, page 12-3). Make sure the correct Ethernet Logging Port has stopped logging.

13.0 Stand-Alone Operation

Stand-alone operation refers to using the Position and Orientation System for Land Vehicles (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 or terminate 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 8-18, 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 SYS light, located on the PCS front panel, begins flashing green. The Ethernet data output will begin as soon as the PCS is powered-on, 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 lights 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 a PC Card may be turned-on and off 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 8-18) prior to PCS power-down. AutoStart must be active for AutoLog to function and AutoLog is only available for PC Card logging.

During the next PCS power-up, the PCS automatically transitions to the **Navigate** mode once coarse levelling is complete. At this time, POS LV begins logging data to the PC Card.

To stop data logging, press the Logging switch twice (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 PC Card is full.

Manual Logging

Start

Logging is started manually by pressing the Logging button twice to begin (PCS front panel), refer to Figure 62. Pressing the button once causes the PC Card light to flash, waiting for the second press. If not pressed a second time the state will expire and the sequence must be repeated.

Stop

Logging is stopped manually by pressing the Logging button twice (PCS front panel). Logging stops after six seconds. If the Logging switch is only pressed once, the PC Card light will flash waiting for the second press. After a few seconds, the state will expire and logging will not stop.

PCS Switches and Indicators

Front Panel Switches

The PCS has two switches: Power and Logging (Figure 62). The Power switch controls the application of operating power to the PCS and illuminates the adjacent light when enabled. The Logging switch is used to start and stop PC Card logging.

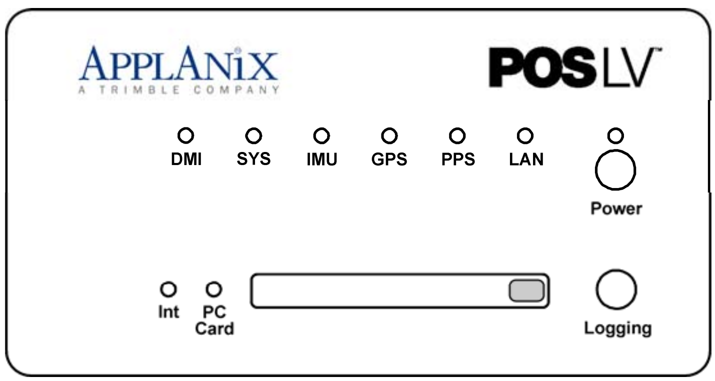


Figure 62: PCS Switches and Indicators

Front Panel Indicators

The front panel 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 of the components or their functions. The following list identifies the front panel indicators (Figure 62) and their indicated status.

Table 13: PCS Front Panel Lights

DMI light - indicates status of DMI:	
Steady green:	Navigate mode - DMI is ok.
Steady amber:	Navigate mode - DMI wheel slipping; once slipping stops light returns to green.
Steady red:	Navigate mode - DMI is defective.
Flashing green:	Navigate mode - DMI is ok; vehicle is starting (Zero Velocity Update [ZUPT]).
Steady *colour*:	Standby mode - assumes colour of last navigate mode (observe in conjunction with SYS light).
SYS 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. A solid red indication while all the other lights behave normally indicates 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. If light frequently shows red during operation, PCS may be receiving poor quality electrical power. Applanix recommends a UPS to power POS LV installation.
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.
IMU light - indicates status of IMU:	
Steady green:	Receiving IMU data and TOV.
Steady red:	IMU down, disconnected or an internal hardware failure.
GPS light - indicates GPS reception in loosely coupled mode or navigation status in tightly coupled mode:	
Steady red:	No GPS solution is available.
Steady amber:	GPS receiver is delivering a C/A or P-Code GPS solution.
Steady green:	GPS receiver is delivering a DGPS or RTK solution.
PPS light - flashes green once per second to indicate reception of GPS 1PPS signal.	
LAN light - indicates transmit and receive local area network activity:	
Flashing green:	Activity on Ethernet LAN.
Steady red:	A LAN fault (e.g. a break in Ethernet line).
Int light - steady green indicates internal data logging (back-up) is functioning, see Table 14 on page 13-6 for details.	
PC Card light - steady green indicates PC Card (external) data logging mode is selected, see Table 14 on page 13-6 for details.	
Power light - illuminates green when the PCS is operating.	

Table 14: Data Logging Status Indicators

Condition	PC Card Light	Int Light
Logging inactive	Off	Off
Storage medium is <75% full (	Steady green	Steady green
Storage medium is 75-90% full	1 Hz slow flash (green)	1 Hz slow flash (green)
Storage medium is >90% full	2 Hz fast flash (green)	2 Hz fast flash (green)
Storage medium is full	2 Hz fast flash (amber)	2 Hz fast flash (amber)
Error writing to Storage medium	Steady red	Steady red
Logging inactive, PCS only powered-on	Lights flash - pressing the Logging switch while in this state resets the PCS configuration and installation parameters to the factory default settings.	
PCS waiting to start or stop logging data	Lights flash - pressing the Logging switch while in this state starts or stops logging.	

Power-Down

Power-down the POS LV by pressing the green Power switch on the front panel of 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 screw.
3. Power to the POS system should be protected by a user-supplied, resettable circuit breaker

GPS Antennas

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

Keep the weatherable polymer antenna domes clean and free 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 IMU light on the POS Computer System (PCS) front panel indicates if the IMU has had a catastrophic failure. Should the light fail to illuminate, inspect the IMU cable for damage. In either case, contact Applanix Customer Support.

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.

The DMI light on the PCS front panel indicates if the DMI has had a failure. If the DMI light fails to illuminate, inspect the DMI cable and cable connectors for damage. In either case, contact Applanix customer support.

POS Computer System

The PCS requires minimal maintenance when protected from moisture and dust. 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.
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:

    Applanix Corporation

    85 Leek Crescent

    Richmond Hill, ON, Canada

    L4B 3B3

    RMA #

    CANADIAN GOODS RETURNING FOR REPAIR

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

Message	Definition
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
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

Message	Definition
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, roll and pitch errors <4.5 arcmin
GAMS ambiguity resolution failure	GAMS is unable to resolve carrier phase ambiguities
GAMS ambiguity resolution failure cleared	Flag reset
GAMS calibration complete	GPS Antenna calibration for use with GAMS complete
GAMS calibration failed	GPS Antennas calibration for use with GAMS unsuccessful
GAMS calibration forced	GPS Antenna calibration started manually
GAMS calibration in progress	GPS Antenna calibration for use with GAMS ongoing
GAMS calibration requested	Calibration AutoStart waiting for RMS heading error to drop below threshold
GAMS calibration suspended	GPS Antenna calibration paused
GAMS calibration suspension cleared	Flag reset - calibration resumed or stopped
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 GPS data; this is normal if it occurs for short periods
GPS Datum parameters corrected	GPS Datum parameters corrected
GPS Datum parameters incorrect	GPS Datum parameters incorrect
GPS excess resets	GPS 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 GPS data for >60 s

Message	Definition
GPS Not in navigate mode	GPS receiver has not entered Navigate mode; still searching for satellites
GPS position failure cleared	Flag reset
GPS position failure	GPS reports horizontal position error >1000 m
GPS position measurement reject cleared	Flag reset
GPS position measurement rejected	Position reported between IMU and GPS are inconsistent; likely GPS Lever Arms are incorrect in installation data
GPS SNR worse	GPS SNR worse
GPS SNR worse cleared	Flag reset
GPS tracking elevation limit corrected	Flag reset
GPS tracking elevation limit incorrect	GPS receiver is not configured
GPS velocity failure cleared	Flag reset
GPS velocity failure	GPS reports speed >35 m/s
GPS velocity measurement reject cleared	Flag reset
GPS velocity measurement rejected	Velocity reported between IMU and GPS are inconsistent; likely GPS 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

Message	Definition
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
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

Message	Definition
Initial position invalid	Geographic position supplied by GPS is invalid
Initial position valid	Geographic position supplied by GPS 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 GPS 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 GPS 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
PC Card logging file closed	PC Card logging stopped

Message	Definition
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	GPS receiver position data difference exceeds tolerance
Primary GPS configuration file sent	File to configure GPS 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 GPS
Primary GPS L1 phase cleared	Flag reset
Primary GPS L1 phase set	Primary GPS L1 phase set
Primary GPS mode: C/A	GPS receiver in standalone operation - no differential corrections are being processed
Primary GPS mode: differential	Primary GPS receiver is in differential mode

Message	Definition
Primary GPS mode: Float RTK	Primary GPS receiver is in float RTK mode
Primary GPS mode: Narrow Lane RTK	Primary GPS receiver is in narrow lane RTK mode
Primary GPS mode: Wide Lane RTK	Primary GPS 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
Primary GPS precise L1 set	Primary GPS precise L1 set
Primary GPS precise wide lane cleared	Flag reset
Primary GPS precise wide lane set	Primary GPS precise wide lane set
Primary GPS Pseudorange cleared	Flag reset
Primary GPS Pseudorange set	Primary GPS Pseudorange set
Primary GPS range rate cleared	Flag reset
Primary GPS range rate set	Primary GPS range rate set
Primary GPS raw observable data gap cleared	Flag reset
Primary GPS raw observable data gap detected	Primary GPS receiver data gap
Primary GPS reset	GPS reset message sent to receiver to clear receiver problem
Primary GPS reset cleared	Flag reset
Primary GPS solution in use	Primary GPS data are in use by the PCS
Primary GPS solution in use for GAMS	Primary GPS data are in use for GAMS

Message	Definition
Primary GPS solution NOT in use	Primary GPS data are not in use
Primary GPS solution NOT in use for GAMS	Primary GPS data are not in use for GAMS
Primary GPS wide lane IF phase cleared	Flag reset
Primary GPS wide lane IF phase set	Primary GPS 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
Secondary GPS data gap detected	Gap in GPS 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 GPS receiver
Secondary GPS solution in use	Secondary GPS data in use
Secondary GPS solution NOT in use	Secondary GPS data not in use
Simulate Mode	Inertial Data from simulator

Message	Definition
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.
GAMS Configuration Control	Start	Begins AutoStart GAMS configuration process or resumes a paused process.
	Stop	Cancels partially completed GAMS calibration process.

Table 16: Settings Menu

Menu Selection	Submenu Selection	Description
	Force	Starts GAMS calibration regardless of heading inaccuracy (manual start).
	Suspend	Pauses GAMS configuration process for later resumption.
Integrated DGPS		Control OmniSTAR and other DGPS functions with compatible primary GPS receivers.
Ethernet Real-time Port		Enable output data groups on Real-time TCP/IP port.
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.
	GPS Receiver	GPS 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.

Table 16: Settings Menu

Menu Selection	Submenu Selection	Description
Display Port		Manual Control of messages sent out over the display port.
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.
PC Card Logging		Configure and control PC Card logging.

⚠ **Logging high rate data to both an Ethernet port and a PC card 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.

Table 18: View Menu

Menu Selection	Submenu Selection	Description
IIN Solution		Displays status of the blended navigation solution.
GNSS & Nav Data		Displays status of GPS satellites tracked and status of the blended navigation solution.
GAMS Solution		Displays status of GAMS ambiguity resolution.
IMU Data		Displays IMU data.
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.
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.

Table 19: Tools Menu.

Submenu Selection	Submenu Options	Description
Configuration		Allows manual configuration of the navigation data integration.
Configure GPS		Sends commands to configure the receivers.
Reset GPS		Sends commands to reset the receivers.
Reset GAMS		Sends command to reset GAMS.
Reset		Reset is equivalent to cycling the PCS power, with the exception that GPS, 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.

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 GPS	Base 1	Displays statistics on incoming Base 1 GPS corrections data.
	Base 2	Displays statistics on incoming Base 2 GPS corrections data.

Table 20: Diagnostic Menu

Menu Selection	Submenu Selection	Description
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.
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
Contents		Gives access to the Help Index.
Using Help		Gives instructions on how to use help.
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.
Manual Calibration	The system continues the self-calibration of the installation parameters, until it receives a user command to stop the calibration or transfer the calibrated parameters.
Auto Calibration	The system continues the self-calibration and replaces the existing set of installation parameters with the new calibrated parameters when the calibration is completed. Then, it resets its Kalman Filter and restarts the normal Navigate mode with the updated installation parameters when all selected calibrations are completed.
Normal Transfer	The system replaces the existing set of the installation parameters with the new calibrated parameters once the selected calibration is completed. Then, it resets its Kalman Filter and restarts the normal Navigate mode with the possibly updated installation parameters.
Forced Transfer	The system replaces the existing set of the installation parameters with the calibrated parameters, regardless of the calibration status once it receives a Forced Transfer command.
Levelling Failed	POS LV was unable to determine vehicle orientation (roll and pitch). This is usually due to gaps in GPS data or receipt of incorrect GPS data from the receivers.
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.

Table 22: POS Mode

Message	Description
Nav: Full	POS LV is operating in full navigation mode. Roll and pitch errors are less that 0.075 degree.
Nav: Aligned	POS LV is operating in heading aligned mode. Heading error is below 10 degree and being continuously improved.
S/D Initialized	Strapdown Navigator Initialized.
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 GPS aiding.
GPS NAV	IIN GPS aiding is loosely coupled.

Table 25: Nav Status

Message	Description
C/A	The GPS receivers are providing positional data without differential correction.
RTCM DGPS	The GPS receivers are providing positional data enhanced by real-time differential correction.
CODE DGPS	The GPS 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. Data Gap	GAMS heading aiding data are available and is being processed by the Kalman Filter.
Aux. NL RTK	The auxiliary GPS receiver is providing real-time positional data using narrow lane ambiguity resolution.
Aux. WL RTK	The auxiliary GPS receiver is providing real-time positional data using wide lane ambiguity resolution.
Aux. Float RTK	The auxiliary GPS receiver is providing real-time positional data using float ambiguity resolution.
Aux. DGPS	The auxiliary GPS receiver is providing positional data enhanced by a differential correction signal.
Aux. C/A	The auxiliary GPS receiver is providing positional data without differential correction.

Table 26: GAMS Status

Message	Description
CAL Suspended	GAMS calibration suspended. Select Start from the Settings, GAMS Calibration Control menu to resume.

Table 26: GAMS Status

Message	Description
Forced CAL	GAM will be calibrated regardless of the RMS heading condition.
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 Failed	GAMS calibration should be finished in 5 minutes, otherwise the calibration fails.
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: PC Card Status

Message	Description
Idle	The PC Card is not currently in use.
Buffering	The PCS is buffering data in preparation for data logging to the PC Card.
Writing	Data are being logged to the PC Card.
Device Full	The PC Card is full.

Table 27: PC Card Status

Message	Description
Write Error	An error occurred while attempting to write to the PC Card. Ensure that the PC Card 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

Tate-Bryant 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 63). 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.

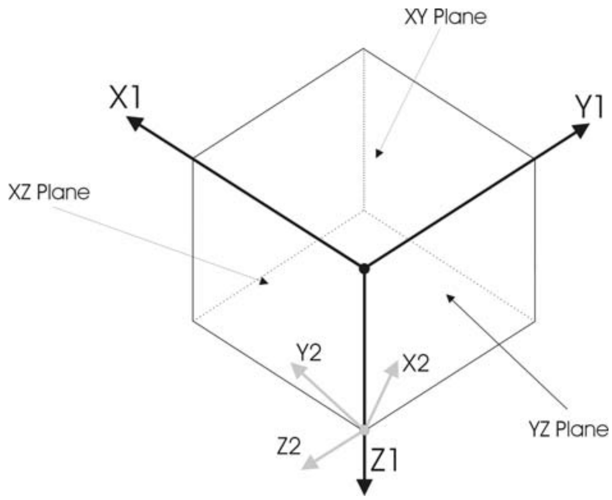
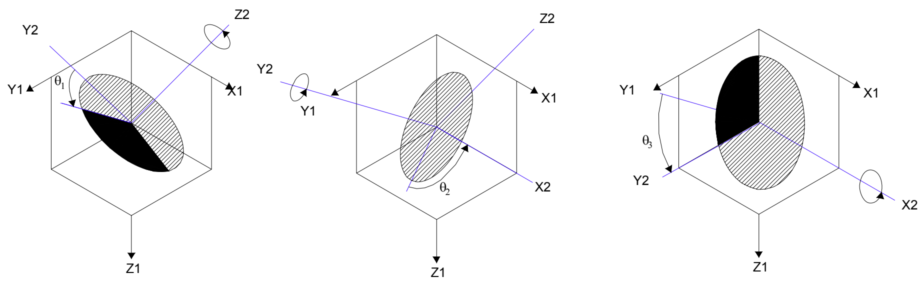


Figure 63: Tate-Bryant Planes and Axis

Tate-Bryant Sequence



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 64: Tate-Bryant 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: Only one message can be output at a time.

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 $INGST Message Format

The $INGST 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 $INGST Message Format

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

Item	Definition	Value	Units
$INGST	Header	$INGST	N/A
hhmmss.sss	UTC time of position	NRG	hours / minutes / seconds. decimal seconds
Null	Not supported	Null	N/A

Table 28: NMEA $INGST Message Format

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

Item	Definition	Value	Units
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
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 $INGGA Message Format

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

Table 29: NMEA $INGGA Message Format

$INGGA,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
$INGGA	Header	$INGGA	N/A
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 $INGGA Message Format

$INGGA,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

Table 30: GPS Quality Indicator Values

Value	GPS Mode
6	Estimated (dead reckoning) mode
7	Manual Input mode (Not Supported)
8	Simulated mode (Not Supported)

NMEA Port $INHDT Message Format

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

Table 31: NMEA $INHDT Message Format

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

Item	Definition	Value	Units
$INHDT	Header	$INHDT	N/A
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 $INZDA Message Format

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

Table 32: NMEA $INZDA Message Format

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

Item	Definition	Value	Units
$INZDA	Header	$INZDA	N/A
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

NRG stands for No Range Given.

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

Table 34: $EVT2 Message Format

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

Item	Definition	Value	Units
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

NRG stands for No Range Given.

NMEA Port $INVTG Message Format

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

Table 35: NMEA $INVTG Message Format

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

Item	Definition	Value	Units
$INVTG	Header	$INVTG	N/A
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

Table 35: NMEA $INVTG Message Format

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

Item	Definition	Value	Units
<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
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

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
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 $INGGA2 Message Format

The $INGGA2 position data are output in the following ASCII NMEA format:

Table 37: NMEA $INGGA2 Message Format

$INGGA,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
$INGGA2	Header	$INGGA	N/A
hhmmss.ss	UTC Time of position	NRG	hours / minutes / seconds. decimal sec

Table 37: NMEA $INGGA2 Message Format

$INGGA,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
llll.llll	Latitude	0^{o} to 90^{o}	degrees / minutes. decimal min
a	N (North) or S (South)	N or S	N/A
yyyyy.yyyy	Longitude	0^{o} to 180^{o}	degrees / minutes. decimal min
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

Table 37: NMEA $INGGA2 Message Format

$INGGA,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
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 $INPPS Message Format

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

Table 38: NMEA $INPPS Message Format

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

Items	Definition	Values	Units
$INPPS	Header	$INPPS	N/A
hhmmss.ss	UTC time of PPS	NRG	hours / minutes / seconds. decimal sec

Table 38: NMEA $INPPS Message Format

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

Items	Definition	Values	Units
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 $INGGK Message Format

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

Table 39: NMEA $INGGK Message Format

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

Items	Definition	Values	Units
$INGGK	Header	$INGGK	N/A
hhmmss.sss	UTC time	NRG	hours / minutes / seconds. decimal sec
ddmmyy	UTC Date	NRG	day / month / year
llll.lllll	Latitude	0^{o} to 90^{o}	degrees / minutes. decimal min
a	N (North) or S (South)	N or S	N/A

Table 39: NMEA $INGGK Message Format

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

Items	Definition	Values	Units
yyyyy.yyyy	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 32)	N/A
nn	Number of Satellites used in fix	0 to 32	N/A
v.v	PDOP	NRG	N/A
EHTxxxx.xx	Ellipsoidal height	EHTxxxx.xx	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 $INRMC Message Format

The $INRMC navigation data are output in the following ASCII NMEA format:

Table 40: NMEA $INRMC Message Format

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

Items	Definition	Values	Units
$INRMC	Header	$INRMC	N/A

Table 40: NMEA $INRMC Message Format

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

Items	Definition	Values	Units
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
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

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
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		

Table 42: PAST2 Message Format

Item	Byte	Format	Value	Units
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

Table 43: RDR1 Message Format

Item	Byte	Format	Value	Units
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.

Appendix G

BD960 GNSS Receiver and OmniSTAR Corrections - POS LV

Certain versions of the POS LV contain a Trimble BD960 GNSS receiver which is used to track and apply Differential GPS corrections from OmniSTAR. The GPS 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 65.

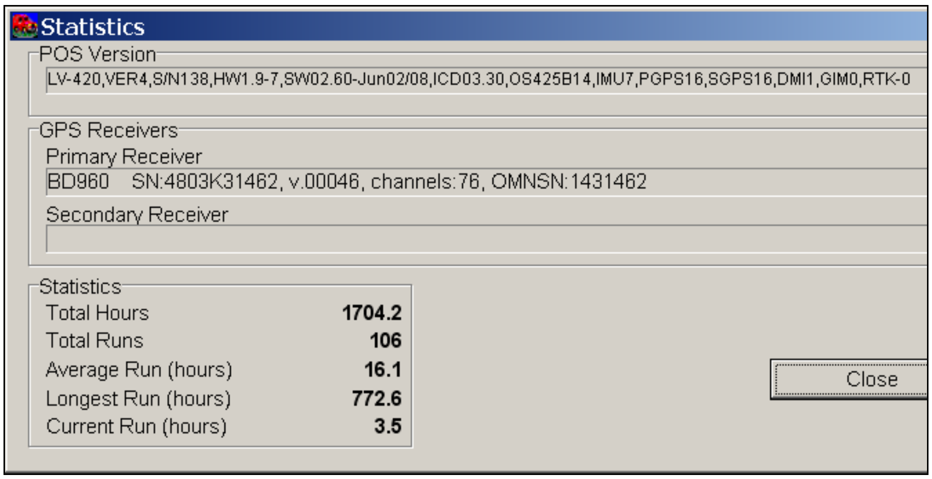


Figure 65: Statistics Window

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

OmniSTAR provides a subscription service for the enhancement of GPS position accuracy. Corrections to the GPS 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 Trimble BD960 GNSS receiver to utilize this broadcast, a Trimble 'Zephyr Model 2 GNSS' antenna is required. This antenna type is included with all complete POS LV systems that include the Trimble BD960 GNSS Receiver.

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

GNSS Time Message Output

This section describes the structure of the One Pulse Per Second (1PPS) time recovery message outputs from the POS Computer System (PCS). The PCS is configured using the Trimble BD960 GNSS receiver. Outputs from this receiver are available at the DIFF port; refer to Output Data Format on page 5-11.

Trimble GPS Receiver Model BD960

The following NMEA message is available to the user to determine the offset to UTC time.

This log will output null data in all fields until a valid almanac is obtained.

Table 44: NMEA $GPGST Message Format

$GPGST,hhmmss.utc,rms,smjr std,smnr std,orient,lat std,lon std,alt std
*xx<CR><LF>

Field	Structure	Field Description	Symbol	Example
1	$GPGST	Log Header		$GPGST
2	utc	UTC time of position (hours / minutes / seconds / decimal seconds)	hhmmss.ss	192911.0
3	rms	RMS value of the standard deviation of the range inputs to the navigation process; range inputs include pseudorange and DGPS corrections	x.x	28.7

Table 44: NMEA $GPGST Message Format

$GPGST,hhmmss.utc,rms,smjr std,smnr std,orient,lat std,lon std,alt std
*xx<CR><LF>

Field	Structure	Field Description	Symbol	Example
4	smjr std	Standard deviation of semi-major axis of error ellipse (metres)	x.x (-x.x)	21.6
5	smnr std	Standard deviation of semi-minor axis of error ellipse (metres)	x.x (-x.x)	12.0
6	orient	Orientation of semi-major axis of error ellipse (degrees from true north)	x.x	20.4
7	lat std	Standard deviation of latitude (metres)	x.x (-x.x)	20.7
8	long std	Standard deviation of longitude (metres)	x.x (-x.x)	13.6
9	alt std	Standard deviation of altitude (metres)	x.x (-x.x)	11.9
10	*xx	Checksum	*hh	*51
11	<CR><LF>	Carriage return & line feed		<CR><LF>

Example: $GPGST,192911.0,28.7,21.6,12.0,20.4,20.7,13.6,11.9*51 <CR><LF>.

Appendix I

POS LV Mission Checklist

This appendix outlines the typical mission procedure.

Mission Preparation

	Step
	Bring several PC cards 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 I-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 DIO 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 GPS 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 PC card and wait until the DATA LOG switch lights stop flashing (refer to Data Logging on page 12-1 for details on using the PC card).
	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 PC card. Refer to Table 14 on page 13-6.

	Step
	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 GPS Differential Corrections Base Station is on, and receiving and transmitting data.
	Log 2-5 minutes of GPS data to resolve ambiguities before departure.
	Allow GAMS to come online.
	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 DATA LOG switch on the front of the PCS to start and stop data logging to the PC Card.

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 PC Card from the drive bay when the PC Card light is on; the drive may still be writing to the PC Card. If the PC Card is removed when the PC Card light is on, there is a chance that all mission data will be lost.

	Step
	Stop logging data. The PC card 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 GPS multipath reception.
	Continue logging data for 2-5 minutes.
	Stop logging data and remove the PC card from the internal drive (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 GPS	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 J

POS LV V4 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 screw.
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 5-16.

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 D38999/26WB35PN 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 D38999/24WB35SN.

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 D38999/24WB35SN connector pin assignments are summarized in the following table.

Table 45: DMI Connector Pin-Outs

PIN	Pin Description		Signal Type	Signal Direction
	DMI Type 1	DMI Type 2		
1	Distance Pulses	Phase B	TTL (Input 1)	Input
2	Direction	Phase A	TTL (Input 2)	Input
3	Reserved (do not connect)		N/A	N/A
4	Common Return		Signal Ground	Input
5	+5 Vdc		Power	Output
6	5 Vdc return		Power	Output
7 to 12	Reserved (do not connect)		N/A	N/A
13	N/C		N/A	N/A

General DMI Electrical Interface Requirements

- The DMI electrical signals input to POS LV should be 5 V Transistor-Transistor Logic (TTL) logic signals. If 5 V TTL logic signals are used, then no current-limiting resistors are required.
- If signals of a different level (between 0 and +50 Vdc) are used, then current through the optoisolators (pins 1-4 and 2-4) shall be in the range of 5 to 10 mA to prevent damage to the POS LV. (Note that a current in the range of 5 to 10 mA must be applied to the optoisolators to register a DMI input to the POS LV).
- The DMI connector pin 4 shall be used as the common return for the two DMI inputs (on pin 1 and pin 2).
- Optical isolation of the DMI inputs (provided by the POS LV POS Computer System [PCS] hardware) shall be used and is necessary in most vehicle electrical environments. Therefore pin 5 and pin 6 on the

DMI connector (+5 Vdc power and return) shall *not* be connected and remain open.

- The DMI sensing device, connected to the POS LV V4 PCS, shall source at least 5 mA of current. This is the minimum current required to register a DMI input to the POS LV.
- If the DMI sensing device, interfaced with the POS LV, outputs a voltage greater than 5 Vdc, then resistors shall be inserted in series with the inputs connected to DMI connector pin 1 and pin 2 to limit the voltage into the optical isolators of the POS LV's DMI input to 5 Vdc.

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 2 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 K

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 46: 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
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

Date	GPS to UTC Offset (sec)	Date	TAI to UTC Offset (sec)
Jul 1, 1997	12	Jul 1, 1997	31
Jan 1, 1999	13	Jan 1, 1999	32
Jan 1, 2006	14	Jan 1, 2006	33

Notes:

1. GPS and TAI are ahead of UTC time, see Figure 66.

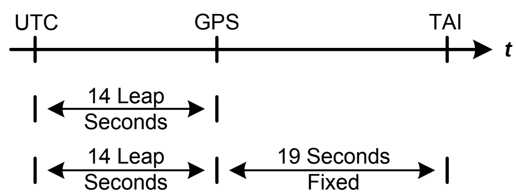


Figure 66: GPS, TAI and UTC Times

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

GPS Timing Basics

One Pulse Per Second

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

The 1PPS GPS Time Message output provides the Universal Time Coordinated (UTC) time of the next 1PPS signal. The RS-232 DIFF port message format is described in detail on page 5-11 and the GNSS Time Message Output are covered starting on page H-1.

To synchronize external equipment time (User Time) with received GPS time, the external equipment reads and records the occurrence of the 1PPS signal (present at the rear panel PPS port at a rate of 1 Hz) in User Time. Figure 67 shows the parameters of the 1PPS signal. With the time differential known, the external device calculates the GPS time.

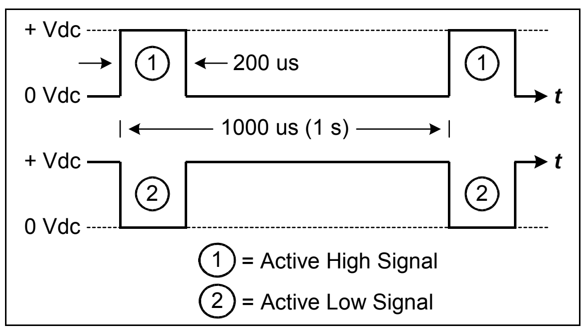


Figure 67: 1PPS Signal Characteristics

The **Events** pane, see Figure 68, displays the Universal Time, Coordinated (UTC) time of the two most recent signals (known as events) from sources external to the Position and Orientation System (POS) system. In addition, the Pulse Per Second (PPS) field displays the UTC time of the most recent PPS pulse transmitted by the primary GPS receiver. The Count field for PPS indicates the total number of signals recorded from the GPS receiver, while the Count fields for Events 1 and 2 indicate the number of event pulses recorded.

Events

	Time	Count
Event 1	14:54:10.653083 UTC	888535
Event 2	14:54:10.653077 UTC	888535
PPS	14:54:10.000000 UTC	1778

Figure 68: Events Group

1PPS Timing

For external timing purposes, the GPS receiver outputs a 1PPS signal that is available at the PPS connector on the POS Computer System (PCS) back panel.

If the PPS signal is an active low TTL strobe, the falling edge is coincident with the exact GPS second. The corresponding GPS time message, which specifies the UTC time of the next 1PPS, is output on the DIFF port. Depending upon the GPS card manufacturer, the GPS time message timing and its contents may vary; see Figure 69 on page K-8. The Trimble BD950 GPS receiver uses an active high strobe.

Time and Distance Tags

POS is capable of simultaneously making Time and Distance tag events through the Digital Input/Output (DIO) connector on the PCS back panel. These tags can be used to identify the start and/or end of data collection, and to synchronize POS data with data from other sensors or systems.

EVENT TAGS

Events are tagged with GPS, UTC, POS or User Time. Distance is computed by the PCS from the DMI or POS distance data. To tag an event, a Transistor-Transistor Logic (TTL) level signal is input into POS. The rising or falling edge corresponds to the exact time and distance of the event. The TTL signal is connected to either the Event 1 or Event 2 DIO line.

DISTANCE TAGS

POS data are further tagged with a distance tag. This distance is the path traveled by the Reference Point, as calculated by the PCS. The distance tag will increase during forward motion, and will decrease during reverse motion of the vehicle.

Timing Synchronization

Figure 69 shows the timing associated with the various output signals from the POS GPS receiver, internally (POS) derived signals and external event signals. The actual signal outputs from the GPS receiver depend upon the manufacturer. The heart of POS timing is the 1PPS signal and the GPS Timing Message. The illustration shows that the GPS time message indicates the UTC and/or GPS time of the next received 1PPS signal. The timing of an event (pulse) at the DIO port can be determined by measuring the time differential between the occurrence of the 1PPS signal and the event signal.

Note: Knowing the time of the 1PPS signal (in UTC and/or GPS time) permits the POS circuitry to determine accurate User Time.

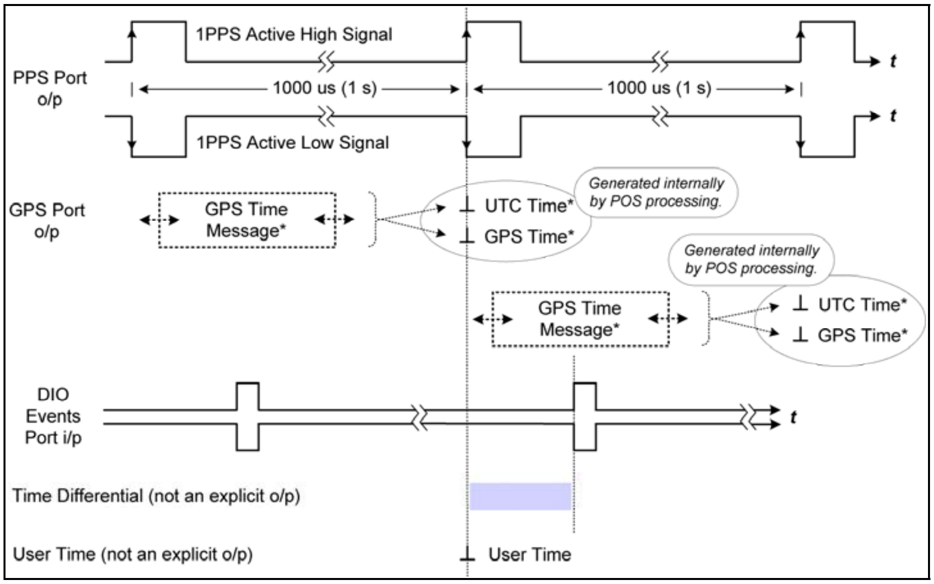


Figure 69: POS Timing Synchronization

POS LV Ports

EVENTS PORT

The DIO Events digital port provides access to the POS LV event timing facility for events one through four. Refer to the Events Connector description on page 5-12 for more information.

GPS 1 & 2 PORTS

Each GPS port serves as an output for the GPS time message that can be used for time synchronization. The GPS time message output provides the UTC time corresponding to the next 1PPS (one pulse per second) signal available on the PPS Out port. Refer to the GPS 1 and GPS 2 Connectors description on page 5-11 for more information.

PPS OUT PORT

The PPS digital port provides a one Pulse Per Second (PPS) output for external timing. The output pulse is derived from either the primary GPS receiver or the external GPS receiver. Refer to the PPS Connectors description on page 5-15 for more information.

ETHERNET PORT

A 10/100Base-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. Refer to the Ethernet Connector description on page 5-13 for more information.

POS Time Synchronization Methods

Three methods of time synchronization are available to the user. The following paragraphs outline these methods.

Event Tags

Events are tagged with GPS, UTC, POS or User Time; see Figure 69 on page K-8. The timing of an event (pulse) at one of the event ports can be determined by measuring the time differential between the occurrence of the 1PPS signal and the event signal. To tag an event, a Transistor-Transistor Logic (TTL) level signal is input into POS. The rising or falling edge corresponds to the exact time of the event. The TTL signal is connected to one of the four event lines; refer to the description of the Events Connector on page 5-12.

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

GROUP FORMAT

POS organizes the data coming from the display, data and logging ports into output groups. Each group contains a block of related data at a specified group rate. The user directs the POS, via the POS Controller or control port messages, to include a group or groups containing data items of interest in the display, data and logging port data streams; refer to Applanix document *PUBS-ICD-000036* for further clarification.

The output data rate on the display port is typically once per second or less. This output is intended for updating the POS Controller display; hence, a higher data output rate is not required. The output data rate on the data and logging ports is group dependent, and has a range 1-200 Hz.

Table 47 is extracted from Applanix document *PUBS-ICD-000036*. The time and distance fields in these two messages indicate the time and distance of events 1 and 2. These messages can be used by a client to attach GPS/UTC time to external events.

Table 47: Group 5, Event 1 or Group 6, Event 2

Item	Bytes	Format	Value	Units
Group start	4	Char	$GRP	N/A
Group ID	2	Ushort	5 or 6	N/A
Byte count	2	Ushort	36	bytes
Time 1	8	Double	N/A	sec
Time 2	8	Double	N/A	sec
Distance tag	8	Double	N/A	m

Table 47: Group 5, Event 1 or Group 6, Event 2

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	
Event pulse #	4	Ulong	N/A	N/A
Pad	2	Byte	0	N/A
Checksum	2	Ushort	N/A	N/A
Group end	2	Char	$#	N/A

NMEA 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-7 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.

Synchronize External Equipment to POS Time

To synchronize external equipment time (User Time) with GPS time, the external equipment must read and record the 1PPS signal in User Time and the GPS time message from the GPS port. With the time differential known, the external device can calculate the correct GPS time tag for the external data. Refer to Figure 70 for an example of synchronizing external equipment to POS time.

In this scenario, the user PC may be recording sensor data in real-time and is using the POS system timing for synchronization of its User Time.

Recording this time differential for each new 1PPS pulse and GPS time message allows the user to compensate for drift in the user clock.

Note: Figure 69 on page K-8 illustrates the timing associated with the various signals received and generated by POS.

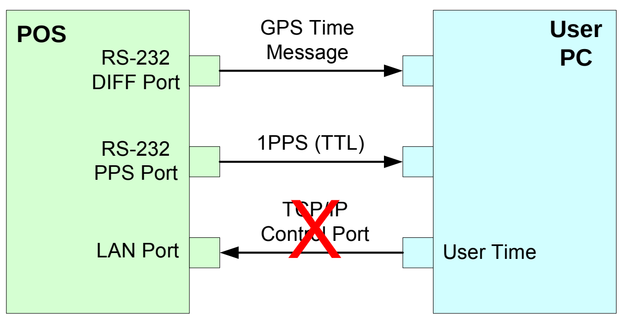


Figure 70: Synchronize External Equipment to POS Time

Synchronize POS to External Equipment Time

To synchronize POS with external equipment time (User Time), the external equipment must read and record the 1PPS signal from the POS PPS port and transmit its User Time to the POS on the Ethernet port, see Figure 71. Refer to the description of the Ethernet Connector on page 5-13.

'Message 55 - User Time Recovery' (Table 48) is extracted from Applanix document *PUBS-ICD-000036*. 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.

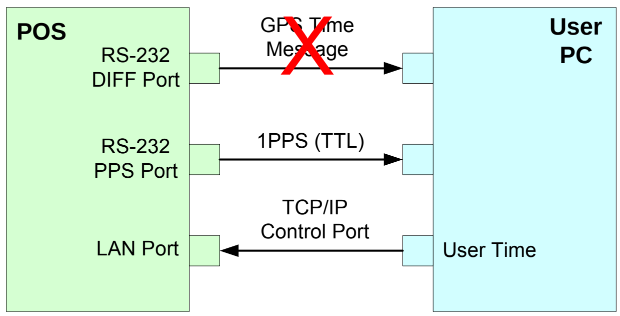


Figure 71: Synchronize POS to External Equipment Time

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
Transaction number	2	Ushort	Input: Transaction number Output: [65533, 65535]	N/A

Table 48: Message 55 - User Time Recovery

Item	Bytes	Format	Value	Units
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

In this scenario, the user PC may be controlling the recording of sensor data on POS by using a substitute controller (i.e. not the LV-POSView software). The user would be required to write a TCP/IP socket interface to accommodate both the User Timing input and the substitute controller communication.

Appendix L

POS LV200 & Trimble 5700/MS750

Important:

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

Overview

This appendix describes the procedures for installing the Applanix Position and Orientation System (POS) LV200 to enhance the performance of the Trimble 5700 or the MS750.

Hardware Requirements

Trimble 5700

Components listed in the following table are required:

Applanix P/N	Descriptions	Trimble P/N
10003603	Cable, DB9 to LEMO interface	32960
10003604	Cable, Power/Serial interface	32345
10003605	Cable, Event Marker/1PPS interface	36451-00
	Trimble 5700 Power Converter	

Trimble MS750

Components listed in the following table are required:

Applanix P/N	Descriptions	Trimble P/N
10003502	Cable, Serial Cable with power	30945
10003503	Cable, T-Serial cable with PPS	37382
10003504	Cable, Coaxial cable, 10 ft	

Software Requirements

POS LV Firmware

The Position and Orientation System for Land Vehicles (POS LV) firmware is installed on the mPOS PCS. It must be version 2.42 or newer.

LV-POSView

LV-POSView is used for monitoring and controlling the POS LV200 and must be version 2.2 or newer.

Cable Connections

Trimble 5700

Cable	Connector	Connection
Cable, DB9 to LEMO interface	LEMO	Trimble 5700 Port 1
Cable, DB9 to LEMO interface	DB9	mPOS COM1
Cable, Event Marker/1PPS interface	LEMO	Trimble 5700 Port 2
Cable, Event Marker/1PPS interface	PPS	mPOS PPS IN
Cable, Power/Serial interface	LEMO	Cable, Event Marker/1PPS interface PORT2
Cable, Power/Serial interface	Power lead	Trimble 5700 Power Converter output

Trimble MS750

Cable	Connector	Connection
Cable, T-Serial cable with PPS		MS750 PORT A
Cable, T-Serial cable with PPS	DATA A1/B1	mPOS COM1
Cable, T-Serial cable with PPS	PPS	mPOS PPS IN
Cable, Serial Cable with power		MS750 PORT B
Cable, Serial Cable with power	Power cable	+12 Vdc supply

Mini-Position and Orientation System (mPOS)

Cable	Connector	Connection
Cable, Multi-I/O		mPOS MULTI I/O
Cable, Multi-I/O	Ethernet	Network
DC power cable		mPOS Power Input
DC power cable	Power cable	Vdc supply
DMI Cable, P/N 10003107		mPOS DMI
DMI Cable, P/N 10003107		DMI
IMU Cable, P/N 10003110		mPOS IMU
IMU Cable, P/N 10003110		IMU

POS LV Firmware Set-up

This procedure applies to the POS LV firmware set-up and both the Trimble 5700 and MS750.

Check Firmware Version

1. Power up the POS Computer System (PCS).
2. Run LV-POSView on a Personal Computer (PC) connected to the network.

3. Wait until the PCS has finished booting.
4. On the LV-POSView menu bar, select **View, Statistic**.
5. Refer to Figure 72 and view the contents of the **POS Version** pane. The software version must be “SW02.35” or newer.
6. Contact Applanix if the software version is incorrect, see page A-1 for contact directions.

Check Firmware Configuration

1. Refer to Figure 72 and view the contents of the **POS Version** pane. The primary GPS field must be “PGPS9” and the last field is “RTK-0”.
2. If either of these fields is incorrect, reconfigure the firmware as described in the following Reconfigure Firmware procedure.
3. If all the values are correct, shutdown the system by selecting **Tools, Shutdown** from the LV-POSView menu bar. Next, click the **Yes** button on the pop-up window.

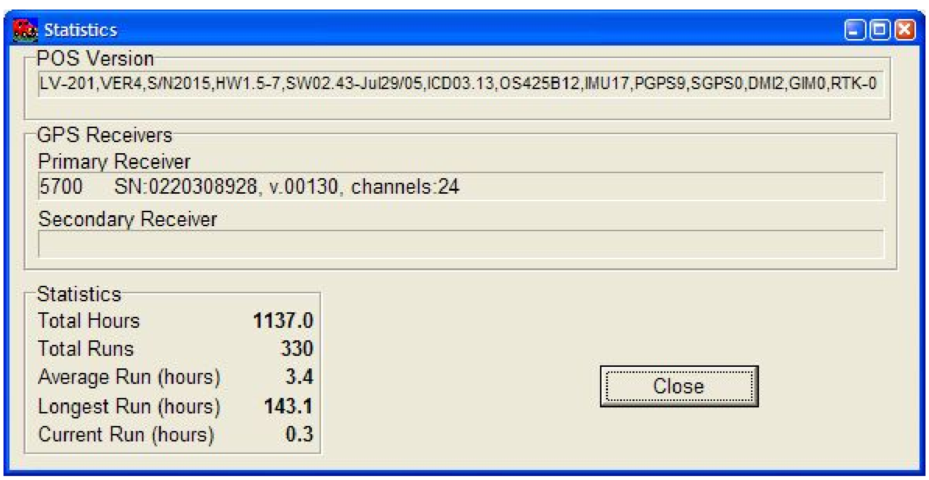


Figure 72: Statistics Window

Reconfigure Firmware

This process is required if the firmware configuration is incorrect.

1. Run the POSConfig utility on the PC.
2. Select the IP address of the PCS.
3. The configuration window as displayed, see Figure 73.

Note: Figure 73 shows the correct field and check box selections.

4. Click the **Update** and **Exit** buttons on the pop-up window.
5. On the LV-POSView tool bar, click the Connect icon.
6. Reset the system by selecting **Tools, Reset** and then click the **Yes** button on the pop-up window.
7. Once the system has rebooted, confirm the firmware versions.

Start the System

POS LV200 is designed for friendly usage; just follow the process below:

1. Power-up the MS750 or Trimble 5700.
2. Power-up the POS LV200.
3. Enable the LV-POSView on the controlling PC.

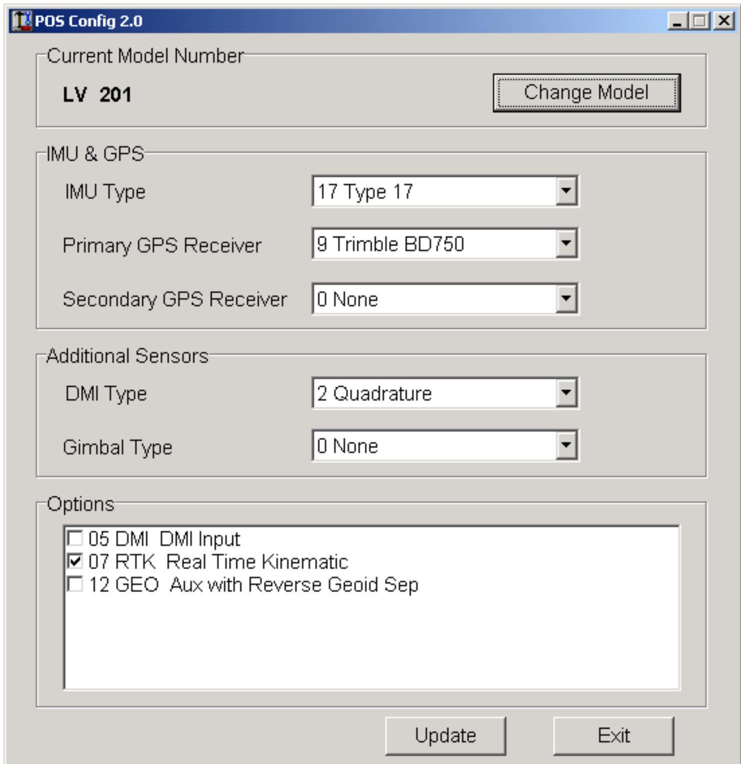


Figure 73: Configuration Window

Appendix M

GPS Reference Station

Overview

The Global Positioning System (GPS) permits users to determine their location on land, sea or in the air. It does this by using satellites and receivers. There are currently 24 satellites in orbit, operated by the Department of Defence (DoD), that provide worldwide coverage 24 hours a day, seven days a week.

Simplistically, the Global Positioning System (GPS) 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 GPS time to determine the time difference between the instant the signal was transmitted and the instant it was received

Position accuracy varies with GPS 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 GPS 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 GPS 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 GPS 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 GPS positions to accurately fit an existing control network. Figure 74 illustrates the difference between precise and accurate.

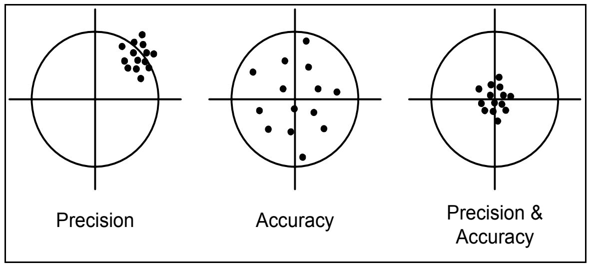


Figure 74: Precision Versus Accuracy

Reducing Errors

Accurate positioning using Differential GPS (DGPS), Real-time Kinematic (RTK) or phase measurements remove most of the errors (identified in the 'Position accuracy' paragraph on page M-2) to produce sub-metre to millimetre level fixes. Figure 75 shows three typical signal modulation methods.

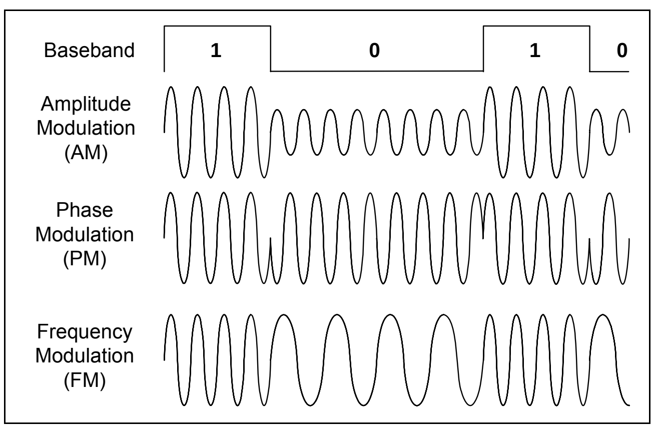


Figure 75: Examples of Signal Modulation

DIFFERENTIAL GPS

DGPS employs position corrections to attain greater accuracy by using a reference station, see Figure 76. 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 GPS satellites. These corrections are transmitted to mobile GPS receivers (DGPS). Typical accuracies are in the one to five metre ranges.

REAL-TIME KINEMATIC

RTK is a process where GPS signal corrections are transmitted in real-time from a reference receiver at a known location to one or more remote rover receivers, see Figure 76. The use of an RTK capable GPS system can compensate for atmospheric delay, orbital errors and other variables in GPS 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 GPS signals, as well as the carrier phase, which delivers the most accurate GPS information, RTK provides differential corrections to produce the most precise GPS 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 75. 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.

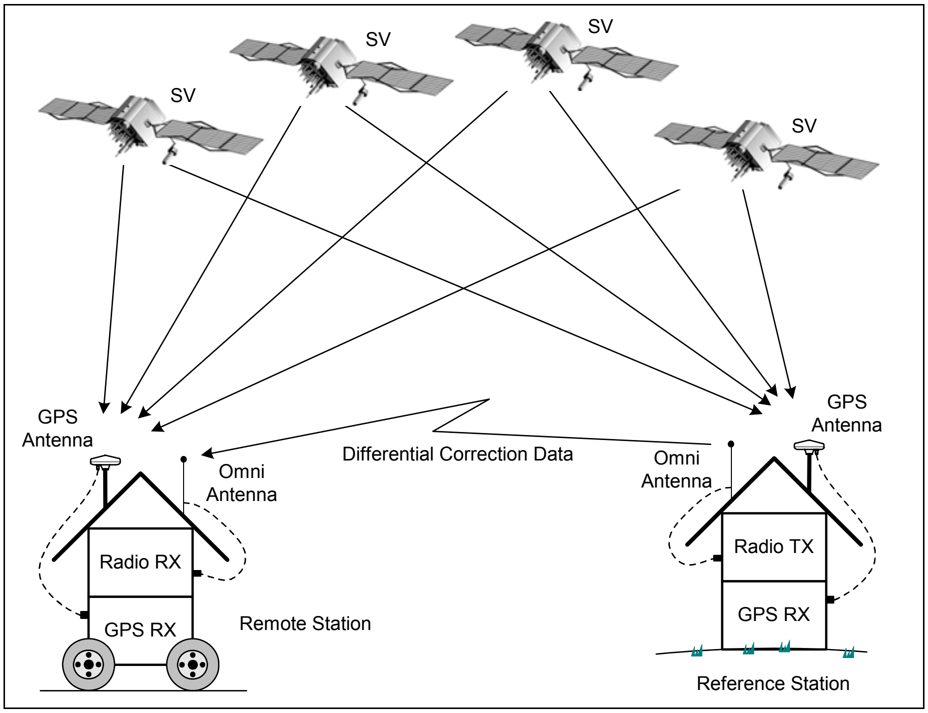


Figure 76: Reference and Remote Station Configuration

DIFFERENCES BETWEEN DGPS & RTK

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

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

Typical Reference Station

Differential Global Positioning System (DGPS) is a method of providing differential corrections to a Global Positioning System (GPS) receiver in order to improve the accuracy of the navigation solution. DGPS corrections originate from a reference station at a known location. The receivers in these reference stations can estimate errors in the GPS because they have an accurate knowledge of their position. As a result of applying DGPS 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 DGPS, this warning happens within a few seconds of the satellite becoming 'unhealthy', compared to GPS warnings where some hours can elapse.

Real-time kinematic is a GPS differential mode of operation using carrier phase measurements and is a technique which makes use of the most accurate information delivered by the GPS system. Figure 77 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.

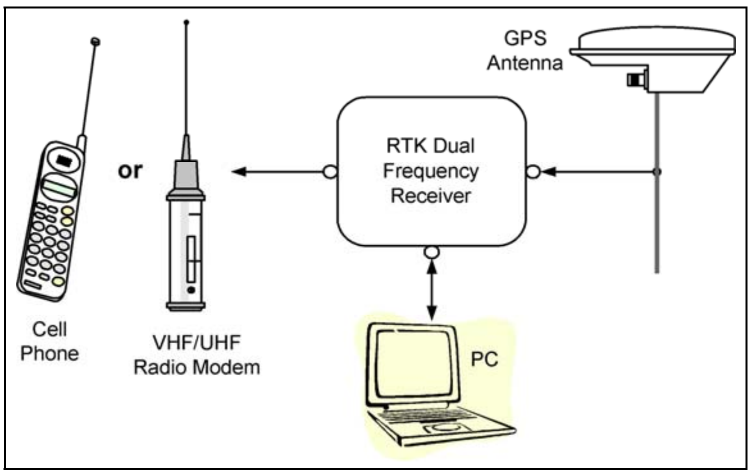


Figure 77: Reference Station Configuration

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. The data transmitted from the reference station radio modem uses the following various formats:

- Compact Measurement Record (CMR)
- Compact Measurement Record plus (CMR+)
- Radio Technical Commission for Maritime Services, message type 3, 18 & 19 (RTCM 3, 18 & 19)

Reference station components:

- Trimble MS750, Trimble MS5700 or NovAtel OEM4 RTK
- Pacific Crest radio modem or compatible cell phone modem
- GPS antenna
- Personal computer (not dedicated)

Trimble MS750 RTK Reference Station - Set-up Procedures for POS LV

The following defines how to configure the Trimble MS750 Dual Frequency RTK Receiver using the Configuration Toolbox v2.06 program.

Required Equipment

- Trimble Reference Station (TRS) Software User Guide v1.00, P/N 39425-00 -ENG
- Trimble Reference Station Software v1.02
- Configuration Toolbox v2.06

Install Software

1. Power-on the PC and insert the Trimble Reference Station CD into PC. PC should automatically detect and install software.
2. Once the software is installed onto PC, restart the PC.
3. Insert the Configuration Toolbox CD into the PC. The PC should detect and install the software.

Hardware Set-up

1. Set-up the GPS hardware as directed by the manufacturer.
2. Connect a serial cable between the PC and the GPS receiver. Record COM port use for future information.
3. Connect a radio cell phone to a COM port on the GPS receiver. Record COM port use for future information.

Configure MS750 Receiver

1. Initiate the Configuration Toolbox application.
2. Select the following:
   a) **File** on the menu bar
   b) Select **New**
   c) Then select the correct receiver, **MS Series**
3. Before any settings are selected, ensure the **Reset to defaults before applying** check box is selected. This is critical to the operation of the MS750 Base Station. Refer to Figure 78 and duplicate the settings, then click the **Save** button.

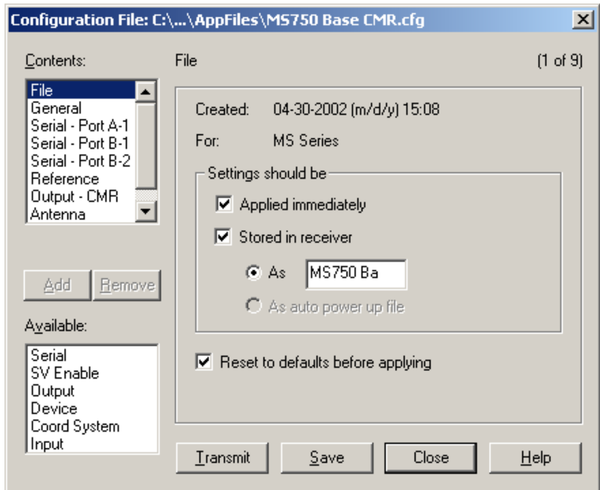


Figure 78: File Set-up

4. Select the **General** option from the **Contents** field. The **Elevation mask**, **PDOP mask** and the **RTK Mode** drop-down fields are critical to the correct operation of the MS750 Base Station. Refer to Figure 79 and duplicate the settings, then click the **Save** button.

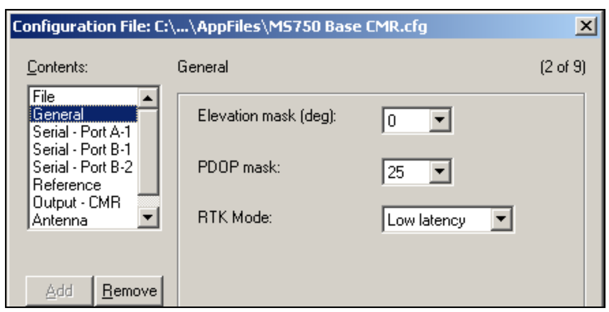


Figure 79: General Set-up

5. Select the **Serial Port A-1** option from the **Contents** field. Select **Port A-1** in the **Receiver serial port** drop-down field. This port is used to send real-time GPS corrections data from the MS750 to the POS LV

(via cell phone or radio). Set the **Baud rate** to the maximum allowable transfer rate of the modem. Using the maximum data transfer rate will mitigate data transmission problems related to latent data. Refer to Figure 80 and duplicate the settings, then click the **Save** button.

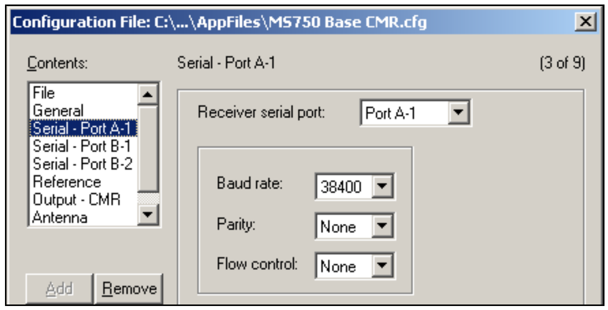


Figure 80: Serial Port A-1 Set-up

6. Select the **Serial Port B-1** option from the **Contents** field. Port B-1 is used to transfer the data from the MS750 to the Trimble Reference Station (TRS). The Baud rate should be set to the maximum allowable transfer rate. Refer to Figure 81 and duplicate the settings, then click the **Save** button.

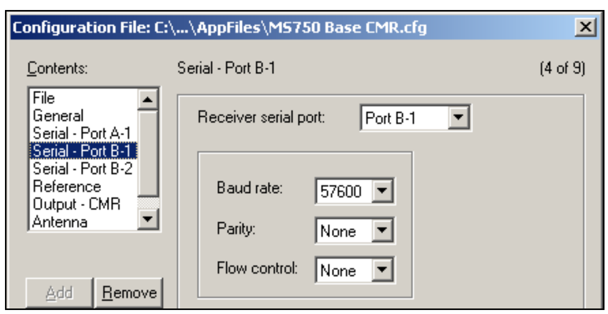


Figure 81: Serial Port B-1 Set-up

7. Select the **Serial Port B-2** option from the **Contents** field. Port B-2 is not used in this set-up. Refer to Figure 82 to view the default settings.

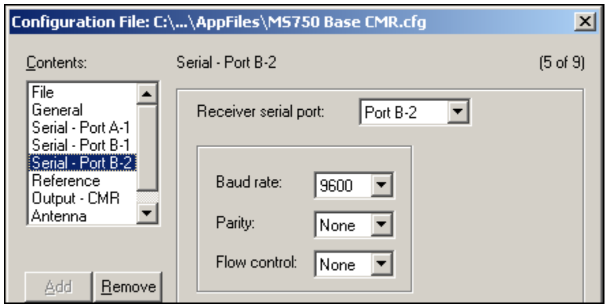


Figure 82: Serial Port B-2 Set-up

8. Select the **Reference** option from the **Contents** field. The reference position point must be surveyed. The Latitude, Longitude and Height values must be as accurate as possible. Inaccurate base station coordinates will result in incorrect positions reported by the POS system. Refer to Figure 83 and duplicate the settings, then click the **Save** button.

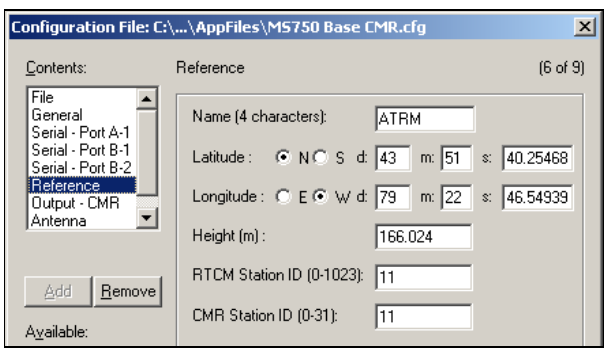


Figure 83: Reference Set-up

9. Select the **Output-CMR** option from the **Contents** field. The real-time GPS **Message type** and associated **Serial port** are selected from the

drop-down fields. Refer to Figure 84 and duplicate the settings, then click the **Save** button.

Note: It is recommended setting the **Message type** field to 'CMR'; and the **Message subtype** field to 'CMR PLUS' (owing to this message's small uniform size - however, 'CMR' can also be used).

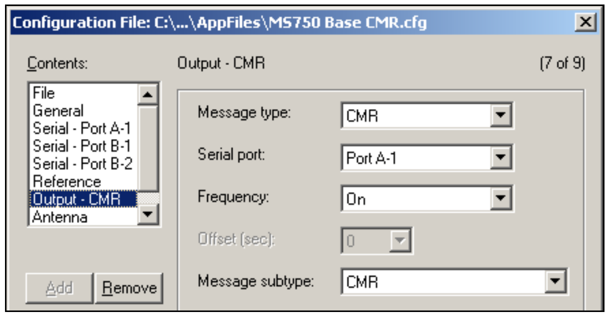


Figure 84: Output-CMR Set-up

10. Select the **Antenna** option from the **Contents** field. Select the correct antenna in the Type drop-down field. Refer to Figure 85 and duplicate the settings, then click the **Save** button.

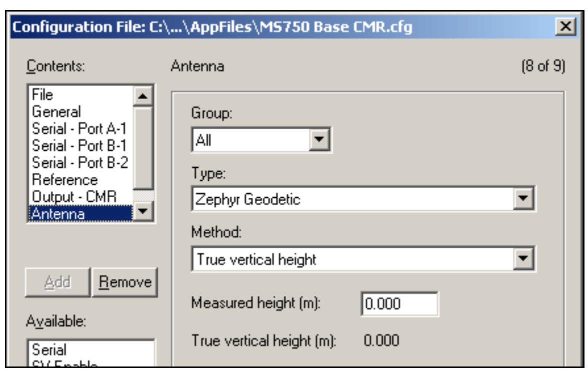


Figure 85: Antenna Set-up

11. Select the **Static** option from the **Contents** field. Refer to Figure 86 and duplicate the settings, click the **Save** button and then select the **Transmit** button. The Trimble MS750 Base Station set-up is complete.

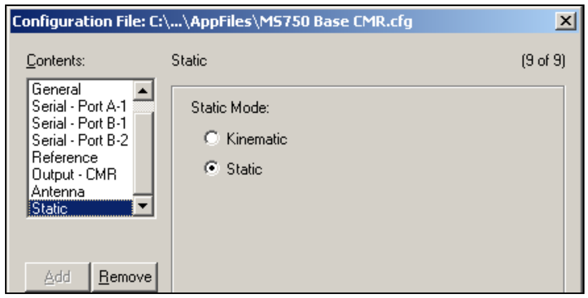


Figure 86: Static Set-up

Trimble 5700 RTK Reference Station - Set-up Procedures for POS LV

The following defines how to configure the Trimble 5700 Dual Frequency RTK Receiver using the GPS Configurator v1.00 program.

Required Equipment

- Trimble Reference Station (TRS) Software User Guide v1.00, P/N 39425-00 -ENG
- Trimble Reference Station Software v1.02
- GPS Configurator v1.00
- Trimble Reference Station Software Upgrade for 5700

Install Software

1. Power-on the PC and insert the Trimble Reference Station CD into the PC. The PC should automatically detect and install the software.
2. Install the 5700 patch (Trimble Reference Station Software Upgrade).
3. Once the software is installed onto the PC, restart the PC.
4. Insert the GPS Configurator CD into the PC. The PC should detect and install the software.

Hardware Set-up

1. Set-up the GPS hardware as directed by the manufacturer.
2. Connect a serial cable between the PC and the GPS receiver. Record COM port use for future information.
3. Connect a radio cell phone to a COM port on the GPS receiver. Record COM port use for future information.

Configure 5700 Receiver

1. Initiate the GPS Configurator application.
2. On the **Connection** tab, click the **Connect now** button to connect the 5700 (Figure 87).
3. Verify that the settings are similar to Figure 87.

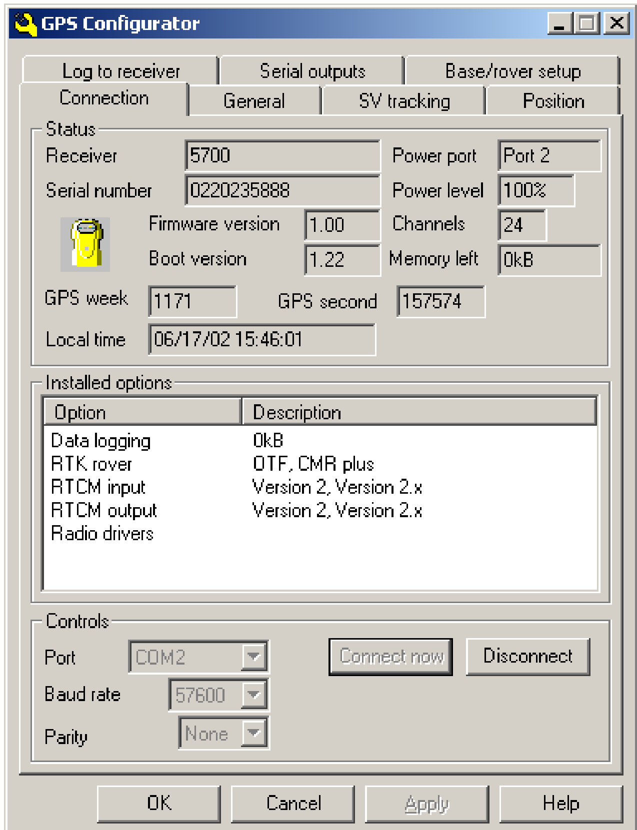


Figure 87: GPS Configurator - Connection Tab

4. Select the **General** tab (Figure 88):

   a) In the **Elevation mask** field enter **0** degrees

   b) In the **PDOP mask** field enter **25**

   c) Set the **Motion** option button to **Static**

5. Verify settings with Figure 88 and then click the **Apply** button.

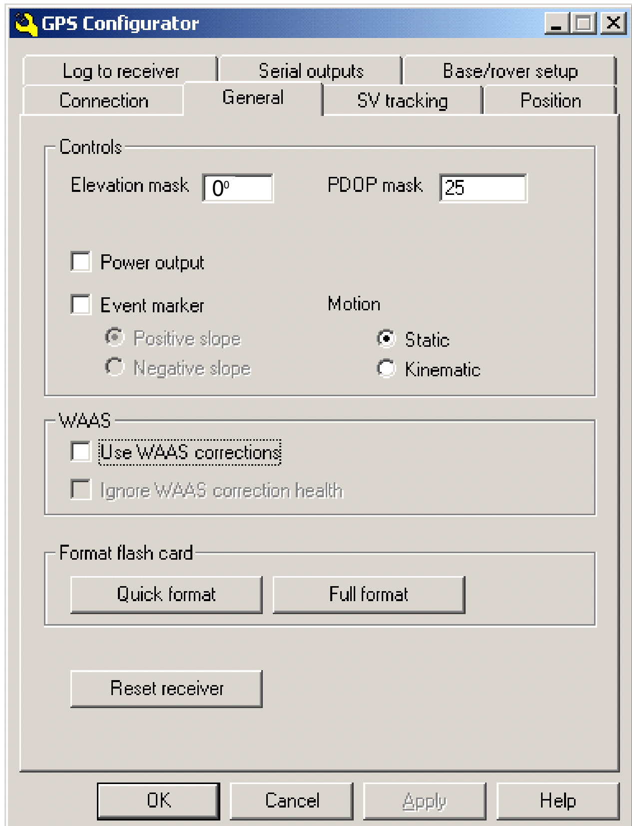


Figure 88: GPS Configurator - General Tab

6. Select the **SV tracking** tab (Figure 89).

7. Verify that the settings are similar and then click the **Apply** button.

Typically, all satellites are tracked.

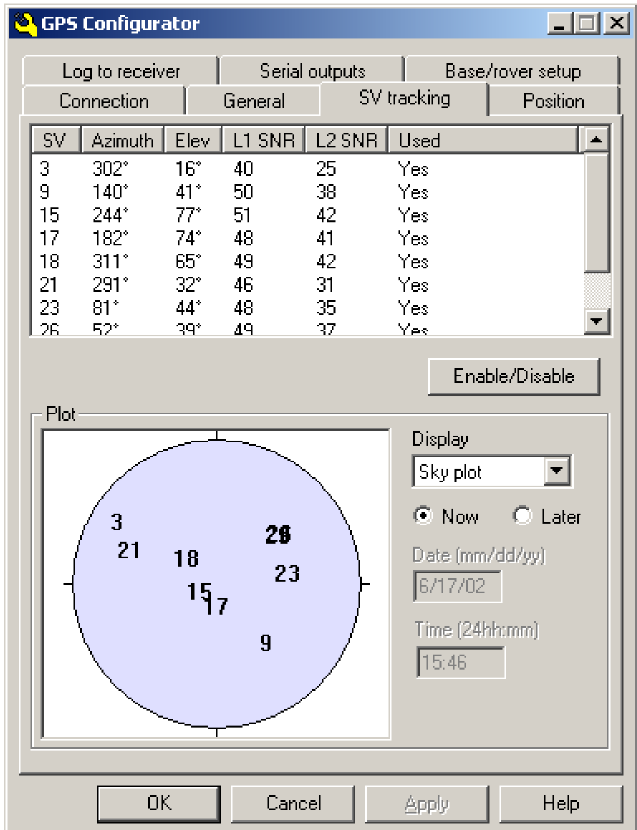


Figure 89: GPS Configurator - SV Tracking Tab

8. Select the **Position** tab (Figure 90).

9. Verify that the settings are similar and then click the **Apply** button.

Note: The coordinate system (datum) must be WGS 1984.

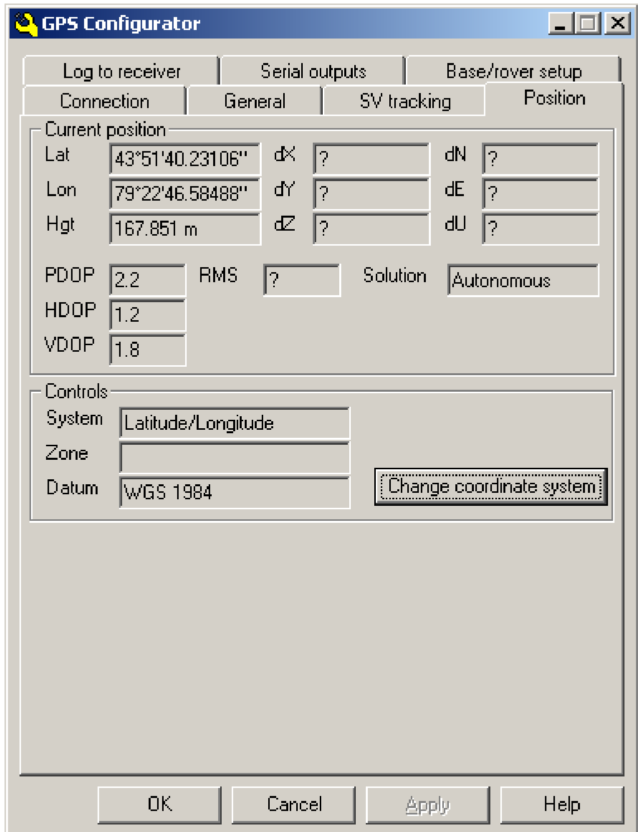


Figure 90: GPS Configurator - Position Tab

10. Select the **Log to receiver** tab (Figure 91).
11. If a compact flash disk is installed in the 5700, raw observables and ephemeris data may be logged on it. Otherwise, the TRS software may be used to log base station data to a PC connected to the 5700.
12. Once selections are made, click the **Apply** button.

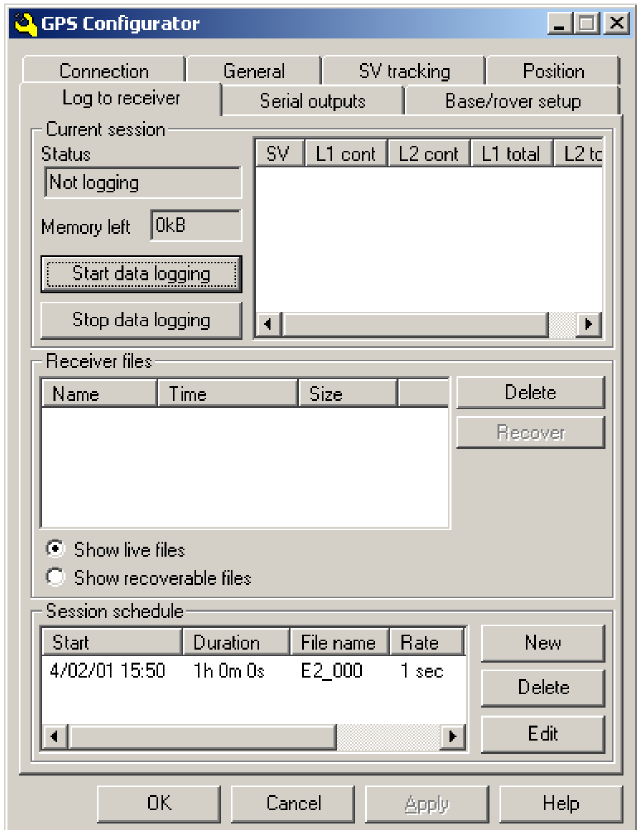


Figure 91: GPS Configurator - Log to Receiver Tab

13. Select the **Serial outputs** tab (Figure 92).

14. In the **Port settings** pane:

    a) Set **Port** to **Port 3**, set **Baud rate** to the fastest setting supported by the modem/radio (in this case 38400), **Parity** is typically set to **None**, **Flow control** is typically set to **None**

b) Set **Port** to **Port 2**, set **Baud rate** to the fastest setting supported by the PC running TRS (57600), set **Parity** to **None**, set **Flow control** to **None**

15. In the **Outputs** pane: do not enable any ports.

16. Once selections are made, click the **Apply** button.

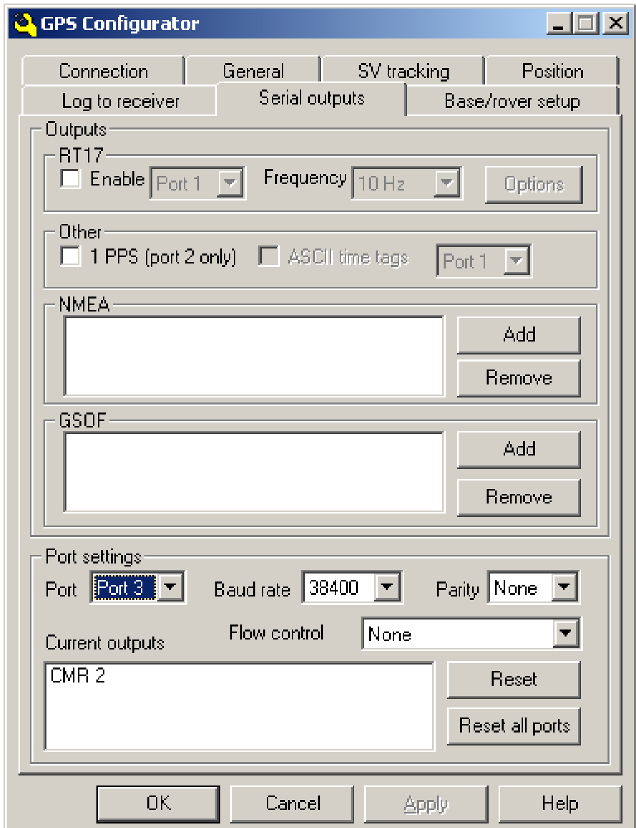


Figure 92: GPS Configurator - Serial Outputs Tab

17. Select the **Base/rover set-up** tab (Figure 93).

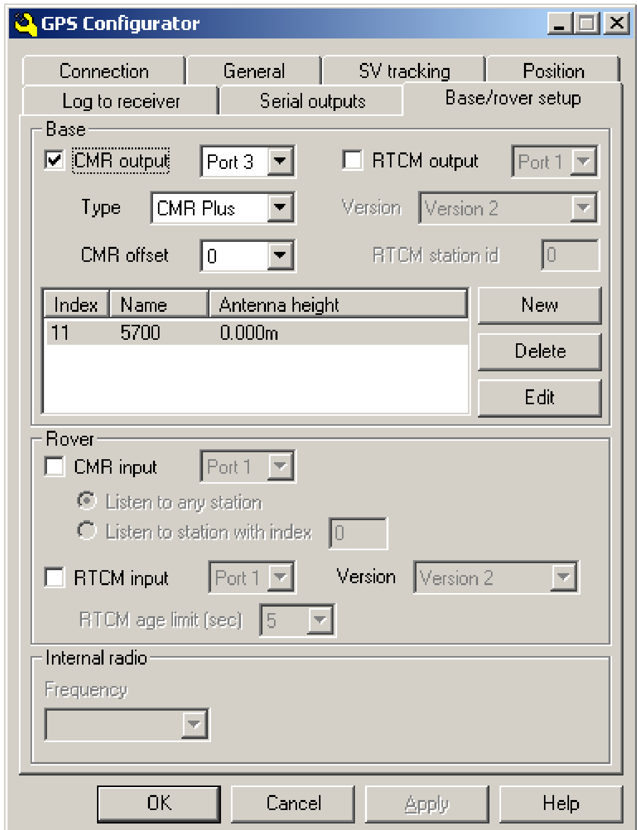


Figure 93: GPS Configurator - Base Rover Set-up Tab

18. In the **Base** pane:

    a) Select **CMR output** and set to **Port 3**, set **Type** to **CMR Plus**, set **CMR offset** to **0**

    b) Do not select **RTCM output**, not recommended due to message size

c) **New** command button - select to display Figure 94. The reference position point must be surveyed. The Latitude, Longitude and Height values must be as accurate as possible. Inaccurate base station coordinates will result in incorrect positions reported by the POS system.

19. In the **Rover** pane (Figure 93): do not select any options.

20. Once selections are made, click the **Apply** button.

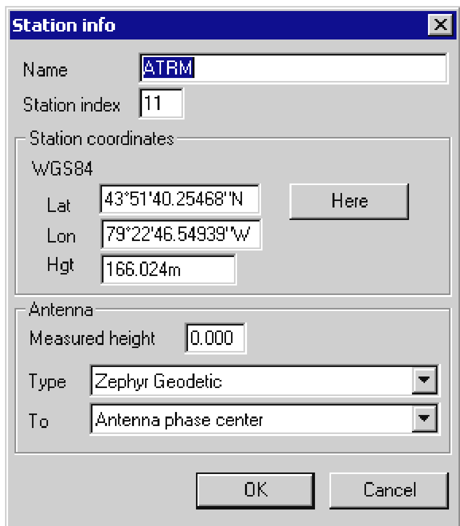


Figure 94: GPS Configurator - Station Info Screen

NovAtel OEM4 RTK Reference Station - Set-up Procedures for POS LV

Set-up and configuration of the NovAtel OEM4 RTK Reference Station may be performed with most terminal communications programs. Screens 2000® ships with HyperTerminal. This program can be accessed through the Help feature on the Screens® Start menu.

HyperTerminal lets the user connect to other computers and serial devices, including the OEM4.

GPS post-processing, ephemeris and range data are logged at the OEM4 base station in binary format. Raw Range is recorded at 1 Hz and Raw Ephemeris is recorded OnChange.

Required Equipment

- NovAtel GPSolution v4.0 software
- Screens® PC with HyperTerminal application

Install Software

1. Power-on the PC and insert the NovAtel GPSolution floppy diskette.
2. Once the software is installed onto the PC, restart the PC.

Hardware Set-up

1. Set-up the GPS hardware as directed by the manufacturer.
2. Connect a serial cable between the PC and the GPS receiver. Record COM port use for future information.
3. Connect a radio/cell phone to a COM port on the GPS receiver. Record COM port use for future information.

Configure OEM4 Receiver

1. Start HyperTerminal and create a COM port profile to connect to the OEM4. Typical settings are 9600 8 n 1.
2. Connect HyperTerminal and confirm that communication is established. Type ‘VER’ and send (Enter key), the receiver returns its version information.

3. Type (into HyperTerminal) the following commands:
   a) For CMR corrections on COM2 (radio/cell phone):

      unlogall

      Undulation user <value>

      fix position <lat> <lon> <alt>

      dgpstxid cmr <id>

      log com2 cmrobs ontime 1

      log com2 cmrref ontime 10

      log com2 cmrdesc ontime 10

      interfacemode com2 none cmr off

      com com2 <baude rate> n 8 1 n n

      saveconfig

   b) For RTCM corrections on COM2:

      unlogall

      Undulation user <value>

      fix position <lat> <lon> <alt>

      dgpstxid rtcm <id>

      log com2 rtcm18 ontime 1

      log com2 rtcm19 ontime 1

      log com2 rtcm3 ontime 10

      interfacemode com2 none rtcm off

      com com2 <baude rate> n 8 1 n n

      saveconfig

Appendix N

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 screw.
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 GPS Configuration

- Refer to Appendix M, GPS 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 GPS configuration (in anyway) while POS LV is operating, especially the Base GPS coordinates
- POS LV may be used with an RTK virtual reference network, DGPS correction service, coastguard beacon or private GPS base station

Base GPS Message Latency

- Does not apply to CA mode
- The choice of radio transmission medium typically affects the GPS 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 the GPS 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 GPS DOP is low - GAMS will not calibrate above a PDOP = 3
- Be patient, calibration will occur faster if the POS LV is well aligned
- Inputting the two antenna separation will speed-up the calibration process
- Calibrate GAMS only under ideal GPS 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 GPS 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 Installation, GAMS Parameter Set-up** screen), refer to Figure 49 on page 9-2

  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 (e.g. the Two Antenna Separation value must be within 2 mm).

- 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 8-18) 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, PC Card Logging, PC Card logging Control** 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

GPS

- Check L1/L2 signal-to-noise ratio
- Check DOP
- Check that the GPS 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 GPS correction faults (**View, Faults, GPS Corr** screen)
- Check Base 1/2 Diagnostic screens (**Diagnostics, Base GPS, 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 GPS receiver:
  - In LV-POSView, select **View, GPS 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 GPS antenna is connected at the ANT1 port - replace with an L1/L2 antenna
- Only GPS 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 GPS 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 GPS 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 GPS 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 GPS reception.
- Static electricity may temporarily interrupt the operation of the PCMCIA drive. Always touch the metal portion of the internal drive case before inserting the PC Card.

Appendix O

Drawings

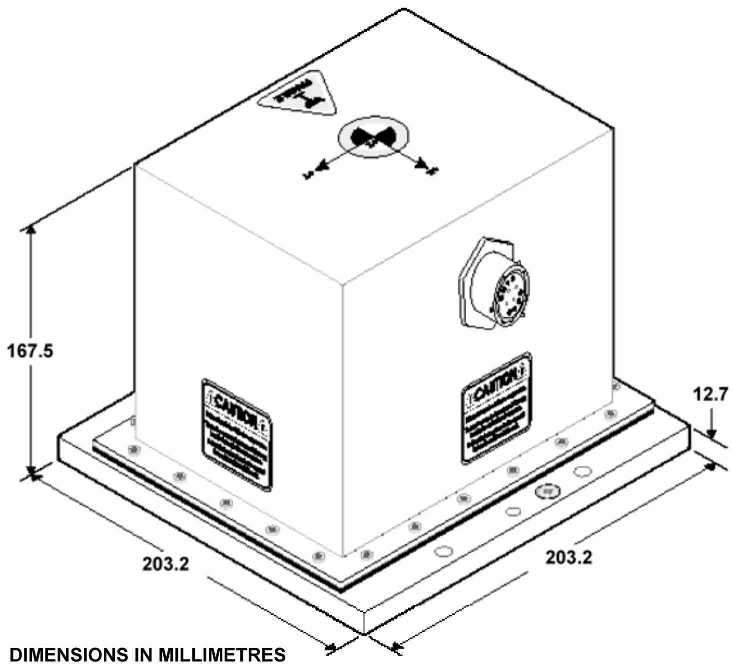


Figure 95: IMU Foot Print

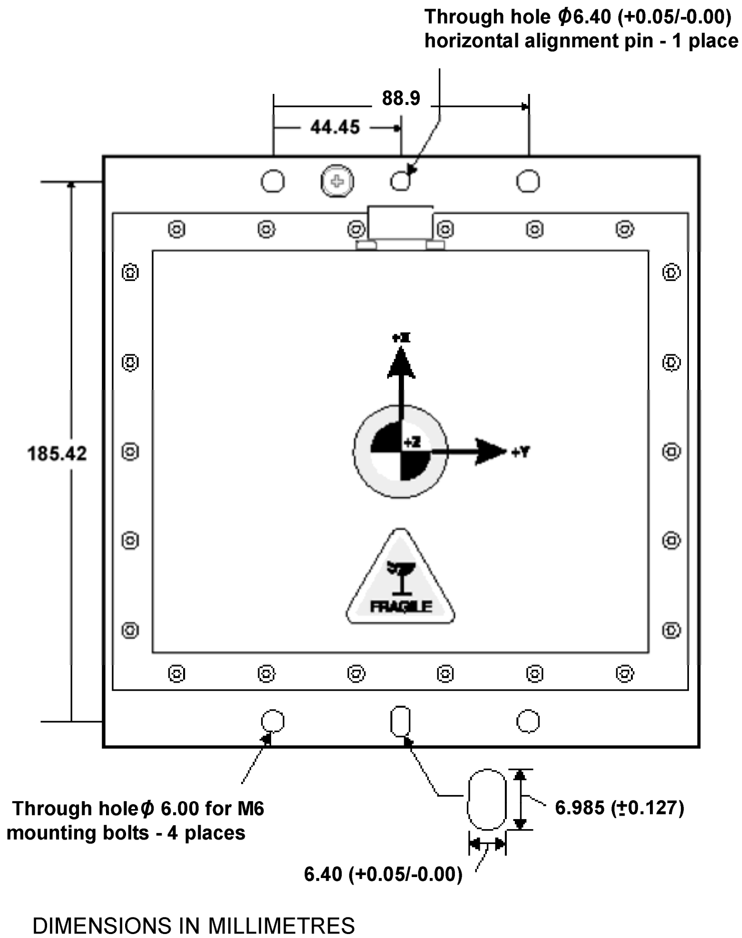


Figure 96: IMU Base Plate Foot Print

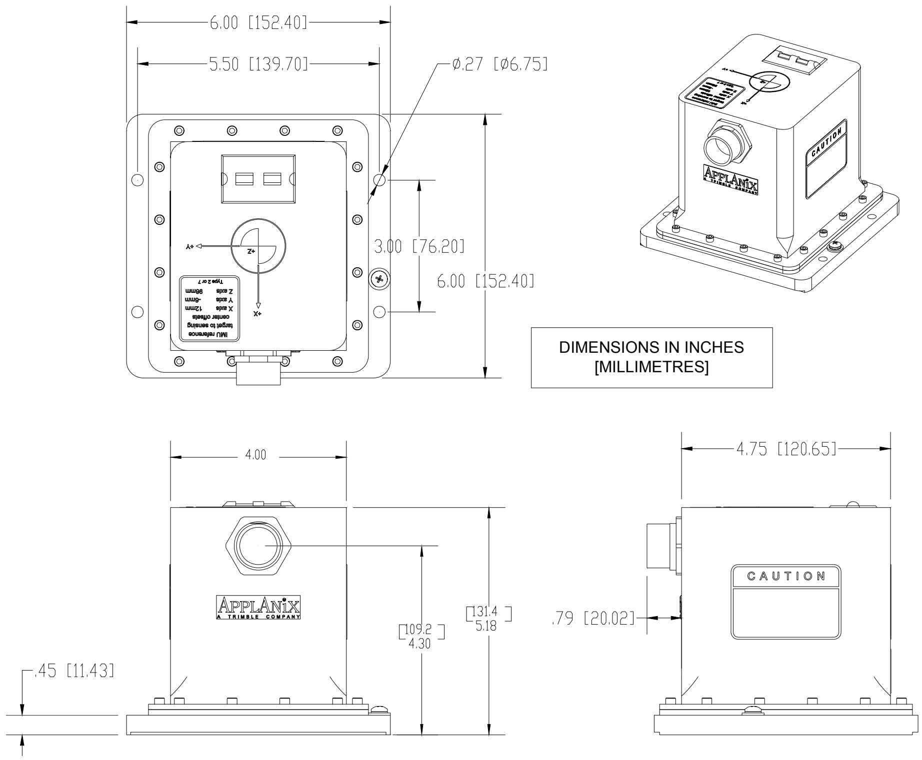


Figure 97: (1 of 2) IMU Type 2 & 7 Outline - Top, Side and Front Views

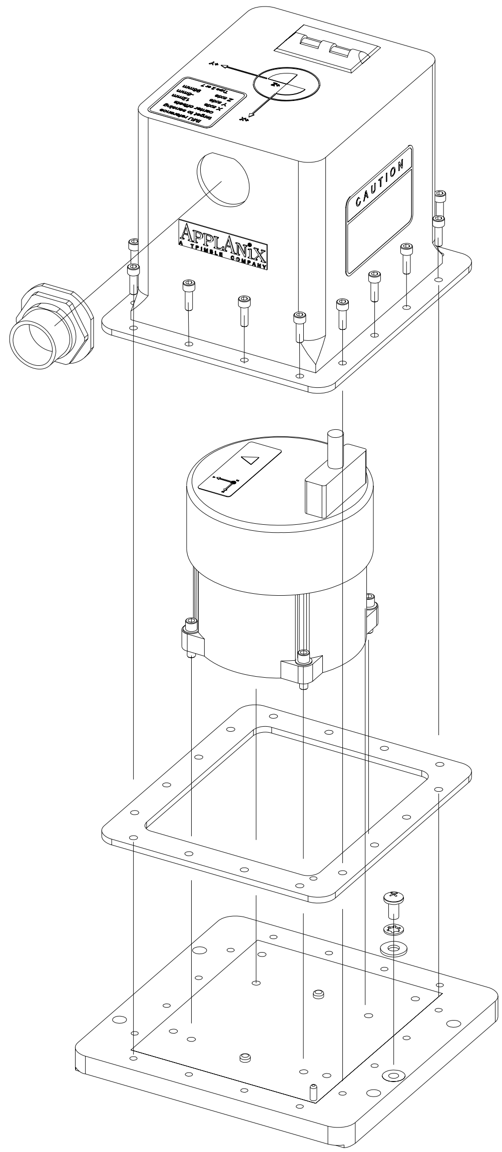


Figure 98: (2 of 2) IMU Type 2 & 7 Construction

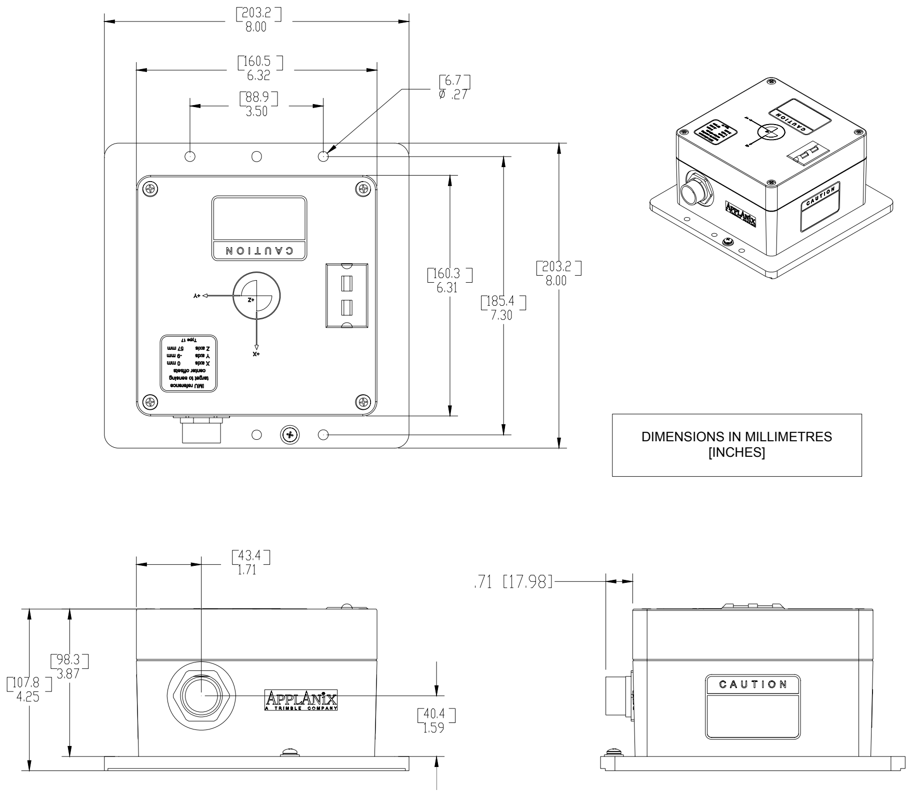


Figure 99: (1 of 3) IMU Type 17 Outline - Top, Side and Front Views

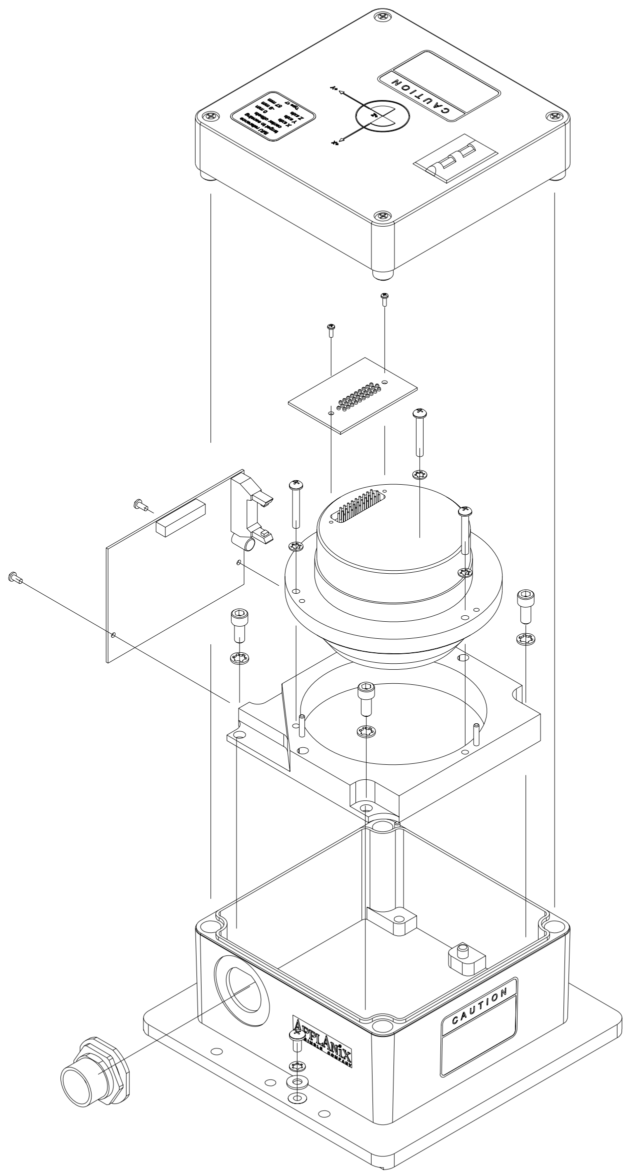


Figure 100: (2 of 3) IMU Type 17 Construction

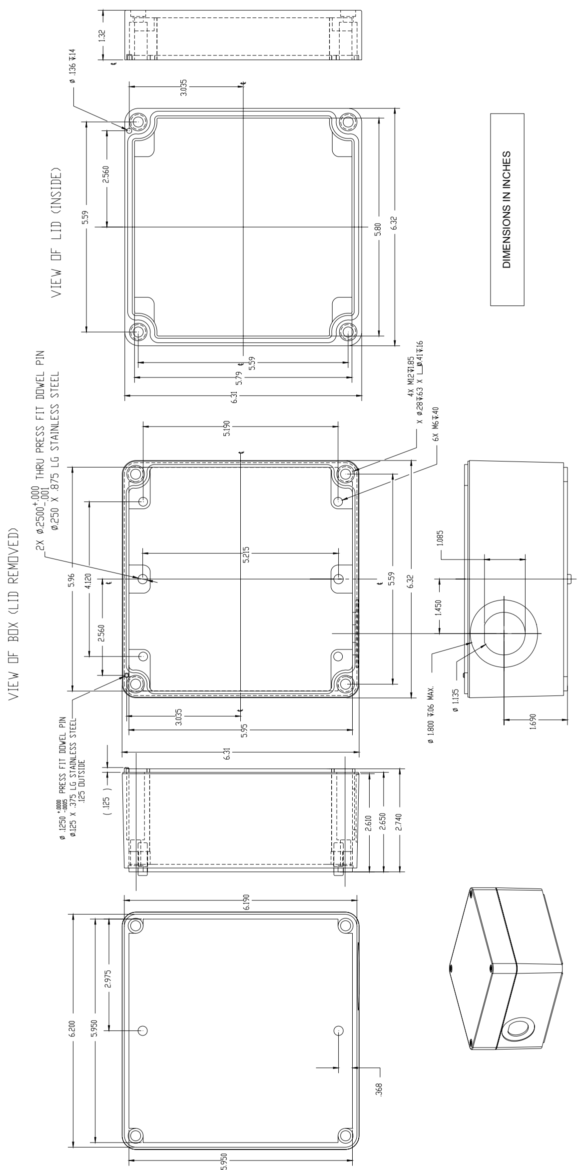


Figure 101: (3 of 3) IMU Type 17 Enclosure

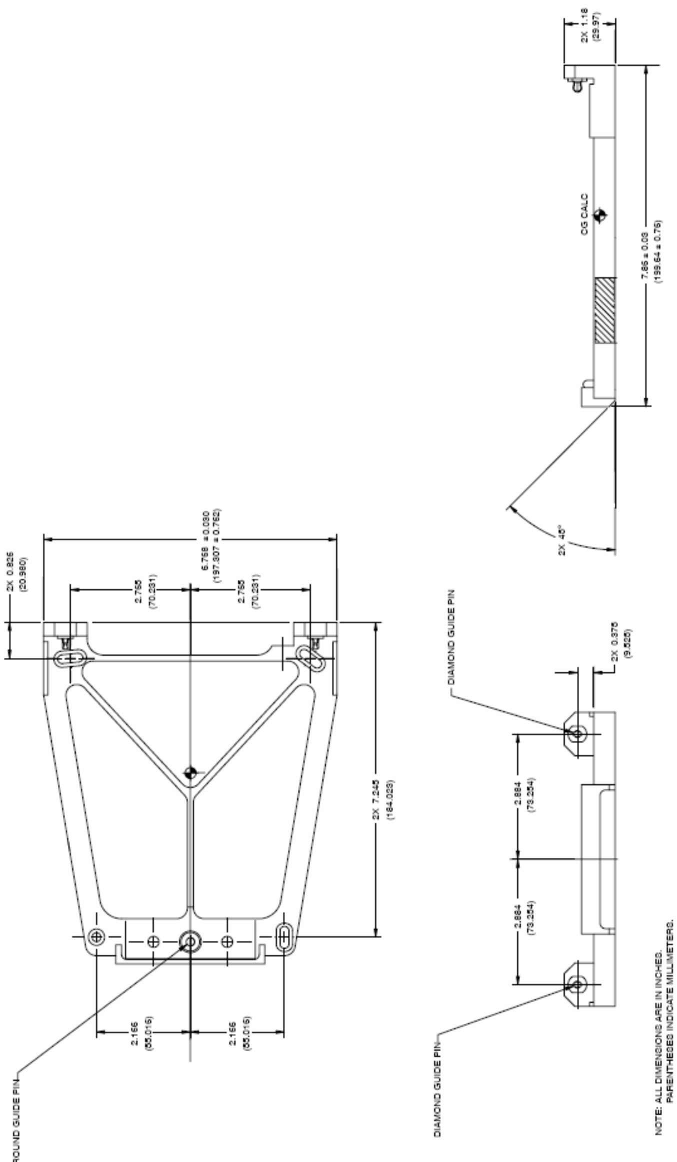


Figure 102: IMU Type 21 Mounting Tray Outline

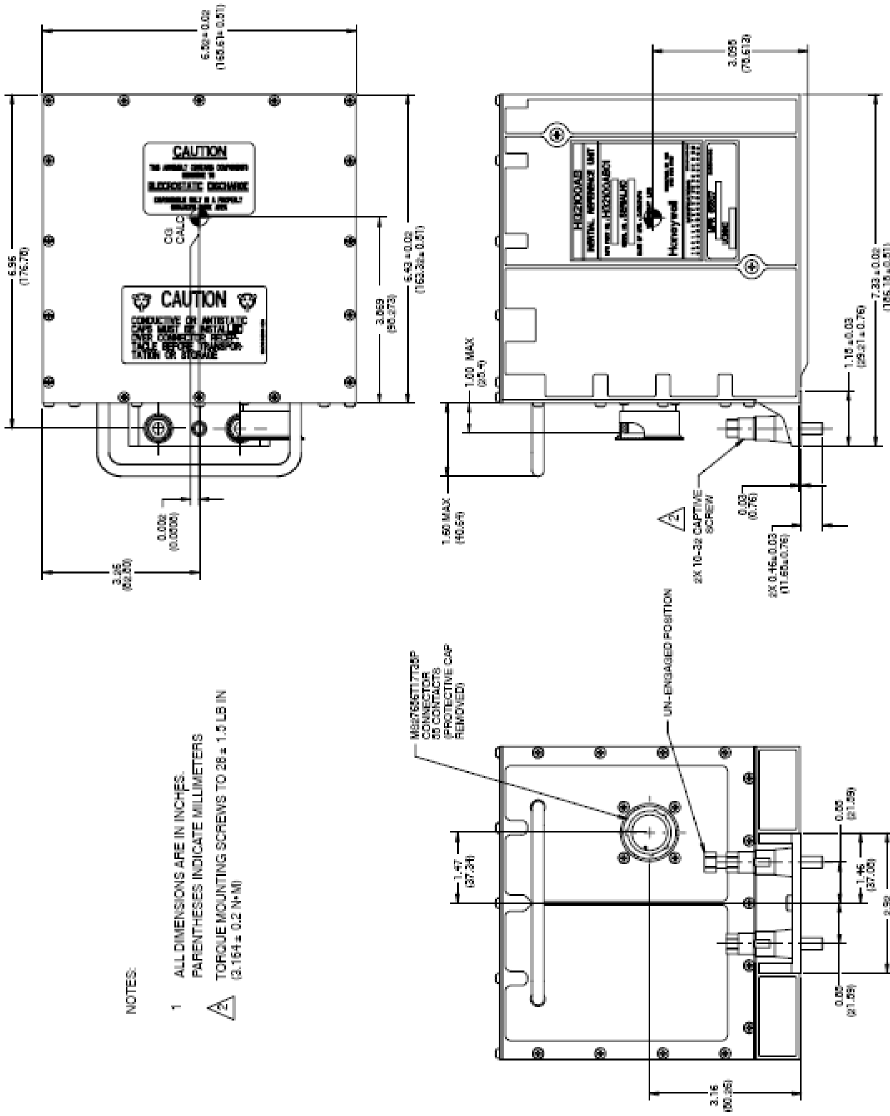
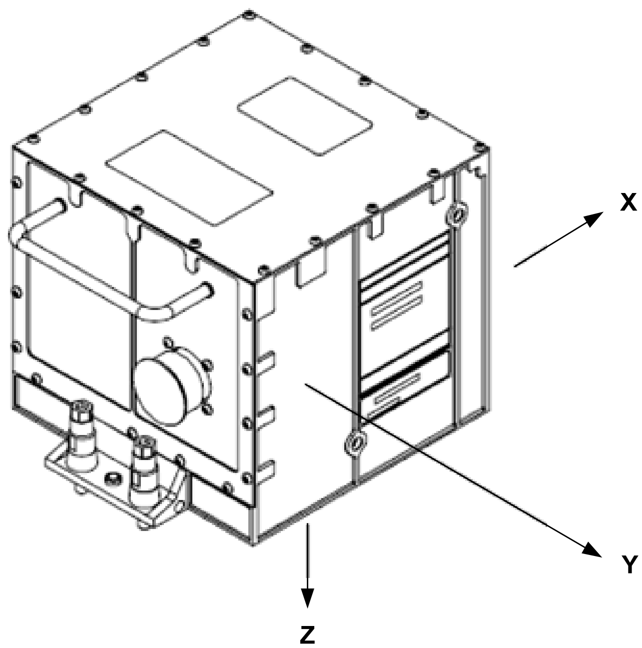


Figure 103: (1 of 4) IMU Type 21 Outline - Top, Side and Front Views



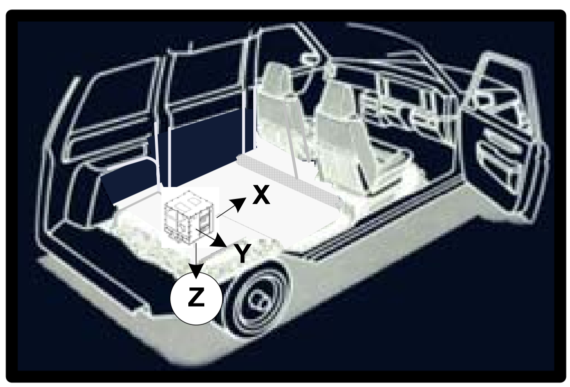


Figure 104: (2 of 4) IMU Type 21 Outline - Rear View

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.

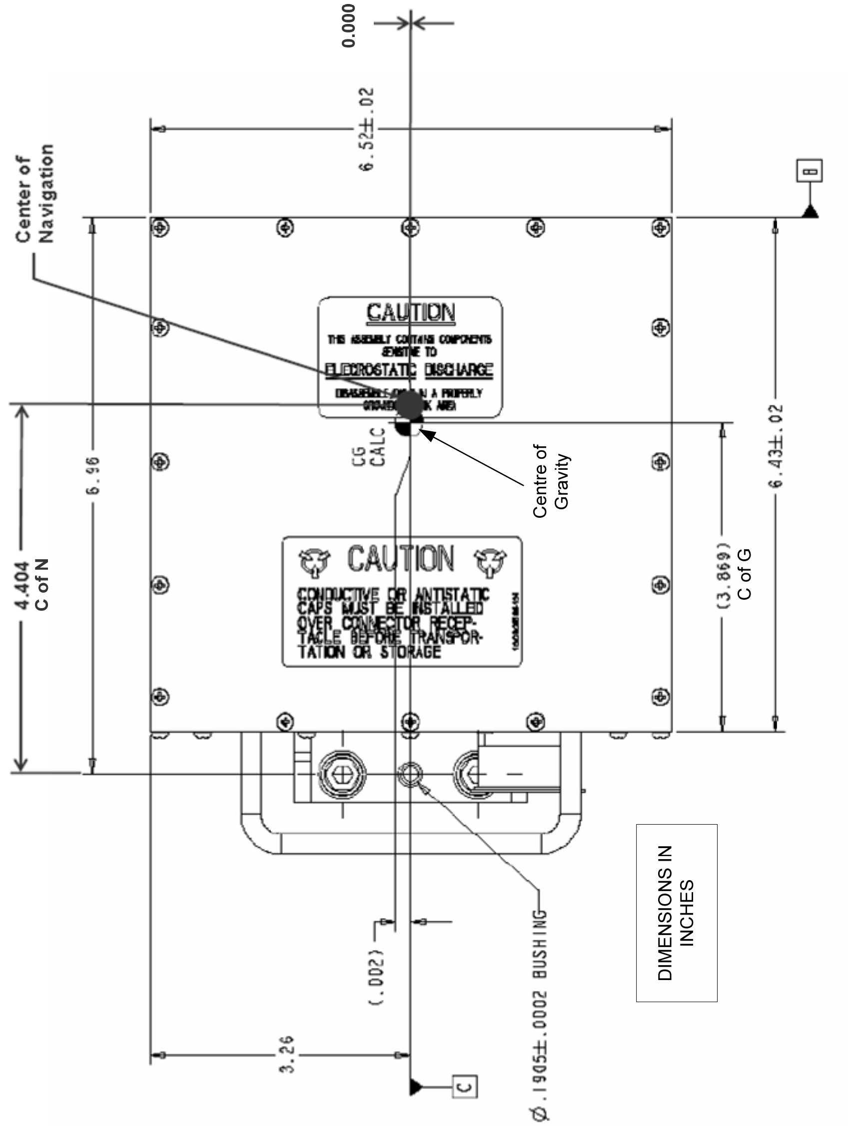


Figure 105: (3 of 4) IMU Type 21 Sensing Centre Diagram

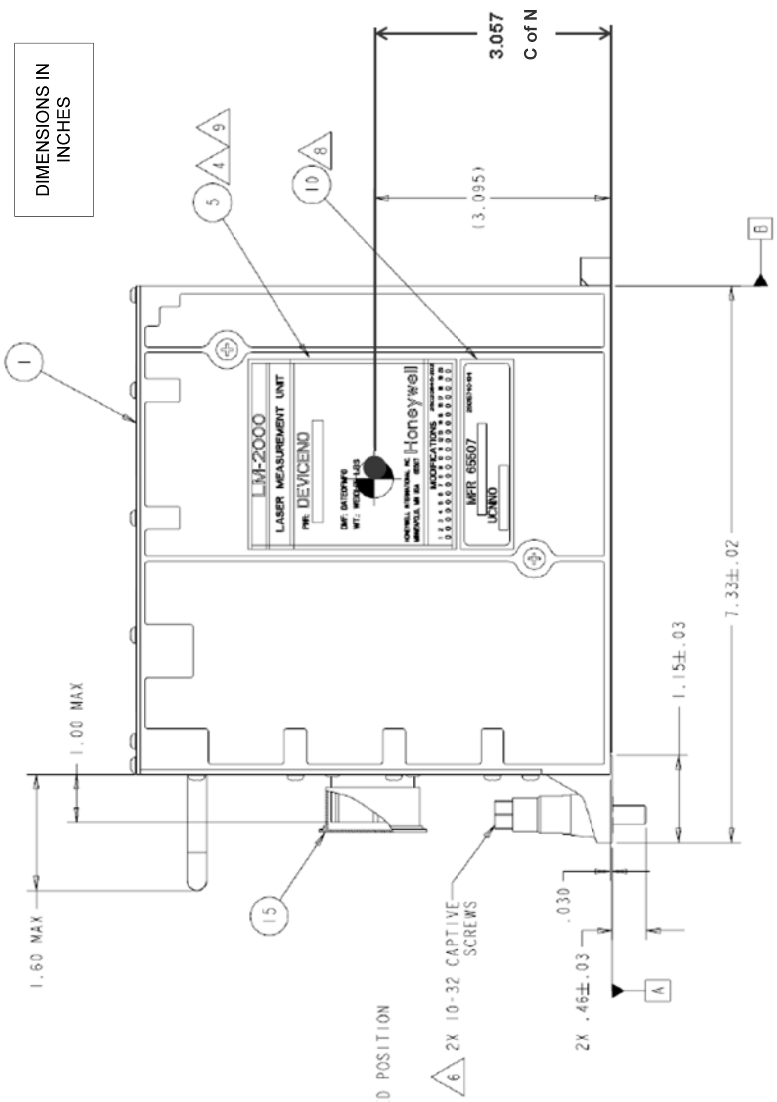


Figure 106: (4 of 4) IMU Type 21 Sensing Centre Diagram

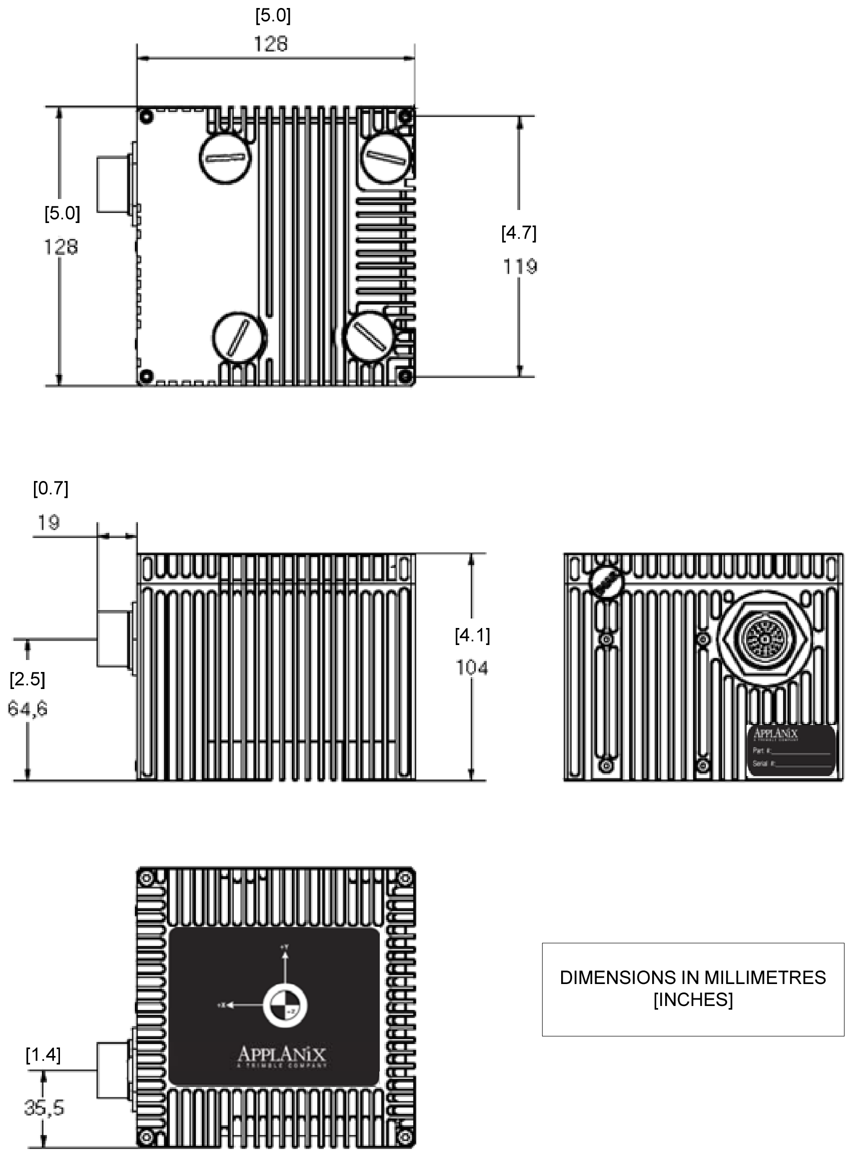


Figure 107: (1 of 4) IMU Type 26 Outline Diagram

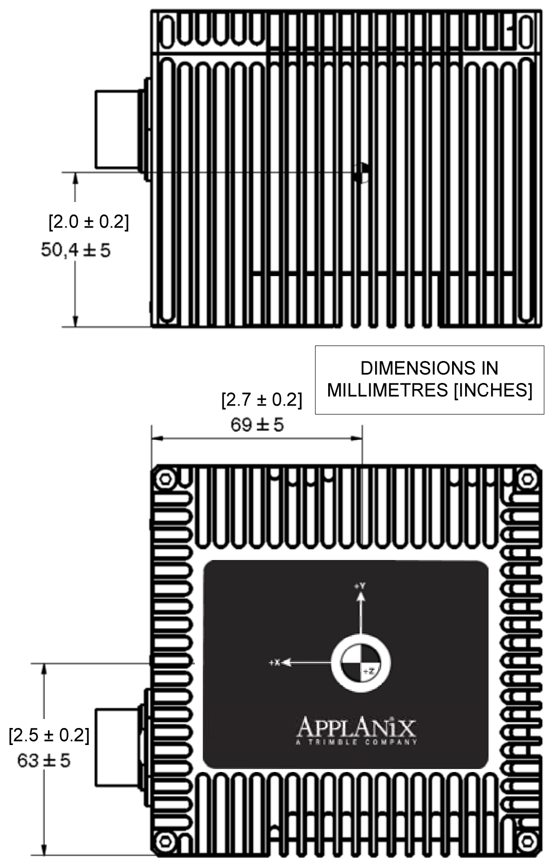


Figure 108: (2 of 4) IMU Type 26 Sensing Centre Diagram

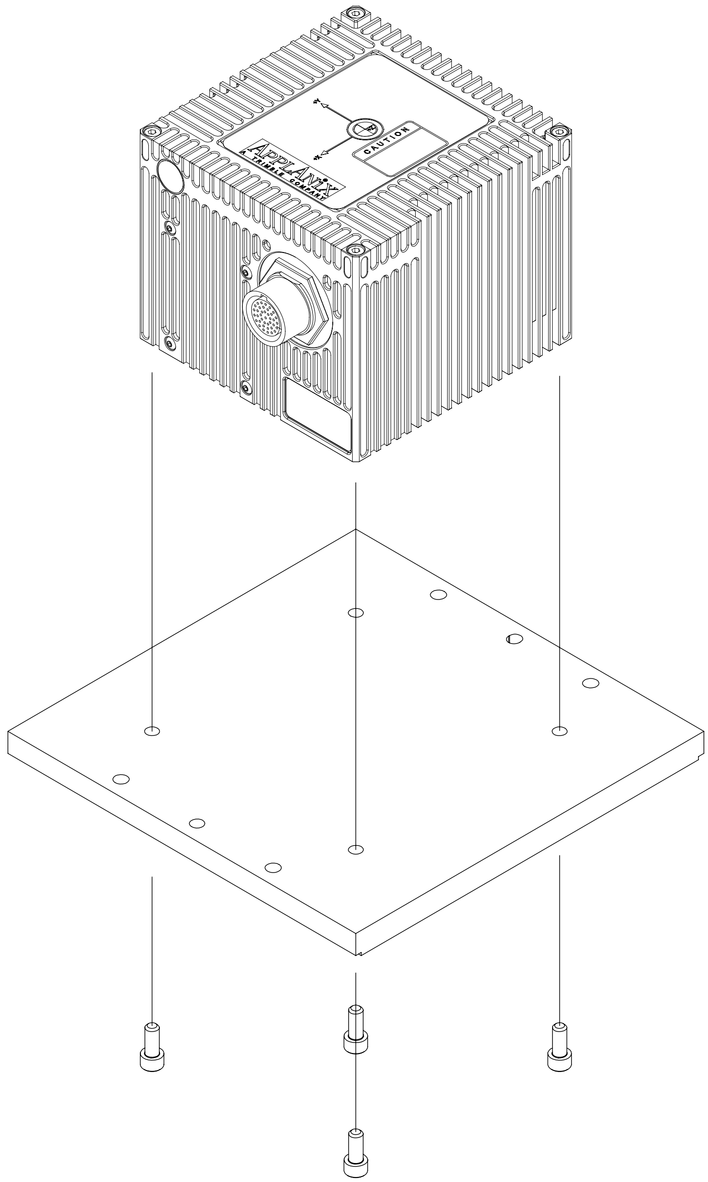


Figure 109: (3 of 4) IMU Type 26 Adapter Plate

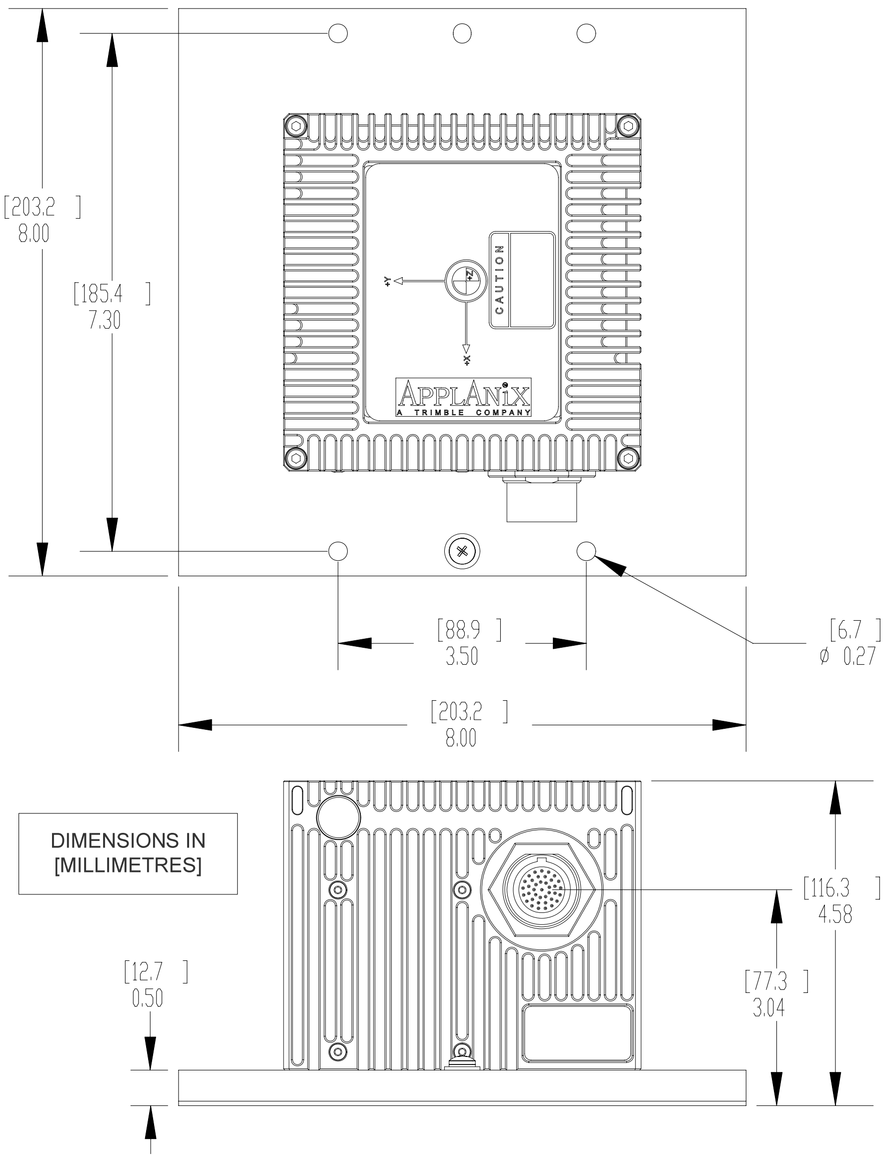


Figure 110: (4 of 4) IMU Type 26 Dimensions

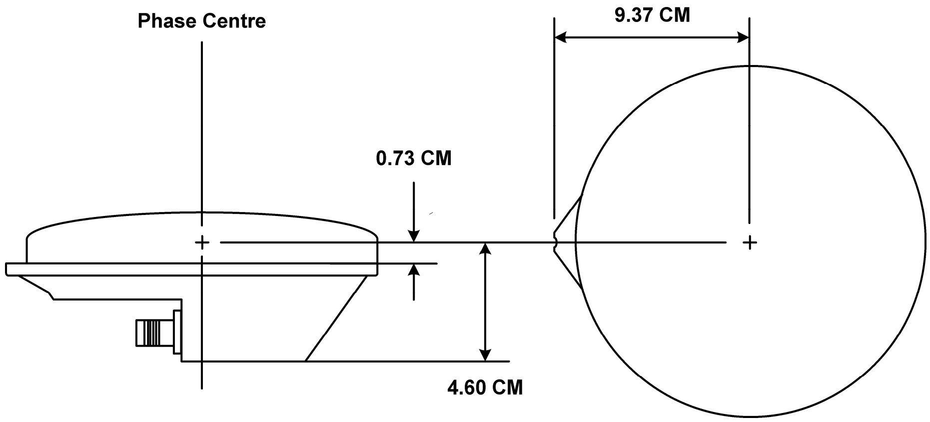
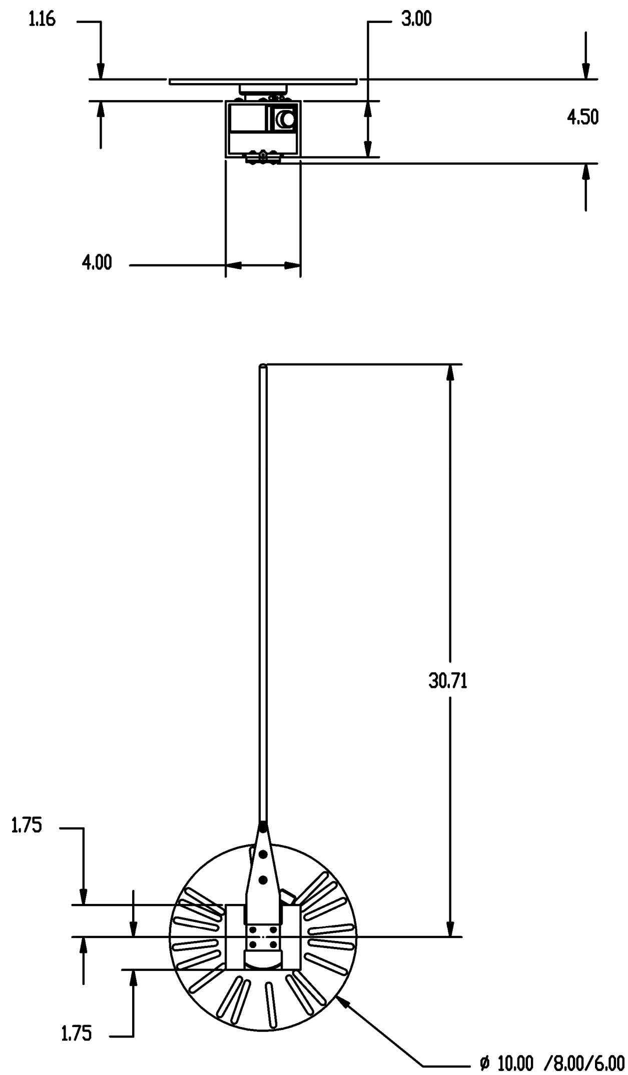


Figure 111: GPS Antenna Foot Print



DIMENSIONS IN INCHES

Figure 112: DMI Foot Print

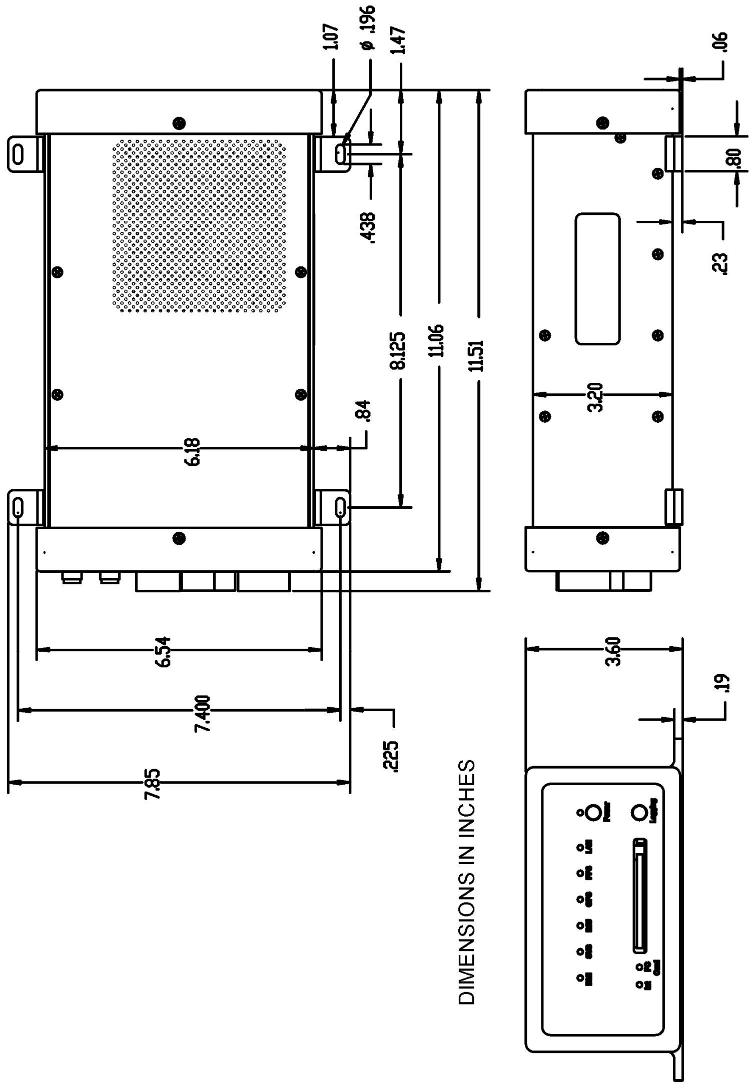


Figure 113: PCS Foot Print

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:

$$\frac{change\ in\ angle}{duration\ of\ \ angle\ change}.$$

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 GPS 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 GPS 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 GPS 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 Marine Electronics Association. NMEA is a standard for interfacing electronic devices. This standard includes the definition of specific message formats.

PC Card

A PC Card disk is a high-capacity, portable storage medium. PC Cards interface with PC Card drives.

PCMCIA

Personal Computer Memory Card International Association. The PCMCIA defines standards that govern PCMCIA cards. This is a subset of the newer PC Card standard.

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.

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).

Index

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