



POS MV V5 Installation and Operation Guide

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Revision 25

General Notice

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This manual describes the POS MV™ V5 and V5-1 in detail and contains full installation and operating instructions. This manual is an important part of the system and should remain with the installation.

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

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Liability and Safety Information



Important: All cables connected to the POS MV V5, POS MV V5-1 and POS MV V5-2 equipment shall be constructed of (in order of preference): a) halogen free, b) low smoke and c) high temperature materials.



CAUTION

DOUBLE POLE/NEUTRAL FUSING

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 supplies 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.

Power Cord - Applanix ships a specially constructed power cord with its POS MV V5 ac products and is detailed in Appendix E . Otherwise, the customer is responsible for supplying and using a compliant power cord. Ensure that the destination country electrical codes are adhered to. Applanix recommends an ac power cord not exceeding 2 m (6 ½ ft) in length and that can safely handle a maximum of 10 A.

Regulatory Information



Caution: Do not make mechanical or electrical modifications to the POS MV 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: Power Cord, GNSS antennas, GNSS antenna cables, Ethernet cable, IMU, IMU cable and RS-232 serial cables.



Notice: POS MV V5, POS MV V5-1 and POS MV V5-2 are not certified to EN 60945 standard and therefore cannot be used for maritime navigation as defined by EN 60945. POS MV cannot be installed near bridge-mounted equipment, in close proximity to receiving antennas, or anywhere it could be capable of interfering with safe navigation of the ship and with radio-communications.

CE DECLARATION OF CONFORMITY

Manufacturer's Name: Applanix Corporation

Manufacturer's Address: 85 Leek Crescent
Richmond Hill, Ontario, Canada L4B 3B3

EC Representative's Name: Applanix Corporation

EC Representative's Address: 85 Leek Crescent
Richmond Hill, Ontario, Canada L4B 3B3

Equipment Model Designation: POS MV V5

Equipment Description: POS MV is a fully integrated, turnkey
position and orientation system for Marine
vessels.

Applicable Equipment Part Numbers: PCS-80

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

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

CE DECLARATION OF CONFORMITY

Manufacturer's Name: Applanix Corporation

Manufacturer's Address: 85 Leek Crescent
Richmond Hill, Ontario, Canada L4B 3B3

EC Representative's Name: Applanix Corporation

EC Representative's Address: 85 Leek Crescent
Richmond Hill, Ontario, Canada L4B 3B3

Equipment Model Designation: POS MV V5-1

Equipment Description: POS MV is a fully integrated, turnkey position and orientation system for Marine vessels.

Applicable Equipment Part Numbers: PCS-76

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

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

CE DECLARATION OF CONFORMITY

Manufacturer's Name: Applanix Corporation
Manufacturer's Address: 85 Leek Crescent
Richmond Hill, Ontario, Canada L4B 3B3
EC Representative's Name: Applanix Corporation
EC Representative's Address: 85 Leek Crescent
Richmond Hill, Ontario, Canada L4B 3B3
Equipment Model Designation: POS MV V5
Equipment Description: POS MV is a fully integrated, turnkey position and orientation system for marine vessels.
Applicable Equipment Part Numbers: PCS-84

Application of Council Directives:

2006/95/EC on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits.

Referenced Standard:

EN 60950-1: 2006 with Amendments: A11:2009, A1:2010, A12:2011

2004/108/EC on the approximation of the laws of the Member States relating to electromagnetic compatibility.

Referenced EMC Standards:

EN 55022: 2010 (Class A)

EN 55024: 2010

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

Referenced RoHS Standard:

EN 50581:2012

DECLARATION OF CONFORMITY

Manufacturer's Name: Applanix Corporation

Manufacturer's Address: 85 Leek Crescent, Richmond Hill
Ontario, Canada, L4B 3B3

EC Representative's Name: Applanix Corporation

EC Representative's Address: 85 Leek Crescent, Richmond Hill
Ontario, Canada, L4B 3B3

Equipment Model Designation: POS MV V5-1

Equipment Description: POS MV V5-1 is a fully integrated, turnkey position and orientation system for marine vessels.

Applicable Equipment part numbers: PCS-86

We, Applanix Corporation, declare under sole responsibility of the manufacturer, that the product to which this declaration refers conforms with the relevant standards or other standardizing documents according to the essential requirements set out in Article 3 of the Radio Equipment Directive 2014/53/EU. Furthermore, the above-mentioned product conforms to Directive 2014/35/EU, RoHS Directive 2011/65/EU and WEEE Directive 2012/19/EU.

Article of Directive 2014/53/EU	Harmonized Standard Reference
3.1a Electrical safety of the user	EN 60950-1:2006/A2:2013
3.1b Electromagnetic compatibility	ETSI EN 301 489-1 V2.1.1; EN 301 489-19 V2.1.0
3.2 Radio spectrum efficiency	EN 303 413 v1.1.1 (BD982 GNSS Receiver)

CE DECLARATION OF CONFORMITY

Manufacturer's Name: Applanix Corporation

Manufacturer's Address: 85 Leek Crescent,
Richmond Hill Ontario,
Canada, L4B 3B3

EC Representative's Name: Applanix Corporation

EC Representative's Address: 85 Leek Crescent,
Richmond Hill Ontario,
Canada, L4B 3B3

Equipment Model Designation: POS MV V5

Equipment Description: uPOS 19" RM, Dual BD992 GNSS is a fully
integrated, turnkey position and orientation
system for Marine vehicles.

Applicable Equipment part numbers: PCS-100

We, Applanix Corporation, declare under sole responsibility of the manufacturer, that the product to which this declaration refers conforms to the relevant standards or other standardizing documents according to the essential requirements set out in Article 3 of the Radio Equipment Directive 2014/53/EU. Furthermore, the above-mentioned product conforms to EMC Directive 2014/35/EU, LVD Directive 2014/35/EU, RoHS Directive 2011/65/EU and WEEE Directive 2012/19/EU.

Article of Directive 2014/53/EU	Harmonized Standard Reference
3.1a Electrical safety of the user	EN 60950-1 Ed. 2 and EN 62368-1
3.1b Electromagnetic compatibility	ETSI EN 301 489-1 V2.1.1; EN 301 489-19 V2.1.0
3.2 Radio spectrum efficiency	EN 303 413 v1.1.1, EN 300 487 V2.1.2 and EN 300 440 V2.1.2 (BD992 GNSS Receiver)

CE DECLARATION OF CONFORMITY

Manufacturer's Name: Applanix Corporation

Manufacturer's Address: 85 Leek Crescent,
Richmond Hill Ontario,
Canada, L4B 3B3

EC Representative's Name: Applanix Corporation

EC Representative's Address: 85 Leek Crescent,
Richmond Hill Ontario,
Canada, L4B 3B3

Equipment Model Designation: POS MV V5-1

Equipment Description: POS MV V5-1 is a fully integrated, turnkey
position and orientation system for Marine
Vehicles.

Applicable Equipment part numbers: PCS-101

We, Applanix Corporation, declare under sole responsibility of the manufacturer, that the product to which this declaration refers conforms to the relevant standards or other standardizing documents according to the essential requirements set out in Article 3 of the Radio Equipment Directive 2014/53/EU. Furthermore, the above-mentioned product conforms to EMC Directive 2014/35/EU, LVD Directive 2014/35/EU, RoHS Directive 2011/65/EU and WEEE Directive 2012/19/EU.

Article of Directive 2014/53/EU	Harmonized Standard Reference
3.1a Electrical safety of the user	EN 60950-1 Ed. 2 and EN 62368-1
3.1b Electromagnetic compatibility	ETSI EN 301 489-1 V2.1.1; EN 301 489-19 V2.1.0
3.2 Radio spectrum efficiency	EN 303 413 v1.1.1, EN 300 487 V2.1.2 and EN 300 440 V2.1.2 (BD992 GNSS Receiver)

CE DECLARATION OF CONFORMITY

Manufacturer's Name: Applanix Corporation

Manufacturer's Address: 85 Leek Crescent
Richmond Hill, Ontario, Canada L4B 3B3

EC Representative's Name: Applanix Corporation

EC Representative's Address: 85 Leek Crescent
Richmond Hill, Ontario, Canada L4B 3B3

Equipment Model Designation: POS MV V5-2

Equipment Description: POS MV is a fully integrated, turnkey position and orientation system for Marine vessels.

Applicable Equipment Part Numbers: PCS-92

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

Referenced Safety Standards:

**EN 60950-1:2006 with Amendment
A2:2013**

Referenced EMC Standards:

**EN 55022:2010 (Class B) / CISPR 22:2008
EN 55024:2010 / CISPR 24:2010**

FCC Section 15.21 Information to the user.

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

FCC Section 15.105 Information to the user.

FCC Class A Notice

PCS-84 and PCS-100 complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

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

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 it is not installed and used in accordance with the instruction manual, it 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.

Modifications: Any modifications made to this device that are not approved by Applanix Corporation may void the authority granted to the user by the FCC to operate this equipment.

FCC Class B Notice

PCS-76, PCS-80 and PCS-92 complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

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

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/television technician for help.

Modifications: Any modifications made to this device that are not approved by Applanix Corporation may void the authority granted to the user by the FCC to operate this equipment.

Industry Canada

This Class B digital apparatus (PCS-76, PCS-80 and PCS-92) complies with Canadian ICES-003.
Cet appareil numérique (PCS-76, PCS-80 et PCS-92) de la classe B est conforme à la norme NMB-003 du Canada.

This Class A digital apparatus (PCS-84, PCS-100 and PCS-101) complies with Canadian ICES-003.
Cet appareil numérique (PCS-84, PCS-100 et PCS-101) de la classe A est conforme à la norme NMB-003 du Canada

VCCI (FOR PCS-76, PCS-80 and PCS-92)

この装置は、クラスB情報技術装置です。この装置は、家庭環境で使用することを目的としていますが、この装置がラジオやテレビジョン受信機に近接して使用されると、受信障害を引き起こすことがあります。

取扱説明書に従って正しい取り扱いをして下さい。 VCCI-B

VCCI (FOR PCS-84, PCS-100 and PCS-101)

この装置は、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。 VCCI-A

Australian/New Zealand Standard

POS MV V5-2 (PCS-92) digital apparatus complies with AS/NZS CISPR 22: 2009.

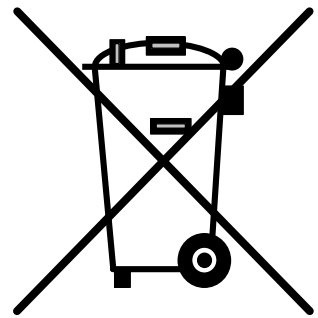
POS MV V5 and V5-1 (PCS-100 and PCS-101) digital apparatus complies with VCCI-CISPR 32: 2016.

For Our European Union Customers the WEEE Recycling Program

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

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

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



About This Document







Text Conventions

The following text conventions are used in this manual:

- Emphasize a term - italic font or bold italic font (e.g. 'An *Inertial Frame* is' or 'An ***Inertial Frame*** is'); a mixture is acceptable but, consistency is preferable
- Referring to another manual or to a file name - italic font (e.g. 'read the *Power Requirements* manual' 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. 'press the **OK** button')
- Path statement - bold font (e.g. 'select **C:\My Computer\ Working Files\Fields**')
- Menu statement - bold font (e.g. 'select **Insert, AutoText, Closing** window menu' or 'select **Insert | AutoText | Closing** window menu'); a mixture is acceptable but, consistency is preferable
- Web address statement - bold font (e.g. 'select **<http://www.applanix.com>** from')

Symbols

The following symbols appear in this manual:

	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

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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
BNC	Bayonet Neil-Concelman (British Naval Connector)
bps	Bits Per Second
C/A	Coarse Acquisition
CD	Compact Disk
cm	Centimetre
CTS	Clear to Send
dB	Decibel
dc	Direct Current
DCM	Direction Cosine Matrix
deg	Degree (plane angle)
DGNSS	Differential Global Navigation Satellite System
dia	Diameter
DOP	Dilution of Position
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FDIR	Fault Detection, Isolation and Reconfiguration
ft	Foot
g	Gravity (acceleration due to gravity)
GAMS	GNSS Azimuth Measurement Subsystem
GB	Gigabyte
GMT	Greenwich Mean Time
GND	Ground
gnd	Ground
GNSS	Global Navigation Satellite System

GUI	Graphical User Interface
HDOP	Horizontal Dilution Of Precision
hex	Hexadecimal
hr	Hour
Hz	Hertz
I/O	Input/Output
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMU	Inertial Measurement Unit
in	Inch
INS	Inertial Navigation System
I/P	Input
IP	Ingress Protection
IP	Internet Protocol
kb	Kilobit
kB	Kilobyte
kbps	Kilobits Per Second
kHz	Kilohertz
LAN	Local Area Network
lb	Pound (weight)
LWH	Length, Width, Height
m	Metre
mA	Milliampere
Mb	Megabit
MB	Megabyte
MHz	Megahertz
mm	Millimetre
mPOS	Mini-Position and Orientation System
N/A	Not Applicable
N/C	No Connection
NED	North, East and Down
NMEA	National Marine Electronics Association

NRG	No Range Given
NVM	Non-Volatile Memory
O/P	Output
OTF	On-the-Fly
PC	Personal Computer
PCS	POS Computer system
PDOP	Positional Dilution of Precision
POS	Position and Orientation system
POS MV	Position and Orientation System for Marine Vessels
POSPac	Position and Orientation Post Processing Package
PPS	Pulse Per Second
pwr	Power
QC	Quality Control
qty	Quantity
RAM	Random Access Memory
RD	Receive Data
RFI	Radio Frequency Interference
RH	Relative Humidity
RMS	Root Mean Square
RTCM	Radio Technical Commission for Maritime Services
RTK	Real-Time Kinematic
RTS	Ready to Sent
RX	Receive Data
s	Second (time interval)
SAE	Society of Automotive Engineers
SI	System of Units
SNR	Signal-To-Noise Ratio
SV	Space Vehicle
sync	Synchronous
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TNC	Threaded-Neill-Concelman (Threaded Navy Connector)

TOV	Time of Validity
TR	Terminal Ready
TTL	Transistor-Transistor Logic
UDP	Universal Datagram Protocol
UNC	Unified National Coarse (Screw Thread)
UPS	Uninterrupted Power Supply
UTC	Universal Time Coordinated (or Coordinated Universal Time)
TX	Transmit Data
Vac	Volt Alternating Current
Vdc	Volt Direct Current
VDOP	Vertical Dilution of Precision
W	Watt

1.0 Introduction

The Applanix POS MV is a Position and Orientation System for Marine Vessels using a system that provides accurate navigation and attitude data for use by equipment on board the vessel, such as multibeam sonar, to correct for the effects of vessel motion during survey operations.

This manual contains full installation and operating instructions for the V5 generation of POS MV and is an important part of the system. The manual should remain easily available for use by those who will install, operate and maintain the system.

Installation and operation of POS MV are not complex tasks. However, you should spend time to familiarize yourself with the contents of this manual before you start to install or use the system.

Provided you follow the installation, operation and maintenance instructions included throughout this manual, POS MV will operate reliably and supply measurements to its specified accuracy.

Unless otherwise stated, the units used throughout this manual conform to the SI International system of units.

Operators who intend to write their own Ethernet software or data extraction software should contact Applanix for additional information on the POS MV V5 Ethernet interface. Refer to Technical Support and Service on page A-1 for contact procedures.

System Description and Overview

Each POS MV system consists of a POS Computer System (PCS) with two embedded Global Navigation Satellite System (GNSS) receivers, two GNSS antennas and an Inertial Measurement Unit (IMU).

The PCS has three versions:

POS MV V5 - a 19-inch Rack Mount (RM) chassis, 1U high, ac powered.

POS MV V5-1 - a Small Form Factor (SFF) chassis, dc powered.

POS MV V5-2 – a Small Form Factor (SFF) chassis with embedded IMU, dc powered

Shown in Figure 1 and detailed in Appendix E are the typical components of a POS MV system.

POS MV V5 Installation and Operation Guide

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Figure 1: Typical POS MV Components

The POS MV delivers an accurate and comprehensive data set, including:

- Geographic position (latitude, longitude and altitude)
- Heading
- Attitude (roll and pitch)
- Vertical displacement (heave)
- Velocity
- Acceleration
- Angular rate of turn
- Performance metrics
- Fault detection and reporting

POS MV combines the IMU and GNSS sensor data into an integrated navigation solution. There are two navigation algorithm designs incorporated into the system, namely *tightly coupled* and *loosely coupled* inertial/GNSS integration. Tightly coupled inertial/GNSS integration involves the processing of GNSS pseudorange, phase and Doppler observables. In this case, the GNSS receiver is strictly a sensor of the

GNSS observables and the navigation functions in the GNSS receiver are not used. With loosely coupled inertial/GNSS integration, the GNSS position and velocity solution are processed to aid the inertial navigator.

POS MV employs tightly coupled integration to enhance performance, especially rapid Real-Time Kinematic (RTK) recovery after a loss of GNSS signal reception. Depending on the availability and relative quality of sensor inputs such as the primary GNSS, auxiliary GNSS and base station GNSS corrections, POS MV will automatically switch between tightly coupled and loosely coupled algorithms to ensure maximum performance.

With its use of leading-edge technology, POS MV marks a significant breakthrough in the field of aided inertial navigation and precision motion measurement for use in marine applications. The accuracy and stability of measurements delivered by the system remain unaffected by vessel turns, changes of speed, wave-induced motion, or other dynamic manoeuvres.

Therefore, by using POS MV, you can continue survey operations during poor weather and throughout deteriorating sea conditions. This allows a more efficient use of survey time and a reduction in the overall cost of the operation.

POS MV generates attitude data in three axis. Measurements of roll, pitch and heading are all accurate to $\pm 0.02^\circ$ ($\pm 0.03^\circ$ for WaveMaster) or better, regardless of the vessel latitude. Heave measurements supplied by POS MV maintain an accuracy of 5% of the measured vertical displacement or ± 5 cm (whichever is the larger) for movements that have a period of up to 20 seconds.

The system includes a compact disk containing the MV-POSView Controller program, which runs on a PC under Microsoft Windows®. After you install the POS MV, you can use this program to configure the system and monitor its status during operation.

After you have configured the POS MV successfully, you can operate the system in two start-up modes:

- You can use the controller program to enable navigation mode and to monitor the status and performance of the system, *or*
- You can operate the POS MV in stand-alone mode. In this mode, after power-on, the system will enable navigation mode and deliver measurements automatically through whichever ports you have selected.

Communication between POS MV and the controller program is through a 10/100BaseT Ethernet link:

- Data output by POS MV may use the Universal Datagram Protocol (UDP) so that other computers attached to the same Ethernet Local Area Network (LAN) can receive the data or Transmission Control Protocol (TCP) so that only a single computer can receive the data.

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- The controller program uses Transmission Control Protocol (TCP) to issue commands to POS MV. This blocks other computers on the LAN from receiving the controlling messages, and prevents POS MV from responding to any other source of controlling message.

Fault Detection, Isolation and Reconfiguration (FDIR) enhances the operating reliability of POS MV. This feature allows the system to monitor the health of its various sensors so that it can reconfigure itself to isolate any that show degraded performance. POS MV also estimates and corrects sensor errors on an ongoing basis using a Kalman Filter that allows it to produce consistent and accurate results.

Operating Modes

POS MV has two operating modes:

Standby Mode: Following power-on, the IMU, GNSS receivers and the processor perform self-test sequences after which POS MV enters standby mode. Typically, this process takes 30 to 40 seconds to complete.

The system will remain in standby mode until you command a change to another mode, or unless you have enabled 'AutoStart'. With AutoStart enabled, the system will transition automatically into navigate mode.

Applanix ships the POS MV with AutoStart enabled.

Navigate Mode: Navigate Mode is the normal operating mode of POS MV.

Once you have selected this mode, the system will go through several stages of navigate mode until it reaches the final stage, which indicates that POS MV has reached its full user-defined operating accuracy.

Subsystems

POS MV includes three subsystems: the PCS, IMU and GNSS receiver card. The following paragraphs describe each subsystem individually and Figure 1, page 1-2, shows these major components.

POS Computer System

The POS Computer System (PCS) comprises the processor, GNSS receivers and interface cards necessary to communicate with and process the IMU and GNSS data.

Inertial Measurement Unit

The IMU comprises three solid-state linear accelerometers and three solid-state gyros arranged in a triaxial orthogonal array. These sensitive components, together with the electronics to convert their analog outputs into the digital information required by the PCS, are all contained in a sealed unit that requires no maintenance.

IMPORTANT

Do not open the IMU housing for any reason. Opening the IMU housing will void the warranty.

While the array of linear accelerometers sense acceleration in all three directions, the array of gyros sense angular motion around all three axis centred on the IMU. The PCS receives these measurements from the IMU and uses them to compute the measurements of motion. Refer to the Theory of Operation description starting on page B-1 for a more detailed explanation of the POS MV operating theory.

GNSS Receiver

POS MV includes a dual antenna GNSS receiver card:

- A primary receiver provides the position, velocity and raw observation information to the POS MV. It also provides a one Pulse Per Second (PPS) strobe together with a time message that the POS MV uses to accurately time-stamp data output with Universal Time Coordinated (UTC) or GPS Time.
- A secondary receiver, in conjunction with the primary receiver, allows the POS MV to compute GNSS heading aiding by performing carrier phase differential measurements between the two GNSS receivers.

The system includes two identical antennas with 15 metre (~50 feet) long cables. You must connect each receiver to a GNSS antenna to receive GNSS signals from the orbiting constellation of satellites.

The antennas supplied with the system have excellent phase centre stability. If you use alternative antennas with the POS MV, Applanix cannot guarantee the heading or position performance of the system.

GNSS Azimuth Measurement Subsystem

GNSS Azimuth Measurement Subsystem (GAMS) is a unique feature of POS MV that allows the system to achieve exceptional accuracy in the measurement of heading. The GAMS subsystem uses two GNSS receivers and antennas to determine a GNSS-based heading that is accurate to $\pm 0.02^\circ$ ($\pm 0.03^\circ$ for WaveMaster) or better (using a two-metre [$\sim 6 \frac{1}{2}$ feet] antenna baseline) when blended with the inertial

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navigation solution. POS MV uses this heading information as aiding data together with the position, velocity and raw observations information supplied by the primary GNSS receiver.

GAMS provides heading aiding to the POS MV. To understand the effect that GAMS has on the system it is useful to compare system performance with and without GAMS, see Table 1.

Note: Operation without GAMS will occur when POS MV has insufficient data to compute a heading solution.

Before POS MV can deliver valid measurements for use in your application, you must configure the system with the relative mounting angles between the IMU and vessel reference frame. You do this by selecting a convenient and fixed reference point on the vessel, and by defining a reference frame orientation centred on that point.

Table 1: System Performance

Parameter	Without GAMS	With GAMS
Heading accuracy:	0.2° to 2.0° RMS after POS MV achieves full alignment (depending on the nature of vessel manoeuvres). Heading accuracy degrades at latitudes above 50°.	0.02° (0.03° for the WaveMaster), or better, independent of vessel manoeuvres and latitude. POS MV tolerates GAMS outages lasting several tens of minutes with no significant degradation of heading accuracy.
Alignment time:	Heading alignment can take as long as 30 minutes.	Alignment occurs within two to five minutes.
Vessel manoeuvres:	More frequent vessel manoeuvres will improve the accuracy of heading measurements. To obtain a faster alignment and better accuracy the vessel must perform a calibration manoeuvre at intervals of ten minutes or less.	Accuracy is independent of vessel manoeuvres.

Follow the instructions in the Installation Parameters description on page 2-24 to measure the mounting angles of the IMU, vessel and multibeam transducer relative to the reference frame that you have defined. Refer to the POS MV Configuration description on page 4-7 for instructions to configure POS MV with these important parameters.

When correctly configured with this information, POS MV delivers measurements for use by the multibeam transducer, compensated for any difference in mounting angles between the transducer, the IMU, the vessel and your chosen reference frame.

Operation without GAMS

Figure 2 and the following paragraphs describe how POS MV computes heading without GAMS.

After power-on, and the initialization and self-test routines have finished, the IMU performs a levelling routine to establish a locally level reference frame. This occurs rapidly and usually finishes within 30 seconds.

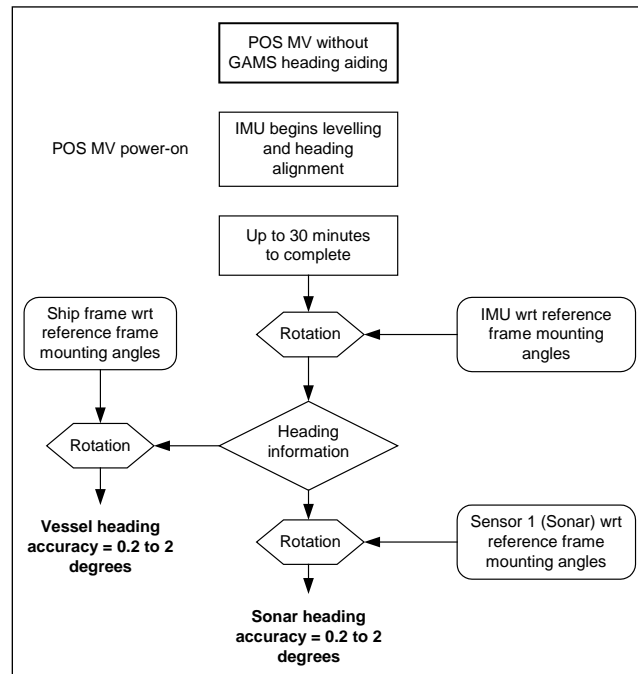


Figure 2: Heading Measurement without GAMS

Following its levelling routine, the IMU begins to align itself to true north. This process, called gyrocompassing, occurs much more slowly and can take from 5 to 30 minutes to complete. The time taken to complete this process will depend on the latitude and on the manoeuvres that the vessel performs during the operation.

A more accurate and rapid alignment will occur if the vessel performs a number of calibration manoeuvres during the alignment process. These manoeuvres consist of full turns, starts and stops, S-curves and figure-of-eight turns.

After alignment, the IMU delivers measurements of its heading with respect to true north. These are accurate to between 0.2° and 2.0°, depending on the manoeuvres made by the vessel and its latitude.

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Manoeuvres that are more frequent will yield a more accurate heading result, while operation in higher latitudes will degrade the unaided heading accuracy.

POS MV rotates the IMU heading measurement, using the relative mounting angles between the IMU, the vessel, the transducer and your chosen reference frame, and delivers heading measurements valid for the multibeam transducer and the vessel.

Operation with GAMS

Figure 3 and the following paragraphs describe how POS MV computes heading with GAMS heading aiding.

After power-on, and the Initialization and self-test routines have finished, the IMU performs a levelling routine to establish a locally level reference frame. This occurs rapidly and usually finishes within 30 seconds.

Following its levelling routine, the IMU begins to align itself to true north. This gyrocompassing process is aided by the heading input from GAMS and is completed within two to five minutes, depending on how long it takes GAMS to come online.

GAMS heading error is largely due to GNSS receiver noise and multipath errors. By blending this information with the IMU data in the Kalman Filter, POS MV can average the GAMS heading error down to a blended heading accuracy of typically 0.02° RMS (0.03° for WaveMaster) or better.

The Kalman Filter uses information in the IMU coordinate frame. POS MV must therefore rotate GNSS heading information into this frame.

After alignment, the IMU delivers measurements of vessel heading relative to true north. These possess an accuracy of $\pm 0.02^\circ$ RMS ($\pm 0.03^\circ$ for WaveMaster) or better, independent of vessel manoeuvres or latitude.

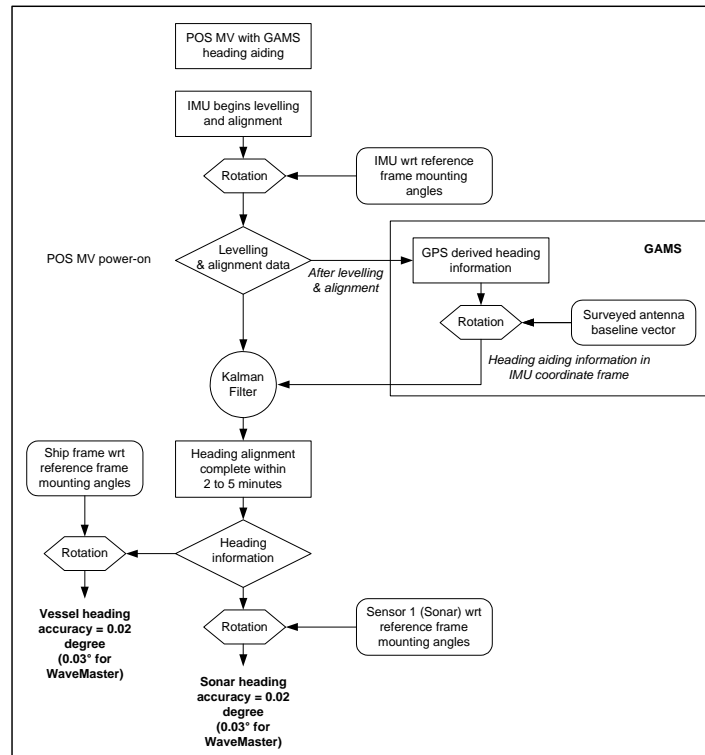


Figure 3: Heading Measurement with GAMS

After alignment, the IMU delivers measurements of multibeam transducer heading relative to true north. These measurements possess the same accuracy as those of vessel heading defined in the paragraph above.

Refer to the Theory of Operation description on page B-1 for a more complete description of GAMS, together with an explanation of GNSS carrier phase differential position measurement, levelling, gyrocompassing and the Kalman Filter.

Refer to the Lever Arm Distances, page 2-26, and the Antenna Baseline Vector

The antenna baseline vector is the vector describing distance from phase centre of primary antenna to phase centre of secondary antenna in the vessel frame. If this vector can be determined accurately (error ≤ 5 mm) then the values can be entered into the GAMS parameter setup window and avoid having to perform a GAMS calibration, which on a large vessel may not be practical or as accurate. If the antenna baseline vector cannot be accurately determined and the vessel can perform dynamics sufficient to achieve a good GAMS calibration then the baseline vector parameters can be left as zero.

Refer to the Lever Arm Distances, page 2-26, and the Antenna Baseline Vector

The antenna baseline vector is the vector describing distance from phase centre of primary antenna to phase centre of secondary antenna in the vessel frame. If this vector can be determined accurately (error ≤ 5 mm) then the values can be entered into the GAMS parameter setup window and avoid

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having to perform a GAMS calibration, which on a large vessel may not be practical or as accurate. If the antenna baseline vector cannot be accurately determined and the vessel can perform dynamics sufficient to achieve a good GAMS calibration then the baseline vector parameters can be left as zero.

, page 2-29, descriptions for instructions to measure the mounting angles of the IMU, multibeam transducer and ship frames with respect to your chosen reference frame.

Functions

The Applanix POS MV offers many advanced functions including:

- Motion measurement
- TrueHeave (software option)
- Position and velocity measurement
- AutoRecovery and fault detection, isolation and reconfiguration
- AutoStart
- Ethernet Data logging
- Event tagging

The following paragraphs describe each of these functions.

Motion Measurement

The principal function of POS MV is to deliver dynamically integrated position and orientation data. It delivers motion measurements (roll and pitch angle, true heading and real-time heave) for use by external equipment such as multibeam sonar. The system also estimates and displays the accuracy of its attitude and heading measurements.

TrueHeave

TrueHeave (different than real-time heave) is based on an advanced two sided filter, making use of both past and present vertical motion data to compute a significantly improved heave estimate. POS MV has sufficient computational speed such that a secondary estimate of heave can be accomplished shortly after the sonar acquisition event.

Delayed time heave output not only removes many of the compromises that must be made in real-time, but provides near real-time Quality Control (QC) of heave performance. The MV-POSView graphical interface includes a time series plot of both real-time and TrueHeave estimates, which allows the operator to react if a divergence between the two heave estimates is observed.

Refer to the TrueHeave Operation description on page 6-28 for a full description of the data formats used by POS MV to output these parameters.

Position and Velocity Measurement

POS MV supplies parameters such as the position, velocity, speed, acceleration and angular rate of the vessel. The system also estimates and displays the accuracy of some of these output parameters.

Refer to Interfaces and Data Formats on page 3-1 for description of the data formats used by POS MV to output these parameters.

AutoRecover and Fault Detection, Isolation and Reconfiguration

Because the IMU is the most important sensing subsystem in POS MV, errors in communication between the PCS and the IMU can cause significant problems. AutoRecovery is a feature that allows POS MV to recover from such a communication error.

POS MV is tolerant of data corruption caused by noise or power problems on board the vessel. However, the MV-POSView Controller program will alert you if either of these problems becomes insurmountable, so that you can take appropriate corrective action.

Fault Detection, Isolation and Reconfiguration (FDIR) allow POS MV to combine data from the GNSS and the IMU sensor subsystems to offer the best possible navigation solution for the current data quality.

The system monitors its sensor subsystems and determines which of them, if any, shows a degraded performance. If it finds any sensor subsystem operating with reduced performance, the system re-combines the available data to retain the highest possible quality in the navigation solution.

AutoStart

You must first configure the system with the following parameters before it can operate properly when you transition POS MV to its navigate mode:

- The lever arm distances including those from the IMU, multibeam transducer and the primary GNSS antenna, to your chosen reference point
- The sensor mounting angles of the IMU and the multibeam transducer relative to your chosen reference frame

These details are generally fixed at the time of installation. You can save them to non-volatile memory so that POS MV initializes itself correctly during each power-on sequence. If necessary, you can use the MV-POSView Controller program at any time to alter and save any of the installation parameters.

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You can configure POS MV to enter navigate mode (the normal operating mode) automatically after power-on. Alternatively, you can configure the system to wait until it receives your command to enter navigate mode.

The ability to automatically enter navigate mode is called AutoStart. You can use the MV-POSView Controller program to enable or disable AutoStart.

Refer to the System Configuration section on page 4-1 for instructions to configure the system using the MV-POSView Controller program. Refer to Software Installation on page D-1 for instructions to install the MV-POSView Controller program on a Personal Computer (PC).

Removable Media Data Logging

Data logging allows the POS MV to store both raw sensor data and real-time processed navigation data to a removable USB flash drive for post-processing using the Applanix POSPac MMS software; post-processing enhances navigation solution accuracy. The USB flash drive is transferable between the PCS and any Microsoft Windows® based computer with a USB port. Note this feature is not available on SurfMaster One.

Back-up Data Logging

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

Ethernet Data Logging

You can log processed navigation or raw sensor data through the Ethernet to a controlling PC. Data gathered by the POS MV during a mission may be post-processed using POSPac to further enhance the quality of seafloor maps generated by multibeam sonar systems. Contact Applanix for more information on POSPac.

Ethernet Real-Time Output

High rate data are available from the PCS data port using Universal Datagram Protocol (UDP) broadcasts. The emphasis here is outputting timely data, even though there may be some data loss.

Event Tagging

POS MV provides the facility to 'time tag' events using either UTC or GPS Time.

Note: UTC and GPS Times are not identical. Due to the occasional need for a 'leap second' to be applied to UTC, there is an integer number of seconds time difference between UTC and GPS Time. Transitions between seconds are precisely coincident for both UTC and GPS Time.

Time tagging of events occurs through the EVENT port on the PCS rear panel. To tag an event using UTC or GPS Time you must provide POS MV with a digital pulse in the range of 3 to 50 V. You can configure POS MV for a positive edge trigger or a negative edge trigger with respect to the ground associated with that event input.

Event time tagging occurs when POS MV detects a TTL pulse on the Event 1 or Event 2 line, it captures the exact time that corresponds to the trigger edge (within a window 1 μ s wide). Event records are available for output on the Ethernet data ports. Contact Applanix for advice if you need additional information about the Ethernet group structure.

Output Summary

There are several types of communication interfaces that POS MV can use to supply its data. You must select whichever type will be most suitable for the specific multibeam sonar in use.

In some cases, a multibeam sonar and / or related acquisition system can accept data in more than one format. However, for specific installations, one type of communications interface usually provides for a more accurate data exchange than the other.

Electrical noise or sonar timing can have a significant effect on the images produced by the multibeam sonar. You must consider this when you select the communications interface used to supply position, attitude and motion data from POS MV. Because each installation will be different, this manual cannot include explicit instructions in this area.

POS MV can use a variety of interface protocols to output information:

- RS-232
- RS-422
- Ethernet

Each interface protocol is unique. Refer to the Interfaces and Data Formats description starting on page 3-1 for information on each of these interface protocols.

MV-POSView Controller Software

You can use the MV-POSView Controller program to configure POS MV; the controller ships with the POS MV system. For subsequent operation of the POS MV you can use the controller program or you can configure the system to start operating automatically with no further need for operator control. A brief description of the AutoStart feature is located on page 1-11.

Refer to the Software Installation description on page D-1 for instructions to install the MV-POSView Controller program on your PC. Refer to the System Configuration description on page 4-1 and the System Operation description on page 5-1 for instructions on how to use the controller program.

2.0 Installation

Installation of the Position and Orientation system for Marine Vessels (POS MV) is reasonably simple, provided the installation instructions in this manual are carefully followed. Installation and connection of the POS Computer System (PCS), the Inertial Measurement Unit (IMU) and the Global Navigation Satellite System (GNSS) antennas should only take a few hours.

This section of the POS MV V5 manual explains each stage of the installation. By following these instructions, you can unpack, install and configure the system so that it is ready to operate with minimal delay.

Handling Precautions

To prevent damage to the system components handle all POS MV assemblies with care. The following paragraphs explain the special handling precautions that apply to the IMU, PCS and GNSS antennas.

Inertial Measurement Unit



The IMU contains sensitive and expensive solid-state accelerometer and gyro components. Permanent damage to these components will result if handled roughly.

Exercise care when handling this unit; in particular, be careful when placing the IMU on or mounting it to any surface. Field repair of the IMU is not possible. If this unit develops a fault or becomes damaged it must be returned to Applanix for repair. Refer to Technical Support and Service on page A-1 for procedures.

POS Computer System

Field repair of the PCS is not recommended. If this unit develops a fault or becomes damaged it must be returned to Applanix for repair. Refer to Technical Support and Service on page A-1 for procedures.

Consider the following when handling the PCS:

- Handle with care.
- Do not drop from any height
- Observe standard Electrostatic Discharge (ESD) procedures.
- Refer to Circular Connectors for a guide on handling the connectors.

GNSS Antennas

Applanix supplies the POS MV with two identical GNSS antennas - handle these with care. Avoid scratching or damaging the antenna housings in any way.

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Any damage to the housings could impair the ability of the antenna to receive satellite signals and therefore degrade the performance of the associated GNSS receiver.

Unpacking and Storage

The supplied POS MV components and cables are listed on the packing list shipped with the system. Physically verify that each item is present.

Applanix tests the POS MV system electrically and mechanically prior to delivery. The protective transit case prevents damage during shipment and ensures the operating integrity of the system.

Important

Retain the original POS MV equipment packing case. Transport or return POS MV equipment in the original packing case. Improper or inadequate POS MV equipment packing for storage or transport will void the warranty.

Upon receipt of the system, check all items carefully against the shipping documents and inspect them for any damage that may have occurred during transit. If any damage has occurred, file a claim with the carrier and notify Applanix immediately. Refer to Technical Support and Service on page A-1 for postal address, contact telephone and fax numbers, and e-mail and Web address for Applanix.

Storage

When storing the POS MV system for an extended period, ensure the following conditions are maintained:

- Protect the PCS from moisture, excessive humidity and temperature extremes (see Specifications starting on page 7-1 for details).
- Protect the PCS and IMU from accidental damage by storing in their original shipping cases.
- Store all remaining components in their original shipping cases.

Site Preparation

You can install the system more efficiently if you give early and careful consideration to the location and layout of the POS MV components.

You should read and understand the instructions in the Installation and Installation Parameters topics on pages 2-4 and 2-24 before you commence to install the POS MV. By taking this precaution, you will become more familiar with the requirements of the system and will be less likely to encounter unexpected problems during this important operation.

Note: Before installing the POS MV, make certain that adequate mounting provisions exist for all components of the system.

Power Requirements

To be CE compliant, the PCS shall be powered by a power supply that is separate from the vessel power supply. This will restrict the PCS from coupling back interference onto the vessel power supply.

Furthermore, Applanix strongly recommends that you arrange to supply electrical power to the POS MV from an Uninterrupted Power Supply (UPS). This is for two reasons:

- Usually, the electrical supply on board the vessel will be noisy. Although the POS MV includes power supply conditioning circuitry, it is a sensible precaution to make certain the power supply is 'clean' before it enters the system.
- The electrical supply on board the vessel may be unreliable and may drop out or fall to an unacceptable level unexpectedly.

A suitable UPS will 'clean' the electrical supply before it enters the PCS and will continue to supply power for a short period if the electrical supply fails for any reason. The UPS should be able to supply the total power requirements of POS MV.

PCS	POS MV V5	POS MV V5-1	POS MV V5-2
Max.Current:	1.1 A Max	7 A Max	2.5 A Max
Voltage range:	100 Vac to 240 Vac	8 Vdc to 34 Vdc	9 Vdc to 34 Vdc
GNSS Antennas	All Models		
Voltage:	Supplied by the GNSS receiver via the antenna coaxial cable		
IMU	All Models		
Voltage:	Supplied by the PCS via the IMU cable.		

Note that for POS MV V5-1 the minimum usable PCS input voltage depends on a combination of IMU type and IMU cable length.
Contact customer support for assistance.

Environmental Requirements

GNSS Antennas

To receive GNSS satellite signals without interruption, the GNSS antennas require a clear view of the sky from horizon to horizon in all directions. You must mount them outside in an elevated position on the vessel. Follow the instructions in the GNSS System paragraphs on page 2-5 to install the GNSS antennas.

Although the antennas are tolerant of an exposed mounting position, please observe the environmental limits starting on page 7-6 when installing these components.

POS MV V5 Installation and Operation Guide

Installation

Inertial Measurement Unit

The IMU has anodized aluminium housing. If you intend to mount the IMU against a steel hull, use stainless steel spacers of 5 mm ($\frac{3}{16}$ in) thickness between the IMU and the hull to prevent galvanic corrosion of the housing. Applanix recommends the use of an IMU mounting plate to aid in aligning the IMU with the vessel reference frame in which lever arms and misalignments are measured. Refer to Applanix for details.

Follow the installation instructions listed on page 2-7, Inertial Measurement Unit, to select a suitable mounting location for the IMU. Observe the environmental limits starting on page 7-6 when selecting a mounting location for the IMU. Although the IMU is sealed in a housing it is not depth-rated; do not mount the IMU where it can become immersed in water. An IP68 rated (submersible) option is available, details of which are available from Applanix Customer Support (see page Appendix A for contact details).

POS Computer System

Applanix ships the PCS in a protective transit case that must be removed prior to operation. Please retain this packing case for reuse should the system need to be shipped for any reason. Follow the instructions in the installation paragraphs, starting on page 2-9 for V5 and page 2-13 for V5-1 and V5-2, to install the PCS. Observe the environmental limits starting on page 7-6 when installing the PCS.

Installation



Important:

1. Equipment shall be installed by qualified personnel. If Installed in Norway, Sweden or Finland, equipment must be installed in a restricted access location such that only trained personnel have access.
2. The PCS (POS MV V5, POS MV V5-1 and POS MV V5-2) shall be grounded via the safety ground screw or stud installed with a maximum torque of 1 N·m.
3. Power to the POS system should be protected by a user-supplied, resettable circuit breaker.
4. Upstream breaker used to protect POS system shall be limited to 20Amp rating.
5. Antenna connection shall be provided only after making the permanent safety earth connection.
6. The POS MV V5 PCS shall have a three conductor power cable with the ground wire properly terminated at the supply end.
7. For installations using a portable generator, the ground wire connected to POS shall be connected to the chassis ground of the generator, and the chassis of the generator shall be connected to the 'earth' ground of the vessel.

GNSS System



Do not connect any input to the PPS (POS MV V5) or PPS OUT (POS MV V5-1/2) port. Connecting a signal input to this port will damage the PCS interface circuitry.

The PCS includes a dual antenna GNSS receiver for operation with the POS MV.

Multipath reflections of the received GNSS signals are the dominant source of measurement errors in the heading aiding information computed by the GNSS Azimuth Measurement Subsystem (GAMS).

Reflectors can include flat surfaces on the vessel and the surface of the sea.

The POS MV GNSS antennas may be installed anywhere on the vessel, provided their locations meet the following criteria:

- Observe the environmental limitations specified on page 2-3, GNSS Antennas.
- Avoid GNSS antenna locations that may experience multipath satellite signals caused by reflections off nearby structures.
- Avoid mounting the GNSS antennas where salt deposits can accumulate and degrade the received signal quality. Remove salt deposits by washing the antenna with fresh water.
- Do not mount the GNSS antennas closer than 0.5 m (~20 in) to any radar, UHF, satellite communications or other communications antennas or transmitters.
- Avoid mounting the GNSS antennas in areas that may experience high levels of vibration, shock or electrical noise.
- Both antennas must have the clearest possible view of the sky from horizon to horizon in all directions. This means mounting them outside and as high as possible on the vessel.
- Mount the GNSS antennas rigidly with respect to each other and with respect to the IMU within the vessel. This requirement may be difficult to achieve if the antennas are mounted on separate masts or on a single mast that can flex with respect to the vessel. Relative movement of one antenna with respect to the other of more than 0.5 cm (~¼ in), or of both antennas with respect to the vessel, will introduce an extra source of heading error to degrade the POS MV heading accuracy.
- Do not mount the antennas near any large flat surface. Large flat surfaces are a source of multipath reflections that may degrade the accuracy of POS MV heading measurements.
- The system includes two GNSS antennas. Install these so that they have less than 5 m (~16 ½ ft) separation distance between them. The antenna separation distance must be more than 1 m (~3 ¼ ft) in the horizontal vector, but it is recommended that the antennas be at least 2 m (~6 ½ ft) apart.

POS MV V5 Installation and Operation Guide

Installation

- Mount both antennas so that the labels on their top surfaces point in approximately the same direction. This precaution means that both antennas have the same orientation relative to the vessel.

The phase centres of the GNSS antennas may move by several millimetres as the vessel turns or as satellites move across the sky. When both antennas have the same orientation, their phase centres will move approximately together. This will allow a better heading resolution by GAMS.

Install GNSS Antennas

The following instructions refer to the GNSS antennas as the primary and the secondary units, although both antennas are physically and electrically identical. Identify, label and connect the antennas in the following manner:

- Primary antenna to ANT1 port on the PCS
- Secondary antenna to ANT2 port on the PCS

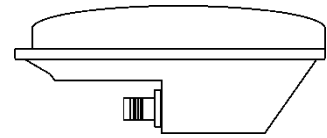


Figure 4: GNSS Antenna

Note: POS MV includes two low-loss antenna cables with connectors at each end. These cables are standard length of 15 m (~50 ft). Applanix can supply longer GNSS antenna cables on request, up to a maximum allowable length of 80 m (~262 ft) with a maximum signal loss of nine Decibels (dB). It is not necessary for both cables to be the same length.

1. Install the primary and secondary antennas at the positions you have chosen and prepared.

Note: Orient the label on the top surface of the secondary antenna so that it points in approximately the same direction as the label on the primary antenna.

2. Connect the TNC cable connector to the GNSS antenna and tighten the connection. Use waterproof tape and a suitable silicone sealant to protect the connection against the ingress of water or dirt.
3. Route the antenna cable from the primary antenna to the PCS mounting location. Ensure the fastened cable does not apply stress to the TNC antenna connector. Avoid subjecting the cable to sharp bends or other mechanical stresses; minimum bend radius of LMR 400 cable is one inch (~25 mm) and LMR 600 cable is 1.5 inches (~38 mm). Use cable clips to secure the cable at regular intervals along its length. At the PCS mounting location, identify the cable clearly as the primary antenna.
4. Connect the primary antenna cable to the ANT1 port on the PCS rear panel.
5. Route the antenna cable from the secondary antenna to the PCS mounting location. Ensure the fastened cable does not apply stress to the TNC antenna connector. Avoid subjecting the cable to sharp bends or other mechanical stresses. Use cable clips to secure the cable at regular intervals

along its length. At the PCS mounting location, identify the cable clearly as the secondary antenna.

6. Connect the secondary antenna cable to the ANT2 port on the PCS rear panel.

Note: You must identify the primary and the secondary antennas clearly. POS MV uses the lever arms distances between your chosen reference point and the primary GNSS antenna to generate a navigation solution.

Once the GNSS antennas are installed, measure the antenna baseline vector if possible. POS MV can calculate this vector automatically during the installation calibration routine, although it will mean the routine will take longer to complete. If you make a manual measurement instead, record the vector between the antenna phase centres to an accuracy of ± 5 mm ($\pm 1/4$ in). The GNSS antenna footprint is shown on page E-14.

Inertial Measurement Unit



The IMU contains sensitive and expensive solid-state accelerometer and gyro components. Permanent damage to these components will result if handled roughly. To prevent irreversible damage, handle the IMU with care while installing the system.

Mechanical Interface Information for POS MV IMU options can be found in Appendix E (beginning on page E-1). For SurfMaster One the IMU is contained inside the PCS enclosure so the following instructions apply to the one enclosure.

Locate the IMU

The IMU is a self-contained unit that must be connected to the PCS using the supplied shielded cable. Consider the following guidelines when selecting a location to install the IMU:

- Observe the environmental limitations specified on page 2-4, Inertial Measurement Unit.
- Avoid mounting the IMU where it may experience high levels of vibration, shock or electrical noise.
- The standard IMU connection cable is 8 m (~26 ft) long. Plan the system layout carefully so that the cable will fit between the IMU and the PCS. Do not subject the cable to sharp bends or other mechanical stresses. Applanix can supply a longer cable of up to 50 m (~165 ft) in length if necessary. Use suitable clips to support the cable at intervals along its length.
- Ensure the mounting location permits easy access to attach the cable to the IMU.
- Mount the IMU with its base plate nominally level.

POS MV V5 Installation and Operation Guide

Installation

- Ideally, install the IMU at a location for which you require roll, pitch, heading and heave measurements. Usually this implies mounting the IMU close to, or even on, the multibeam transducer. The chosen location must provide rigid support so that the IMU does not move relative to the GNSS antennas; see GNSS System on page 2-5.
- It is not necessary to install the IMU at the vessel's centre of rotation. There is no degradation of POS MV performance if the IMU is mounted away from the vessel's centre of rotation, although this offset should be measured and applied during configuration of the system; see the POS MV Configuration topic starting on page 4-7.
- There is a label on the top plate of the IMU to identify its sensing axis. It is not required to align these marks closely with the vessel or the multibeam transducer. Instead, measure the mounting angles, save them in the PCS when you first power-on and configure the system.
- Two offset holes are predrilled in the base to accept 5 mm (0.197 in) diameter alignment pins. These holes maintain IMU orientation and alignment when the unit is replaced, see Figure 5. Two colinear slots are machined in the base to mate with corresponding rails on the IMU mounting plate. These slots maintain IMU alignment on the mounting plate when the unit is replaced but allow the orientation to be reversed in case of cable interference during installation.

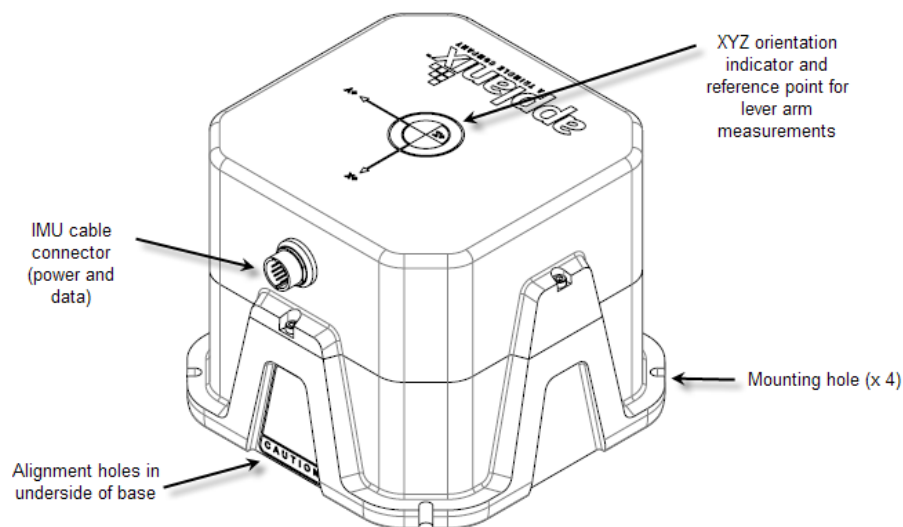


Figure 5: Typical IMU Mounting Features

Install the IMU

Once a suitable mounting location is selected, perform the following steps to install the IMU:

1. Apply a thin film of anti-seize grease from the supplied packet all around the alignment pins or rails, whichever is used, to prevent the IMU housing from becoming stuck on the mounting plate.

2. Attach the IMU to the mounting location using four M5 (#10) pan head bolts inserted through the fixing holes in the base plate, isolating the IMU from the hull by way of an electrically non-conductive material if possible. Use flat and shake proof washers under the IMU mounting screws. Ensure that the flat washers (not shake proof washers) are placed in direct contact with the IMU base plate.
3. Tighten the mounting bolts in a uniform manner, exercising care not to over torque. Avoid warping the IMU base plate.
4. Attach the IMU connection cable to the IMU connector. Route the cable from the IMU to the PCS mounting location. Avoid subjecting the cable to sharp bends or other mechanical stresses. Use cable clips to secure the cable at regular intervals along its length.
5. Connect the IMU cable to the IMU port on the rear panel of the PCS.
6. After IMU installation, measure the lever arm distances and the mounting angles that POS MV requires to generate its navigation solutions. Refer to page 2-24, Installation Parameters for details of these parameters.

POS Computer System - POS MV V5

The PCS is the heart of the POS MV V5 systems. The PCS footprint is shown in Appendix E .

Install the PCS

Remove the PCS from its transit case to allow connection and operation. With the PCS removed from the transit case, you can install, connect and use the unit in a 19 inch instrument rack where it occupies one rack unit of space. Use an instrument rack that provides isolation against shock and vibration.

Observe the following installation constraints:



Do not hang the PCS from the loose panel mounting hardware. Support the PCS weight from underneath while tightening the panel mounting hardware.

- Observe the environmental limitations starting on page 7-6.
- Do not install the PCS where it may come into direct contact with water or high concentrations of dust.
- The PCS may be mounted in a shock isolating 19-inch instrument rack if one is available. The PCS occupies one rack unit of space in a 19 inch instrument rack.
- Do not mount the PCS to a vibrating surface or one that may experience severe shocks.

POS MV V5 Installation and Operation Guide

Installation

- A minimum of 15 cm (~6 in) clearance is required behind the PCS cabinet for cable connection and ventilation. Do not restrict the airflow intakes located on each side of the cabinet. If necessary, provide additional fan ventilation inside the instrument rack to prevent overheating.
- Provide sufficient cable lengths to allow easy connection to the ports on the PCS rear panel.

Rear Panel Electrical Connections

The rear panel of the PCS provides connections for power and communications with sensors and other devices, see Figure 6.

ELECTRICAL HAZARD



The PCS employs double pole / neutral fusing on the power receptacle. Each of the two RoHS compliant fuses are rated at:



- Rating = 250 V
- Current = 4 A
- Type = fast acting
- Case = 5.2 mm x 20 mm

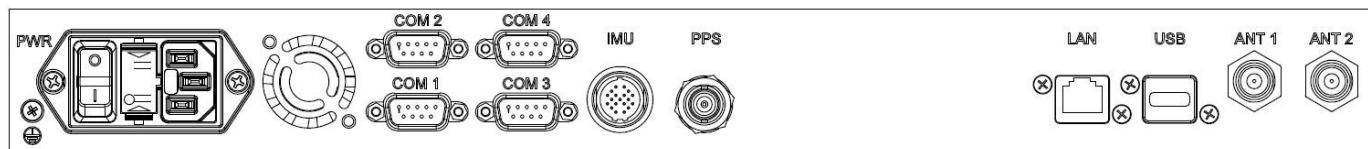


Figure 6: PCS Rear Panel - POS MV V5 – PCS-80

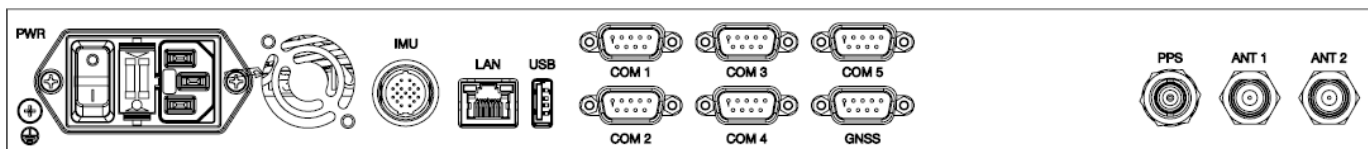


Figure 7: PCS Rear Panel - POS MV V5 – PCS-84 and PCS-100

Use Table 2 as a guide when making cable connections to the PCS rear panel.

Table 2: Connector/Cable Summary - POS MV V5

Connector	Cable	Description
PWR, 3-pin male	Standard 3-conductor IEC cable	The internal power supply is auto-switching; see page 2-3 for details
IMU, 19-pin female	Shielded cable	<ul style="list-style-type: none">• RS-422 serial data• Supplies dc power to and receives data from IMU

Table 2: Connector/Cable Summary - POS MV V5

Connector	Cable	Description
LAN, RJ-45 female	Straight through or Cross over cable (meets Cat5)	<ul style="list-style-type: none"> Ethernet interface communicates with a controlling PC through this 10/100 Base-T port Port used to complete initial POS MV configuration <p>Note: The POS MV system may be configured in the 'AutoStart' mode, so that subsequent operations uses a standalone mode without the further need for an Ethernet connection.</p>
PPS, BNC female	75 ohm coaxial cable (RG59/U)	<ul style="list-style-type: none"> A TTL strobe at one pulse per second. Output pulse polarity and pulse width is configurable from POSView controller. Leading edge of pulse is coincident with exact GNSS second. Provides synchronization with GPS Time. <p>Note: Do not connect an input signal to the PPS OUT port; otherwise, damage to the PCS interface circuitry may result.</p>
COM(1), DE-9P	Single-shielded cable	RS-232 Serial I/O port (digital)
COM(2), DE-9P	Single-shielded cable	RS-232 Serial I/O port (digital)
COM(3), DE-9P	Single-shielded cable	RS-232 / RS-422 (software switchable) Serial I/O port (digital)
COM(4), DE-9P	Single-shielded cable	RS-232 / RS-422 (software switchable) Serial I/O port (digital)
COM(5)1, DE-9P	Single-shielded cable	RS-232 Serial I/O port (digital)
GNSS1	Single-shielded cable	Direct connection to COM port on internal GNSS receiver for supplying corrections or firmware upgrades.
ANT1, TNC female	50 ohm coaxial cable (RG303/U)	Supplies dc power to and receives signals from primary GNSS antenna
ANT2, TNC female	50 ohm coaxial cable (RG303/U)	supplies dc power to and receives signals from secondary GNSS antenna

[1] – COM5 and GNSS ports are only available on POS MV V5 part number PCS-84 and PCS-100.

POS MV V5 Installation and Operation Guide

Installation

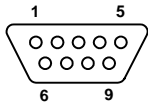
If the POS MV V5 receives power from an Uninterruptible Power Supply (UPS), make certain that it is operating at the correct voltage; refer to the Power Requirements description on page 2-3 for details. Good grounding practices are essential for proper operation of the POS MV V5 systems.

COM (1) through COM (4/5) Interface

PHYSICAL INTERFACE

Serial cables should not exceed 15 m [~49 ft] in length. 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 7, page 2-18 and Table 9, page 2-19 provide COM port connector assignments and mapping for the POS MV V5-1 PCS. Table 3 provides the same information for the POS MV V5 PCS.

Table 3: COM Connectors Pin Assignment - POS MV V5

Pin	Pin Description		Signal Type	Signal Direction
1	N/C	(port 1 & 2)	N/A	N/A
	RXa	(port 3 & 4)	RS-422	Input
2	RX	(port 1 & 2)	RS-232	Input
	RXb	(port 3 & 4)	RS-422	Input
3	TX	(port 1 & 2)	RS-232	Output
	TXb	(port 3 & 4)	RS-422	Output
4	N/C	(port 1 & 2)	N/A	N/A
	TXa	(port 3 & 4)	RS-422	Output
5	GND	(port 1 through 4)	N/A	N/A
6	N/C	(port 1 through 4)	N/A	N/A
7	RTS	(port 1 & 2)	RS-232	Output
	N/C	(port 3 & 4)	N/A	N/A
8	CTS	(port 1 & 2)	RS-232	Input
	N/C	(port 3 & 4)	N/A	N/A
9	N/C	(port 1 through 4)	N/A	N/A
POS MV V5 Rear Panel DE-9P Male Connector				

INTERFACE CONFIGURATION

Table 4 identifies the configuration for the COM ports.

Table 4: 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

POS Computer System - POS MV V5-1 & POS MV V5-2

The PCS is the heart of the POS MV V5 systems. The PCS footprints are shown in Appendix E .

Install the PCS

Remove the PCS from its transit case to allow connection and operation. The MV V5-1 and MV V5-2 PCS is a sealed unit and may be installed in almost any location that is convenient.

Observe the following installation constraints:

- Observe the environmental limitations starting on page 7-6.
- The PCS is sealed so the only way for it to shed heat is via conduction, either to the air or another metal surface. Allow for air circulation around the PCS or remove the rubber feet and bolt the PCS to another metal surface that can conduct the heat away. If necessary, provide additional fan ventilation to prevent overheating.
- Do not mount the PCS to a vibrating surface or one that may experience severe shocks.
- A minimum of 15 cm (~6 in) clearance is required behind the PCS for cable connection.
- Provide sufficient cable lengths to allow easy connection to the connectors on the PCS rear panel or cable stubs supplied with the PCS.

Rear Panel Electrical Connections

The rear panel of the PCS provides connections for power and communications with sensors and other devices, see Figure 8.

The POS MV V5-1 PCS footprint is shown in Appendix E . There are ten connectors located on the rear panel of the PCS, see Figure 8. Each rear panel connector supports a single cable except for the I/O and

POS MV V5 Installation and Operation Guide

Installation

COM connectors, which support a multi-connector breakout cable. Table 5 provides a summary of the connectors used in the POS MV configuration.

The POS MV V5-2 PCS footprint is shown in Appendix E . There are nine connectors located on the rear panel of the PCS, see Figure 9. Each rear panel connector supports a single cable except for the I/O and COM connectors, which support a multi-connector breakout cable. Table 5 provides a summary of the connectors used in the POS MV configuration.

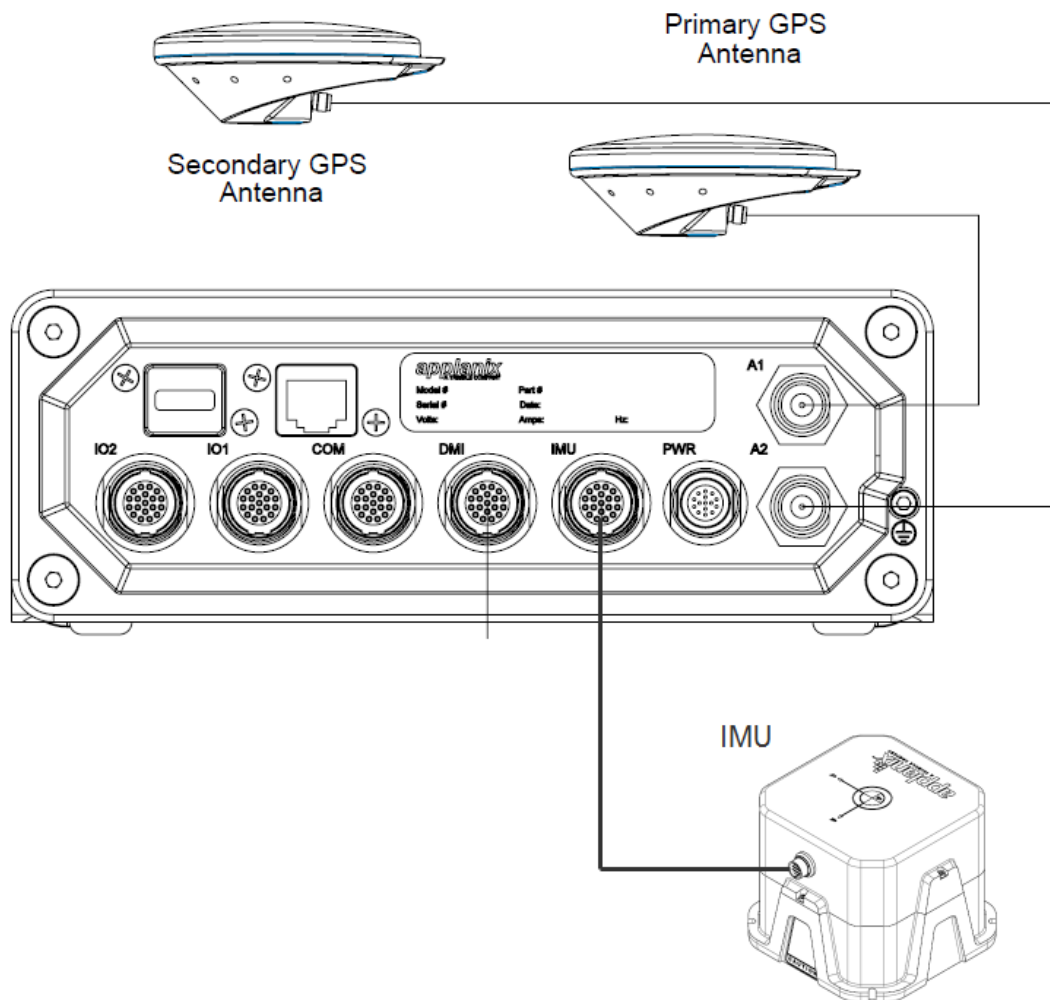


Figure 8: PCS Rear Panel – POS MV V5-1

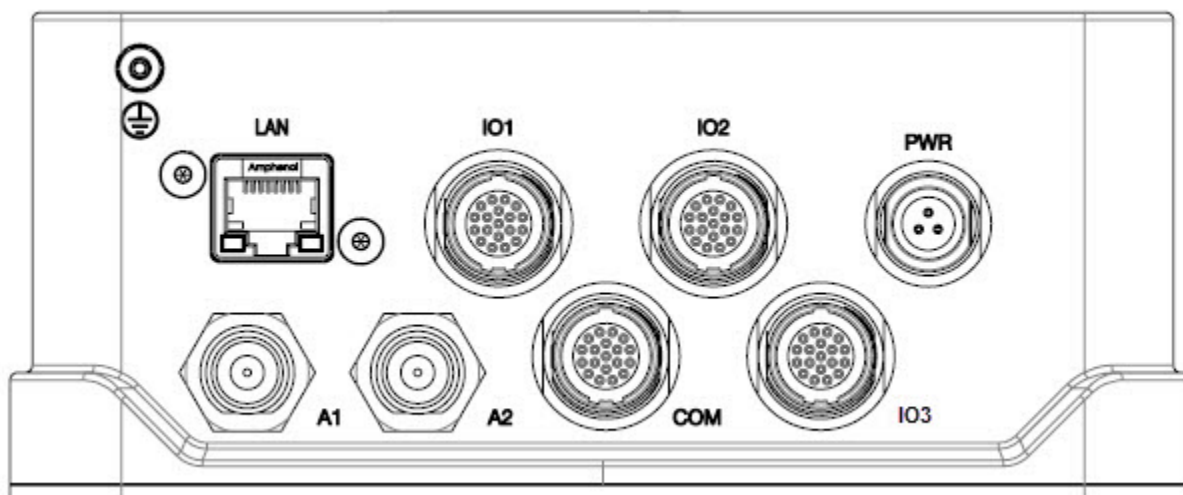


Figure 9: PCS Rear Panel – POS MV V5-2

Table 5: Connector and Port Summary

Connector	Port	Description
PWR		Connects to a customer source
IMU		<ul style="list-style-type: none"> • RS-422 serial I/O data port • Supplies dc power to IMU • Not applicable to POS MV V5-2
COM	COM (1)	RS-232 Serial I/O port (digital) with Tx/Rx/CTS/RTS
	COM (2)	RS-232 Serial I/O port (digital) with Tx/Rx/CTS/RTS
	PPS In	<ul style="list-style-type: none"> • Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirement • Only effective if external GNSS option is enabled through POSConfig
I/O 1	COM (3)	<ul style="list-style-type: none"> • RS-232/422 Serial I/O port (digital) with Tx/Rx only • Software control of 232 / 422 switch • Software switch to connect with Primary GNSS receiver COM 1 for software upgrade - contact Applanix Customer Support for details
	DIO - Event 1	<ul style="list-style-type: none"> • Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirement • Event 1 time tagging

POS MV V5 Installation and Operation Guide

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Table 5: Connector and Port Summary

Connector	Port	Description
	DIO - Event 2	<ul style="list-style-type: none">Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirementEvent 2 time tagging
	PPS Out	<ul style="list-style-type: none">One pulse per second for synchronization with GPS timeTTL signal level
	COM (5)	<ul style="list-style-type: none">RS-232 Serial I/O port (digital) with Tx/Rx only.
I/O 2	COM (4)	<ul style="list-style-type: none">RS-232/422 Serial I/O port (digital) with Tx/Rx onlySoftware control of 232 / 422 switchSoftware switch to connect with Secondary GNSS receiver COM 1 for software upgrade - contact Applanix Customer Support for details
	DIO - Event 3	<ul style="list-style-type: none">Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirementEvent 3 time tagging
	DIO - Event 4	<ul style="list-style-type: none">Optically isolated digital input, 3 to 50 Vdc signal level, 1 mA maximum input current requirementEvent 4 time tagging
	PPS Out	<ul style="list-style-type: none">One pulse per second for synchronization with GPS timeTTL signal level
	GNSS	<ul style="list-style-type: none">RS-232 Serial I/O port (digital) with Tx/Rx onlyDirect connection to COM port on internal GNSS receiver for supplying corrections or firmware upgrades.
I/O 3		<ul style="list-style-type: none">Not Implemented
Ethernet		<ul style="list-style-type: none">10/100 Base-TCommunication between POS MV and MV-POSView
USB		<ul style="list-style-type: none">USB 2.0 HostNot applicable to POS MV V5-2
ANT1		I/O TNC connector - supplies dc power and receives signal from primary GNSS antenna
ANT2		I/O TNC connector - supplies dc power and receives signal from secondary GNSS antenna

Power Connector

Table 6 and Figure 10 identify the pin assignments for the power connector.

Table 6: PWR Connector Pin Assignment

PIN	Pin Description
1	+10 to +34 V dc input on POS MV V5-1 +9 to +34 V dc input on POS MV V5-2
2	N/C
3	Return



Figure 10: 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**.

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

The IMU is internal on POS MV V5-2 so there is no IMU connector or cable.

COM Connector

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

Table 7 and Figure 11 provide the pin assignment for the COM connector and pin mapping of the COM cable.

POS MV V5 Installation and Operation Guide

Installation

Table 7: COM Connector Pin Assignment

I/O Pin	Pin Description	I/O Cable Mapping		Signal Type	Signal Direction
		PIN	Connector		
1	COM 1 Rx	2	DE-9 (Male)	RS232	Input
3	COM 1 Tx	3		RS232	Output
4	COM 1 RTS	7		RS232	Output
2	COM 1 CTS	8		RS232	Input
10	Signal Ground	5		Common	Common
8	COM 2 Rx	2	DE-9 (Male)	RS232	Input
6	COM 2 Tx	3		RS232	Output
5	COM 2 RTS	7		RS232	Output
7	COM 2 CTS	8		RS232	Input
11	Signal Ground	5		Common	Common
9, 12	Reserved – do not connect	4,12			

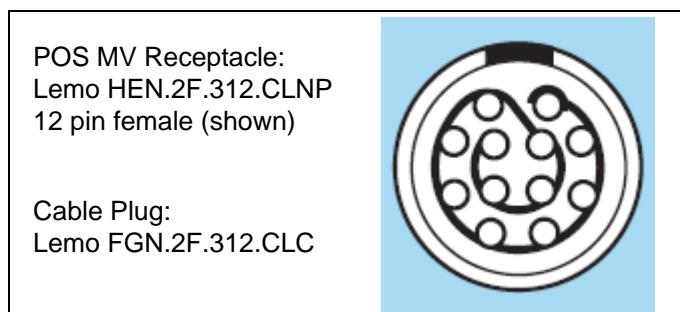


Figure 11: COM Connector Pin Arrangement

Physical Interface

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

Interface Configuration

Table 8 identifies the possible configurations for the COM connector COM ports (default in bold).

Table 8: COM Connector COM Port Configuration

Setting	Value
Baud Rate	2400 to 115200 (9600)
Parity	None , Even, Odd

Setting	Value
Data Bits	7, 8
Stop Bits	1, 2
Flow Control	Hardware, Software, None

I/O Connector

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

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

Table 9 and Figure 12 provide the pin assignment for the I/O connector and pin mapping of the I/O cable.

Table 9: I/O Connector Pin Assignment					
I/O Pin	Pin Description	I/O Cable Mapping		Signal Type	Signal Direction
		PIN	Connector		
3	COM 3(4) Rx+	1	DE-9 (Male)	RS422	Input
4	COM 3(4) Rx	2		RS232 / RS422	Input
2	COM 3(4) Tx	3		RS232 / RS422	Output
1	COM 3(4) Tx+	4		RS422	Output
15	Signal Ground	5		Common	Common
7	Strobe 1(2) Z Out	No connection		RS422	Output
8	Strobe 1(2) Y Out			5V TTL / RS422	Output
16	Strobe 1(2) Out Return			5V TTL / RS422	Output
13	Event 1(3) In			**see notes	Input
11	Event 1(3) In Return			**see notes	Input
10	Event 2(4) In			**see notes	Input
9	Event 2(4) In Return			**see notes	Input
12	PPS Out	centre	BNC	5V TTL	Output
14	PPS Return	shell		5V TTL	Output

POS MV V5 Installation and Operation Guide

Installation

Table 9: I/O Connector Pin Assignment					
I/O Pin	Pin Description	I/O Cable Mapping		Signal Type	Signal Direction
		PIN	Connector		
18	COM 5 Rx / GNSS Rx	2	DE-9 (Male)	RS232	Input
19	COM 5 Tx / GNSS Tx	3		RS232	Output
17	COM 5 Ret / GNSS Ret	5		RS232	Common
5, 6	Reserved	No connection		N/A	N/A

** All Event Inputs are optically isolated digital inputs.

** Inputs (and their return lines) are not referenced and are independent of internal μ POS power supplies and GND.

** Event inputs can be triggered from an external 3 – 50 Vdc source capable of supplying a minimum of 1 mA of sourcing or sinking current.

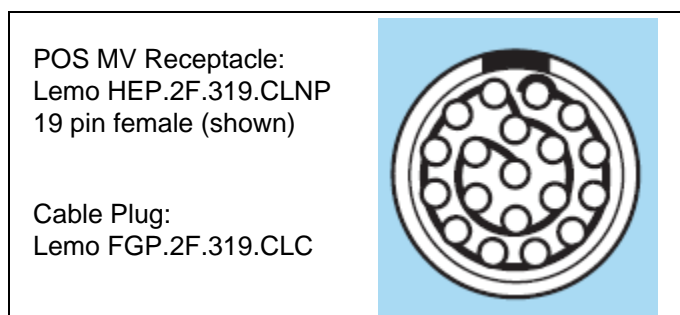


Figure 12: I/O Connector Pin Arrangement

COM Port Configuration

Table 10 identifies the possible configurations for the I/O connector COM ports (default in bold).

Table 10: I/O Connector COM Port Configuration

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

GNSS Access

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

PPS Output

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



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

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

Ethernet Connector

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

Physical Interface

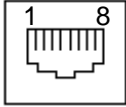
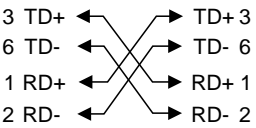
An Ethernet cable is supplied with the POS MV system: a shielded straight through cable. The Ethernet interface on the PCS is auto detecting so a cross-over cable is not required. The cable is terminated with shielded RJ-45 connectors. Ensure that replacement cables meet the RJ-45 Cat5 standard, or better (i.e. Cat6, Cat6e), to avoid an impedance mismatch. In addition, the maximum cable length is determined by the Ethernet specification.

Table 11 provides connector pin assignments and mapping.

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Table 11: Ethernet Connector Pin Assignment

Pin	Pin Description	Signal Type	Signal Direction
1	BI_DA+	Analog	Bidirectional
2	BI_DA-	Analog	Bidirectional
3	BI_DB+	Analog	Bidirectional
4	BI_DC+	Analog	Bidirectional
5	BI_DC-	Analog	Bidirectional
6	BI_DB-	Analog	Bidirectional
7	BI_DD+	Analog	Bidirectional
8	BI_DD-	Analog	Bidirectional
POS MV Rear Panel RJ-45 Female Connector			
Pin out for a 100 BaseT crossover cable			

The Ethernet interface provides a means for configuring and monitoring the POS MV 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 MV and operates in conjunction with the Display port described below
- One display port - UDP provides data at a 1 Hz rate for use by MV-POSView software
- One real-time data port – user configurable data output, at rates up to 200 Hz - (asynchronous events at higher rates), broadcast using UDP protocol to minimize latency.
- One logging data port - user configurable data output, at rates up to 200 Hz - (asynchronous events at higher rates), using TCP/IP protocol to ensure data integrity.

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 5-16 for information on selecting data groups for output. Please refer to Applanix document *PUBS-ICD-004089* (supplied on CD with POS MV or available from Applanix Customer support on request) if the data are used with software other than MV-POSVIEW or POSpac MMS.

Input Data Format

The data input to the POS MV on the control port is organized into a message structure. Refer to Applanix document *PUBS-ICD-004089* (supplied on CD with POS MV or available from Applanix Customer support on request) if control commands will be generated by software other than MV-POSVIEW.

USB Connector

A USB A type connector is located on the rear of the PCS. This Host port supports the USB 2.0 standard and is intended for external sensor connections. POS MV V5-2 does not have this feature.

ANT1 and ANT2 Interfaces

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

The operating dc voltage for each antenna is coupled through the centre conductor of each cable and is supplied by the PCS; GNSS signals are routed through the same conductor to the 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 GNSS antennas and the PCS ANT1 and ANT2 ports are female TNC connectors.

Ancillary Equipment Interfaces

Auxiliary GNSS Receiver

Any of the five COM ports may be used for connecting one or two auxiliary GNSS receivers to the PCS. The output of the auxiliary GNSS receiver must be manually configured before it can be used by POS MV. The PCS will only use an auxiliary GNSS receiver if its quality is better than the primary GNSS

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receiver. The state of the auxiliary GNSS receiver input is displayed in the GNSS Data window, see Figure 56 on page 8-2.

Obtain a cable and connector to suit the particular requirements of the GNSS receiver in use. Refer to Table 3 on page 2-12 for the connector pin assignments of the COM ports.

Sonar Hardware and Acquisition Software

Any of the five COM ports may be used for connecting the sonar to the PCS. Note that Applanix strongly recommend the use of an Ethernet interface in preference to serial for interfacing to sonar acquisition systems. Unlike asynchronous serial messages, the Applanix defined Ethernet messaging (see PUBS-ICD-004089 for details) includes a microsecond accurate time of validity.

Installation Parameters

Once the POS MV components are installed, the installation parameters must be measured. These measurements allow the POS MV to deliver the best possible performance.

After you have configured the system with these parameters, save the data to non-volatile memory for immediate use each time the POS MV is powered-on.

The POS MV configuration information defines the layout of the system and its associated peripheral equipment relative to a reference point. The reference point is defined as any convenient location on the survey vessel, and it may be assigned any orientation that you choose. Once you have decided on a reference point, make the following measurements as carefully and accurately as possible.

Lever Arm Distances

Note: Measure distances in metres, resolved into their longitudinal, lateral and vertical components in the reference frame.

NB POS MV uses a right-hand Cartesian co-ordinate system. Hence the lever arm offsets should be entered using the following rules:

+X=to Bow, +Y=to Starboard, +Z=Down

NB When using DGPS, lever arms should be measured to $\pm 0.05\text{m}$. When using RTK or POSPac MMS IAPPK, lever arms should be measured to $\pm 0.005\text{m}$.

- Reference to IMU

- Reference to primary GNSS antenna:
- Reference to vessel
- Reference to sensor 1 and sensor 2
- Reference to auxiliary GNSS antenna:
- Reference to centre of rotation measurement location - measure to an accuracy of ± 0.10 m

When measuring the lever arm distances, you must resolve them into their longitudinal, lateral and vertical components using the reference frame. Refer to the Theory of Operation description on page B-1 for an explanation of the various frames of reference used by POS MV.

Additionally, the vector separating the GNSS antennas may be measured to an accuracy of 5 mm ($\sim 1/4$ in), although this is not necessary as this value will be computed by POS MV as part of the GAMS calibration process.

Record the measurements carefully so that you can use the MV-POSView Controller program to configure the system. These measurements inform POS MV of the relative positions of the IMU, the GNSS antenna, the multibeam transducer (sensor 1) and the vessel by relating them all to a common reference point that you have defined. It may be convenient for you to define the reference point to be coincident with the IMU for example, in which case the lever arm distances for this relationship will be zero.

Measurements of position, attitude, velocity and dynamics displayed by the main window of the MV-POSView Controller program (

Figure 40, page 5-3) are valid for the vessel location. You define their precise point of validity by configuring the system with the lever arm distances between the reference point and your chosen vessel location.

Mounting Angles

Note: Measure angles in degrees, resolved into the longitudinal, lateral and vertical axis in the reference frame:

- IMU with respect to the reference frame
- Sensor with respect to the reference frame

When measuring the mounting angles you must resolve them into rotations, in a strict sequence, about the longitudinal, lateral and vertical axis using the reference frame.

Record the measurements carefully so that you can use the MV-POSView Controller program to configure the system. These measurements inform POS MV of the relative orientations of the IMU and the multibeam transducer (sensor 1) by relating them all to a common reference frame that has been

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defined. It may be convenient to define the reference frame to be coincident with the multibeam transducer for example, in which case the mounting angles for this relationship will be zero. Note that, by definition, the vessel frame and the reference frame co-align.

The accuracy with which you measure the mounting angles will affect the accuracy of measurements made by the multibeam sonar:

- Measure the mounting angles to the same degree of accuracy that you require of POS MV. For example, if you require POS MV to deliver roll measurements for multibeam sonar compensation to an accuracy of 0.02° , then you must measure the mounting angles to an accuracy of 0.02° .
- Not measuring the mounting angles to the required accuracy will cause a constant offset in all the images from the multibeam sonar. Additionally, some multibeam sonar may calculate the beam forming parameters incorrectly.
- Perform a 'patch test' to determine whether there is any uncorrected misalignment between the multibeam sonar and the POS MV. Many operators have a defined procedure to complete a patch test to refine the accuracy of the POS MV and multibeam sonar interface. The Patch Test topic on page F-1 describes a suitable patch test procedure that can be used.

The following subsections of this manual explain how to measure the lever arm distances and mounting angles in readiness to configure POS MV.

Note: After you have made all the required physical measurements on the POS MV installation, refer to the System Configuration description on page 4-1 for instructions on configuring the system and saving all the information to non-volatile memory.

Lever Arm Distances

Before starting to measure the lever arm distances, you must define a reference starting point. Choose an easily identifiable point at some convenient location on the vessel that allows you to measure offset distances in three axes. The reference point must be fixed and rigid relative to the IMU, the GNSS antennas and the multibeam transducer.

Measure and resolve the lever arm distances using the reference frame:

- X lever arm - the distance measured along the surveyed horizontal fore-aft axis of the vessel (X is positive towards the bow of the vessel)
- Y lever arm - the distance measured along the surveyed horizontal port-starboard axis of the vessel (Y is positive towards starboard)
- Z lever arm - the distance measured along the surveyed vertical axis of the vessel (Z is positive down)

Reference to IMU Lever Arm

Measure and record the distance from your reference point to the centre of the circular black and white label on top of the IMU.

- A positive value for the X lever arm means the IMU is forward of your reference point
- A positive value for the Y lever arm means the IMU is to starboard of your reference point
- A positive value for the Z lever arm means the IMU is below your reference point

Reference to Primary GNSS Lever Arm

Measure and record the distance from your reference point to the centre of the primary GNSS antenna.

- A positive value for the X lever arm means the primary GNSS antenna is forward of your reference point
- A positive value for the Y lever arm means the primary GNSS antenna is to starboard of your reference point
- A negative value for the Z lever arm means the primary GNSS antenna is above your reference point

Reference to Vessel Lever Arm

POS MV uses the main window of the controller program to display its navigation solution, valid for the point you have defined as the vessel datum. Measure and record the distance from your reference point to the vessel datum.

- A positive value for the X lever arm means the vessel datum is forward of your reference point
- A positive value for the Y lever arm means the vessel datum is to starboard of your reference point
- A positive value for the Z lever arm means the vessel datum is below your reference point

Reference to Sensor 1 Lever Arm

Sensor 1 is typically a multibeam transducer. Measure and record the distance from your reference point to the sensing centre of the multibeam transducer array.

- A positive value for the X lever arm means the multibeam transducer is forward of your reference point
- A positive value for the Y lever arm means the multibeam transducer is to starboard of your reference point
- A positive value for the Z lever arm means the multibeam transducer is below your reference point

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Reference to Sensor 2 Lever Arm

Measure and record the distance from your reference point to the second sensor.

- A positive value for the X lever arm means the second sensor is forward of your reference point
- A positive value for the Y lever arm means the second sensor is to starboard of your reference point
- A positive value for the Z lever arm means the second sensor is below your reference point

Note: If your application does not use a second sensor, record these lever arm distances as zero.

Reference to Auxiliary GNSS Lever Arm

The auxiliary GNSS supplies DGNSS, P-Code or RTK measurements to POS MV. Measure and record the distance from your reference point to the auxiliary GNSS antenna.

- A positive value for the X lever arm means the auxiliary GNSS antenna is forward of your reference point
- A positive value for the Y lever arm means the auxiliary GNSS antenna is to starboard of your reference point
- A negative value for the Z lever arm means the auxiliary GNSS antenna is above your reference point

Note: If your application does not include an auxiliary GNSS receiver, record these lever arm distances as zero.

Reference to Centre of Rotation

Normal dynamics in a marine environment apply a complex combination of forces to a survey vessel, causing the vessel to experience a continuously varying pattern of heave, roll and pitch.

Under the influence of these, vertical movements experienced by the multibeam transducer include two components:

- Heave movements as the vessel moves vertically in the water - in the absence of any changes in vessel attitude, these will be the same throughout the vessel.
- Apparent heave movements under the influence of roll and pitch - the amplitude of these will vary directly with distance from the vessel centre of rotation.

The vessel centre of rotation is a point of the vessel that experiences only rotations with changes in attitude. Any heave measured at this point arises entirely from vertical movements that affect the whole vessel equally.

The multibeam transducer will be some distance from the vessel centre of rotation. The transducer will therefore experience a small component of heave as the vessel moves vertically in the water and a much larger component of apparent heave with changes in vessel attitude.

To separate these effects, POS MV translates the IMU measurements to the vessel centre of rotation. Having done so, it applies filtering to the measurements of pure heave as explained in the Theory of Operation on page B-1 and then translates the filtered measurements back to the positions of sensors 1 and 2.

This method for measuring heave avoids the errors that can occur if you filter direct heave measurements made from a point remote from the vessel centre of rotation.

Measure and record the distance from your reference point to the vessel centre of rotation.

- A positive value for the X lever arm means the vessel centre of rotation is forward of your reference point
- A positive value for the Y lever arm means the vessel centre of rotation is to starboard of your reference point
- A positive value for the Z lever arm means the vessel centre of rotation is below your reference point

Antenna Baseline Vector

The antenna baseline vector is the vector describing distance from phase centre of primary antenna to phase centre of secondary antenna in the vessel frame. If this vector can be determined accurately (error ≤ 5 mm) then the values can be entered into the GAMS parameter setup window and avoid having to perform a GAMS calibration, which on a large vessel may not be practical or as accurate. If the antenna baseline vector cannot be accurately determined and the vessel can perform dynamics sufficient to achieve a good GAMS calibration then the baseline vector parameters can be left as zero.

Mounting Angles

General

Measure and record the mounting angles relative to the reference frame that you have chosen. Resolve these angles into three rotations that you must apply, in a strictly defined sequence, to align the mounting angles with your chosen reference frame. The Tait-Bryan sequence of rotations is used.

Tait-Bryan Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

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- Heading rotation - apply a right-hand screw rotation θ_z about the z-axis to align one frame with the other
- Pitch rotation - apply a right-hand screw rotation θ_y about the once-rotated y-axis to align one frame with the other
- Roll rotation - apply a right-hand screw rotation θ_x about the twice-rotated x-axis to align one frame with the other

Frames of Reference

The IMU frame of reference includes the vertical and the horizontal axis of the IMU with which the orthogonal array of sensing elements aligns. These are fixed relative to the IMU and are identified by a label on the IMU housing.

By convention, POS MV uses the right-hand orthogonal coordinate system, with its origin centred on the black and yellow circle on the top of the IMU.

The sensor 1 reference frame includes the vertical and the horizontal axis of the multibeam transducer. These axis are fixed relative to the multibeam transducer.

By convention, POS MV uses the right-hand orthogonal coordinate system, with its origin at the sensing centre of the multibeam transducer.

The vessel reference frame co-aligns with your chosen reference frame.

Right-Hand Orthogonal System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame
- The z-axis points downwards in the appropriate reference frame

Figure 13 shows an example of a frame centred on the vessel and aligned with its surveyed fore-aft, port-starboard and vertical axis.

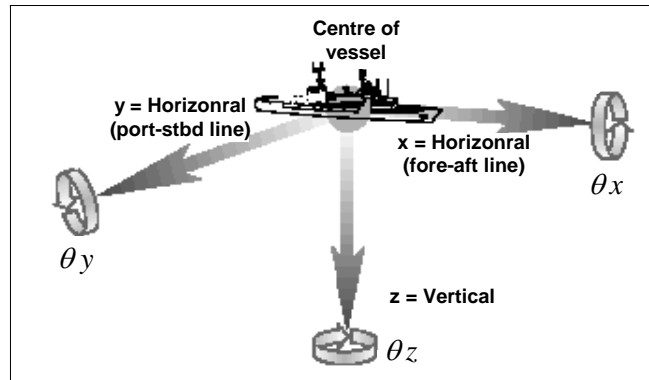


Figure 13: Right-Hand Orthogonal System

The mounting angles describe the relative angles between one frame and another, for example between your reference frame and the IMU frame. The following examples use the mounting angles between your chosen reference frame and the IMU frame to illustrate how to measure and apply these parameters.

The examples use the following assumptions:

- The IMU is installed so that it has a permanent roll angle of -5° relative to your reference frame. That is, if you consider your reference frame as level, then the port edge of the IMU is lower than the starboard edge.
- The IMU is installed so that it has a permanent pitch angle of $+2^\circ$ relative to your reference frame. That is, if you consider your reference frame as level, then the bow edge of the IMU is higher than the stern edge.

The circular label on the top of the IMU identifies the directions of the IMU x and y-axis.

Example 1 - The IMU x-axis nominally points towards the x-axis of the chosen reference frame, but with a small yaw offset so that the IMU has a 3° clockwise rotation relative to your reference frame. Record the following:

- $+3^\circ$ for the IMU with respect to reference frame z mounting angle
- $+2^\circ$ for the IMU with respect to reference frame y mounting angle
- -5° for the IMU with respect to reference frame x mounting angle

Example 2 - The IMU x-axis nominally points towards the starboard side of the chosen reference frame, but with a small yaw offset so that the IMU has a 3° clockwise rotation relative to the y-axis of your reference frame. Record the following:

- $+93^\circ$ for the IMU with respect to reference frame z mounting angle
- $+2^\circ$ for the IMU with respect to reference frame y mounting angle

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- -5° for the IMU with respect to reference frame x mounting angle

IMU with respect to Reference Frame

Measure and record the rotations that you must apply, using the Tait-Bryan sequence explained above, to align your chosen reference frame with the IMU reference frame.

Sensor 1 with respect to Reference Frame

Sensor 1 is typically a multibeam transducer. Measure and record the rotations that you must apply, using the Tait-Bryan sequence explained above, to align your chosen reference frame with the sensor 1 frame.

Sensor 2 with respect to Reference Frame

Measure and record the rotations that you must apply, using the Tait-Bryan sequence explained above, to align your chosen reference frame with the sensor 2 frame.

Note: If your application does not use a second sensor, record these mounting angles as zero.

Installation Checklist

This checklist is included to help you install the POS MV efficiently and with minimal disruption to the vessel, its crew or any ongoing operations.

After installing the system correctly and all items have been checked against this list, refer to the Interfaces and Data Formats description starting on page 3-1 to configure and start using the POS MV.

1. Mechanical Interface

a) IMU Positioning:

- ☐ Mount the IMU as close as possible to the multibeam transducer.
- ☐ Mount the IMU rigidly so that it cannot move or rotate independently of the vessel.
- ☐ Install the IMU where the data and power cable will reach easily between the IMU and the PCS.
- ☐ Ensure there is sufficient clearance for the connectors at both ends of the data and power cable. Tighten the connectors by hand only.
- ☐ Mount the IMU so that it is approximately level.
- ☐ Do not immerse the IMU in water or any liquid.
- ☐ Respect the environmental limits listed for the Inertial Measurement Unit on page 2-4 for storage and operation.
- ☐ Refer to the Drawings section on page E-1 for dimensional details to help when you install the IMU.
- ☐ Connect the IMU housing to a good ground connection.

b) PCS Positioning:

- ☐ Protect the PCS from shock, vibration and moisture.
- ☐ Allow easy access to the front and the rear panels of the PCS.
- ☐ Refer to the Drawings section on page E-1 for dimensional details to help when you install the PCS.
- ☐ Connect the primary GNSS antenna to the ANT1 port.
- ☐ Connect the secondary GNSS antenna to the ANT2 port
- ☐ If necessary, connect the Differential GNSS corrections to a COM port.
- ☐ Connect the IMU data and power cable to the IMU port.
- ☐ (POS MV V5) Connect an electrical supply of nominal voltage 110/220V (voltage range - 100 Vac to 240 Vac) to the 3-pin IEC mains inlet connector on the PCS. The PCS uses an auto-switching power supply that configures itself to the applied ac electrical supply.
- ☐ (POS MV V5-1) Connect an electrical supply of nominal voltage 12/24V (voltage range - 10 Vdc to 34 Vdc) to the 3-pin power inlet connector on the PCS.

c) GNSS Antenna Positioning:

- ☐ Ensure there is a horizontal separation distance of between 1.0 and 5.0 m (~3 ¼ and ~16 ½ ft) between the primary and the secondary GNSS antennas.
- ☐ Mount the antennas as high as possible on the vessel.
- ☐ Do not mount the antennas close to MF, HF, VHF or UHF transmitters or antennas. Do not mount the GNSS antennas within 0.5 m (~±19 ¾ in) of radar or satellite communications equipment.
- ☐ Avoid mounting the antennas near large flat surfaces.
- ☐ Avoid mounting the antennas in a location where they may move, twist or vibrate significantly relative to the vessel or the IMU.

2. Offset Measurements

- ☐ Measure the lever arm distances and mounting angles, as instructed in Lever Arm Distances on page 2-26 and Mounting Angles on page 2-29. Be as careful and accurate as possible.

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- ☐ Measure the GNSS antenna separation distance, as instructed in Antenna Baseline Vector

The antenna baseline vector is the vector describing distance from phase centre of primary antenna to phase centre of secondary antenna in the vessel frame. If this vector can be determined accurately (error ≤ 5 mm) then the values can be entered into the GAMS parameter setup window and avoid having to perform a GAMS calibration, which on a large vessel may not be practical or as accurate. If the antenna baseline vector cannot be accurately determined and the vessel can perform dynamics sufficient to achieve a good GAMS calibration then the baseline vector parameters can be left as zero. on page 2-29. Be as careful and accurate as possible.

3. Power Supply



The application of incorrect electrical power to the PCS may result in damage to POS MV system.

- ☐ (POS MV V5) Arrange a clean, stable electrical supply at a nominal voltage 110/220V (voltage range - 100 Vac to 240 Vac) for the PCS. If possible, supply electrical power to the PCS from an uninterruptible power supply.
- ☐ (POS MV V5-1) Arrange a clean, stable electrical supply at a nominal voltage 12/24V (voltage range 10 Vdc to 34 Vdc) for the PCS. If possible, supply electrical power to the PCS from an uninterruptible power supply.

4. Cable Runs

- ☐ Install all cables carefully so that they do not present a hazard.
- ☐ Avoid applying sharp bends or other mechanical stresses to the cables when you install them. Do not run cables where they may bend or twist after installation. Use cable clips to secure the cables at regular intervals along their length.
- ☐ If you need to extend any cables, use approved cables and connectors of the highest quality. Refer to Applanix for advice, see Technical Support and Service on page A-1 for procedures.

3.0 Interfaces and Data Formats

This section of the manual describes the data formats for each of the following interface ports on the POS Computer System (PCS) rear panel.

Note: Each port has a different format. To avoid operating problems, give careful attention to the structure of each interface.

LAN (Ethernet) Data

The POS MV 10/100BaseT Ethernet interface conforms to the Institute of Electrical and Electronics Engineers (IEEE) 802.3i standard. It allows you to configure the system and to monitor its status during operation.

The interface comprises four ports:

- Control port - used to transmit configuration information to POS MV
- Display port - provides navigation and attitude information at a low update rate for use by the MV-POSView Controller program running on a separate PC
- Real-time data port - provides user selectable navigation and attitude data, at higher update rates with minimal latency, for use by other computers on a shared Ethernet LAN
- Logging data port - provides user selectable navigation and attitude data, at higher update rates but is buffered for robust logging by other computers on a shared Ethernet LAN

POS MV broadcasts information from the display port using the Universal Datagram Protocol (UDP) protocol and outputs data on the logging data port using the Transmission Control Protocol (TCP) protocol. For the real-time data port the protocol can be selected from UDP, UDP Unicast or TCP. Information is organised into a data group structure and each port may be configured independently to permit the output of selected data groups.

The MV-POSView Controller program configures the groups transmitted through the display port automatically according to the specific windows that the program has open at any one time. The group structure is therefore user transparent. POS MV enables groups automatically to support the demands that you make by opening windows within the controller program.

COM Ports

The five RS-232 serial ports, COM(1) through COM(5), allow communication between the PCS and external equipment. Two of the five COM ports are software switchable between the RS-232 and RS-422 protocols. Two of the five COM ports are software switchable to connect with the internal GNSS receiver COM ports. All COM ports are assignable for input and/or output. The following identifies the available port assignments:

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- NMEA sentence types
- Binary data formats
- Base 1 and 2 GNSS outputs
- Base 1 and 2 GNSS inputs
- Auxiliary 1 and 2 GNSS inputs
- GNSS 1 and 2 COM port access

Table 12 identifies the default COM port settings.

Table 12: Default COM Port Settings

Baud Rate	9600
Parity	None
Data Bits	8 Bits
Stop Bits	1 Bit
Flow Control	None
Output Select	None
Input Select	None

Note: Baud rates may require different settings, other than the default settings, for the transmission of various sentence formats.

NMEA Data Formats

The PCS can be configured to use any number of the five COM ports to output data using the National Marine Electronics Association (NMEA) 0183 format at rates up to 50 Hz. POS MV makes twelve sentence formats available.

1. \$xxGGA: global system position fix data
2. \$xxGGK: time, position, position type and DOP values
3. \$xxHDT: heading - true data
4. \$xxVTG: course over ground and ground speed data
5. \$xxGST: GNSS pseudorange noise statistics
6. \$xxRMC:
7. a) \$PASHR: attitude data
b) \$PASHR-TSS: attitude data (TSS indicates the use of the TSS standard instead of the Tait-Bryan standard, see page 2-29 for a description)

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8. a) \$PRDID: attitude data
b) \$PRDID-TSS: attitude data (TSS indicates the use of the TSS standard instead of the Tait-Bryan standard, see page 2-29 for a description)
9. \$xxZDA: time and date
10. \$UTC: time and date
11. \$xxPPS: time and offset
12. UTC: date and time (Trimble UTC format)

Note: The initial two characters following the \$ (noted as “xx” above) may be configured to either “IN” or “GP”. Although “IN” is more correct in the context of a GNSS aided inertial navigation system, some third party software applications may accept only “GP”.

Use the MV-POSView Controller program to set the system to output one or more of these sentences, as well as to set the output frequency of these sentences.

Note: System performance may degrade if multiple ports are configured for high rate output simultaneously.

Note: \$PASHR and \$PASHR-TSS are mutually exclusive, as are \$PRDID and \$PRDID-TSS.

Information supplied through the COM port is valid for the point described by the vessel lever arms and mounting angles, as selected by the user.

NMEA Sentence Formats

\$xxGGA: Global Positioning Fix Data

Time and position fix related data. POS MV supplies information using the following American Standard Code for Information Interchange (ASCII) NMEA 0183 sentence format.

\$xxGGA,hhmmss.sss,llll.llll,a,yyyyy.yyyyy,b,t,nn,v.v,xxxxx.xx,M,,,ccc,rrrr*hh<CRLF>

Table 13: \$xxGGA Sentence Format

Item	Definition	Value	Units (If Applicable)
\$xxGGA	Header	\$xxGGA	
hhmmss.sss	UTC time of position	N/A	hours minutes seconds decimal seconds 2 fixed digits for hours 2 fixed digits for minutes 2 fixed digits for seconds 3 digits for decimal seconds

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\$xxGGA,hhmmss.sss,llll.llll,a,yyyyy.yyyyy,b,t,nn,v.v,xxxxx.xx,M,,,ccc,rrrr*hh<CRLF>

Table 13: \$xxGGA Sentence Format

Item	Definition	Value	Units (If Applicable)
llll.llll	Latitude	0 to 90	degrees minutes decimal minutes 2 fixed digits for degrees 2 fixed digits for minutes 5 digits for decimal minutes
A	N (North) or S (South)	N or S	
yyyyy.yyyyy	Longitude	0 to 180	degrees minutes decimal minutes 3 fixed digits for degrees 2 fixed digits for minutes 5 digits for decimal minutes
B	E (East) or W (West)	E or W	
T	GNSS quality indicator	0 = fix not available or invalid 1 = C/A standard GNSS; fix valid 2 = DGNSS mode; fix valid 3 = GNSS PPS mode; fix valid 4 = RTK fixed 5 = RTK float 6 = free inertial	
nn	Number of satellites used in the fix	0 to 32	
v.v	Horizontal dilution of precision		
xxxxx.xx	Altitude above or below mean sea level; a negative value indicates below sea level	N/A	metres
M	Units of measure = metres	M	
Null	Null		
Null	Null		
ccc	Age of differential corrections in seconds since last RTCM-104 message	0 to 999	seconds

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\$xxGGA,hhmmss.sss,IIII.IIIII,a,yyyyy.yyyyy,b,t,nn,v.v,xxxxx.xx,M,,,ccc,rrrr*hh<CRLF>

Table 13: \$xxGGA Sentence Format

Item	Definition	Value	Units (If Applicable)
rrrr	DGNSS reference station identity	0000 to 1023	
*hh	Checksum		
<CRLF>	Carriage return and line feed	<CRLF>	

Note: Commas separate all items, including null fields. The information is valid at the location of the vessel frame.

\$xxGGK: Time, Position, Position Type and DOP Values

The message string is shown below.

\$xxGGK,hhmmss.ss,mdddy,IIII.IIIIIII,a,yyyyy.yyyyyyyy,b,t,nn,v.v,x.xxx,M*hh<CRLF>

Table 14: \$xxGGK Sentence Format

Item	Definition	Value	Units (If Applicable)
\$xxGGK	Header	\$xxGGK	
hhmmss.ss	UTC of position fix	N/A	hours minutes seconds decimal seconds 2 fixed digits for hours 2 fixed digits for minutes 2 fixed digits for seconds 2 digits for decimal seconds
mdddy	UTC date of position	N/A	month day year 2 fixed digits for month 2 fixed digits for day 2 fixed digits for year
IIII.IIIIIII	Latitude	0 to 90	degrees minutes decimal minutes 2 fixed digits for degrees 2 fixed digits for minutes 8 digits for decimal minutes
A	Direction of latitude	N or S	
yyyyy.yyyyyyy	Longitude	0 to 180	degrees minutes decimal minutes 3 fixed digits for degrees 2 fixed digits for minutes 8 digits for decimal minutes
B	Direction of longitude	E or W	

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\$xxGGK,hhmmss.ss,mddyy,IIII.IIIIII,a,yyyyy.yyyyyyyy,b,t,nn,v.v,x.xxx,M*hh<CRLF>

Table 14: \$xxGGK Sentence Format

Item	Definition	Value	Units (If Applicable)
T	GNSS quality indicator	0 = fix not available or invalid 1 = C/A standard GNSS; fix valid 2 = RTK float 3 = RTK fixed 4 = DGNSS mode; fix valid 5 = free inertial	
nn	Number of satellites used in GNSS solution	0 to 32	
v.v	DOP of fix		
x.xxx	Ellipsoid height of fix (vessel height above WGS84 ellipsoid)	N/A	metres decimal metres 1 fixed digit for metres 3 fixed digits for decimal metres
M	Ellipsoid height	N/A	metres
*hh	Checksum		
<CRLF>	Carriage return and line feed	<CRLF>	

\$xxHDT: Heading - True Data

True vessel heading is in degrees. POS MV supplies information in the following ASCII NMEA 0183 sentence format.

\$xxHDT,xxx.x,T*hh<CRLF>

Table 15: \$xxHDT Sentence Format

Item	Definition	Value	Units (If Applicable)
\$xxHDT	Header	\$xxHDT	
xxx.x	True vessel heading in the vessel frame	000.0 to 359.9	degrees decimal degrees 3 fixed digits for degrees 1 digit for decimal degrees
T	True	T	
*hh	Checksum	N/A	
<CRLF>	Carriage return and line feed	<CRLF>	

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\$xxVTG: Course Over Ground and Ground Speed Data

Actual course and speed relative to the ground. POS MV supplies information in the following ASCII NMEA 0183 sentence format.

\$xxVTG,xxx.x,T,,M,n.n,N,k.k,K*hh<CRLF>

Table 16: \$xxVTG Sentence Format

Item	Definition	Value	Units (If Applicable)
\$xxVTG	Header	\$xxVTG	
xxx.x	True vessel track in the vessel frame	000.0 to 359.9	degrees decimal degrees 3 fixed digits for degrees 1 digit for decimal degrees
T	True	T	
Null	Not supported	null	
M		M	
n.n	Speed in the vessel frame	N/A	knots
N	Knots	N	
k.k	Speed in the vessel frame	N/A	km/h
K	Kilometres per hour	K	
*hh	Checksum	N/A	
<CRLF>	Carriage return and line feed	<CRLF>	

Note: Commas separate all items, including null fields.

\$xxGST: GNSS Pseudorange Noise Statistics

GNSS pseudorange noise statistics indicate the quality of the position solution delivered by the integrated navigation solution. POS MV supplies information in the following ASCII NMEA 0183 sentence format.

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\$xxGST,hhmmss.sss,,smjr.smjr,smnr.smnr,ooo.o,l.l,y.y,a.a
*hh<CRLF>

Table 17: \$xxGST Sentence Format

Item	Definition	Value	Units (If Applicable)
\$xxGST	Header	\$xxGST	
hhmmss.sss	UTC time of position	N/A	hours minutes seconds decimal seconds 2 fixed digits for hours 2 fixed digits for minutes 2 fixed digits for seconds 3 digits for decimal seconds
Null	Not supported	null	
smjr.smjr	Standard deviation of semi-major axis of error ellipse	N/A	metres
smnr.smnr	Standard deviation of semi-minor axis of error ellipse	N/A	metres
ooo.o	Orientation of semi major axis of error ellipse	000.0 to 359.9	degrees from true north
l.l	Standard deviation of latitude	N/A	metres
y.y	Standard deviation of longitude	N/A	metres
a.a	Standard deviation of altitude	N/A	metres
*hh	Checksum	N/A	
<CRLF>	Carriage return and line feed	<CRLF>	

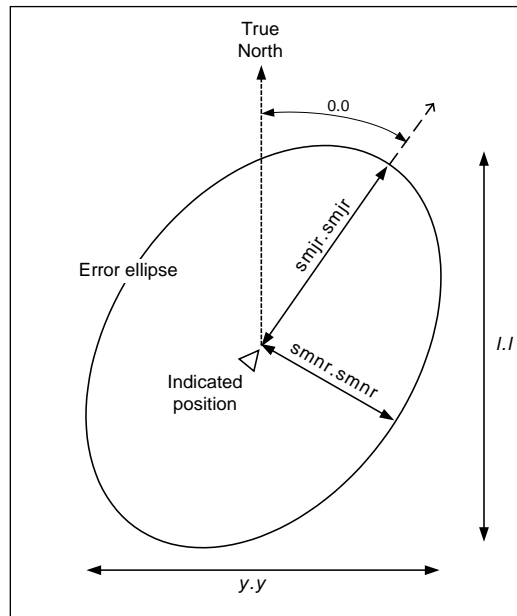


Figure 14: \$xxGST Sentence Nomenclature

NMEA Port RMC Message Format

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

Table 18: NMEA RMC Message Format

\$xxRMC,hhmmss.ssss,S,IIII.IIIII,A,yyyyy.yyyyy,B,sssss.s,
hhh.h,ddmmyy,,,C*hh<CR><LF>

Items	Definition	Values	Units
\$xxRMC	Header with talker ID	\$ttRMC	tt = IN or GP
hhmmss.ssss	UTC time of navigation data	NRG	hours / minutes / seconds. decimal sec
S	Status	A = Active V = Void	N/A
IIII.IIIII	Latitude	0° to 90°	degrees / minutes. decimal min
A	Latitude direction	N (North) or S (South)	N/A
yyyyy.yyyyy	Longitude	0° to 180°	degrees / minutes. decimal min

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Table 18: NMEA RMC Message Format

\$xxRMC,hhmmss.ssss,S,lll.llll,A,yyyy.yyyy,B,sssss.s,
hhh.h,ddmmyy,,,C*hh<CR><LF>

Items	Definition	Values	Units
B	Longitude direction	E (East) or W (West)	N/A
sssss.s	Speed in knots	NRG	knots
hhh.h	Heading	0° to 359.9°	degrees
ddmmyy	Date of navigation data	NRG	days/ months/ year
Null	Not supported	null	
Null	Not supported	null	
C	Mode indicator	See Table 19	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 19: RMC Mode Indicator Values

Value	RMC Mode
A	Autonomous
D	Differential
E	Dead reckoning
N	Not valid

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\$PASHR (\$PASHR-TSS): Attitude Data

POS MV supplies attitude data information in the following ASCII NMEA sentence format.

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

Table 20: \$PASHR Sentence Format

Item	Definition	Value	Units (If Applicable)
\$PASHR	Header	\$PASHR	
hhmmss.sss	UTC time of data string	N/A	hours minutes seconds decimal seconds • 2 fixed digits for hours • 2 fixed digits for minutes • 2 fixed digits for seconds • 3 digits for decimal seconds
xxx.xx	True vessel heading	0 to 359.99	degrees
T	True	T	
RRR.RR	Roll	-90.00 to +90.00	degrees
PPP.PP	Pitch	-90.00 to +90.00	degrees
HHH.HH	Heave	-99.00 to +99.00	metres
a.aaa	Accuracy roll	0 to 9.999	degrees
b.bbb	Accuracy pitch	0 to 9.999	degrees
c.ccc	Accuracy heading	0 to 9.999	degrees
D	Flag - accuracy heading	0, 1, 2	0 = no aiding 1 = GNSS aiding 2 = GNSS & GAMS aiding
E	Flag - IMU	0, 1	0 = IMU out 1 = satisfactory
*hh	Checksum	N/A	
<CRLF>	Carriage return and line feed	<CRLF>	

Note: Commas separate all items. Two attitude data strings are available. The strings are identical except for the definition of roll and pitch angles. One string uses Tait-Bryan angles and the other uses TSS angles. Use the MV-POSView Controller program to set the required angle convention. Refer to COM Port Set-up on page 4-15 for instructions and Mounting Angles on page 2-29 for a definition of the Tait-Bryan angles. The information is valid in the vessel frame, except for heave, which is valid in the sensor 1 frame.

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\$PRDID (\$PRDID-TSS): Attitude Data

POS MV supplies attitude data information in the following ASCII NMEA sentence format.

\$PRDID,PPP.PP,RRR.RR,xxx.xx*hh <CRLF>

Table 21: \$PRDID Sentence Format

Item	Definition	Value	Units (If Applicable)
\$PRDID	Header	\$PRDID	
PPP.PP	Pitch	-90.00 to +90.00	degrees
RRR.RR	Roll	-90.00 to +90.00	degrees
xxx.xx	Sensor heading	0 to 359.99	degrees
*hh	Checksum	N/A	
<CRLF>	Carriage return and line feed	<CRLF>	

Note: Commas separate all items. Two attitude data strings are available. The strings are identical except for the definition of roll and pitch angles. One string uses Tait-Bryan angles and the other uses TSS angles. Use the MV-POSView Controller program to set the required angle convention. Refer to COM Port Set-up on page 4-15 for instructions and Mounting Angles on page 2-29 for a definition of the Tait-Bryan angles. The information is valid in the vessel frame, except for heave, which is valid in the sensor 1 frame.

\$xxZDA: Time and Date

POS MV supplies time and date information in the following ASCII NMEA sentence format.

\$xxZDA,hhmmss.ssss,DD,MM,YYYY,*,*hh<CRLF>

Table 22: \$xxZDA Sentence Format

Item	Definition	Value	Units (If Applicable)
\$xxZDA	Header	\$xxZDA	
hhmmss.ssss	UTC time	N/A	hours minutes seconds decimal seconds • 2 fixed digits for hours • 2 fixed digits for minutes • 2 fixed digits for seconds • 4 digits for decimal seconds
DD	Day of month	01 to 31	
MM	Month of year	01 to 12	
YYYY	Year		
Null	Null		
Null	Null		
*hh	Checksum	N/A	

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\$xxZDA,hhmmss.ssss,DD,MM,YYYY,*,*hh<CRLF>

Table 22: \$xxZDA Sentence Format

Item	Definition	Value	Units (If Applicable)
<CRLF>	Carriage return and line feed	<CRLF>	

Note: Commas separate all items.

Note: UTC time is the time of the previous 1PPS signal.

\$UTC: Time and Date

POS MV supplies UTC time and date information in the following ASCII NMEA sentence format.

\$UTC,YYYYMMDD,hhmmss.ssss,*hh<CRLF>

Table 23: \$UTC Sentence Format

Item	Definition	Value	Units (If Applicable)
\$UTC	Header	\$UTC	
YYYY	Year		
MM	Month	01 to 12	
DD	Day	01 to 31	
hhmmss.ssss	UTC time	000000.0000 to 235959.9999	hours minutes seconds decimal seconds • 2 fixed digits for hours • 2 fixed digits for minutes • 2 fixed digits for seconds • 4 digits for decimal seconds
*hh	Checksum	N/A	
<CRLF>	Carriage return and line feed	<CRLF>	

Note: Commas separate all items.

Note: UTC time is the time of the previous 1PPS signal.

\$xxPPS: Time and Offset

POS MV supplies UTC time and GPS Time offset information in the following ASCII NMEA sentence format.

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\$xxPPS,hhmmss.ssss,d,www,uu.uu,pppp,*hh<CRLF>

Table 24: \$xxPPS Sentence Format

Item	Definition	Value	Units (If Applicable)
\$xxPPS	Header	\$xxPPS	
hhmmss.ssss	UTC time	000000.0000 to 235959.9999	hours minutes seconds decimal seconds <ul style="list-style-type: none">• 2 fixed digits for hours• 2 fixed digits for minutes• 2 fixed digits for seconds• 4 digits for decimal seconds
D	Offset day ^{N1}	0 to 6	
www	GNSS week number	0000 to 9999	
uu.uu	Offset of GPS Time from UTC time ^{N2}	00.00 to 99.99	seconds decimal seconds <ul style="list-style-type: none">• 2 fixed digits for seconds• 2 digits for decimal seconds
pppp	PPS count ^{N3}	1 to n	
*hh	Checksum	N/A	
<CRLF>	Carriage return and line feed	<CRLF>	

^{N1} First day of week (Sunday) = 0.

^{N2} GPS Time = UTC time + UTC offset.

^{N3} Variable length.

Note: Commas separate all items.

Note: UTC time is the time of the previous 1PPS signal.

UTC: Date and Time (Trimble format)

POS MV supplies UTC date and time information in the following Trimble ASCII sentence format.

UTC YY.MM.DD hh:mm:ss ab<CRLF>

Table 25: UTC Sentence Format

Item	Definition	Value	Units (If Applicable)
UTC	Header	UTC	
YY	Year	00 to 99	

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UTC YY.MM.DD hh:mm:ss ab<CRLF>

Table 25: UTC Sentence Format

Item	Definition	Value	Units (If Applicable)
MM	Month	01 to 12	
DD	Day	01 to 31	
hh:mm:ss	UTC time	00:00:00 to 23:59:59	hours:minutes:seconds • 2 fixed digits for hours • 2 fixed digits for minutes • 2 fixed digits for seconds
a	Position fix type	1 to 5 or ?	1 – time only 2 – 1D & time 3 – unused 4 – 2D & time 5 – 3D & time ? – no SV tracked, time based on receiver clock
b	# of SV tracked	≥ 1 or ?	? – no SV tracked, time based on receiver clock
<CRLF>	Carriage return and line feed	<CRLF>	

Note: UTC time is the time of the **next** 1PPS signal.

\$xxGGAT: Global Positioning Fix Data Applanix format

Time and position fix related data. POS MV supplies information using the following Applanix unique sentence format

\$xxGGA,hhmmss.ss,IIII.IIIIII,a,yyyyy.yyyyyyy,b,t,nn,v.v,xxxx.xxx,M,xxxx.xxx,M,,ccc,rrrr*hh<CRLF>

Table 26: \$xxGGAT Sentence Format

Item	Definition	Value	Units (If Applicable)
\$xxGGA	Header	\$xxGGA	
hhmmss.ss	UTC time of position	N/A	hours minutes seconds decimal seconds 2 fixed digits for hours 2 fixed digits for minutes 2 fixed digits for seconds 2 digits for decimal seconds
IIII.IIIIII	Latitude	0 to 90	degrees minutes decimal minutes 2 fixed digits for degrees 2 fixed digits for minutes 8 digits for decimal minutes

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\$xxGGA,hhmmss.ss,llll.lllllll,a,yyyyy.yyyyyyyy,b,t,nn,v.v,xxxx.xxx,M,xxxx.xxx,M,,ccc,rrrr*hh<CRLF>

Table 26: \$xxGGAT Sentence Format

Item	Definition	Value	Units (If Applicable)
A	N (North) or S (South)	N or S	
yyyyy.yyyyyyy	Longitude	0 to 180	degrees minutes decimal minutes 3 fixed digits for degrees 2 fixed digits for minutes 5 digits for decimal minutes
B	E (East) or W (West)	E or W	
T	GNSS quality indicator	0 = fix not available or invalid 1 = C/A standard GNSS; fix valid 2 = DGNSS mode; fix valid 3 = GNSS PPS mode; fix valid 4 = RTK fixed 5 = RTK float 6 = free inertial	
nn	Number of satellites used in the fix	0 to 32	
v.v	Horizontal dilution of precision		
xxxxx.xxx	Altitude above or below mean sea level; a negative value indicates below sea level	N/A	metres
M	Units of measure = metres	M	
xxxxx.xxx	Geoidal Seperation	N/A	metres
M	Units of measure = metres	M	
ccc	Age of differential corrections in seconds since last RTCM-104 message	0 to 999	seconds

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\$xxGGA,hhmmss.ss,llll.llllllll,a,yyyyy.yyyyyyyy,b,t,nn,v.v,xxxx.xxx,M,xxxx.xxx,M,,ccc,rrrr*hh<CRLF>

Table 26: \$xxGGAT Sentence Format

Item	Definition	Value	Units (If Applicable)
rrrr	DGNSS reference station identity	0000 to 1023	
*hh	Checksum		
<CRLF>	Carriage return and line feed	<CRLF>	

Note: Commas separate all items, including null fields. The information is valid at the location of the vessel frame.

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Binary Data Formats

The PCS outputs attitude data using any of the following output string formats (any number of COM ports can be independently configured for Binary output):

1. TSS1 format
2. Simrad 1000 format using Tait-Bryan or TSS angles
3. Simrad 3000 format using Tait-Bryan or TSS angles
4. TSM 5265 format using Tait-Bryan or TSS angles
5. Atlas format
6. PPS format
7. Time of PPS format (copy of Novatel TM1B)

Output String Formats

The following descriptions include the update rate for each output format. To achieve these update rates, you must set an appropriate communication speed for the COM port.

Note: System performance may degrade if multiple ports are configured for high rate output simultaneously.

Information supplied through the COM port is valid for the point described by the sensor 1 or sensor 2 lever arms and mounting angles, as selected by the user.

TSS1 Format

Format TSS1 consists of five fields and contains 27 ASCII characters. Each record begins with a start character and ends with the two-character carriage-return line-feed sequence. All fields contain measurements in real-world units; POS MV supplies acceleration measurements in ASCII coded hexadecimal values and heave, roll and pitch as ASCII coded decimal values. You can use the MV-POSView Controller program to change the sense of the roll, pitch and heave outputs. POS MV supplies information in the following format.

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:XXAAAASMHHHQMRRRRSMPPPP<CRLF>

Table 27: TSS1 Output Format

Field	Definition	Value	Units (If Applicable)
:	Start of packet character	3A hex	ASCII
XX	Horizontal acceleration	0 to +9.81 cm/s ²	3.83 cm/s ²
AAAA	Vertical acceleration	0 to +40.96 cm/s ²	0.0625 cm/s ²
S	Space character	20 hex	ASCII
MHHHH	Heave	-99 to +99 m	1 cm
Q	Status flag	U = unaided mode - settled condition u = unaided mode - settling G = GNSS aided mode - settled condition g = GNSS aided mode - settling H = heading aided mode - settled condition h = heading aided mode - settling F = full aided mode - settled condition f = full aided mode - settling	
MRRRR	Roll	-90 to +90°	0.01°
S	Space character	20 hex	ASCII
MPPPP	Pitch	-90 to +90°	0.01°
<CRLF>	Carriage return & line feed	0D hex and 0A hex	ASCII

Note 1: M = space if positive or minus if negative. You can use the MV-POSView Controller program to change the sense of the roll, pitch and heave outputs.

Note 2: POS MV sends records using the TSS1 format at an update rate from one to 200 Hz. It updates the TOV at the same rate. The recommended minimum baud rate for use with this format is 9600 baud at 25 Hz.

Simrad 1000 Format

You can use this format with the Simrad 1000 multibeam sonar. The MV-POSView Controller program is used to select the TSS or the Tait-Bryan convention of rotations for the attitude measurement. Refer to page 2-29 for an explanation of these conventions.

The Simrad attitude data are a 10-byte message with the following format.

- Sync format: 90 hex
- Roll format: 2's complement, LSB = 0.01°, roll sense is user selectable from the MV-POSView Controller program
- Pitch format: 2's complement, LSB = 0.01°, pitch sense is user selectable from the MV-POSView Controller program

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- Heave format: 2's complement, LSB = 1 cm, heave sense is user selectable from the MV-POSView Controller program
- Heading format: LSB = 0.01°, 0 to 359.99°, positive = clockwise

A frame of Simrad digital attitude data, as supplied by the POS MV, has the format shown in Table 27.

Table 28: Simrad 1000 Digital Output Format

Item	Byte	Value	Units (If Applicable)
Header LSB	0	0x00	N/A
Header MSB	1	0x99	
Roll LSB	2	±180°	0.01°
Roll MSB	3		
Pitch LSB	4	±180°	0.01°
Pitch MSB	5		
Heave LSB	6	±327 m	1 cm
Heave MSB	7		
Heading LSB	8	0 to 359.99°	0.01°
Heading MSB	9		

Note: POS MV sends records using the Simrad 1000 format at an update rate from one to 200 Hz; TOV is updated at the same rate. The recommended minimum baud rate for use with this format is 19200 baud at 100 Hz.

Simrad 3000 Format

You can use this format with the Simrad 3000 multibeam sonar. The MV-POSView Controller program is used to select the TSS or the Tait-Bryan convention of rotations for the attitude measurement. Refer to page 2-29 for an explanation of these conventions.

The Simrad attitude data are a 12-byte message with the following format.

- Status format: 99 hex
- Sync format: 90 hex
- Roll format: 2's complement, LSB = 0.01°, roll sense is user selectable from the MV-POSView Controller program
- Pitch format: 2's complement, LSB = 0.01°, pitch sense is user selectable from the MV-POSView Controller program
- Heave format: 2's complement, LSB = 1 cm, heave sense is user selectable from the MV-POSView Controller program
- Heading format: LSB = 0.01°, 0 to 359.99°, positive = clockwise

A frame of Simrad digital attitude data, as supplied by the POS MV, has the format shown in Table 28.

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Table 29: Simrad 3000 Digital Output Format

Item	Byte	Value	Units (If Applicable)
Header LSB	0	0x00	N/A
Header MSB	1	0x90	
Roll LSB	2	$\pm 180^\circ$	0.01°
Roll MSB	3		
Pitch LSB	4	$\pm 180^\circ$	0.01°
Pitch MSB	5		
Heave LSB	6	± 327 m	1 cm
Heave MSB	7		
Heading LSB	8	0 to 359.99°	0.01°
Heading MSB	9		

Note: POS MV sends records using the Simrad 3000 format at an update rate from one to 200 Hz; TOV is updated at the same rate. The recommended minimum baud rate for use with this format is 19200 baud at 100 Hz.

TSM 5265 Format

You can use this format with the Thompson TSM 5265 multibeam sonar. The output message supplies the sonar with a time tag (roll, pitch and heave), heading and sonar velocity. POS MV updates the message and the TOV from one to 200 times per second.

The message is a 24-byte data string with the following format.

- Header: 90 hex
- Time tag: double precision float, UTC time in seconds of the week
- Roll format: 2's complement, LSB = 0.01°, roll sense is user selectable from the MV-POSView Controller program
- Pitch format: 2's complement, LSB = 0.01°, pitch sense is user selectable from the MV-POSView Controller program
- Heave format: 2's complement, LSB = 1 cm, heave sense is user selectable from the MV-POSView Controller program
- Heading format: LSB = 0.01°, 0 to 359.99°, positive = clockwise
- Longitudinal velocity format: 2's complement, LSB = 0.1 cm/s, positive = forward
- Transverse velocity format: 2's complement, LSB = 0.1 cm/s, positive = starboard
- Down velocity format: 2's complement, LSB = 0.1 cm/s, positive = down

The recommended minimum baud rate for use with this format is 38400 baud at 100 Hz.

You can use the MV-POSView Controller program to change the sense of the roll, pitch and heave outputs. You can also select the TSS or the Tait-Bryan convention of rotations for the

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attitude measurement. Refer to page 2-29 for instructions to do this and for an explanation of the TSS and Tait-Bryan conventions.

The time tag attached to the data is Universal Time Coordinated (UTC) time in seconds of the week. For the purposes of this feature, a week begins on Sunday morning so that the first second occurs at 00:00:01 UTC.

A frame of TSM 5265 digital attitude data, as supplied by the POS MV, has the format shown in Table 29.

Table 30: TSM 5265 Digital Output Format

Item	Byte	Value	Units (If Applicable)
Header LBS	0	0x00	N/A
Header MSB	1	0x90	
Time tag	2 to 9		seconds
Roll LSB	10	$\pm 180^\circ$	0.01°
Roll MSB	11		
Pitch LSB	12	$\pm 180^\circ$	0.01°
Pitch MSB	13		
Heave LSB	14	± 327 m	1 cm
Heave MSB	15		
Heading LSB	16	0 to 359.99°	0.01°
Heading MSB	17		
Longitudinal velocity LSB	18	± 32.8 m/s	0.1 cm/s
Longitudinal velocity MSB	19		
Transverse velocity LSB	20	± 32.8 m/s	0.1 cm/s
Transverse velocity MSB	21		
Down velocity LSB	22	± 32.8 m/s	0.1 cm/s
Down velocity MSB	23		

Atlas Format

The Atlas format consists of a series of fields of 16-bit 2's complement numbers expressed as two binary-coded digits.

POS MV supplies attitude measurements in units of 0.0054931641° ($=360^\circ/65536$).

The system uses millimetres for measurements of heave. You can use the MV-POSView Controller program to change the roll, pitch and heave sense outputs. POS MV supplies information in the following format.

POS MV V5 Installation and Operation Guide

Interfaces and Data Formats

DLERrPpHhQDLE

Table 31: Atlas Output Format

Field	Definition	Value	Units (If Applicable)
DLE	Start of packet character	10 hex	ASCII
R R	Roll MSB Roll LSB	+90 to -90°	0.00549°
P P	Pitch MSB Pitch LSB	+90 to -90°	0.00549°
H H	Heave MSB Heave LSB	+9999 to -9999	mm
Q	Status flag	0 = unaided mode - settled condition 1 = unaided mode - settling 2 = GNSS aided mode - settled condition 3 = GNSS aided mode - settling 4 = heading aided mode - settled condition 5 = heading aided mode - settling 6 = full aided mode - settled condition 7 = full aided mode - settling	
DLE	Stop character	10 hex	ASCII

Note: POS MV sends records using the Atlas format at an update rate from one to 200 Hz. The recommended minimum baud rate for use with this format is from 9600 to 19200 baud at 50 Hz.

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Interfaces and Data Formats

PPS Format

Table 32: PPS Digital Output Format

Item	Byte	Value	Units (If Applicable)
Header LBS	0	0x00	N/A
Header MSB	1	0x99	
PPS time (GNSS seconds into the week, coincident with PPS strobe [GPS Time])	2 to 9		seconds
Week (GNSS week number)	10 to 13		N/A
UTC offset (offset of GPS Time from UTC time where UTC time = GPS Time - UTC offset)	14 to 17		seconds
PPS count	18 to 21		N/A
Checksum	22 to 23		N/A

Note: PPS time is the time of the previous 1PPS signal.

Time of PPS Format (copy of Novatel TM1B)

Table 33: Time of PPS Digital Output Format

Item	Byte	Value	Units (If Applicable)
Sync	0	0xAA	N/A
	1	0x44	
	2	0x11	
Checksum	3		N/A
Msg ID	4 to 7	3	N/A
Bytes	8 to 11	52	N/A
Week (GNSS week number)	12 to 15		N/A
PPS time (GNSS seconds into the week, coincident with PPS strobe [PCS time])	16 to 23		seconds
Clock offset (PCS clock offset where GPS Time = PPS time - clock offset)	24 to 31		seconds
Clock offset standard deviation (standard deviation of PCS clock offset)	32 to 39		seconds

Table 33: Time of PPS Digital Output Format

Item	Byte	Value	Units (If Applicable)
UTC offset (offset of UTC time from GPS Time where UTC time = GPS Time + UTC offset)	40 to 47		seconds
Clock model status (PCS clock model status where 0 is valid and values -20 to -1 implies that clock is in process of stabilization)	48 to 51		N/A

Note: PPS time is the time of the previous 1PPS signal.

GNSS Ports

Some older versions of POS MV systems contain two separate GNSS receivers, referred to as primary and secondary, while newer systems contain one dual antenna GNSS receiver. In either case the PCS configures the GNSS receiver card(s) automatically for its own use.

The user may require access to the GNSS receiver directly to; 1) upgrade the receiver firmware or, 2) supply corrections directly to the receiver rather than the Base GNSS input to POS.

All POS MV V5 systems provide a mechanism to switch COM3 and COM4 to connect directly to the COM port on the internal GNSS receiver(s) by selecting that connection in POSView (see COM Port Set-up). Newer systems also provide a dedicated “GNSS” port which is permanently connected to the COM port of the internal GNSS receiver.

Physical Interface

COM ports 3 and 4 may be configured using the MV-POSView software to allow direct access to the primary and secondary GNSS receiver cards. Table 33 lists the factory port settings.

Table 34: COM 3 and 4 Port Settings

Setting	Default Value
GNSS Output Rate	1 Hz
Auto Configuration	Enabled
Baud Rate	115200
Parity	None
Data Bits	8
Stop Bits	1

4.0 System Configuration

This section of the manual includes instructions on how to power-on, power-off and configure the Position and Orientation System for Marine Vessels (POS MV) after installation.

The installation specific parameters described in this section are very important. The accuracy with which you measure them contributes significantly to the overall accuracy and performance of the system.

Refer to the Installation Parameters topic on page 2-24 for instructions on how to measure the installation parameters.

Once POS MV is configured using the installation parameters, save the data to Non-Volatile Memory (NVM) so that the system takes the same configuration each time the POS Computer system (PCS) is powered-on. The MV-POSView Controller program that provides these functions is contained on the compact disk supplied with the system. Refer to the Software Installation description on page D-1 for instructions on how to install the MV-POSView Controller program on your Personal Computer (PC).

Power-On

Once the system is installed and configured, POS MV is ready for operation in a stand-alone mode. This feature allows POS MV to start processing information after power-on without further need for the controller program or a controlling PC.

The initial power-on for the POS MV system occurs in two stages:

- a) Power-on the POS MV system
- b) Power-on the controlling PC and start the MV-POSView Controller program

POS MV Power-On

Power for the POS MV V5 system is applied to the PCS rear panel PWR connector, refer to Figure 15. Two power switches are available on the PCS; a rear panel PWR switch and a front panel POWER switch. Enabling the rear panel PWR switch applies operating power to an internal power supply, which in turn supplies power to the internal electronics stack and to the external Inertial Measurement Unit (IMU) once the front panel POWER switch is enabled. On the MV V5-1 and MV V5-2, energizing the power cable connected to the rear of the PCS applies power to the internal electronics.

The internal electronics stack is the heart of the PCS and interfaces directly with the front panel switches and indicators. The front panel POWER switch is an alternate action push-and-hold switch; press once for power-on, press again for power-off. Press and hold the POWER switch until the light illuminates indicating that the PCS is powered-on. To power-off, press and hold the POWER switch until the light

POS MV V5 Installation and Operation Guide

System Configuration

starts blinking, then release the switch. On the MV V5-2, energizing the power cable connected to the rear of the PCS applies power to the internal electronics and causes the system to power up.

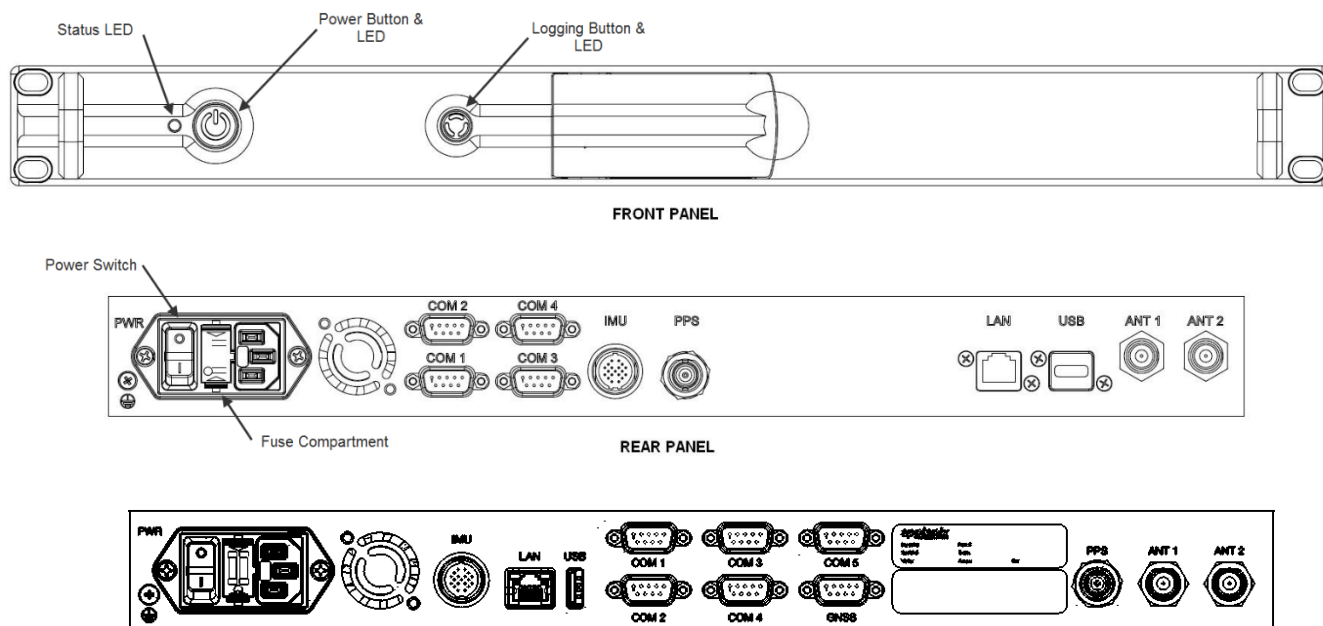


Figure 15: PCS Front and Rear Panels - POS MV V5

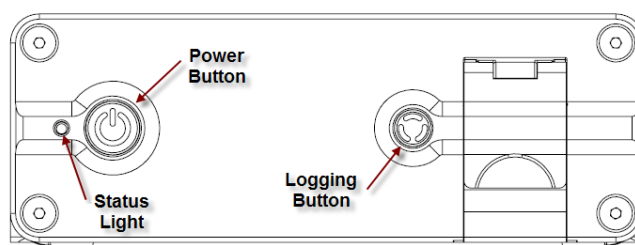


Figure 16: POS MV PCS V5-1 PCS Front Panel

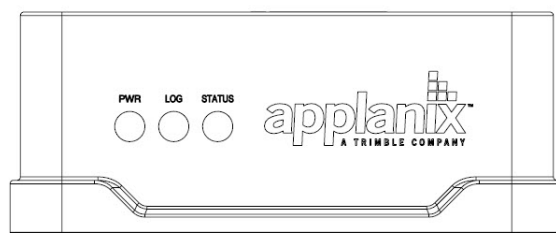


Figure 17: POS MV PCS V5-2 PCS Front Panel

Front Panel Status LEDs

Table 34 identifies the functions and status of the various PCS front panel lights.

Table 35: PCS Front Panel Lights

Status light - indicates current status of POS MV:	
Steady red:	POS MV failure - shows red when PCS is first powered-on. Changes to a valid condition when PCS internal program begins to run, but will turn red again if there is a fault in PCS. If a fault occurs, do not power-off PCS. Refer to Fault Detection window of controller program, see Fault Identification topic starting on page 9-3.
Steady amber:	Standby mode - POS MV is waiting for instructions.
Flashing amber:	Navigate mode - initialising and aligning attitude (coarse levelling).
Flashing green:	Navigate mode - degraded attitude performance. Attitude measurements are acceptable but do not meet user-set accuracy limits.
Steady green:	Navigate mode - normal system operation. System meets accuracy limits set by user for position, velocity, attitude and heading.
Logging light - indicates status of logging device.	
Steady green:	Logging device is active and recording data.
Steady amber:	Logging media is > 80% full.
Steady red:	Logging has failed – check that the device is not full, and for MV V5 and MV V5-1 that there is a USB memory stick properly inserted.
Power light - illuminates when the PCS is operating.	

Initial Power-On Considerations

The POS MV AutoStart feature is enabled prior to shipment from Applanix. The system will transition to navigate mode automatically after start-up.

Before the system can successfully navigate for first time, the installation parameters measured during the installation procedures need to be entered; refer to Installation Parameters on page 2-24.

Use the MV-POSView Controller program to enter this information. Save these parameters to NVM if you require the system to use the same configuration after each power-on sequence. POS MV retrieves these details from memory after a power-up or after a reset command. Refer to the POS MV Configuration

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description on page 4-7 for instructions on configuring the system with installation parameters using the MV-POSView Controller program.

MV-POSView Controller Program

Refer to the Software Installation appendix, page D-1, for instructions on installing the MV-POSView Controller program on a PC.

The following assumes that the controlling PC has a suitable version of windows installed and that you are familiar with its operation. If necessary, refer to the manuals supplied with the controlling PC for instructions on how to use your version of windows.

- Connect the PCS and the controlling PC to the 10/100 BaseT Ethernet LAN
- Power-on the PCS and the controlling PC, and start Microsoft Windows®; from windows, launch the MV-POSView Controller program

MV-POSView connects automatically and starts to display information broadcast by the PCS over the Ethernet if you have installed and configured the PCS, the controlling PC and the MV-POSView Controller correctly.

The controller program can operate in either of two modes:

- Monitor mode - the MV-POSView Controller program displays all PCS data that is broadcast over the Ethernet, however, changes to any of the PCS settings cannot be made. This mode allows several users to monitor the PCS data simultaneously.
- Control mode - the MV-POSView Controller program displays all PCS data that is broadcast over the Ethernet, and allows changes to the system configuration and the saving of new configurations to NVM. Only one MV-POSView Controller program can control a given POS at any time.

MV-POSView Controller - Initial Use

Note: Certain MV-POSView windows have an icon in the lower left corner. They are either all locked (password protected) or all unlocked (no password). Refer to the Password Protection description on page 4-31 for more details.



When you install and operate the POS MV for the first time, perform the procedures described in the following paragraphs.

PCS IP Address

Applanix sets the IP address of the PCS to **192.168.53.100** and the subnet mask to **255.255.255.0**.

Initially, to communicate with the PCS, you must give the controlling PC a unique address within the same subnet. Applanix recommends using address **192.168.53.101**.

IP Addresses

IP addresses consist of four sets of numbers separated by full stops (e.g. 192.168.53.100). The first three sets of numbers are the network part of the address and the last set of numbers is the host part. For example, 192.168.53 are the default value for the PCS network IP address and 100 is the default value for the PCS host.

To be compatible with a network the first two sets of numbers in the IP addresses of all items attached to the network must be the same.

Once communication with the PCS is established you can change the IP address of the PCS to any suitable address within your subnet. The IP address of the controlling PC may also be reset back to the original setting. The following paragraphs provide instructions on doing this.

Running the MV-POSView Controller Program

Check the MV-POSView Controller program main window (illustrated in

Figure 40 on page 5-3) for update activity; the window should update at one-second intervals. If not, check that the LAN light, located on the front panel of the PCS, is flashing green.

Changing Address

It is unlikely that the default IP address of the PCS will be compatible with your local area network. Therefore, you must change the system IP address before you can exercise control over the POS MV.

Follow the instructions below carefully, noting that you must begin all menu selections from the main window of the controller.

- a) Power-on the PCS, open Windows® and start MV-POSView.
- b) On the MV-POSView menu bar, select **Tools, Connect**.
- c) The tool bar shows the current IP address of the PCS Ethernet connection (this address may not be compatible with your network). Make a written note of this address so that you can change the address of the controlling PC temporarily to a compatible one. This must be done before you can communicate with the PCS through the LAN.
- d) In MV-POSView, select **File, Exit** (or press the Alt, F4 keys) to exit MV-POSView.
- e) Select the configure option from the Ethernet driver software included with your Windows® environment.

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- f) Note the original IP address of the controlling PC so that you can change it back once you have changed the PCS address.
- g) Change the IP address of the controlling PC to one that has the same network identity as the PCS. Set a new and unique address for the controlling PC (e.g. set the PC to IP address 129.100.1.230).
- h) For some versions of Windows®, the new IP address does not become active until you have rebooted the PC - Exit Windows® and power-off the controlling PC; wait thirty seconds and power-on the PC again.
- i) Run Windows® and start MV-POSView. In MV-POSView, select **Tools, Connect**.
- j) On MV-POSView menu bar, select **Settings, Installation, POS IP Address** and insert a new IP address and/or subnet mask, see Figure 18. The new address must be valid for the network on which you will operate the PCS. Press the **OK** button.
- k) The new IP address for the PCS will take effect immediately and a 'Lost connection with POS' message is displayed at the controlling PC.
- l) At the controlling PC, select **File, Exit** (or press the Alt, F4 keys) to exit the MV-POSView Controller program.

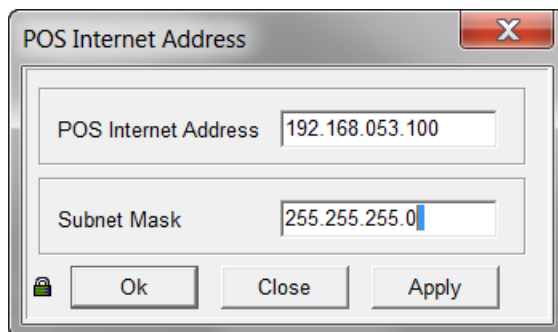


Figure 18: POSView POS Internet Address

- m) Follow the instructions in steps e) and g) above and reset the controlling PC to its original IP address.
- n) Exit Windows® and power-off the controlling PC. Wait thirty seconds and power-on the PC. The new IP addresses become active during the PC reboot sequence.
- o) At completion of the reboot sequence:
 - The IP address of the PCS is set to be compatible with your network
 - The original IP address to the controlling PC is restored

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

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

FTP guest credentials

File Transfer Protocol (FTP) may be used to download internal logged data (or backup data). The user name is *guest* and password is *applanix*. In order to comply with California Connected Devices legislation, POS MV shipped from Applanix commencing January 1, 2020 have a unique password for ftp access. The user name will remain *guest* but the password will be **PSW** followed by the POS MV 5 digit serial number (for example, **PSW12345**).

POS MV firmware v10.2 and later allows the default password to be changed using POSView. To do so, select **Settings, Installation, POS IP Address** from the POSView menu bar and check "Enable Password Change".

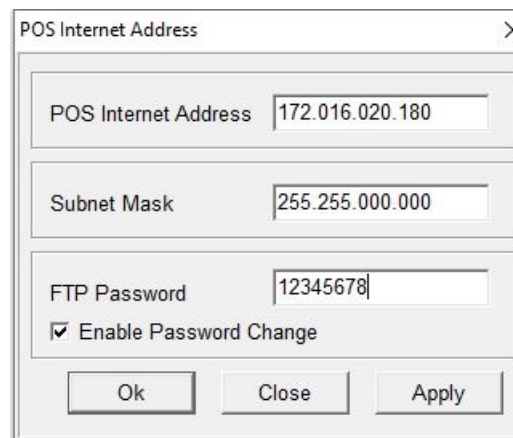


Figure 19: POSView POS FTP Password

Once checked a new FTP password may be entered. Click apply to make the change. The password must be between 4 and 8 characters long, and may include upper and lower case letters or numbers only. The username remains "guest".

POS MV Configuration

Once the POS MV components are installed and the physical installation parameters measured, these measurements are then entered in to the MV-POSView Controller program. The PCS stores this data in non-volatile memory for use on subsequent start-ups of POS MV.

The POS MV has a built-in feature that permits automatic fine-tuning of the configuration data. However, the more accurate the initial physical measurements are the quicker the automatic fine-tuning process.

Figure 19 outlines the configuration data refinement process.

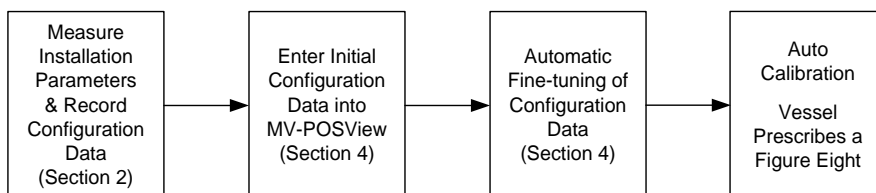


Figure 20: Configuration Data Refinement

Automatic fine-tuning permits the accurate measurement of the longitudinal, lateral and vertical distances between the installed components. Accurate manual measurements are often difficult to obtain and are subject to errors caused by accessibility. If it is not possible to measure the installation parameters to within Real-Time Kinematic (RTK) level accuracy (about 2 cm) then the automatic lever arm calibration feature should be used to improve accuracy. Although only the Reference to Primary GNSS measurement is presently available, other automatic measurements will be available in the future.

Set the initial configuration of POS MV by performing the following.

- Connect the PCS and the controlling PC to the 10/100BaseT Ethernet LAN. Both must have compatible IP addresses; if necessary refer to the Changing Address description on page 4-5 for instructions on IP addressing.
- Power-on the PCS and the controlling PC, and start Microsoft Windows®; from windows, launch the MV-POSView Controller program.
- Select **Tools, Connect** on the MV-POSView main window menu bar.

Configuration Data

To configure the POS MV consult the list of installation parameters that was created as you progressed through the physical installation. Refer to the Installation Parameters description starting on page 2-24 for detailed instructions.

Configuration - Initial

Note: Select the standby mode prior to changing lever arm or mounting angle values.

From the menu bar of the MV-POSView Controller program, select **Settings, Installation, Lever Arms & Mounting**; the **Lever Arms & Mounting Angles** tab is displayed (see Figure 20). Use metres for lever arm distances and degrees for misalignment angles.

In circumstances where you do not have the complete set of installation parameters, you *must* at least enter values in the **Ref. to IMU Lever Arm** and the **Ref. to primary GNSS Lever Arm** panes. This basic information allows the system to supply useful data to the multibeam sonar.

Lever Arms & Mounting Angles

Levers Arms & Mounting Angles | Sensor Mounting | Tags, AutoStart

Ref. to IMU Target		IMU Frame w.r.t. Ref. Frame		Target to Sensing Centre		Resulting Lever Arm	
X (m)	0.000	X (deg)	0.000	X (m)	0.000	X (m)	0.000
Y (m)	0.000	Y (deg)	0.000	Y (m)	0.000	Y (m)	0.000
Z (m)	-0.066	Z (deg)	0.000	Z (m)	0.066	Z (m)	0.000

Ref. to Primary GPS Lever Arm		Ref. to Vessel Lever Arm		Ref. to Centre of Rotation Lever Arm	
X (m)	0.000	X (m)	0.000	X (m)	0.000
Y (m)	0.000	Y (m)	0.000	Y (m)	0.000
Z (m)	0.000	Z (m)	0.000	Z (m)	0.000

Notes:

1. Ref. = Reference
2. w.r.t. = With Respect To
3. Reference Frame and Vessel Frame are co-aligned

Compute IMU w.r.t. Ref. Misalignment

Ok Close Apply View

In Navigation Mode, to change parameters go to Standby Mode!

Figure 21: POSView Lever Arms & Mounting Angles Tab

Next, select the **Sensor Mounting** tab (Figure 21) and enter the values for the lever arm distances and mounting angles. Once these values are entered, select the **OK** button.

Note: These settings become active immediately. To save the settings to non-volatile memory, select **Settings, Save Settings**. This permits the system to initialize using these installation parameters whenever the PCS is powered-on.

Note: Any changes made to the IMU or the Global Navigation Satellite System (GNSS) lever arm parameters will cause the fields to reset and begin again automatically.

Note: The Compute IMU w.r.t Ref. Misalignment option provides a tool that allows converting of measured roll, pitch, and heading of IMU in Vessel frame and automatically compute and populate the correct values for “IMU Frame w.r.t Ref. Frame” in Figure 18.

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The screenshot shows a software window titled "Lever Arms & Mounting Angles". It has three tabs: "Lever Arms & Mounting Angles", "Sensor Mounting" (which is selected), and "Tags, AutoStart". The "Sensor Mounting" tab contains six input fields arranged in a 3x2 grid. The left column contains three "Ref. to Aux. GPS Lever Arm" sections (Aux. 1, Aux. 2, and Sensor 1/2) with X (m), Y (m), and Z (m) inputs. The right column contains three "Sensor Frame w.r.t. Ref. Frame" sections (Aux. 1, Aux. 2, and Sensor 1/2) with X (deg), Y (deg), and Z (deg) inputs. All input fields are currently set to 0. At the bottom of the window, there are four buttons: "Ok", "Close", "Apply", and "View".

Section	X (m)	Y (m)	Z (m)	X (deg)	Y (deg)	Z (deg)
Ref. to Aux. 1 GPS Lever Arm	0	0	0			
Ref. to Aux. 2 GPS Lever Arm	0	0	0			
Ref. to Sensor 1 Lever Arm	0	0	0			
Sensor 1 Frame w.r.t. Ref. Frame				0	0	0
Ref. to Sensor 2 Lever Arm	0	0	0			
Sensor 2 Frame w.r.t. Ref. Frame				0	0	0

Figure 22: POSView Sensor Mounting Tab

GAMS Parameters are entered separately in **Settings, Installation, GAMS Parameter Setup**. If user knows the vector from phase centre of primary antenna to phase centre of secondary antenna in vehicle frame, they enter it directly without having rely on calibration procedure outlined on page 4-22.

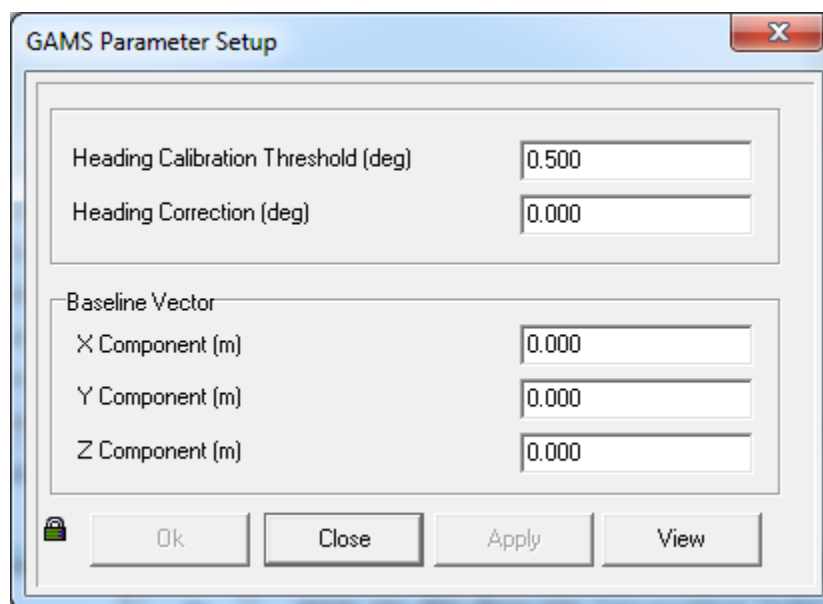


Figure 23: GAMS Parameter Setup

Configuration - Automatic

Note: Perform a GNSS Azimuth Measurement Subsystem (GAMS) calibration prior to running this procedure, see Antenna Installation Calibration on page 4-22.

Note: The integrated navigation solution should be delivering a RTK solution; may be tightly coupled or using an auxiliary RTK GNSS receiver. The Nav Status (MV-POSView Status pane) indicates FLOAT RTK or FIXED RTK.

Ensure that GAMS is on-line then select **Settings, Installation, Installation Calibration Control** from the menu bar of the MV-POSView Controller program. The Calibration Control window is displayed (Figure 23).

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Lever Arm Calibration Select		Figure of Merit	X (m)	Y (m)	Z (m)
<input checked="" type="checkbox"/>	Reference to Primary GPS	0.000	0.000	0.000	0.000
<input type="checkbox"/>	Reference to Auxiliary 1 GPS	0.000	0	0	0
<input type="checkbox"/>	Reference to Auxiliary 2 GPS	0.000	0	0	0
<input type="checkbox"/>	Position Fix	0.000	0	0	0

Calibration Action

Last Calibration Action: **None**

Buttons: Stop Calibration, Manual Calibration, Auto Calibration, No Action, Normal Transfer, Forced Transfer, Ok, Close, Apply

Figure 24: Calibration Control Screen

LEVER ARM CALIBRATION SELECT PANE

Note: The Figure of Merit (FOM) may not reach 100 if the vessel dynamics (speed and rate of turn) are not great enough, the GNSS coverage is not good or the base corrections are not reliably received.

Figure of Merit field - indicates the completeness of the correction level of the selected parameter; the calibration (X, Y and Z) are complete when FOM reaches 100

X, Y, Z fields - computed values are complete when the Figure of Merit reaches 100 and the field values stop changing; the field values may not correspond with the measured values

Reference to Primary GNSS check box - select to compute corrected values

Reference to Auxiliary 1 GNSS check box - not enabled

Reference to Auxiliary 2 GNSS check box - not enabled

Position Fix check box - not enabled

CALIBRATION ACTION PANE

Last Calibration Action field - indicates the last action performed

Stop Calibration button - select to stop the selected calibration action

Manual Calibration button - (only use for special situations) select to start the manual calibration procedure; vessel must prescribe a loose figure eight pattern; the FOM reaches

100 and continues to update the X, Y, Z fields; next command would be Normal Transfer of calibrated parameters

Auto Calibration button - (preferred) select to start the auto calibration procedure; vessel must prescribe a loose figure eight pattern; once the corrections are complete they become active, the Kalman filter is reset and POS restarts in the Navigate mode

No Action button - select to cancel all calibration actions

Normal Transfer button - select to make the Manual Calibration corrections active; the Kalman filter is reset and POS restarts in the Navigate mode

Forced Transfer button - select to make the corrections active (FOM must be >0 and <100); the Kalman filter is reset and POS restarts in the Navigate mode

COMMAND BUTTONS

OK button - enables all window parameter settings and closes the window, calibration does not start

Close button - closes the window without saving or enabling any changes

Apply button - enables all window parameter settings, but does not close the window, calibration does not start

Time Tags

POS attaches time 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), GNSS, POS or User time; has a resolution of 1 μ s; and has an accuracy of less than 10 μ s.

Select **Settings, Installation, Tags & AutoStart** on the MV-POSView Controller menu bar to display (Figure 24) the settings.

Note: UTC and GPS Times are not identical. Due to the occasional need for the addition of a leap second to UTC, there is an integer difference between UTC and GPS Time. Transitions between the seconds are precisely coincident between the two times.

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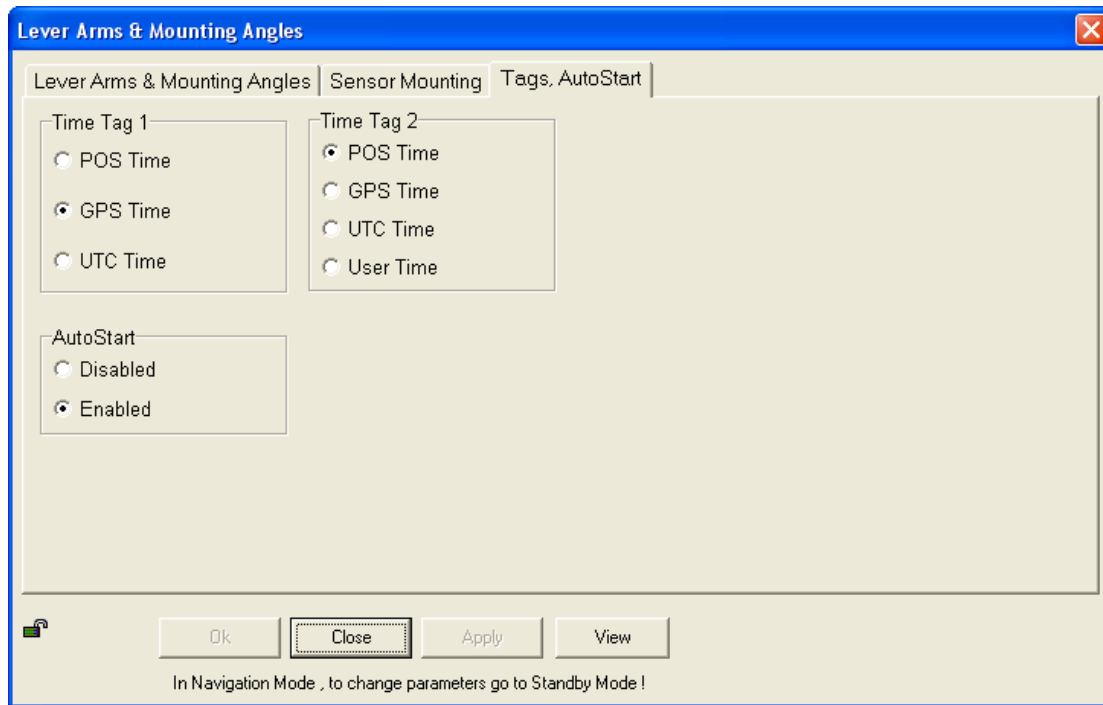


Figure 25: Controller Tags, Multipath & AutoStart Tab

The User Time Data screen (Figure 26) on the controller shows the status of the user time synchronization; select **View, User Time Data**. The user's equipment can send message 55 (see POS MV V5 User Interface Control Document [Applanix document control number - PUBS-ICD-004089]) with their own time recovery time and POS will create an internal offset. Also, the user can then select the User Time (Figure 24) to be output in the time '2' field of ICD groups. This feature allows the user to synchronize with a time base other than POS, GNSS or UTC. If more information is required, please contact Applanix customer support, see page A-1 for contact details.

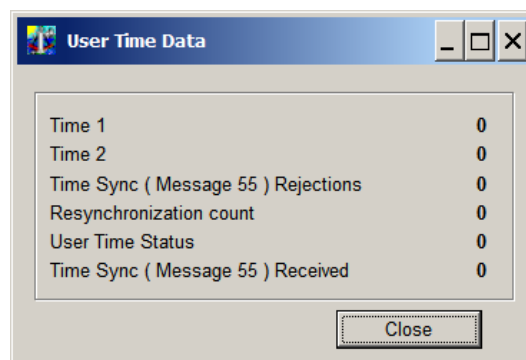


Figure 26: User Time Data Screen

AutoStart

AutoStart is a feature of POS MV that allows operation in a stand-alone configuration. With AutoStart enabled, POS MV will transition to navigate mode after power-on, without operator intervention.

- With AutoStart enabled, POS MV will transition to navigate mode each time the PCS is powered-on. In this configuration, the PCS can operate independently without the need for a controlling PC.
- With AutoStart disabled, the system will remain in standby mode after power-on. The operator must issue a command from the controlling PC, via the controller program, to make the system transition to navigate mode.

To enable AutoStart, select **Settings, Installation, Lever Arms & Mounting** from the MV-POSView menu bar, then select the **Tags, Multipath and AutoStart** tab and click the **Enabled** option button in the **AutoStart** pane, see Figure 24. Select the **OK** button to accept the change.

Note: The AutoStart configuration change must be saved to NVM to retain its new setting when POS MV is powered-on again; refer to the 4-22

description on page 4-20 for instructions.

Input/Output Ports Set-up

The **Input/Output Ports Set-up** screen shown in Figure 26 is accessed from the MV-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:

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

In addition to the 5 COM ports there is an Ethernet Input port tab on the setup window. This allows configuration of data input on an Ethernet port in a similar manner to the COM port input.

COM Port Set-up

Select a tab for the COM port to be configured. All COM ports allow selection of **Baud Rate**. COM 1, 2 and 5 allow selection of **Parity**, **Data Bits**, **Stop Bits** and **Flow Control** (Figure 26). COM 3 and 4 allow selection of the physical **Interface** (Figure 27). Settings that are not available on a particular COM port tab will be hidden or dim and not selectable.

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System Configuration

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

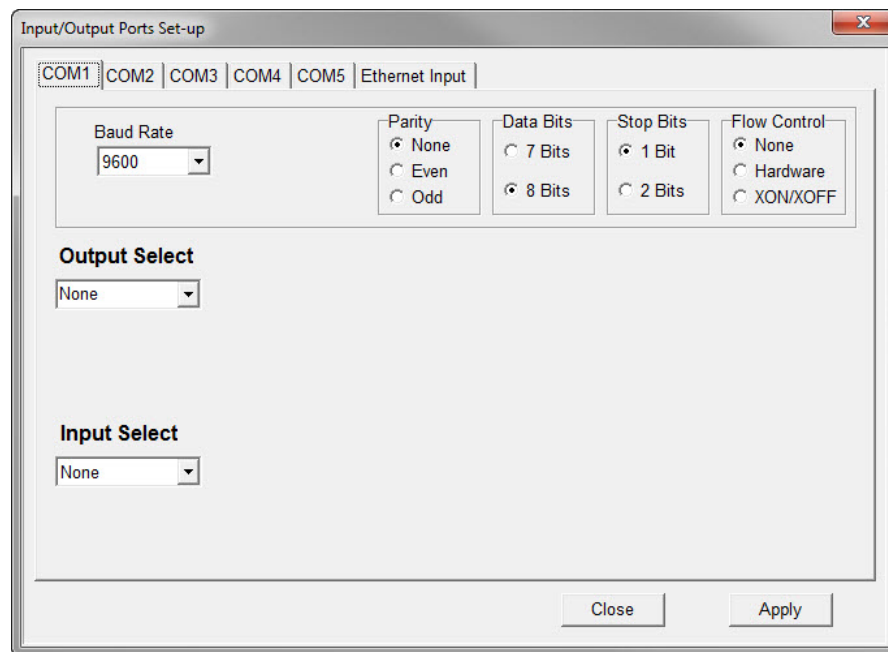


Figure 27: Input/Output Ports Set-up – COM1

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

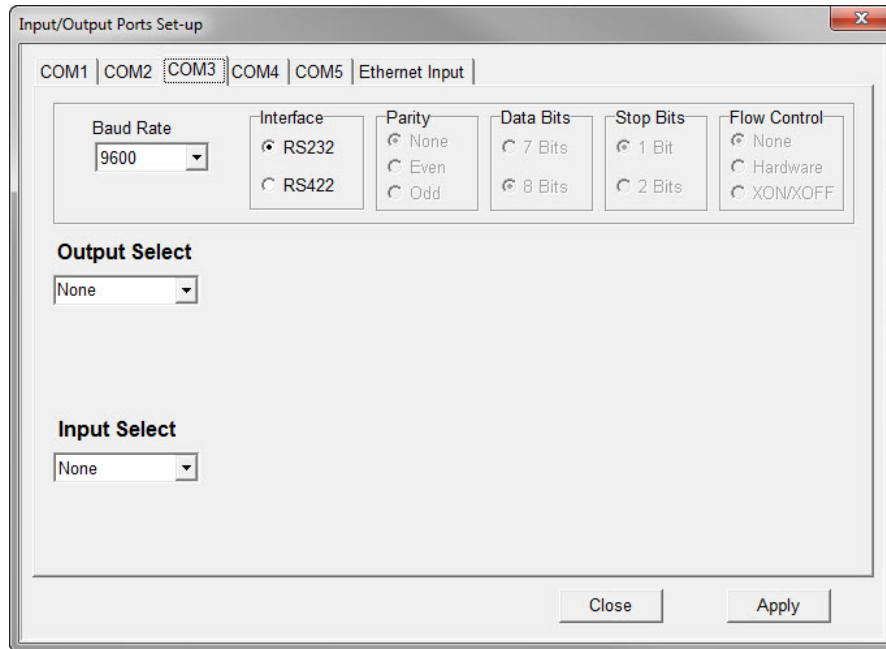


Figure 28: Input/Output Ports Set-up – COM3

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

Ethernet Input Port Set-up

The Ethernet Input tab on the Input/Output Ports Setup window is similar to the COM port setup except that only Base 1 & 2 inputs are available, and of course Ethernet parameters must be specified instead of COM port parameters as shown in Figure 28. A valid Internet Address, Port number must be entered and a Protocol selected or the Ethernet connection will not be established.

POS MV V5 Installation and Operation Guide

System Configuration

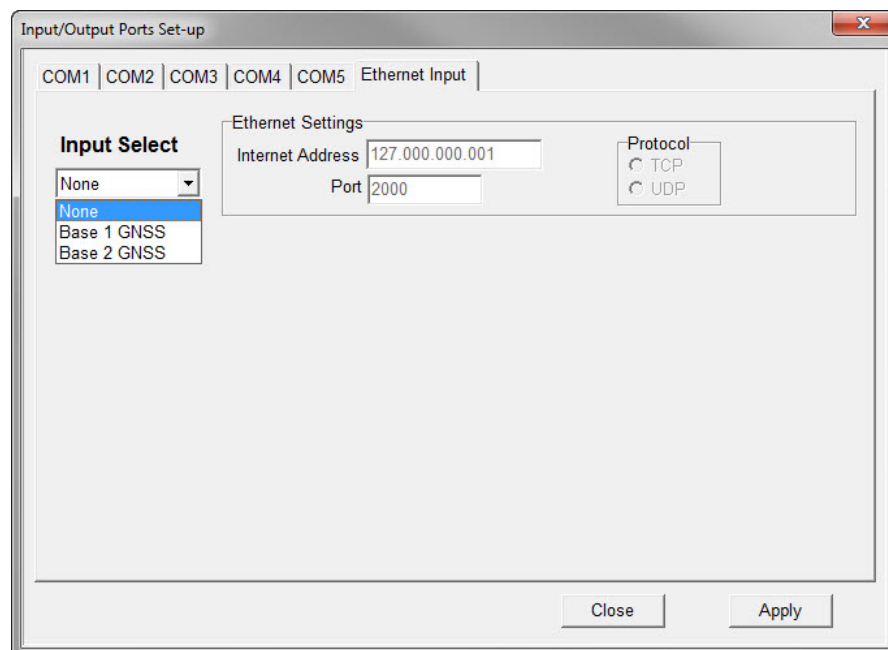


Figure 29: Input/Output Ports Set-up – Ethernet Input

Corrections over NTRIP client

Differential corrections can also be received through the NTRIP client built into POSView. One must have access to an NTRIP caster, or subscribe to a service that provides access to NTRIP caster, in order to receive differential corrections. To access the NTRIP client please select “Tools->NTRIP client”:



Figure 30: NTRIP Client User Interface

Enter the correct information for Server, Port and login credentials, as advised by the service provider.

Select “Use POS position” if the position transmitted to the caster is to be the same as the POS position. If not, then unchecking the “Use POS position” and enter custom values. Applanix recommends using POS position for this purpose such that the position transmitted to the VRS service is updated as the vessel moves.

Select “Automatically select options” to pick the first available corrections stream from the caster. Applanix recommends examining the available streams and manually selecting the desired one. This may be done by deselecting “Automatically select options” and then clicking “Request Options”. If the information entered is correct, then a list of all available streams from the caster are displayed in the drop down menu below the “Request Options” button. Select the desired corrections stream and then hit the “Connect” button.

The LED on the bottom right will turn green and the POS will receive and decode the corrections.

Heave Filter

Certain characteristics of the POS MV heave filter can be adjusted to obtain the best compromise between steady-state heave error and the time that the filter takes to settle after abrupt changes in vertical displacement; refer to Figure 30. You may have to modify the characteristics of the heave filter, for example, to allow for the dynamic characteristics of different vessels, variations of sea state or to meet the particular requirements of a survey.

Optimum settings for the heave filter can depend upon a number of factors, including the size and weight of the vessel, the weather conditions in the survey area and the direction of travel into the sea.

Refer to the Theory of Operation description starting on page B-1 for a more detailed explanation of heave filter settings.

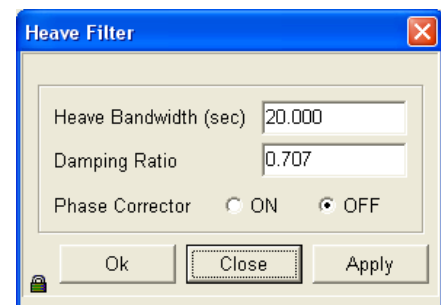


Figure 31: POSView Heave Filter

The default settings for the heave filter have proved to be satisfactory for use with a wide range of vessel characteristics and across a broad spectrum of sea states:

- Heave bandwidth = 20.00 seconds. You can set the heave bandwidth to any positive number greater than 1.0.
- Damping ratio = 0.707. You can set the damping ratio to any positive number less than 1.0.

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System Configuration

Important

Although you cannot harm any part of the POS MV by changing the heave filter characteristics, inappropriate values for heave bandwidth and damping factor can severely degrade the measurement performance.

Do not alter the characteristics of the heave filter unless you are entirely confident that your changes will improve the performance of the system for a given set of survey conditions.

Note: Save the settings to NVM so that they are effective next time POS MV is powered-up. Refer to the Save Settings topic on page 4-22 for instructions. Settings become active once the **OK** or the **Apply** button is pressed.

To modify the characteristics of the heave filter select **Settings, Heave** from the menu bar of the MV-POSView Controller program. Enter appropriate values into the **Heave Bandwidth** and **Damping Ratio** fields of the **Heave Filter** pane. Select the **OK** button to activate the settings and close the dialogue box.

Refer to the Reference to Centre of Rotation instructions on page 2-28 for an explanation of the method that POS MV uses to measure and filter heave values.

The **Z Altitude** option allows the user to replace the heave filter with an inertial smoothed RTK height in the chosen output string.

GNSS 1/2 Interface

The PCS provides a mechanism to connect directly to the internal GNSS receivers' COM ports through the external COM 3 and COM 4 ports. This is a bi-directional RS232 link so both input and output are automatically assigned when either one is selected. GNSS 1 is accessible through COM 3 (Figure 31) and GNSS 2 is accessible through COM 4 (Figure 32). Newer POS MV V5 systems also provide a dedicated GNSS port which is permanently connected to a COM port of the internal GNSS receiver.



The purpose of this link is to allow field upgrades of the GNSS receiver firmware if necessary. This connection could also be used to output data directly from the GNSS if configured to do so.

Applying a configuration to the internal GNSS via the COM port must be done with extreme care so as not to interfere with the PCS configuration. Contact Applanix customer support for assistance.

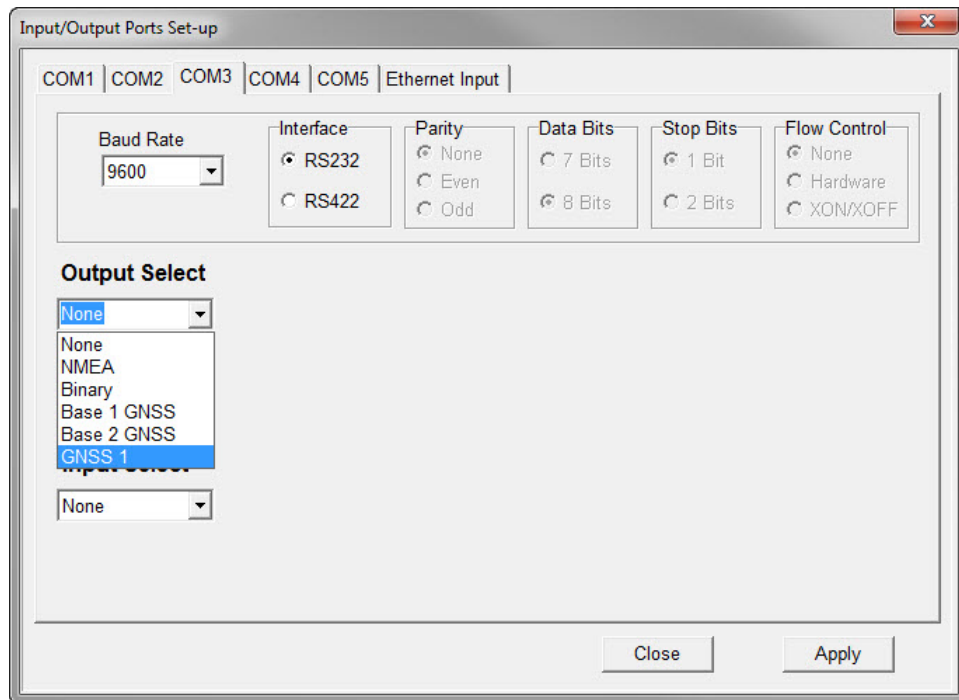


Figure 32: Input/Output Ports Set-up – GNSS 1 Interface

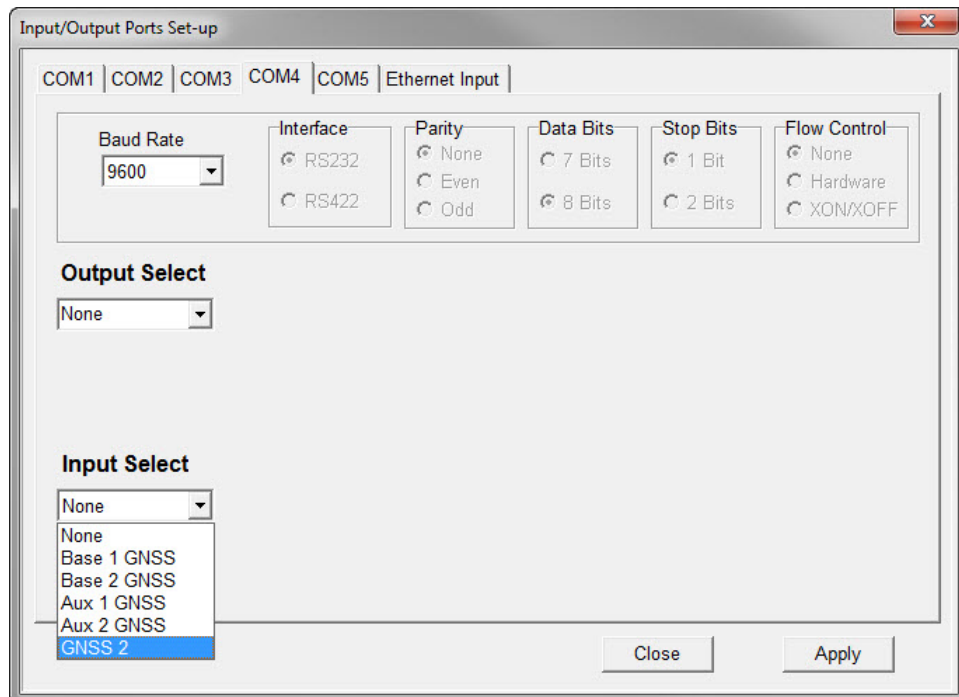


Figure 33: Input/Output Ports Set-up – GNSS 2 Interface

The GNSS connection for firmware upgrades requires 2-way communication, hence selecting GNSS 1/2 on either the Input or Output will automatically reserve both for that function.

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System Configuration

Save Settings

Changes made to the POS MV parameters will have an immediate effect on system operation. However, if you require the changes to apply to all future occasions when you power-on the POS MV, you must save them to NVM.

The non-volatile memory is resident in the PCS so that all stored operating parameters will be available to the system during the start-up sequence, even when it operates in a stand-alone configuration.

To save the system parameters to NVM, select **Settings, Save Settings** from the MV-POSView menu bar.

Note: If you do not save any new settings for the installation parameters to NVM, POS MV will apply the values stored previously (or the factory default values) when you next power-on the system.

Initial GNSS Configuration

Applanix supplies POS MV with two GNSS receiver cards installed in the PCS and optimally configured for use with the system.

If either of the GNSS receivers loses its configuration for any reason, the PCS will reconfigure the receiver cards automatically for its own use. The messages supplied by the GNSS receivers are only those required by POS MV.

If you ever need to configure the installed GNSS receivers manually, you must select **Tools, Configure GNSS** from the menu bar window of the MV-POSView Controller program.

Antenna Installation Calibration

A successful antenna installation calibration depends upon the GNSS Azimuth Measurement Subsystem (GAMS) being able to use data from five or more satellites with a Positional Dilution of Precision (PDOP) equal to or less than three. Perform the antenna installation calibration at a time when there is good satellite geometry.

Note: Applanix recommends that the user make use of the GNSS mission planning software to identify an optimal time of day during which the PDOP is at a minimum in order to achieve a good GAMS calibration.

Perform the following steps with the vessel under way in an area where unrestricted manoeuvring is possible. You have the option of allowing POS MV to start the calibration automatically (this is called a calibration auto-start) or to start the calibration manually.

1. Ensure that MV-POSView is **Connected** as indicated in the status bar, refer to
2. Figure 40 on page 5-3.

3. Select **View, GAMS Solution** from the menu bar to open POS MV **GAMS Solution** window shown in Figure 33.

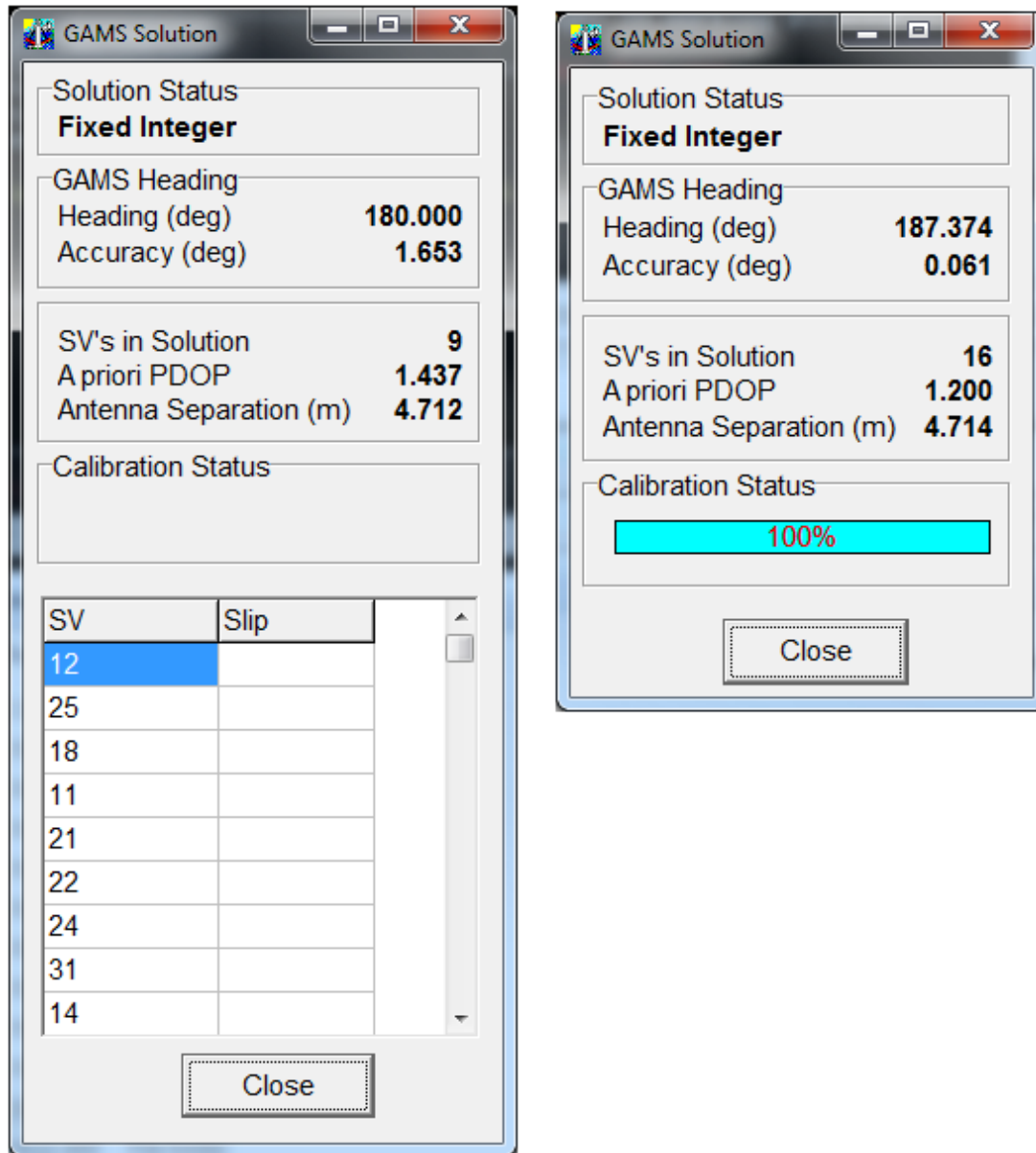


Figure 34: GAMS Solution
BD960 system left, BD982/BD992 system right

4. Transition the system to standby mode by selecting the **Standby** icon from the MV-POSView tool bar.

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System Configuration

5. Select **Settings, Installation, GAMS Parameter Setup** from the menu bar to open the **GAMS Parameter Setup** window shown in Figure 34 POSView GAMS Parameters Setup.
6. In the **GAMS Parameter Setup** window, enter a value in the **Heading Calibration Threshold** field that represents the best achievable with the vessel, ideally 0.5° or less. Select the **OK** button.

When the indicated **Heading Accuracy** (**Attitude** pane on the controller main window) falls below the setting in the **Heading Calibration Threshold** field and the **GAMS** status (main window **Status** pane) reads **Ready Offline**, POS MV will start the antenna installation calibration routine. Choose an easy value for POS MV to achieve as you perform a series of calibration manoeuvres with the vessel:

- Set a lower value (approximately 0.2°) if you can manoeuvre the vessel aggressively.
- Conversely, set a higher value (approximately 1°) if the most aggressive manoeuvres you can perform are 180° turns followed by a straight run.

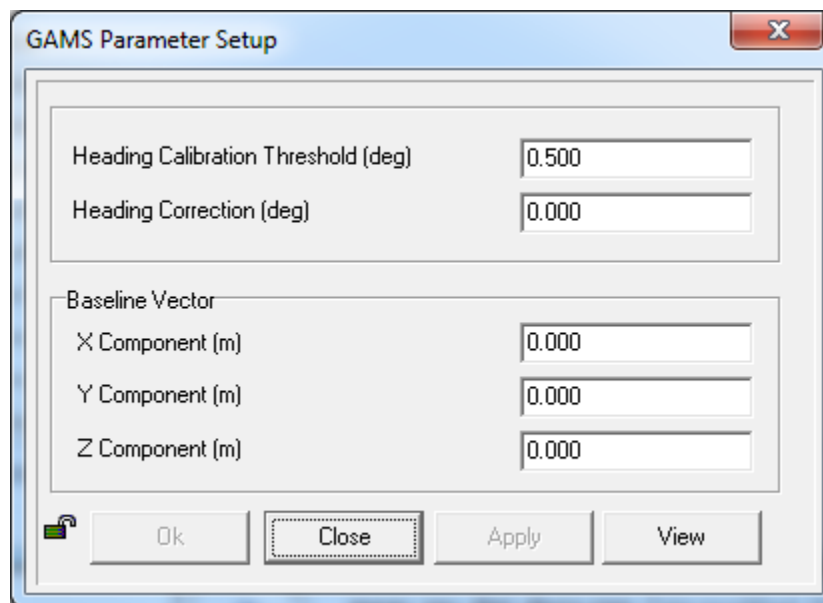


Figure 35: POSView GAMS Parameters Setup

7. Leave the Heading Correction as 0, at least for now.
8. Enter the Baseline Vector components. In most cases, the baseline vector components are entered as '0'. Only if you are able to measure the antenna baseline vector to 1 cm accuracy or better should you enter values.

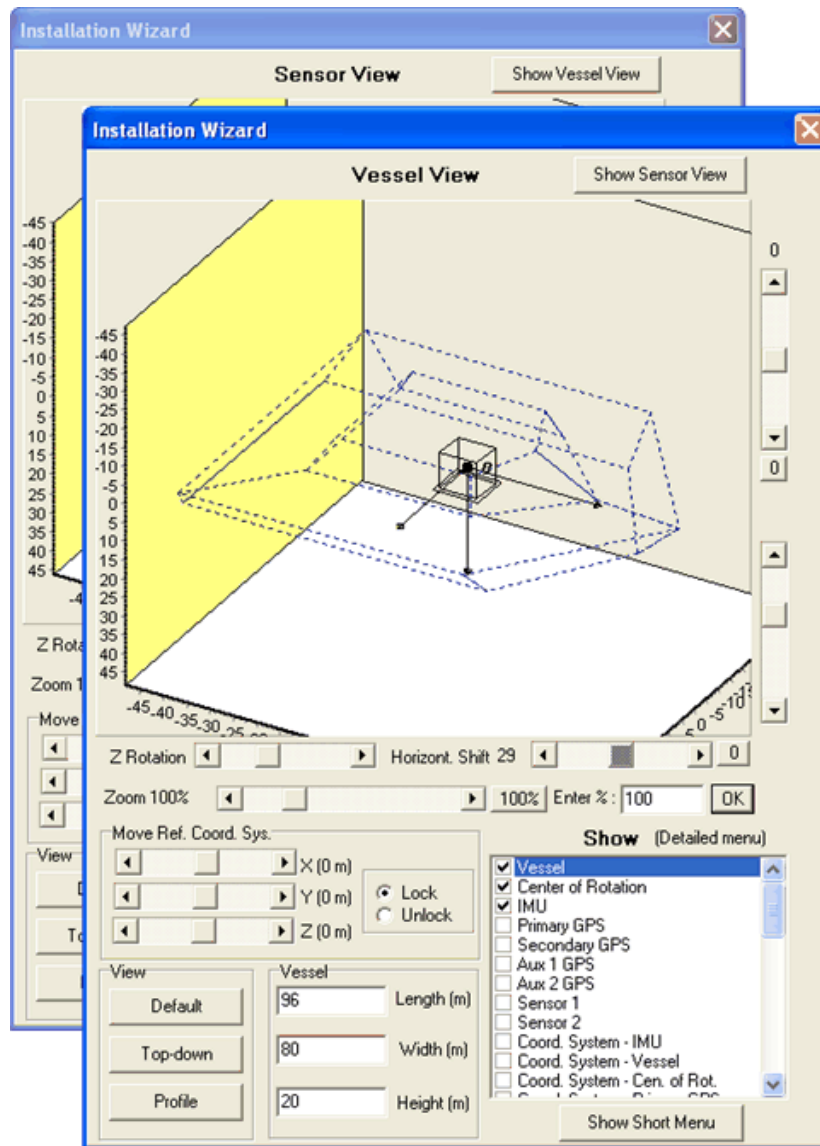


Figure 36: POSView GAMS Installation Wizard

9. Manually transition POS MV to the navigate mode. This also commands GAMS to begin execution of its on-the-fly (OTF) ambiguity resolution algorithm.
10. Select **Settings, GAMS Calibration Control, Start** from the MV-POSView menu bar (Figure 40: POSView Controller Main Window, page 5-3). The **Status** pane for **GAMS** indicates **CAL Requested** (Figure 51: POSView GAMS Solution and Status Pane, page 5-19).

The **Start** command prepares the system for an automatic start to the calibration process, but does not actually start it. Instead, the calibration process will start automatically when the POS

POS MV V5 Installation and Operation Guide

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MV RMS heading error falls below the value that you set for the **Heading Calibration Threshold** field in step 6 above.

An option is to wait until the MV RMS heading error falls below the threshold value set by performing manoeuvres described in 11 and then select the **Start** command. In this case the **Status** pane for **GAMS** will indicate **CAL in Progress**.

11. If possible, when GAMS has resolved the carrier phase ambiguities (**GAMS** on the main window **Status** pane reads **Ready Offline**), perform a series of full turns, 'S-turns' or 'Figure-8' manoeuvres, each lasting approximately one minute.

During these manoeuvres, monitor the POS MV **Heading Accuracy** field on the MV-POSView main window **Attitude** pane (Figure 40: POSView Controller Main Window, page 5-3). When the value displayed falls below the setting for the **Heading Calibration Threshold** field (Figure 34: POSView GAMS Parameters Setup), finish the turns and manoeuvres and hold the vessel steady on a course and at a fixed speed.

The **Status** pane for **GAMS** now indicates **CAL in Progress** and this condition lasts for approximately 60 seconds. When POS MV has completed the calibration, the displayed **GAMS** status becomes **CAL Complete**. This condition lasts for approximately five seconds and then changes to **Online**.

If the POS MV **Heading Accuracy** field on the MV-POSView main window **Attitude** pane (Figure 40: POSView Controller Main Window, page 5-3) shows the heading accuracy deteriorating close to or above the calibration threshold then the vessel manoeuvres should be continued during the calibration. This should keep the heading accuracy below the threshold.

12. Save calibration data: Select **Settings, Save Settings**. Wait until the MV-POSView Controller program displays the **Settings Saved** message panel. Select the **OK** button to close the message panel.
13. Monitor system operation: Indications of a successful calibration appear in the main window of the MV-POSView Controller program:
 - The **Status** pane for **GAMS** indicates **Online**.
 - The **Altitude** pane **Heading Accuracy** field drops slowly to less than 0.15° and eventually settles to a value of 0.03° in a low multipath environment.

If the calibration was successful and no GNSS dropouts occurred, POS MV should settle into a steady-state operation using the GAMS heading aiding, as indicated by the **Online** status.

If the calibration was not successful, GAMS will reject the carrier phase ambiguities repeatedly and will eventually reject the installation parameters. If this occurs, repeat the calibration process.

14. Record data: If the installation parameters appear to be correct, select **Settings, Installation, GAMS Parameter Setup** from the menu bar (Figure 34: POSView GAMS Parameters Setup, page 4-24) and write down the displayed parameters. Keep the written record in a safe place for future reference.

Refer to the Operation with GAMS topic on page 1-8 for a description of how GAMS uses the GAMS installation parameters to aid the On-the-Fly (OTF) ambiguity search.

Installation Parameter Correction

The surveyed antenna baseline vector may include the following errors:

- The length of the vector may not be correct if there were large multipath errors during the calibration process. This may affect the reliability of the GAMS ambiguity resolution during future POS MV Initialization sequences.
- There may be an azimuth error similar in size to the displayed heading accuracy that existed during the calibration process. This results in a constant offset in the displayed heading during normal operation of the POS MV with GAMS heading aiding.

Correct these errors by:

1. If the displayed antenna separation differs by more than 5 mm ($\sim\frac{1}{4}$ in) from the value that you measured after you installed the antennas, clear the installation parameters and then re-enter the measured separation distance in the **GAMS Parameter Setup** window, see Figure 34: POSView GAMS Parameters Setup on page 4-24. Select the **OK** button to install the new antenna separation distance.

Begin a new calibration procedure, see Antenna Installation Calibration on page 4-22.

The 5 mm ($\sim\frac{1}{4}$ in) allowance accounts for differences that may exist between the antenna phase centres and their geometric centres.

2. If you can identify a heading offset then enter this value in the **Heading Correction** field of the **GAMS Parameter Setup** window, see Figure 34: POSView GAMS Parameters Setup on page 4-24. Select the **OK** button to install the new correction value.

POS MV will then compute new components of the surveyed antenna baseline vector having a corrected azimuth.

3. Select **Settings, Save Settings** from the MV-POSView menu bar to save the new values to the PCS Non-Volatile Memory (NVM).

Note: The **Heading Correction** field in the **GAMS Parameter Setup** window allows you to correct an inaccurately surveyed baseline vector. You can use this method to obtain a more accurate vector.

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Note: You should *not* use this facility to implement the installation angles of the IMU body frame with respect to the echo-sonar frame. Refer to the Installation Parameters and the Configuration Data descriptions on pages 2-24 and 4-8 respectively, for instructions on how to measure and enter these installation parameters.

Power-Off

The initial power-off sequence for the POS MV system occurs in three stages:

- a) Save parameter and configuration changes
- b) Exit the MV-POSView Controller program and power-off the controlling PC
- c) Power-off the POS MV system

Save Changes



Powering-off the PCS before the MV-POSView displays the confirmation message panel may corrupt the settings held in NVM.

Whenever changes are made to the POS MV installation parameters or its configuration, they must be saved to NVM in order to retain them for the next power-on sequence.

The MV-POSView Controller program displays a message panel to confirm that it has saved the settings successfully to NVM. Wait for this message to appear prior to powering-off the PCS or the POS MV system.

Save Parameter Values

Select **Settings, Save Settings** from the MV-POSView menu bar to save all parameter settings to NVM. Refer to the Save Settings description on page 4-30 for more information.

Perform the following to check that the PCS has stored the parameters correctly:

1. Select **File, Exit** (or press **Alt, F4**) to close the MV-POSView Controller program.
2. Press and hold the POWER switch on the PCS front panel until the POWER light starts flashing.
3. Wait thirty seconds and then press and hold the POWER switch to power-on the PCS and illuminate the POWER light.
4. Start the MV-POSView Controller program.
5. Select **Settings, GAMS Calibration Control** and check that the PCS has saved all the GAMS installation parameters correctly. Select the **Cancel** button.

Save Configuration

Select **File, Save POS Config** from the MV-POSView menu bar to save the new configuration settings to the PC. Refer to the Manage Multiple Configurations description on page 4-31 for more information.

POS MV Power-Off

POS MV V5 PCS

Power for the POS MV V5 system is applied to the PCS rear panel PWR connector, refer to Figure 36. Two power switches are available on the PCS; a rear panel PWR switch and a front panel POWER switch. Refer to the POS MV Power-On description on page 4-1 for more information.

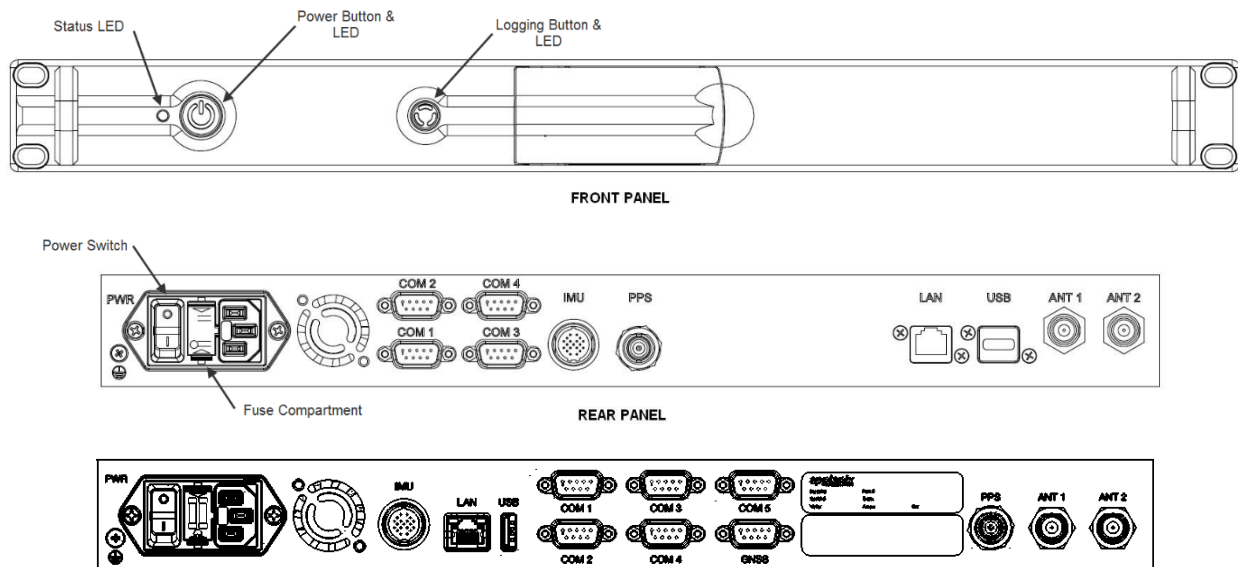


Figure 37: PCS Front and Rear Panels - POS MV V5

POS MV V5-1 PCS

Power for the POS MV V5-1 system is applied to the PCS rear panel PWR connector, refer to Figure 8. The front panel POWER switch (Figure 37) is an alternate action push-and-hold switch; press once for power-on, press again for power-off.

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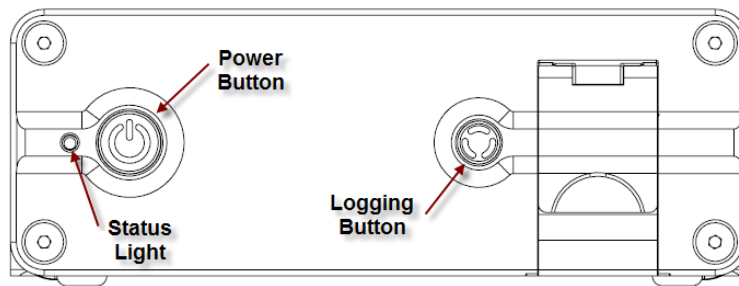


Figure 38: PCS Front Panel – POS MV V5-1

Both Systems (POS MV V5 and POS MV V5-1)

To power-off the POS MV system, perform the following steps:

1. Select **File, Exit** from MV-POSView menu bar to close MV-POSView Controller program.
2. Press and hold the PCS front panel POWER switch until front panel POWER light starts flashing.
3. Set PCS rear panel PWR switch to off (POS MV V5).



Leave the POS MV powered-on to reduce the electrical and thermal stresses that occur when the system is powered-off and powered-on.

POS MV V5-2 PCS

Power for the POS MV V5-2 system is applied to the PCS rear panel PWR connector, refer to Figure 9. The PCS is powered off by removing power from the input. For a controlled power down it is preferred to select the **Tools, Shutdown** command from POSView and waiting until the power light goes off before removing power.

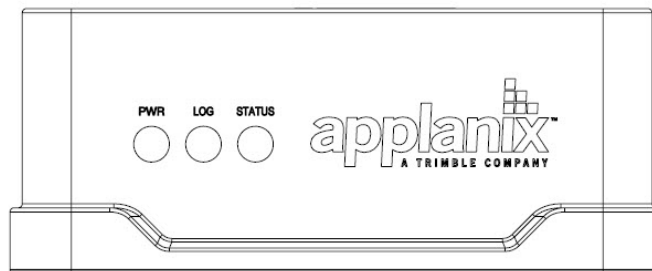


Figure 39: PCS Front Panel – POS MV V5-2

Save Settings



Cycling power while saving may result in lost settings.

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

Making Changes

If you need to change any of the POS MV operating parameters, you must use the MV-POSView Controller program as described throughout this section of the manual.

Any changes that you make will take effect immediately, although you must save them to NVM if you require the changes to apply each time you power-on the system.

Note: To make any parameter changes permanent you must save them to NVM. Do this by selecting **Settings, Save Settings** from the main window of the controller program.

Manage Multiple Configurations

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

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

Note: By default, POS MV boots to the last saved configuration located in the PCS NVM.

Note: Occasionally a change is made in the Ethernet interface that affects the format of configuration data. The effects of the change are described in the release notes accompanying the firmware upgrade or contact an Applanix Customer Support representative for additional information; refer to page A-1 for contact details.

Password Protection

The password protection feature protects the controller's critical settings from unauthorized personnel. An authorized user must login from the MV-POSView Controller program when attempting to change settings in the following menu selected windows:

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- File, Load POS Config menu selection
- Settings, Heave menu selection - Heave Filter window
- Settings, Installation menu selection - Lever Arms & Mounting Angles, Sensor Mounting and Tags, Multipath & AutoStart windows
- Settings, Installation, GAMS Parameter Setup menu selection - GAMS Parameter Setup window
- Settings, Installation, User Accuracy menu selection - User Parameter Accuracy window
- Settings, Installation, POS IP Address menu selection - POS Internet Address window
- Settings, Save Settings menu selection

Each of the above windows has an icon in the lower left corner. They are either all locked (password protected) or all unlocked (not protected or the user has logged in).



Note: The password protection feature can be disabled using the POS Config utility.

The following outlines the password protection operation:

- Default password is pcsPasswd
- User is prompted to log in when one of the above windows are selected (a change is made and the **OK** button is selected), see Figure 39 left
- User is logged in until one of the following occurs:
 - A period of 10 minutes elapses
 - User disconnects via the MV-POSView Controller monitor icon (disconnect) located on the tool bar
 - User terminates the TCP connection
- Change the password by selecting **Settings, Installation, Set Password**, see Figure 39 right side
- Reset the password to the default setting (pcsPasswd) by:
 - Acquire an authorization code, from Applanix Customer Support, for Option 10 of the POS Config utility (contained on the installation CD); refer to page A-1 for details
 - Start the POS Config utility and select the left box (10 DPW Disable Password Protection)
 - Reset POS MV
 - Start the POS Config utility again, select the POS chassis IP address (appears automatically), then de-select Option 10



- Reset POS MV again, the password protection is enabled and the password is reset to its default value (pcsPasswd)

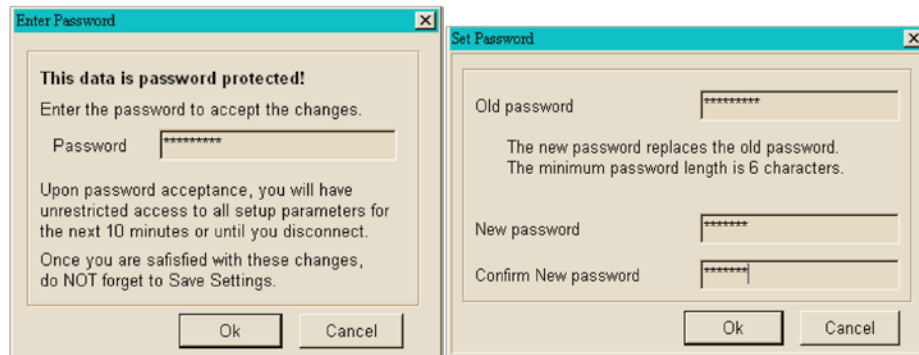


Figure 40: POSView Controller Password Protection

5.0 System Operation

This section describes how to use the MV-POSView Controller program to operate the POS MV. To perform the instructions in this section:

- The Position and Orientation System for Marine Vessels (POS MV) controller program (MV-POSView) must be installed on the controlling Personal Computer (PC).
- The controlling PC and the POS Computer System (PCS) must both be connected to the same Ethernet Local Area Network (LAN).
- The controlling PC and the PCS must both have network compatible Internet Protocol (IP) addresses and subnet masks.
- The POS MV must be configured with the correct installation parameters, which are saved to Non-Volatile Memory (NVM).

POS MV may be configured to transition directly to navigate mode after power-on and deliver integrated navigation solutions through the enabled ports. This is performed by enabling AutoStart, refer to page 4-15 for instructions.

If necessary, refer to the following instructions for assistance:

- Installation starting on page 2-1.
- System Configuration starting on page 4-1
- Power-On starting on page 4-1
- PCS IP Address starting on page 4-4
- AutoStart starting on page 4-15
- Power-Off starting on page 4-28
- Password Protection starting on page 4-31
- Software Installation starting on page D-1

MV-POSView Controller Program

Modes of Operation

The controller program operates in one of two modes:

- Monitor mode - the controller program displays all the PCS data broadcast over the Ethernet display port but cannot change any of the PCS settings. This mode allows several users to monitor the PCS data simultaneously.

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- Control mode - the controller program displays all the PCS data broadcast over the Ethernet display port and has an established Transmission Control Protocol (TCP) connection to the PCS control port. This allows you to change the system configuration and save any new configurations to NVM. Only one MV-POSView Controller program can connect to a given PCS at any one time.

In control mode, when a controller window is opened, the controller automatically requests the appropriate group(s) to be output from the display port.

PCS Ethernet Connection

Refer to

Figure 40 on page 5-3 for this discussion. The MV-POSView Controller constantly receives broadcast display data and records the originating PCS IP address. This list of IP addresses is displayed in the tool bar drop-down field. The user selects the IP address for the PCS of interest from the drop-down field. The controller monitors or connects to the IP address displayed on the controller tool bar.

Monitoring POS MV

Main Window Regions

Figure 40 shows the main window of the MV-POSView Controller. The window can be divided into five regions:

Title bar (top):	Identifies the controller type; in this case MV-POSView.
Menu bar (top):	Select any of these items to display its pull-down menu tree.
Tool bar (top):	Contains icons or action buttons (hot buttons) of frequently used functions; the IP address of the Ethernet connection is displayed.
POS MV status (centre):	Contains sensor and processing data; cannot be changed.
Status bar (bottom):	This shows from left to right: <ul style="list-style-type: none">• Current date in mm/dd/yyyy format• Universal Time Coordinated (UTC) or Global Navigation Satellite System (GNSS) time in hh:mm:ss format (user selectable)• POS MV time in hh:mm:ss format since the POS MV was powered-on (not the time since the controller program was started)

- Connection status of the MV-POSView Controller program:

Connected - the controller is communicating with the specified IP address in control mode

Disconnecting - the controller is terminating communication with the specified IP address

Connecting - the controller is attempting to connect to the control port of the specified IP address

Monitor - the controller is receiving broadcast data from the specified IP address

Waiting - the controller cannot communicate with the specified IP address

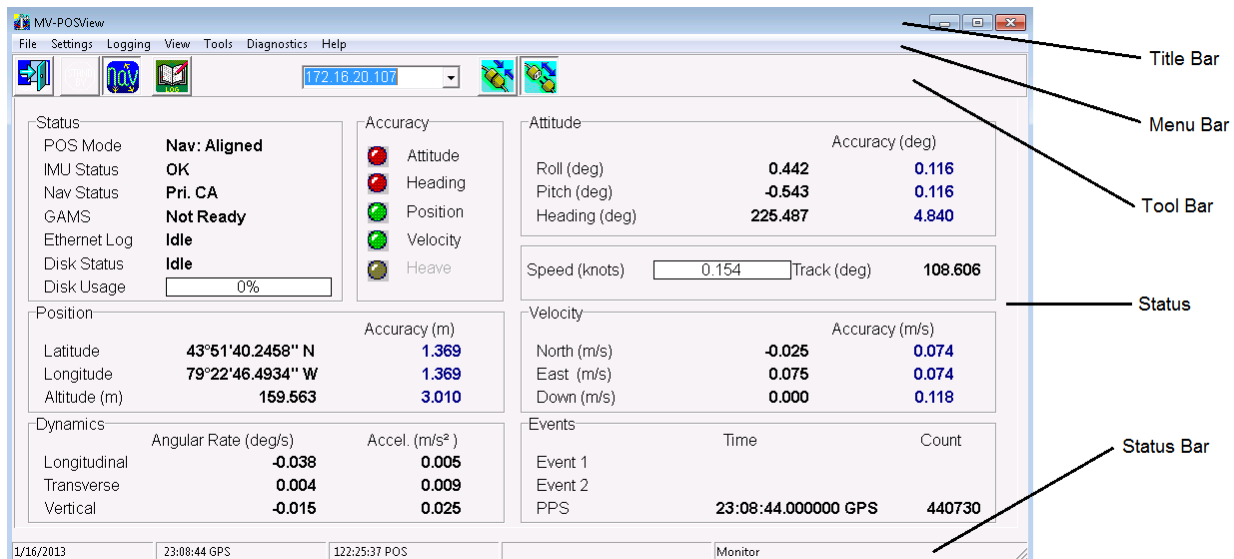


Figure 41: POSView Controller Main Window

POS MV Status Region

POS MV status is displayed in the centre area of the MV-POSView Controller window. The following describes these areas.

Status Pane

Displays the status of POS MV.

POS Mode - POS MV may be in standby mode or in one of its navigation modes.

Levelling Active Basic levelling and heading determination; no navigation output

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System Operation

Nav: Degraded Navigation active but with loose error model

Nav: Aligned Navigation with full error model correction

Nav: Full All user specified accuracies are met

The normal operating condition for POS MV is navigate mode.

IMU Status - this field may display **OK**, **Warning** or **Failure**.

If the Inertial Measurement Unit (IMU) status field shows anything except **OK**, check the **Fault Detection** window described in Faults and Messages on page 5-8. Contact Applanix for advice if necessary.

Nav Status - displays the source and quality of the GNSS sensors and the resulting mode of the navigation solution.

DR (Dead Reckoning) No GNSS input is available; navigation is using only the IMU data

RTCM DGNSS Navigator is tightly coupled using the primary GNSS raw observables plus base GNSS corrections (RTCM 1 or 9)

CODE DGNSS Navigator is tightly coupled using the primary GNSS raw observables plus base GNSS corrections (RTCM 18 and 19, CMR, CMR+)

FLOAT RTK Navigator is tightly coupled using the primary GNSS raw observables plus base GNSS corrections (RTCM 18 and 19, CMR, CMR+)

FIXED RTK Same as **Float RTK** but better accuracy

Pri. C/A Navigator is loosely coupled using the primary GNSS position data in C/A mode

Pri. DGNSS Navigator is loosely coupled using the primary GNSS position data in DGNSS mode

Pri. P Code Navigator is loosely coupled using the primary GNSS position data in P-CODE mode

Pri. RTK Navigator is loosely coupled using the primary GNSS position data in RTK mode

Aux. DGNSS Navigator is loosely coupled using the auxiliary GNSS position data in DGNSS mode

Aux. P Code Navigator is loosely coupled using the auxiliary GNSS position data in P-CODE mode

Aux. Float RTK Navigator is loosely coupled using the auxiliary GNSS position data in Float RTK mode

Aux. WL RTK Navigator is loosely coupled using the auxiliary GNSS position data in Wide Lane RTK mode

Aux. NL RTK Navigator is loosely coupled using the auxiliary GNSS position data in Narrow Lane RTK mode

GAMS - this field can display **Online**, **Ready Online**, **Ready Offline**, **Cal in Progress**, **Cal Requested**, **Cal Complete** or **Not Ready**.

Ethernet Log – this field displays the status of Ethernet data logging

Disk Status – this field display the status of the USB disk logging

Disk Usage – this field displays the percentage of disk space available on the USB drive

Note: Measurement of attitude, position, velocity and dynamics described below are valid for the vessel location as determined by the Reference to vessel lever arm distances. Accuracy indications are described in the Accuracy Pane heading on page 5-5.

Attitude Pane

Displays angles of roll, pitch and heading using degrees in the vessel frame of reference.

Position Pane

Displays latitude and longitude solutions in degrees from the equator and the Prime Meridian respectively, and WGS84 ellipsoid altitude solutions in metres.

Velocity Pane

Displays velocities in their longitudinal, lateral and downward components in metres per second.

Dynamics Pane

Displays vessel dynamics (angular rates in degrees per second, and accelerations in m/s²) in their longitudinal, lateral and downward components.

Accuracy Pane

There are five coloured lights, one adjacent to the **Attitude**, **Heading**, **Position**, **Velocity** and real-time **Heave** labels. The lights show whether the associated measurement is within a user-defined accuracy threshold (green) or outside it (red).

These lights provide a visual indication of an acceptable user defined performance level. The threshold settings do not affect POS MV performance.

Note: POS MV will not transition to full navigation mode until it has met all of the user-defined accuracy requirements and the entire **Accuracy** pane indicators show green.

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ATTITUDE, HEADING, POSITION AND VELOCITY PARAMETERS

To set the thresholds for each measurement, select **Settings, Installation, User Accuracy** from the MV-POSView menu bar. Enter the preferred accuracy threshold for each of the four fields; see Figure 41. Click the **OK** button to accept.

The threshold settings do not affect the operation of POS MV, however, POS MV will not transition to full navigation mode until it achieves the RMS accuracy setting boundaries.

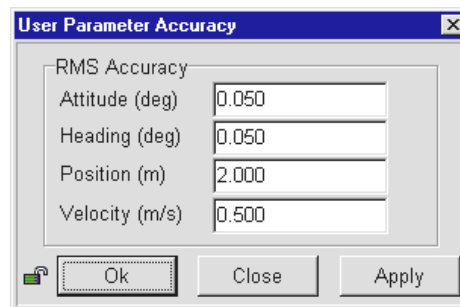


Figure 42: POSView User Parameter Accuracy

In addition, POS MV estimates the accuracy of the data contained in the **Attitude, Position** and **Velocity** panes. These estimations reflect the confidence boundaries on the displayed parameters; they vary according to the current performance level of the GNSS receiver, the number of satellites tracked and whether DGNSS corrections are available to the navigation algorithm. It also depends on the level of motion that POS MV is experiencing; more dynamics will tend to improve the accuracy of the solution (reducing the displayed confidence boundaries).

HEAVE PARAMETER

The real-time heave accuracy parameter is not adjustable by the user. The fixed setting is based on the industry standard performance ratings of 5 cm or 5% (whichever is greater). For heave amplitudes (peak-to-peak) of 1 m or less, a 5 cm threshold is used, while for heave amplitudes which exceed 1 m, 5% of the peak-to-peak amplitude is used.

Events Pane

Displays the identification count number and the time of occurrence for the most recent recorded events.

Speed Pane

Displays the current speed in nautical miles per hour (knots) and the direction of the velocity vector (Track) in degrees. When the vessel is travelling in the forward direction, the direction should be similar to the **Heading** displayed in the **Attitude** pane.

Sensor Navigation Data

The **Navigation Data at Sensors** window, shown in Figure 42, displays the navigation data for sensor 1 and sensor 2. Access this window selecting **View, Sensor Navigation**; a tab is available for each sensor.

Sensor 1 and sensor 2 may be used to define the location of a multibeam transducer or other equipment. Refer to the Installation Parameters description starting on page 2-24 when assigning lever arms and mounting angles.

Position Pane

The sensor position appears as latitude and longitude in degrees, minutes and seconds. The altitude of the sensor position is shown in metres above the WGS84 ellipsoid. POS MV defines latitude, longitude and altitude with respect to the World Geodetic System 1984 (WGS-84) referenced ellipsoid.

Latitude is reference to the equator and is either North or South. Longitude is reference to the Prime Meridian and is either East or West. Estimations of accuracy are in metres.

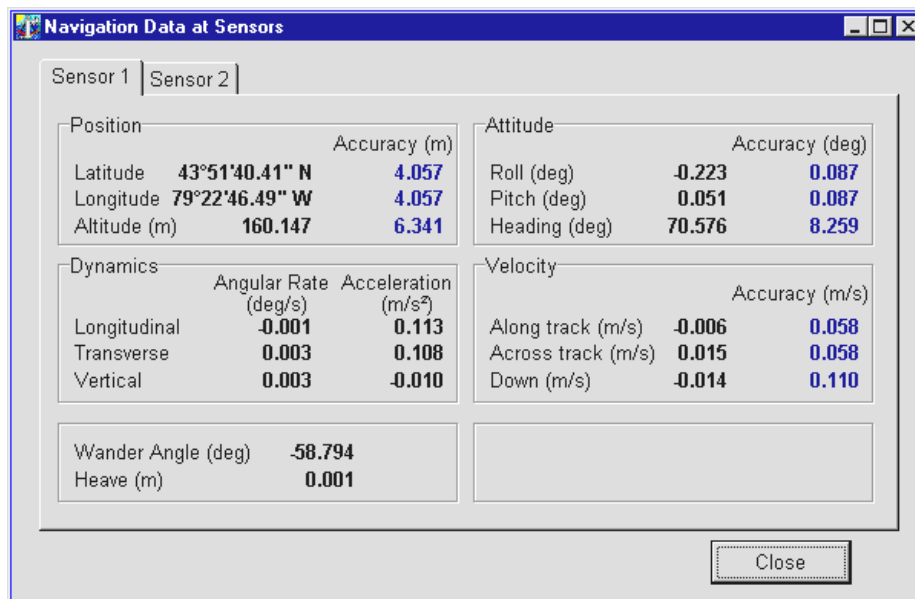


Figure 43: POSView Navigation Data at Sensors

Attitude Pane

Displays the angles of roll, pitch and heading of the sensor using the sensor frame of reference. POS MV uses degrees to display the attitude measurements and their estimated boundaries of accuracy.

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Velocity Pane

Velocities of the sensor are given in the longitudinal and down directions. POS MV uses metres per second to display the velocities and their estimated boundaries of accuracy.

Dynamics Pane

Displays the angular rates and linear accelerations of the sensor in the longitudinal and vertical directions. POS MV uses degrees per second or m/s^2 to display the dynamics and their estimated boundaries of accuracy.

Wander Angle Field

The navigation frame is derived from the North, East and Down (NED) frame by a rotation of “ α ” (wander angle) about the down axis. This provides a locally level coordinate frame that is well-defined at the earth’s poles.

Heave Field

Heave is the filtered vertical motion (acceleration data) plus roll and pitch derived heave at the sensor location. Heave is in a positive down direction in a ‘local level’ or ‘platform’ frame, so the heave is in the gravity direction.

Faults and Messages

The **Fault Detection** window displays the status of POS MV system and reports any fault conditions that may occur during operation, see Figure 43. Two other tabs on the window show IMU and GNSS Correction fault status. Three light conditions may occur where; *green* indicates an acceptable condition, *red* indicates an unacceptable condition and *greyed* is not applicable. Access to the **Fault Detection** window is from the MV-POSView menu bar, select **View, Faults**.



Figure 44: POSView Fault Detection

Note: Some fields may display a red indicator (intermittently) during initialization and operation.

The Fault Identification description starting on page 9-1 includes a list of the messages that may appear in the message log. If you suspect that a fault condition has occurred, but the **Faults Detection** window does not show it, check the message log. To access the Message Log (Figure 44) select **View, Message Log** from the MV-POSView menu bar.

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System Operation

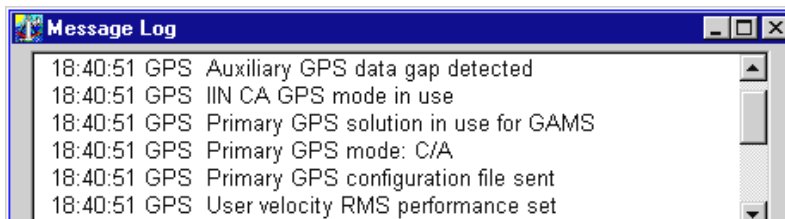


Figure 45: POSView Message Log

POS MV uses AutoRecovery and Fault Detection, Isolation and Reconfiguration (FDIR) to assist in its recovery from fault conditions. AutoRecovery helps POS MV to recover from a communications failure between the PCS and the IMU, and provides alerts for any problems in this area. Investigate persistent communication failures with the IMU, the most likely cause being a faulty data cable or connector. Never open the IMU; if you suspect the IMU is faulty, contact Applanix for return instructions. Refer to Technical Support and Service on page A-1 for procedures.

POS MV monitors its sensing subsystems continuously and determines which of them, if any, shows degraded performance. FDIR allows POS MV to combine data from the GNSS and IMU to offer the best navigation solution for the current data quality.

For more information on AutoRecovery and FDIR refer to page 1-11.

Data Logging

POS MV real-time and raw data may be recorded on storage media for post-processing. Typically, the data are recorded on removable media, a USB flash drive using the USB connector installed in the front of the POS Computer System (PCS). Alternately, the data may be transferred across the Ethernet Data Port to a disk file on an external PC. The USB flash drive is useable for post-processing in any PC with a USB connector.

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

Most PCSs contain a USB connector and an internal memory device, both dedicated to data logging. The system includes a 8GB industrial grade USB flash drive which is inserted into a USB connector behind a door on the front of the PCS; see Figure 48, page 5-13 for MV V5 and Figure 49, page 5-14 for MV V5-1.

A 4 GB internal memory device functions as a circular buffer and is used to back-up the last data logging file. Back-up logging is automatic and does not require any user maintenance. Once the user begins removable media logging, back-up logging will log the same data and continues to back-up the data until the system is reset or powered-off. In the case of POS MV V5-2 there is no USB connector for removeable media so the internal memory is configured to act as the primary logging device instead of performing the back-up logging function. The data selection, start and stop logging control and log file names for the primary internal logging are managed using the same MV-POSView controls as for the

typical USB logging. The internal logged data is downloadable using POS File Transfer (under POSView Tools menu).

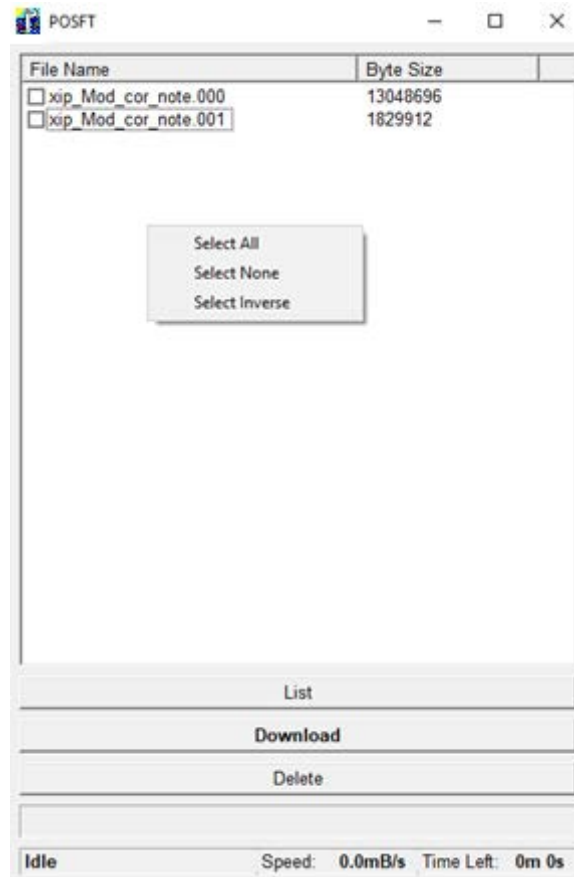


Figure 46: POSFT

To use POSFT first launch it by clicking POSFT Client under Tools. Now hit the List button shown in figure above to list all the stored files. Select all the desired files to be downloaded and hit the download button and select the folder to download the logged files (or backup files). One may delete selective files if desired. Right clicking on POSFT will allow various selection methods as shown in figure above. POSTFT must be used when the POS is in standby.

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

The logging screens (Figures 46 and 47) permit the selection of data groups to be recorded and define the logging rate for those data groups.

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System Operation

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

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

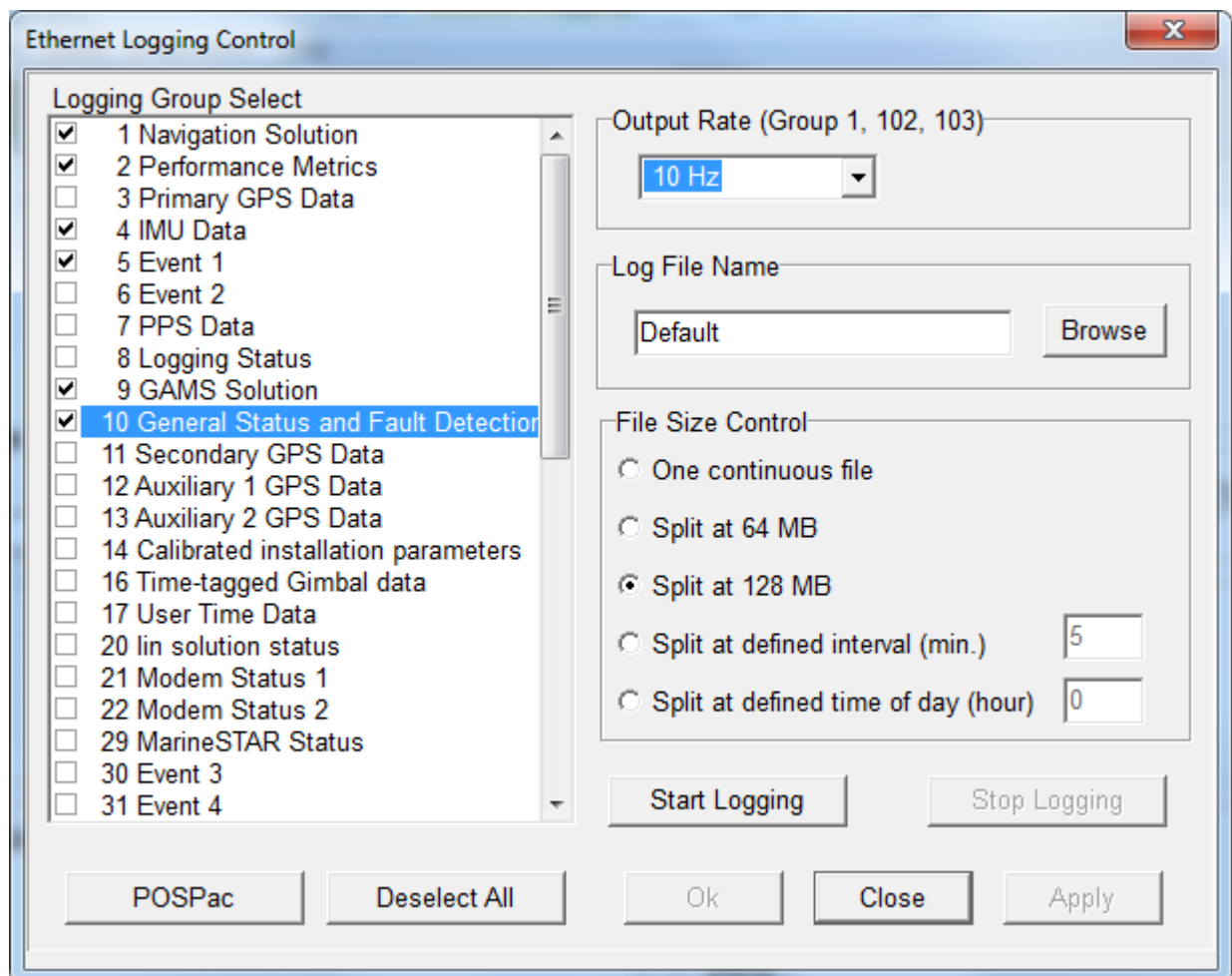


Figure 47: Ethernet Logging Control

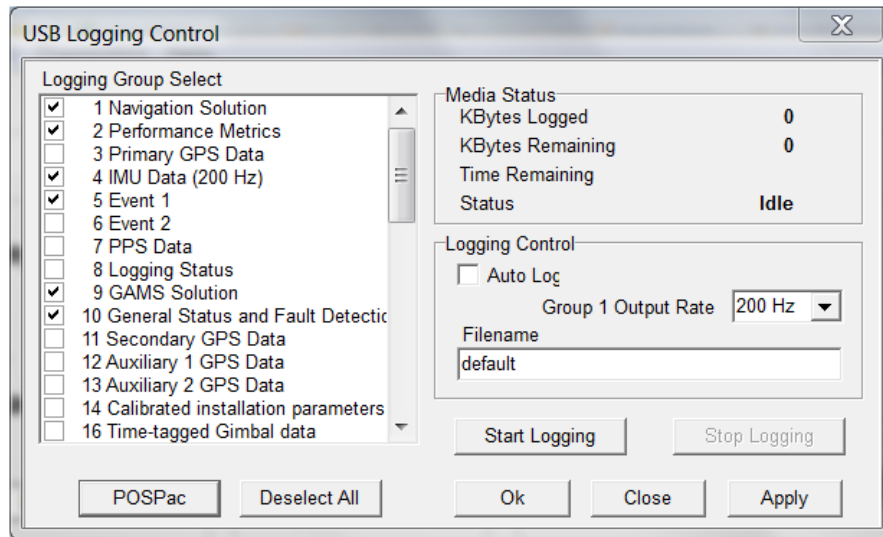


Figure 48: USB Logging Control

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

Data Logging – Removable Media

Insert a USB flash drive

The USB flash drive can be inserted into the PCS at any time (i.e. with PCS power on or off). Both V5 and V5-1 versions have the removable USB connector behind a door on the front of the PCS but the internal mechanism is different.

MV V5

Open the spring loaded USB access door on the front of the PCS all the way and it will stay open on its own. Insert the USB flash drive into the bay (Figure 49) ensuring that the card is facing up, Applanix logo showing. The logging bay door should close without hitting the USB flash drive if it is properly seated in the connector.

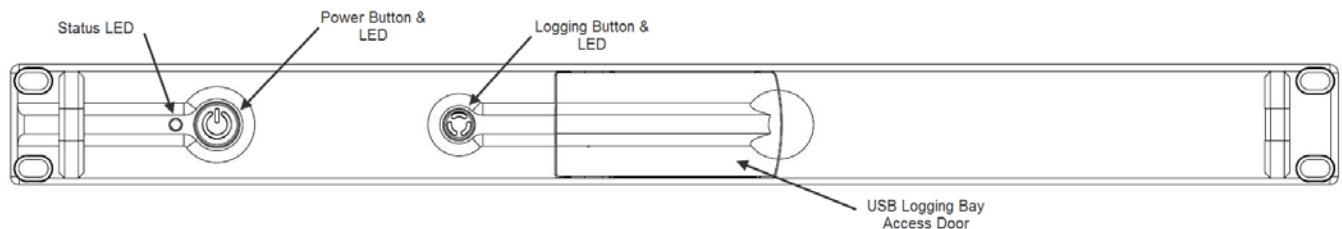


Figure 49: Removable Media Bay – POS MV V5

POS MV V5 Installation and Operation Guide

System Operation

MV V5-1

The USB connector is attached to a moving shuttle that allows the USB flash drive to be entirely enclosed by the PCS housing. Insert the USB flash drive into the bay (Figure 49) ensuring that the card is facing up, Applanix logo showing. The shuttle mechanism will move back to its innermost position, at which point the USB flash drive must be pressed into the connector. The logging bay door should close without hitting the USB flash drive if it is properly seated in the connector.

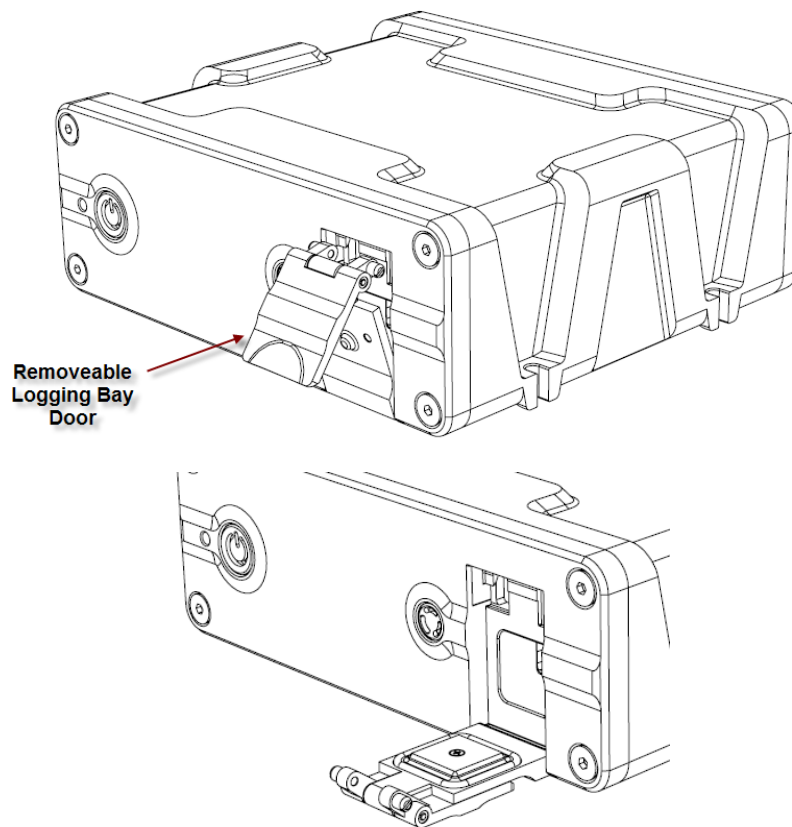


Figure 50: Removable Media Bay – POS MV V5-1

MV V5-2

This PCS does not have removable logging media. Instead, the data is logged to an internal flash drive and is subsequently accessed via FTP. The following sections that describe logging to removable media apply equally to the internal logging for MV V5-2.

Start Logging – Removable Media

AutoLog

If AutoLog is enabled (refer to Figure 47 on page 5-13), logging starts automatically on PCS power-up. If AutoLog is enabled and there is no USB flash drive in the logging bay, the Logging light will turn red. If this occurs, insert a USB flash drive and start manually as described in the following paragraphs.

Manual Start

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

An alternate method to start logging is to click the MV-POSView **Start Logging** button on the USB Logging Control screen (Figure 47, page 5-13).

For a description of the logging status lights, refer to Table 34.

Stop Logging – Removable Media

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

An alternate method to stop logging is to click the MV-POSView **Stop Logging** button on the USB Logging Control (Figure 47, page 5-13) screen.

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

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

Logged Data

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

Remove the USB flash drive



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

Stop logging before attempting to remove the USB flash drive from the logging bay.

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System Operation

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

MV V5

When the logging light is off, open the logging bay door, grasp the USB flash drive and remove it from the connector (Figure 48, page 5-13).

MV V5-1

When the logging light is off, open the logging bay door, press in on the USB flash drive and then release. The shuttle mechanism will partly eject the USB flash drive to a point where it is possible to remove it from the connector (Figure 49, page 5-14).

Data Logging - Ethernet

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

Ethernet logging is performed using the MV-POSView software or other user supplied software. Any custom designed logging software's interface must conform to the POS MV Ethernet ICD specifications. Please refer to Applanix document *PUBS-ICD-004089* for a description of the Ethernet data output format.

Note the following points regarding the Ethernet circuit:

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

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



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

Start logging - Ethernet Data Port

To start Ethernet data logging to a local PC, select **Logging** on the MV-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 46 on page 5-12.

Stop logging - Ethernet Data Port

To stop Ethernet data logging, click the **Stop Logging** button on the **Ethernet Logging Control** screen (Figure 46, page 5-12).

File Size Control - Ethernet Data Port

The following file size options are available for Ethernet logging:

- One Continuous File – continuously log the Ethernet data over onto a single file
- Split at 64 MB – automatically split the Ethernet logged data in 64 MB files
- Split at 128 MB - automatically split the Ethernet logged data in 128 MB files
- Split at defined interval (min) - automatically split the Ethernet logged data after an elapsed time in minutes (i.e. every 60 mins)
- Split at defined time of day (hour) - automatically split the Ethernet logged data at a specific time of day (i.e. at the 11th hour of each day)

Data Output – Ethernet

The Ethernet real-time data output port is intended for real-time control applications where the most current position and orientation data are required. Real time data output on an Ethernet port is intended to provide data for a third-party application that is capable of decoding the POS MV Ethernet ICD format. Please refer to Applanix document *PUBS-ICD-004089* for a description of the Ethernet data output format. These ports implement small storage buffers which are flushed frequently to ensure timely delivery of the data.



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

Start Output - Ethernet Realtime Data Port

To start Ethernet real-time data output, select **Settings** on the MV-POSView menu bar and **Ethernet Real-time Port** on the drop-down menu. The window shown in Figure 50 appears.

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

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System Operation

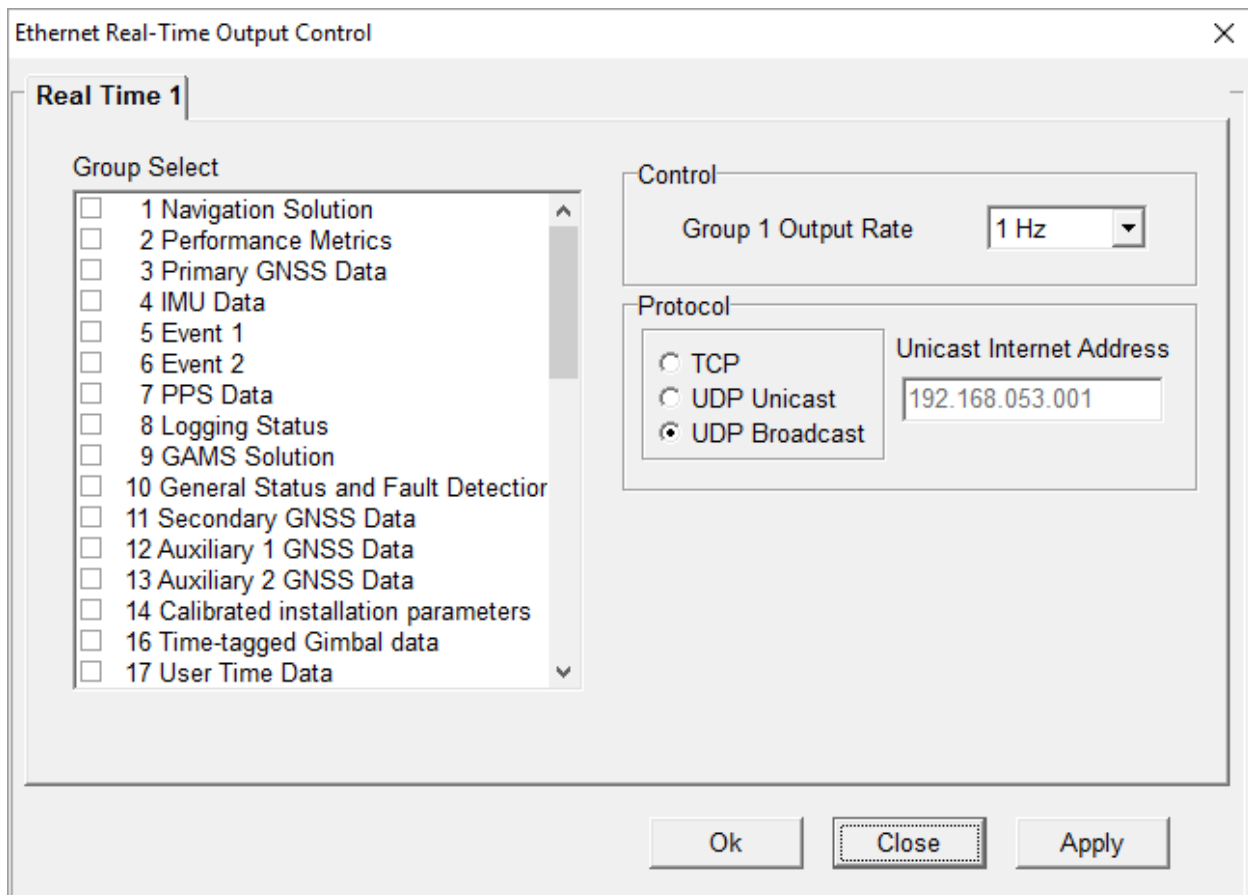


Figure 51: Ethernet Realtime Output Control.

Operation with GAMS

Normal Operation

If POS MV has valid installation parameters stored in NVM then it is ready to operate with GAMS heading aiding.

- a) Follow the instructions in the Power-On topic on page 4-1 to power-on the PCS.
- b) If you have not enabled AutoStart, transition POS MV to the navigate mode by selecting the **Nav** icon on the MV-POSView tool bar.

View both the **GAMS Solution** and the **Status** pane windows (Figure 51) to follow the GAMS Initialization sequence.

1. Once the POS MV has completed its levelling routine GAMS will start-up. The controller program will show the following indicators:

- The **Status** pane will show **GAMS** as **Not Ready**. This indicates that GAMS has not resolved the carrier phase ambiguities.
 - The **GAMS Solution** window shows **SVs in solution**, **A priori PDOP** and **Antenna Separation**.
 - In addition, the **GAMS Solution** window shows:
 - For BD960 GNSS receiver equipped POS systems a list of satellites (SVs or space vehicles) that are being tracked by POS MV. The order in which they appear in the window is not important.
 - For BD982 and BD992 GNSS receiver equipped POS systems the calibration status completion bar.
2. If POS MV is tracking fewer than five satellites, or if the indicated Position Dilution of Precision (PDOP) is greater than 4.5, then GAMS becomes dormant. In this dormant state, GAMS continues to monitor tracked satellites but does not process the observables from the GNSS receivers. **GAMS** status displays **Not Ready**.

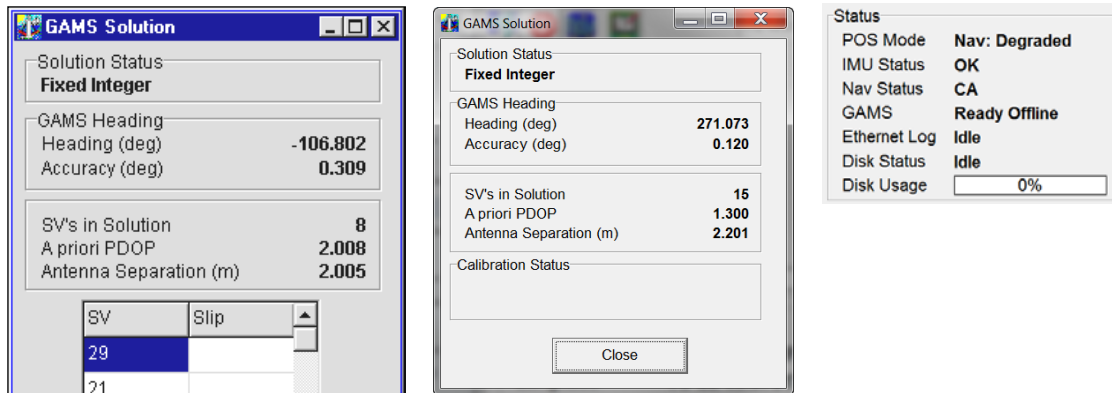


Figure 52: POSView GAMS Solution and Status Pane

3. Following the successful completion of coarse levelling, the **POS Mode** transitions to **Degraded Navigation** status. During this time, errors in the reported roll and pitch angles will be larger than 0.05°. If five or more satellites are being tracked and the indicated PDOP is less than 4.5 then GAMS begins the On-the-Fly (OTF) ambiguity search, using only the antenna separation distance to aid the search process. **GAMS** status displays **Not Ready**.
4. When the **POS Mode** transitions to **Nav Aligned** status, the errors in the reported angles of roll and pitch will be less than 0.075° RMS. The heading error remains large - in the order 10° to 15° RMS - unless the vessel performs dynamic manoeuvres, in which case errors may fall to below 5°.

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The computed angles of roll and pitch are now sufficiently accurate to be used by GAMS, together with the antenna separation distance, in the OTF ambiguity search process. Additional aiding data shortens the time that it takes to fix ambiguities from as long as 20 minutes to as short as two minutes, depending on the satellite geometry.

5. Once GAMS has resolved the carrier phase ambiguities, the **GAMS** status displays **Ready Online** to indicate that GAMS is ready to provide heading aiding data to the POS MV Kalman Filter.

This status may exist for up to ten seconds. If it exists beyond 20 seconds then this indicates that, for some reason, the Kalman Filter may have rejected the GAMS heading aiding data.

6. When the POS MV Kalman Filter begins to process the GAMS heading aiding data GAMS status displays **Online**. Within 30 seconds the heading errors should fall to 0.25° RMS and to between 0.02° and 0.15° RMS within two minutes.
7. The **GAMS** status display will transition from **Online** to **Ready Online** to indicate that the POS MV Kalman Filter has stopped processing GAMS heading aiding data. This can occur if one of the following conditions arise:
 - A one or two-second GNSS data dropout occurs in either/both GNSS receivers. A data dropout comprises either/both of the following:
 - Valid phase observables are available from fewer than four satellites
 - The indicated PDOP is greater than 4.5
 - The tracking Signal-to-Noise Ratio (SNR) for one or more satellites in either or both GNSS receivers drops to below 32 Decibels (dB). GAMS processes the observables for a satellite if the corresponding tracking SNR ratio in both receivers is greater than 30 dB. The POS MV Kalman Filter rejects GAMS heading aiding data computed from any marginal observables.
 - The POS MV Kalman Filter rejects the GAMS heading aiding data as being inconsistent with the inertial navigator heading. This can occur if a large multipath error causes GAMS to temporarily exhibit an unusually large heading error.

Once the cause of the heading aiding data rejection has been cleared, **GAMS** status displays **Online**.

8. The **GAMS** status display will transition from **Online** to **Not Ready** to indicate that GAMS has reset (i.e. it has abandoned the current fixed phase ambiguities and has restarted the OTF ambiguity search).

This can occur for two reasons:

- A GNSS data gap occurs and lasts for longer than two seconds. This can be caused by a blockage of the GNSS signal, for example, as the vessel passes under a bridge.
- GAMS has rejected the current fixed phase ambiguities. This can occur if the carrier phase ambiguity for a recently acquired satellite is fixed to the wrong integer due to multipath errors or excessive phase noise.

If the cause of the GAMS reset has been cleared then GAMS will quickly resolve the carrier phase ambiguities and return to **Online** status.

Abnormal Behaviour

Abnormal behaviour that occurs after a period of normal operation is symptomatic of environmental anomalies such as multipath errors, GNSS signal masking, or unexpected changes in IMU or GNSS antenna geometry.

The following are symptoms of abnormal behaviour together with their possible causes and some suggested remedies.

Repeated Ambiguity Rejection

Symptom

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

Possible Causes and Remedies

1. ***Cause - Installation Parameters*** - The installation parameters are incorrect or have become incorrect. This can occur if either/both GNSS antennas move with respect to the IMU by more than a few centimetres or if the IMU has moved with respect to the GNSS antennas by more than a few centimetres.

Remedy - Ensure that you have mounted the antennas and the IMU rigidly with respect to each other. Measure the correct installation parameters (Installation Parameters on page 2-24) and re-configure the POS MV installation parameters (POS MV Configuration on page 4-7).

2. ***Cause - Multipath Environment*** - A temporarily high multipath environment may occur if the vessel passes near a large reflecting surface

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such as a large ship or a building. SNR degradation for low elevation satellites may occur in either/both GNSS receivers if trees, buildings or a bridge partially masks the satellite signal paths. If, for example, the vessel has sailed into a harbour where large ships are moored then their hulls may generate multipath reflections.

Remedy - Move the vessel away from the source of the high multipath environment.

GAMS Status Remains 'Ready Online' Indefinitely

Symptom

The **GAMS** status display remains **Ready Online** for several minutes, although the **Navigator Configuration** window commands POS MV to use GAMS. Select **Tools, Configuration** to see the **Navigator Configuration** window.

Possible Causes and Remedies

1. **Cause - Incorrect Ambiguity Resolution** - GAMS has identified the wrong carrier phase ambiguities and has computed the wrong heading. The POS MV Kalman Filter continuously rejects the GAMS heading aiding data because it is inconsistent with the heading solution computed by the system without GAMS aiding.

Remedy - Click on the **Standby** icon on the MV-POSVIEW tool bar to transition POS MV to standby mode. Then click on the **Nav** icon to return to navigate mode. This action will re-initialize POS MV and GAMS.

2. **Cause - Incorrect Heading Resolution** - POS MV has computed a heading that is incorrect in spite of the displayed heading accuracy. This may occur if the POS MV Kalman Filter processes highly inaccurate GNSS data during the heading alignment.

Remedy - Click on the **Standby** icon on the tool bar to transition POS MV to standby mode. Then click on the **Nav** icon to return to navigate mode. This action will re-initialize POS MV and GAMS.

3. **Cause - Low SNR** - GAMS uses one or more satellite observables with a tracking SNR that is consistently below 32 dB from either/both GNSS receivers. This can arise from:
- Partial masking of a GNSS signal from a low elevation satellite; masking of this type may be caused by a bridge, trees, cliffs or hills along a nearby shore
 - Interference from nearby high voltage power lines
 - Very long antenna cables or the use of coaxial antenna cables that have excessive losses at the L1 frequency (1575 MHz)
 - GNSS receiver failure

Remedy - The problem of partial masking or interference will go away when the vessel moves away from the suspected shore-based source of signal degradation. You can identify a problem with antenna cables by substituting shorter low-loss cables.

Refer to Figure 43 on page 5-9, **Fault Detection** window (by selecting **View, Faults**), to check the GNSS receiver status and to determine whether either receiver has reported a fault.

Obvious Incorrect Heading

Symptom

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

Status		Attitude		
POS Mode	Nav: Aligned			Accuracy (deg)
IMU Status	Ok	Roll (deg)	0.002	0.025
Nav Status	CA	Pitch (deg)	0.006	0.025
GAMS	Ready Offline	Heading (deg)	350.239	5.411

Possible Causes and Remedies

1. **Cause** - GAMS has resolved the wrong carrier phase ambiguities and computes the wrong heading. The heading computed by POS MV has aligned to the incorrect heading reported by GAMS.

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Remedy - Click on the **Standby** icon on the MV-POSVIEW tool bar to transition POS MV to the standby mode. Then click on the **Nav** icon to return to the navigate mode. This action will re-initialize POS MV and GAMS.

There may be a problem with the IMU being out of specification. Contact Applanix for advice.

Repeatedly Rejected Carrier Phase Ambiguities

If GAMS is operating in a high multipath environment there may be repeated ambiguity rejections or an inability to resolve the carrier phase ambiguities. This may also occur if you experience degraded signal reception in either/both GNSS receivers due, possibly, to satellites being at a low elevation.

POS MV will continue indefinitely to try to resolve these carrier phase ambiguities. However, if either GNSS antenna has moved by more than a few centimetres with respect to the IMU, GAMS will never be able to resolve ambiguities until you have completed another calibration.

Provided there has been no change to the relative mounting positions of the antennas or the IMU, the displayed **GAMS** status will become **Ready Online** when GAMS resolves the carrier phase ambiguities. **GAMS** status will show **Not Ready** if GAMS has started a new OTF search.

Without GAMS heading aiding, the POS MV heading accuracy will degrade slowly at an approximate rate of one arc-minute per minute of operation. This slow rate of deterioration allows sufficient time to remove the vessel from the source of GNSS signal degradation while it continues to maintain an acceptable heading accuracy.

Once you have removed the vessel from the source of GNSS signal degradation, **GAMS** status should become **Online**.

Installation Parameters

Figure 52 shows the **GAMS Parameter Setup** window. Refer to Antenna Installation Calibration on page 4-22 for instructions on how to configure this window with the GAMS installation parameters.

Once you have identified the GAMS installation parameters correctly, save them to Non-Volatile Memory (NVM). It is unlikely you will ever need to modify these parameters again unless you move either/both GNSS antennas or the IMU.

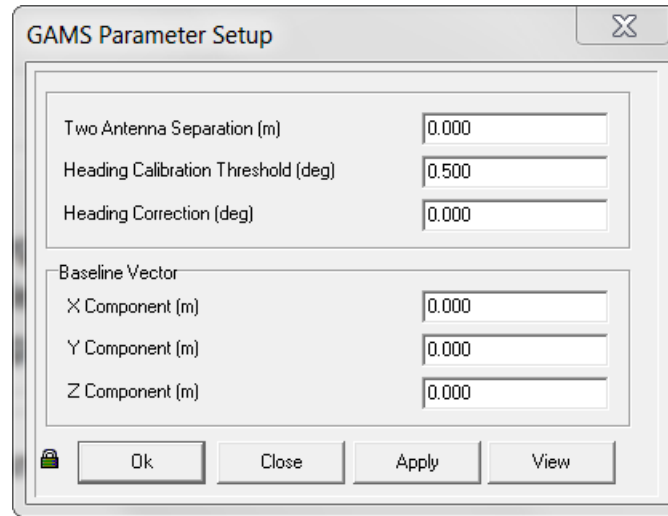


Figure 53: POSView GAMS Parameters Setup

GAMS uses the installation parameters to aid the OTF search algorithm. Please note the following:

- If the antenna separation and the surveyed antenna baseline vector installation parameters are zero, then the GAMS OTF search algorithm runs completely unaided. GAMS can be forced to operate in this mode by clearing the GAMS installation parameters.
- If the surveyed antenna baseline vector components are zero, and:
 - The antenna separations are non-zero, or
 - If the non-zero surveyed antenna baseline vector components are flagged as invalid, then
 - The GAMS OTF algorithm assumes the non-zero antenna separation to be correct, and
 - Uses the antenna separation to aid the OTF carrier phase ambiguity search.

You can force GAMS to operate in this mode by clearing the GAMS installation parameters and then entering an antenna separation distance.

- If the surveyed antenna baseline vector components and the antenna separation are non-zero and flagged as valid, then the GAMS OTF algorithm uses the complete set of parameters to aid the OTF search process.

If the POS MV roll and pitch errors are less than 0.25° RMS, GAMS constrains the ambiguity search space to a circle centred on the primary GNSS antenna (ANT 1). Ambiguity resolution in these circumstances takes less than five minutes.

Additionally, if the POS MV heading error is of the order of 1.0° to 2.0° , then the ambiguity is a small arc of the circle containing one or two candidate sets of ambiguities. In these circumstances, ambiguity resolution is nearly instantaneous and occurs in less than 10 seconds.

POS MV V5 Installation and Operation Guide

System Operation

Stand-Alone Operation

Note: Prior to power-on and POS MV operation in stand-alone mode, the AutoStart feature must be enabled. Refer AutoStart on page 4-15 for instructions on how to enable AutoStart. The following instructions assume that you have enabled the AutoStart feature.

Follow the Power-On instructions on page 4-1 to power-on the POS MV. The system will initialize using the configuration parameters that it holds in NVM. These include the IP address, the installation parameters, the output configuration, the heave filter parameters and the data groups that you selected for output on the display, and real-time and logging data ports. Once the system is initialized, it will begin to output data across the enabled ports.

Refer to the Data Logging instructions page 5-10 for a full description of the data logging facilities available for the POS MV.

When the system operates in stand-alone mode, the front panel status LED on the PCS continues to provide an indication of the system status as described in the Power-On instructions on page 4-1.

In stand-alone mode, whichever outputs you enabled and saved to the NVM will be available from the PCS. Data output will begin when the status LED, on the PCS front panel, begins to flash green.

The PCS will begin to broadcast Ethernet data as soon as the POS MV is powered-on. The Ethernet messages contain only POS MV status and time until the status LED begins to flash green, at which time the PCS will start to broadcast all the selected output groups.

POS Auto Upgrade

From version 10.3, POS firmware and POSView controller may be upgraded using the POS Auto Update utility included in POSView. This allows the user to upgrade to the latest eligible firmware version (as per the system warranty) without contacting Applanix.

Upgrade Procedure

1. Start POSView on PC with internet connection.
2. Connect to POS AV/LV/MV system; select **Tools, Connect** or click the **Connect** icon.
3. On first connection user will be informed if an update is available. (Alternatively, select **Tools, POS Auto Update** at any time while connected.)
4. Follow the on-screen instructions to complete the update.

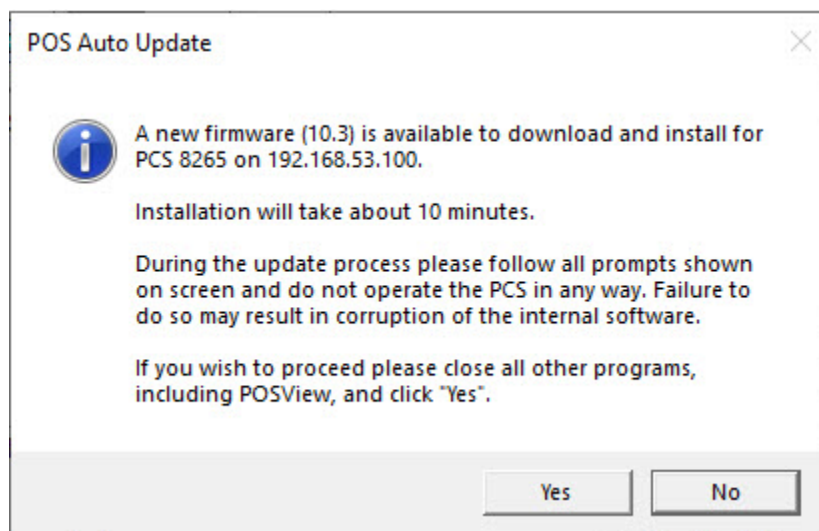


Figure 54: POS Auto Upgrade popup

Automatic check for updates

Each time POSView is run, a check for updates will occur on the first connection to POS. To disable the automatic check for updates, select **Tools, Options** and disable the "Automatically check for updates" option. Updates may still be initiated by selecting **Tools, POS Auto Update** while connected to POS.

Notes

POS Auto Update requires that POSView is run with system administrator privileges.

6.0 TrueHeave Operation

Overview

TrueHeave™ provides an estimate of vessel heave during conditions that often defeat traditional real-time heave filters. The POS MV TrueHeave solution uses algorithms that provide a zero phase response across the range of 0.03 to 0.2 Hz (30 to 5 s). Traditional real-time heave solutions tend to exhibit their most notable artefacts in long (>16 s) period swell conditions, often encountered with vessels in following seas. The frequency range of the TrueHeave solution dramatically reduces such low frequency artefacts.

Figure 53 illustrates the relationship of the TrueHeave solution to the current real-time approach and shows how it is computed and applied.

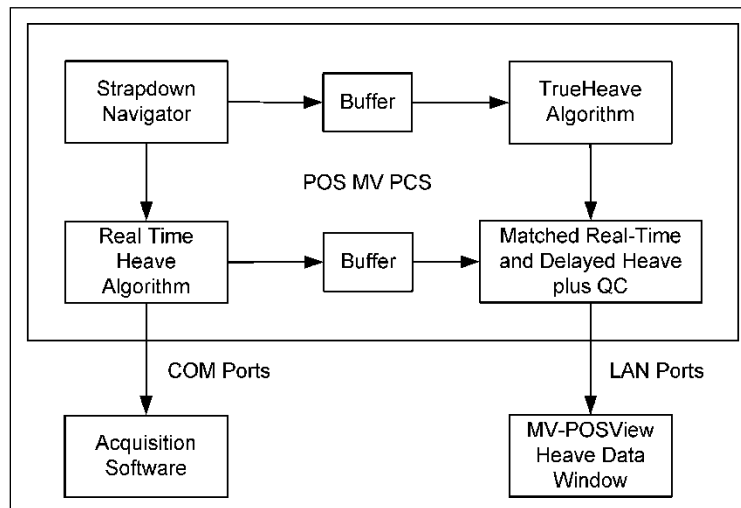


Figure 55: TrueHeave Functional Block Diagram

Configuration Requirements

TrueHeave is a turnkey solution and requires none of the tuning of standard real-time heave solutions.

Initialization Requirements

TrueHeave requires a period of up to five minutes after the commencement of navigation in order to initialize. After this initial period, no further initialization or settling time is required.

Data Output

The TrueHeave solution is provided at the Ethernet interface, LAN port. Details of the output message format are provided in the POS MV V5 User Interface Control Document (Applanix document control number - PUBS-ICD-004089). This delayed output is provided by the Group 111 heave data message

which provides the TrueHeave output, the equivalent of the real-time heave solution and the applicable Time of Validity (TOV) signal. Group 113 contains the associated performance metrics.

Groups 111 and 113 data are output on the real-time Ethernet data port at a rate of 25 Hz to provide sufficient resolution on the Heave Data display, see Figure 54. It may be selected for internal or Ethernet logging.

Note: The heave data output, in real-time, is in no way affected by the addition of TrueHeave; it can and should continue to be used as normal.



Figure 56: POSView Heave Data

TrueHeave Procedure

Use the following procedure to enable the TrueHeave feature prior to its first use.

1. Initialize POS MV ensuring that all pre-set user accuracy values are acceptable. This is indicated by green light buttons adjacent to the Attitude, Heading, Position, Velocity and Heading labels in the **Accuracy** pane on the MV-POSView Controller, see Figure 55.
2. View real-time heave and TrueHeave data by selecting **View, Heave Plot**, see Figure 54. Due to the delay inherent in creating the TrueHeave solution, the heave data plot remains blank for the first three minutes after initialization.

POS MV V5 Installation and Operation Guide

TrueHeave Operation

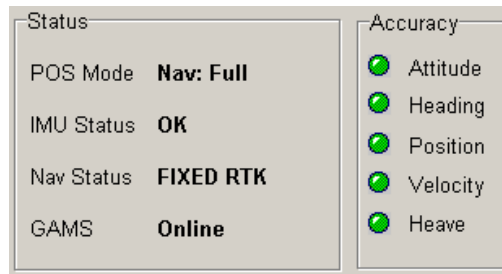


Figure 57: POSView Status and Accuracy Panes

3. TrueHeave data may be used two ways:
 - a) To adjust the real-time heave parameters to improve the real-time data available on the COM ports
 - b) To log the TrueHeave data for post-mission processing
4. Refer to the Data Logging procedures on page 5-10, noting the following points:
 - a) Select the **111 Heave data** and **113 Heave data quality control** check boxes in the Ethernet Logging Control window
 - b) Since there is a three-minute delay between real-time and the calculation of the equivalent *TrueHeave* solution, logging must continue for at least three minutes past the end of the survey session or line

Following the survey, the TrueHeave data may be analysed offline by third party post-processing software. Contact Applanix for a list of software packages which currently provide support for TrueHeave, refer to page A-1.

7.0 Specifications

POS MV OceanMaster

Main Specifications (with Differential Corrections)

Roll, Pitch accuracy:	0.02° (1 sigma with GNSS or DGNSS) 0.01° (1 sigma with RTK)
Heave Accuracy:	5 cm or 5% (whichever is greater) for periods of 20 s or less
Heading Accuracy:	0.02° (1 sigma) with 2 m antenna baseline, 0.01° (1 sigma) with 4 m baseline
RTK Positioning Accuracy	Horizontal: $\pm(8 \text{ mm} + 1 \text{ ppm} \times \text{baseline length})$ Vertical: $\pm(15 \text{ mm} + 1 \text{ ppm} \times \text{baseline length})$ Note: RTK accuracies assume 1 m IMU-GNSS antenna offset
DGPS Positioning Accuracy	0.5 - 2 m (1 sigma) depending on quality of differential corrections
Velocity Accuracy:	0.03 m/s horizontal

During GNSS Outages

Roll, Pitch accuracy:	0.02° (1 sigma)
Heave accuracy:	5 cm or 5% (whichever is greater) for wave periods of 18s or less
Heading accuracy:	Drift less than 1° per hour (negligible for outages < 60 s)
Position accuracy degradation:	2.5 m (1 sigma) for 30 s outages <6 m (1 sigma) for 60 s outages

POS MV V5 Installation and Operation Guide

Specifications

POS MV WaveMaster & WaveMaster RM Main Specifications (with Differential Corrections)

Roll, Pitch accuracy:	0.03° (1 sigma with GNSS or DGNSS) 0.02° (1 sigma with RTK)
Heave Accuracy:	5 cm or 5% (whichever is greater) for periods of 20 s or less
Heading Accuracy:	0.03° (1 sigma) with 2 m antenna baseline, 0.015° (1 sigma) with 4 m baseline
RTK Positioning Accuracy	Horizontal: $\pm(8 \text{ mm} + 1 \text{ ppm} \times \text{baseline length})$ Vertical: $\pm(15 \text{ mm} + 1 \text{ ppm} \times \text{baseline length})$ Note: RTK accuracies assume 1 m IMU-GNSS antenna offset
DGPS Positioning Accuracy	0.5 - 2 m (1 sigma) depending on quality of differential corrections
Velocity Accuracy:	0.05 m/s horizontal

During GNSS Outages

Roll, Pitch accuracy:	0.04° (1 sigma)
Heave accuracy:	5 cm or 5% (whichever is greater) for wave periods of 18 s or less
Heading accuracy:	Drift less than 2° per hour
Position accuracy degradation:	3 m (1 sigma) for 30 s outages <10 m (1 sigma) for 60 s outages

POS MV SurfMaster, SurfMaster RM & SurfMaster One Main Specifications (with Differential Corrections)

Roll, Pitch accuracy:	0.04° (1 sigma with GNSS or DGNSS) 0.03° (1 sigma with RTK)
Heave Accuracy:	5 cm or 5% (whichever is greater) for periods of 20 s or less
Heading Accuracy:	0.08° (1 sigma) with 2 m antenna baseline 0.06° (1 sigma) with 4 m antenna baseline
RTK Positioning Accuracy	Horizontal: $\pm(8 \text{ mm} + 1 \text{ ppm} \times \text{baseline length})$ Vertical: $\pm(15 \text{ mm} + 1 \text{ ppm} \times \text{baseline length})$ Note: RTK accuracies assume 1 m IMU-GNSS antenna offset
DGPS Positioning Accuracy	0.5 - 2 m (1 sigma) depending on quality of differential corrections

During GNSS Outages

Roll, Pitch accuracy:	0.05° (1 sigma)
Heave accuracy:	5 cm or 5% (whichever is greater) for wave periods of 18 s or less
Heading accuracy:	0.3° (RTK, 60s outage)
Position accuracy degradation:	6 m (1 sigma) for 30 s outages

POS MV V5 Installation and Operation Guide

Specifications

Physical Characteristics

Size and Weight

	Size	Weight
OceanMaster		
IMU type 26	203 mm X 203 mm X 116 mm	2.1 kg
IMU type 36	158 mm X 158 mm X 124 mm	2.5 kg
IMU type 38	208 mm Ø X 196 mm	5.5 kg Al, 8.4 kg Ti, 13 kg SS
IMU type 40	131 mm X 163 mm X 124 mm	1.8 kg
IMU type 44	126 mm X 179 mm X 127 mm	2.6 kg
IMU type 52	119 mm X 149 mm X 110 mm	1.8 kg
IMU type 64	158 mm X 158 mm X 124 mm	2.4 kg
IMU type 65	132 mm Ø X 158 mm	2.2 kg
IMU type 89		
Housing type 108	158 mm X 158 mm X 124 mm	2.0 kg
Housing type 109	132 mm x 176 mm x 158 mm	1.8 kg
WaveMaster & WaveMaster RM		
IMU type 26	203 mm X 203 mm X 116 mm	2.1 kg
IMU type 37	158 mm X 158 mm X 124 mm	2.5 kg
IMU type 39	208 mm Ø X 196 mm	5.5 kg Al, 8.4 kg Ti, 13 kg SS
IMU type 42	158 mm X 158 mm X 124 mm	2.5 kg
IMU type 82		
Housing type 108	158 mm X 158 mm X 124 mm	2.0 kg
Housing type 109	132 mm x 176 mm x 158 mm	1.8 kg
SurfMaster & SurfMaster RM		
IMU type 69	158 mm X 158 mm X 124 mm	2.5 kg
IMU type 70	132mm Ø X 114 mm	1.3 kg
Elite		
IMU type 21	200 mm X 197 mm X 176 mm	4.8 kg ¹
IMU type 33	229 mm X 315 mm X 196 mm	3.5 kg
IMU type 57	126 mm X 179 mm X 127 mm	2.6 kg
PCS (POS MV V5):	483 mm X 44 mm X 334 mm	3.9 kg
PCS (POS MV V5-1):	167 mm X 185 mm X 68 mm	2.5 kg
PCS (POS MV V5-2)	160 mm X 164 mm X 66 mm	2.5 Kg

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Specifications

Size and Weight

Zephyr GNSS Antenna:	165 mm Ø X 76 mm	0.64 kg
382AP GNSS Antenna:	146 mm Ø X 63 mm	0.5 kg
540AP GNSS Antenna	178 mm Ø X 73 mm	0.45 kg
GA830 GNSS Antenna	149 mm Ø X 99 mm	0.82 kg

POS MV V5 Installation and Operation Guide

Specifications

Power

IMU: Power provided by PCS

PCS POS MV V5 (PCS-80,
PCS-84 & 100):

Voltage: 100 Vac to 240 Vac, 50 to 60 Hz, auto-switching

Current: 1.1 A Max (@ 100 V)

PCS POS MV V5-1
(PCS-76):

Voltage: 10 Vdc to 34 Vdc ¹

Current: 5.5 A Max (@ 10 Vdc)

GNSS Antennas: Power provided by PCS

PCS POS MV V5-1
(PCS-86 & 101):

Voltage: 8 Vdc to 34 Vdc

Current: 7.0 A Max (@ 8 Vdc)

PCS POS MV V5-2
(PCS-92):

Voltage: 9 Vdc to 34 Vdc

Current: 2.5 A Max (@ 9 Vdc)

GNSS Antennas: Power provided by PCS

Notes:

1 – minimum acceptable input voltage supplied to the MV V5-1 PCS-76 depends on the IMU type and length of IMU cable. PCS-86 and PCS-101 will power all IMUs over the complete input voltage range. Contact Applanix for details.

Environmental

Temperature Range (Operating)

IMU: -40 °C to +60 °C -40 °F to +140 °F

PCS POS MV V5: -20 °C to +70 °C -4 °F to +158 °F

POS MV V5-1: -20 °C to +60 °C -4 °F to +140 °F

POS MV V5-2 -20 °C to +55 °C -4 °F to +131 °F

GNSS Antenna: -50 °C to +70 °C -58 °F to +158 °F

Temperature Range (Storage)

IMU: -40 °C to +60 °C -40 °F to +140 °F

PCS: -40 °C to +70 °C -40 °F to +158 °F

GNSS Antenna: -50 °C to +70 °C -58 °F to +158 °F

Humidity

IMU (OceanMaster)	10 - 80% RH
IMU (WaveMaster & WaveMaster RM):	0 - 100% RH
PCS (POS MV V5):	10 - 80% RH, non-condensing
PCS (POS MV V5-1):	10 - 95% RH, non-condensing
PCS (POS MV V5-2):	10 - 95% RH, non-condensing
GNSS Antenna:	0 - 100% RH

Ingress Protection

PCS-76/80/84/86/92	to be deployed in a between decks environment, protected from weather
IMU-42/64/69	to be deployed in a between decks environment, protected from weather
IMU-45/65/70	suitable for deployment in weather or pole mounted below the water surface

Shock & Vibration (IMU)

OceanMaster

Operating:	90 g, 6 ms terminal saw tooth
Non-Operating:	220 g, 5 ms half-sine

WaveMaster & WaveMaster RM

Operating:	35 g, 6 ms terminal saw tooth
Non-Operating:	40 g, 5 ms half-sine

8.0 Tools and Diagnostics

The Position and Orientation System for Marine Vessels (POS MV) provides a diagnostics function to help solve some of the problems that may arise when connecting the system within an integrated suite of survey equipment.

GNSS Configuration

Upon installation, the POS MV configures the GNSS receivers so that they output only those messages used by the system. When necessary, the POS Computer System (PCS) will reconfigure the receivers automatically if either one ever loses its configuration for any reason.

Additionally, you can send the GNSS configuration message to the GNSS receivers manually by selecting **Tools, Configure GNSS** from the MV-POSView menu bar.

GNSS Reset

The MV-POSView Controller program allows you to send a reset command to the GNSS receivers. To do this, select **Tools, Reset GNSS** from the MV-POSView menu bar.

Once the reset command is initiated, the GNSS receivers will take approximately two minutes before they return to the navigation mode and POS MV can use their data.

Use the GNSS reset feature only as a final option if the receivers exhibit inexplicable, uncharacteristic behaviour. Examples of such behaviour include a failure to track satellites, a failure to compute or a failure to output a valid navigation solution for an extended period. Before using the GNSS reset feature, verify that you cannot attribute the cause to faults in cables or connectors.

GNSS Data

Select **View, GNSS Data** from the MV-POSView menu bar to view the **GNSS Data** window shown in Figure 56.

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Tools and Diagnostics

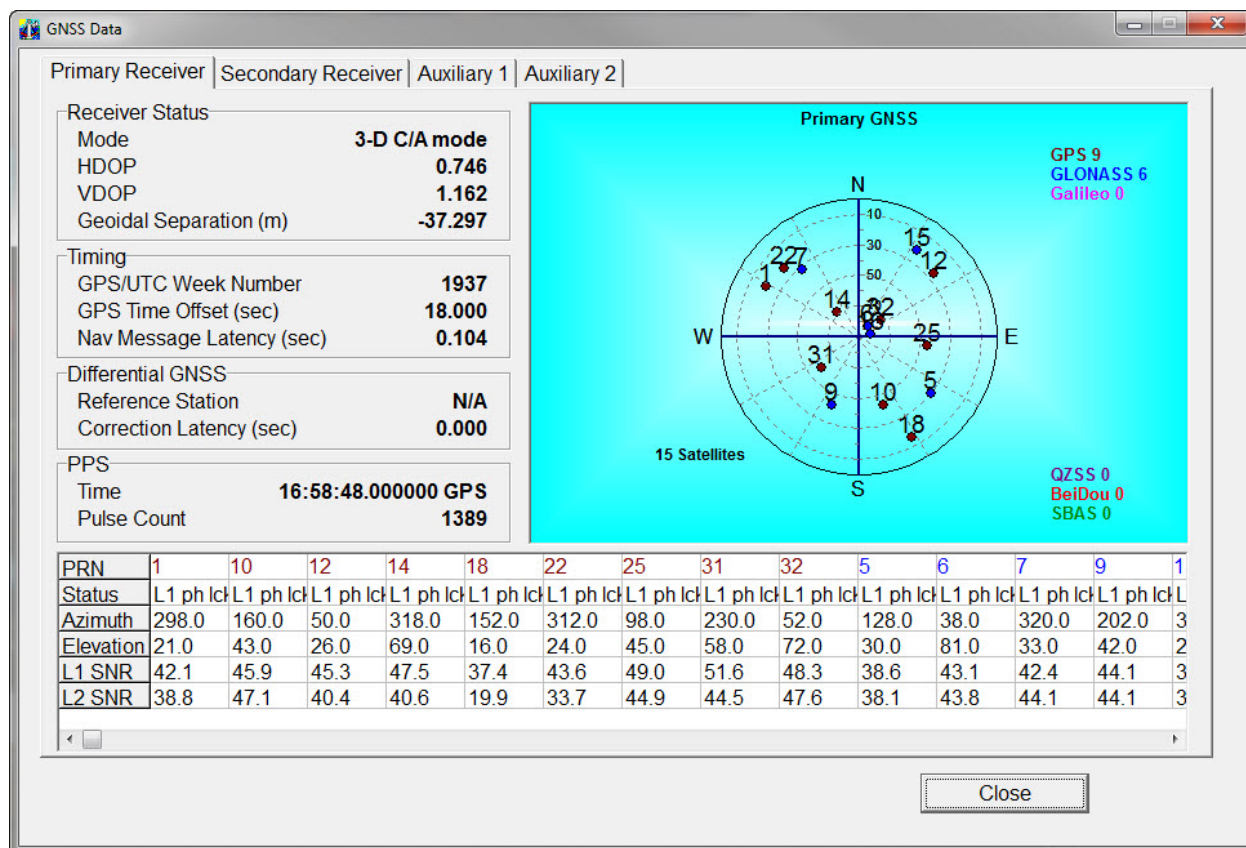


Figure 58: POSView GNSS Data

The **GNSS Data** window shows the GNSS navigation status in a polar style display. POSMV generates an identification number for each satellite in use and indicates its location in the sky, with the centre of the display directly overhead. From this display, a person can deduce if a satellite signal is being blocked.

The bottom of the window displays a list of the satellites in solution and includes details of their Signal-to-Noise Ratios (SNR) at the important L1 frequency (L1 SNR). Low SNR values for all satellites could indicate deterioration in the quality of the GNSS antenna cable. The window will show the L2 SNR for L1/L2 GNSS, if fitted.

Diagnostics

POS MV provides both control and display diagnostic functions. The control functions permit the selection and setting of various binary outputs to specific values. The display functions allow the viewing of real-time parameters. This provides POS MV with a debugging function that can be used to establish a successful integration of the system into an extended suite of survey equipment.

Control Diagnostics

Diagnostic values that are entered and enabled for the digital ports will replace any real-time attitude information on those channels. To resume normal operation, disable the diagnostic output for the relevant channel.

Enter and enable diagnostic values by following the steps below. The diagnostic values that are entered have no effect on the configuration of affected ports; refer to Figure 57.

1. On the MV-POSView menu bar, select **Settings, Diagnostics Control, Binary** to open the **Diagnostics** window.
2. Select the appropriate tab and enter the diagnostic values for the displayed parameters in the **Operator Input** pane.
3. Select the **Enable** option in the **Output** pane.
4. Select the **OK** or **Apply** button. The diagnostic values then appear on the appropriate output port, using the current configuration for that port.
5. Return to normal operation by performing the following steps:
 - a) Set all values in the **Operator Input** pane to zero (optional)
 - b) Select the **Disable** option in the **Output** pane
 - c) Finally, select the **OK** or **Apply** button

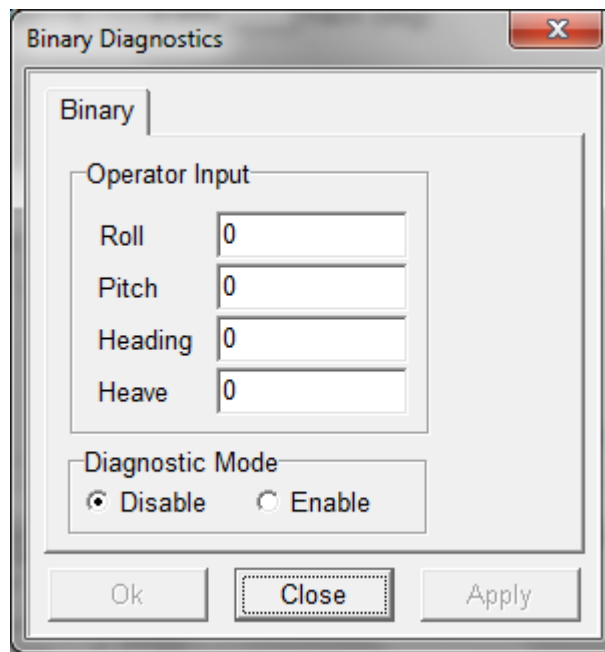


Figure 59: POSView Binary Diagnostics

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Tools and Diagnostics

Display Diagnostics

Display diagnostics permit the operator to view selected POS MV real-time internal data as an aid to debugging system problems. Select **Diagnostics** on the MV-POSView menu bar to display the following selections:

- Primary GNSS
- Secondary GNSS
- Base GNSS (Base 1 and Base 2)
- Aux GNSS
- Control Port
- Display, Data & NVM
- Time & Pulses
- IMU
- NMEA & Binary Output
- Other

Contact Applanix Customer Support for assistance, see page A-1

Base 1/2 GNSS Diagnostics

The PCS provides a diagnostic window for input differential corrections. This window provides information that can aid in diagnosing problems related to input differential corrections. Separate windows for Base 1/2 corrections can be viewed by navigating to **Diagnostics, Base GNSS** from the menu bar. An example of this window is shown in Figure 58 below.

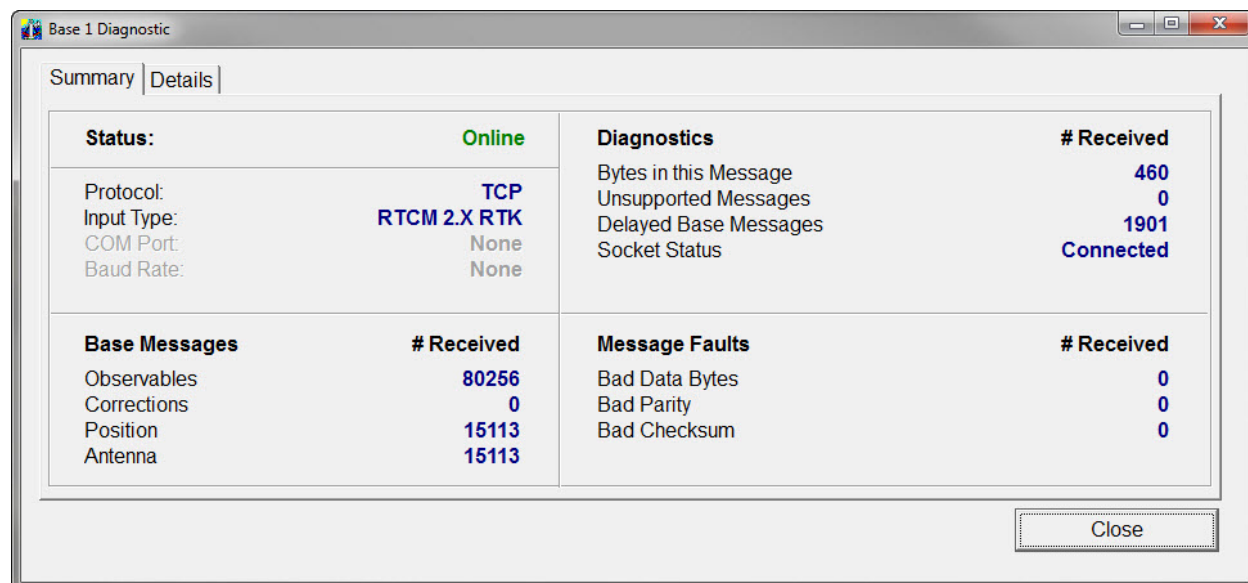


Figure 60: Base 1/2 Diagnostics Window

The **Summary** tab, shown in Figure 58 above, provides a summary of diagnostics information. This tab is split into four main categories: Status, Base Messages, Diagnostics, and Message Faults.

- **Status** provides connectivity information. The main status field can be any of the following, provided their conditions are met:
 - **Online:** The PCS is receiving observables/corrections and already has the base position. RTK is working as expected.
 - **Waiting for base position:** The PCS is receiving observables/corrections but has not yet received the base position. Wait until it has been received or check if the base position is being transmitted to the PCS.
 - **Receiving bad data:** The PCS is receiving data but it cannot be decoded. Check the baud rate and selected communications protocol the PCS is set to and make sure they match with your corrections provider.
 - **Waiting for data:** The PCS is setup to receive corrections data but it is currently not receiving data. Check the physical connection and make sure your corrections provider is outputting data.
 - **Offline:** The PCS is not setup to receive corrections.
- **Base Messages** provides a summary of the types of messages that have been received, regardless of the specified message protocol.
- **Diagnostics** provides fields relating to the health of the messages.
- **Message Faults** provides a list of faults for incoming messages and the number of times they have been encountered.

The details tab contains lists of messages and the number of times they have been successfully recorded by the PCS. The messages are split up based on the message protocol they belong to. This can be seen in Figure 59 below.

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Tools and Diagnostics

Base 1 Diagnostic

SummaryDetails

RTCM 2.X Messages	# Received	RTCM 3.X Messages	# Received
Type 01	0	Types 1001-1004	0
Type 03	0	Types 1005-1006	0
Type 09	0	Types 1007-1008	0
Type 18 L1	20185		
Type 18 L2	20207		
Type 19	40392		
Type 20	0		
Type 21	0		
Type 23	15127		
Type 24	15127		
Type 59	0		

CMR/CMR+ Messages	# Received
Type 00	0
Type 01	0
Type 02	0
Type 94	0

Close

Figure 61: Base 1/2 Diagnostics Window, Details Tab

Regular Maintenance

Important:

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

POS MV has a minimal requirement for scheduled maintenance on its subassemblies and components. Performing these procedures at the recommended intervals enables the POS MV to maintain the highest standard of service and performance throughout its lifetime.

Inertial Measurement Unit



The IMU contains sensitive and expensive solid-state accelerometer and gyro components. Permanent damage to these components will result if handled roughly.

IMPORTANT

Unauthorised opening of the IMU housing will void the warranty. The IMU is a sealed unit that contains no user serviceable parts and does not require internal maintenance.

Maintenance Procedures:

- Wipe the IMU housing with a damp cloth every six months, or more often if necessary, to protect the finish and to remove oil and salt deposits.
- Check the cables and connectors for signs of damage, degradation or contamination. Repair or renew them as necessary.
- Ensure that cables are securely connected.

GNSS Antennas



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

Maintenance Procedures:

- Use fresh water to wash any deposits of salt or other contamination from the antennas.
- Inspect the antennas, cables and connectors every six months, or more often if necessary, for signs of damage, degradation or contamination. Repair or renew them as necessary.
- Ensure that cables are securely connected.
- When operating in very cold conditions, use an appropriate method to remove any ice accumulation from the antennas.

POS Computer System

If you protect the PCS from moisture and dust in its mounting location, the unit will require very little regular maintenance.

Maintenance Procedures:

- Wipe the PCS housing with a damp cloth every six months, or more often if necessary, to protect the finish and to remove oil and dust deposits.
- Check all cables and connectors for signs of damage, degradation or contamination. Repair or renew them as necessary.
- Ensure that cables are securely connected.

Technical Support

Refer to the Technical Support and Service information and procedures on page A-1.

9.0 Fault Identification

Important:

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

Position and Orientation System for Marine Vessels (POS MV) development efforts are centred on the need for the system to operate for long periods in rigorous marine environments with minimal maintenance requirements.

POS MV incorporates self-diagnostics in the form of a Fault Detection Isolation and Reconfiguration (FDIR) algorithm. FDIR monitors the health of the various system components and, in the case of sensor degradation or failure, automatically reconfigures the system to minimise the effect of the degradation.

The POS MV uses two methods simultaneously, to inform you that the system has experienced a failure or performance degradation:

- Lights on the POS Computer System (PCS) front panel will show a fault condition
- The MV-POSView Controller program will provide a more detailed description of the problem

By planning and conducting regular maintenance procedures, described in the Regular Maintenance description starting on page 8-6, the POS MV will continue to provide a high standard of service and performance.

If you suspect a fault condition on the POS MV, follow the instructions in this section of the manual to identify the cause. Field maintenance procedures allow the following operations only:

- Identifying problems associated with system integration
- Identifying the cause of system failures
- Repairing the system by replacement of the PCS, cables, or sensing subsystems

Component Description

POS MV comprises the following subsystem components:

- One Inertial Measurement Unit (IMU)
- One POS Computer System (PCS)
- Two Global Navigation Satellite System (GNSS) antennas

POS MV V5 Installation and Operation Guide

Fault Identification

In addition to the above hardware, the POS MV includes all cables to interconnect the components of the system and certain additional cables that can be used to connect to external equipment.

Previous sections of this manual describe the cables, the connection ports and the data formats; refer to the Table of Contents at the beginning of the manual or the Index at the end of the manual for specific items. The Handling Precautions on page 2-1 describes the precautions that should be exercised when unpacking and installing the POS MV subsystems.

Inertial Measurement Unit



The IMU contains sensitive and expensive solid-state accelerometer and gyro components. Permanent damage to these components will result if handled roughly.

The IMU includes an orthogonal array comprising three accelerometers and three gyros. The accelerometers sense translational acceleration along one of three axis (x, y, and z) and the gyros sense angular rate around each axis. Incremental velocities and angles are output across a digital interface to the PCS.

The IMU is a sensitive device and must be handled carefully to prevent damage to the sensing elements. Refer to the Inertial Measurement Unit description on page 2-1 for instructions pertaining to IMU handling and care.

GNSS Antennas



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

The GNSS antennas are solid state devices with no moving parts. They are rugged and reliable and, with a little care, will provide long-term trouble free operation. Follow the steps outlined in the GNSS Antennas topic on page 8-7 to maintain their operating efficiency.

To prevent damage caused by moisture ingress, ensure that the TNC connection between the GNSS antenna receptacle and its mating cable plug is waterproof. Use a good waterproof tape and sealant.

POS Computer System

Note: An optional field support kit includes a replacement PCS.

The PCS contains a computer module, an interface module, two GNSS receivers, and power supplies for the internal electronics and the remote IMU. Constructed of rugged, industrial grade components, the PCS should be handled with care to minimize risk of damage.

Fault Identification

Field maintenance for the POS MV involves the following actions:

- Identification of a fault condition
- Repair of the fault by substitution or product return

POS MV has self-diagnostics to assist with isolating a fault to the following subsystems:

- IMU subsystem, including the IMU and the IMU cable
- PCS subsystem
- GNSS subsystem, including the GNSS antennas, GNSS antenna cables and GNSS receivers

If POS MV detects a failure condition in either the GNSS or IMU subsystems, it will use two methods to alert you:

- Indicates a fault condition through status lights on the PCS front panel
- Outputs appropriate status warning messages to the various MV-POSView Controller windows (Fault Detection and Message Log)

The following paragraphs describe both types of failure indications.

Front Panel Indicators

The lights on the PCS front panel display status information about the PCS system. To isolate faults follow the advice and instructions provided in Table 35.

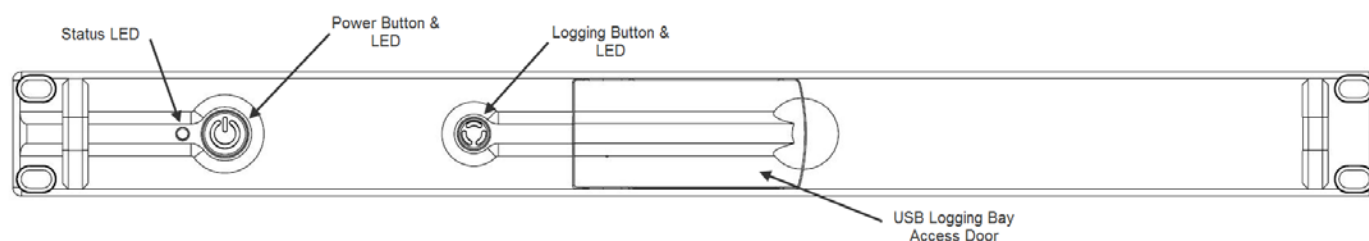


Figure 62: POS MV V5 Front Panel

POS MV V5 Installation and Operation Guide

Fault Identification

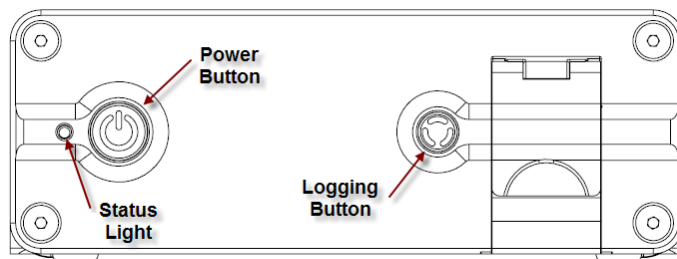


Figure 63: POS MV V5-1 Front Panel

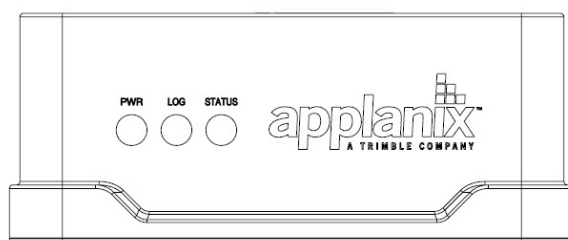


Figure 64: POS MV V5-2 Front Panel

Table 36: PCS Front Panel Indicators - Fault Identification

Status light - indicates current status of POS MV:	
Steady red:	POS MV failure - shows red when PCS is first powered-on. Changes to a valid condition when PCS internal program begins to run, but will turn red again if there is a fault in PCS. If a fault occurs, do not power-off PCS. Refer to Fault Detection window of controller program, see Fault Detection starting on page 9-5.
Steady amber:	Standby mode - POS MV is waiting for instructions.
Flashing amber:	Navigate mode - initialising and aligning attitude (coarse levelling).
Flashing green:	Navigate mode - degraded attitude performance. Attitude measurements are acceptable but do not meet user-set accuracy limits.
Steady green:	Navigate mode - normal system operation. System meets accuracy limits set by user for position, velocity, attitude and heading.
Logging light - indicates status of logging device.	
Steady green:	Logging device is active and recording data.
Steady amber:	Logging media is > 80% full.

Steady red:	Logging has failed – check that the device is not full, and for POS MV V5 and V5-1 check that a USB memory stick is properly inserted.
Power light - illuminates when the PCS is operating.	

Fault Detection

To access the **Fault Detection** window select **View, Faults** from the MV-POSView menu bar. This window, shown in Figure 63, shows the faults detected by the POS MV during operation. A fault is present if an indicator shows red against any item in the list. Three tabs provide a list of the system health monitoring items: General, IMU and GNSS Corrections.

If you suspect that a fault condition has occurred, but the **Fault Detection** window does not show it, check the Message Log. The Message Log description starting on page 9-9 lists the possible messages that may appear in the message log. Of interest, at this point, are the items in Figure 63. The monitored items are organized by category and each fault has a brief description.

If you suspect that the system has developed a fault, note the condition of the indicators on the **Fault Detection** window. If necessary, contact Applanix for advice, refer to Technical Support and Service on page A-1 for procedures.

General Tab

The **Primary GNSS** pane, Figure 63, shows the status of the primary GNSS receiver and any faults reported by it. If this pane reports any persistent faults, they could be caused by a faulty GNSS antenna or its cable.

The **Secondary GNSS** pane monitors the data gaps from the secondary GNSS receiver. A persistent loss of secondary GNSS information will prevent GNSS Azimuth Measurement Subsystem (GAMS) from performing carrier phase differential measurements to determine the heading. Investigate the secondary GNSS antenna and its cable as a possible cause of persistent data gaps.

Data gaps experienced by both GNSS receivers simultaneously are likely to occur if nearby buildings or structures block the satellite signals (this is not a system fault). During such data gaps, the POS MV will continue to navigate inertially with only a gradual degradation in position and heading accuracy.

The **Auxiliary GNSS** pane reports the status of navigation solutions supplied from any auxiliary GNSS receiver connected to the PCS.

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Fault Identification

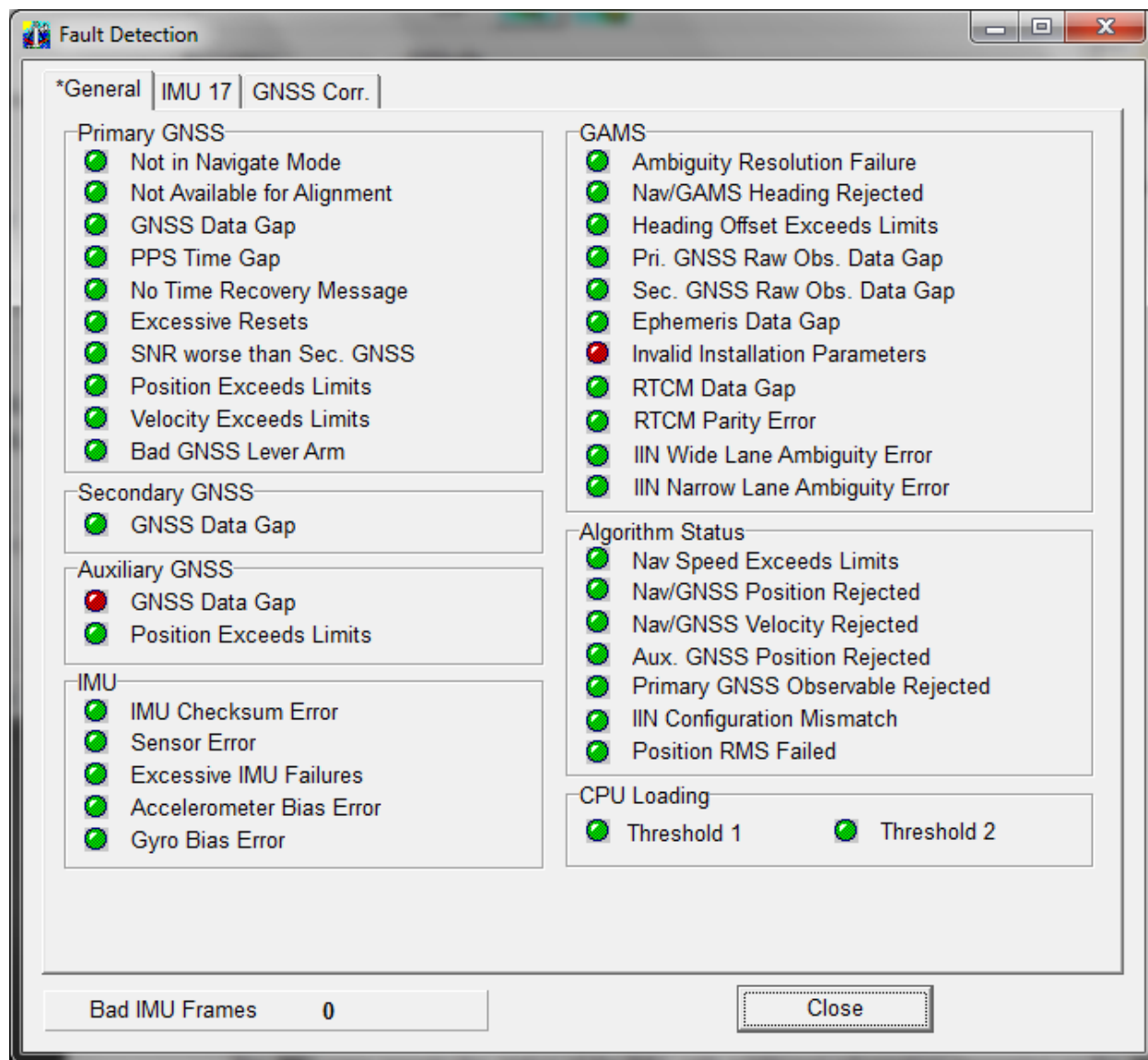
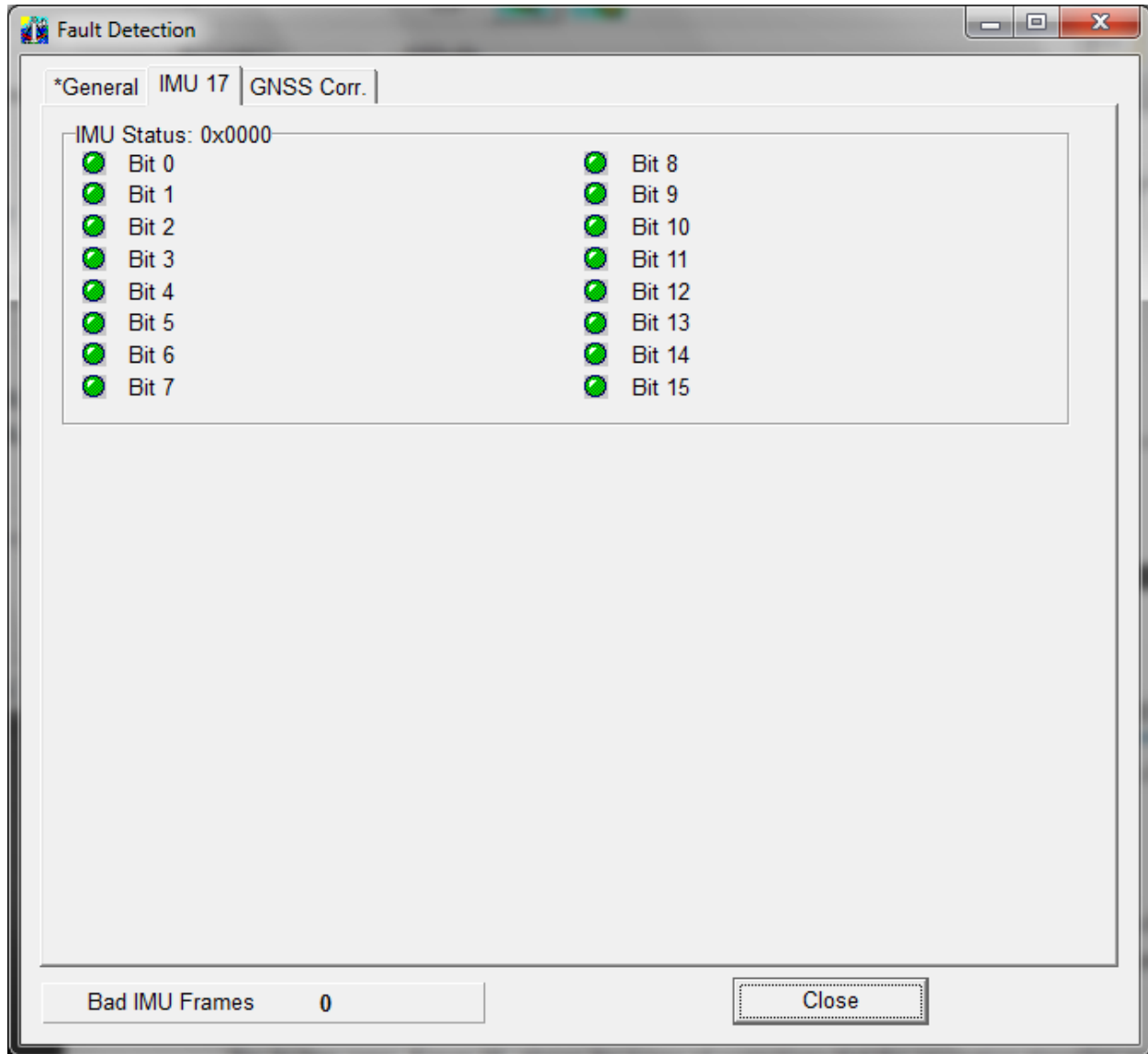


Figure 65: POSView Fault Detection

The **IMU** pane reports the status of the IMU, with additional information appearing on the **IMU** tab shown in Figure 64. There is also an additional field that appears at the bottom left-hand side of each **Fault Detection** tab to show the number of bad data frames received from the IMU. An occurrence of several consecutive bad IMU frames will cause the POS MV to reinitialize and start coarse levelling.



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Fault Identification

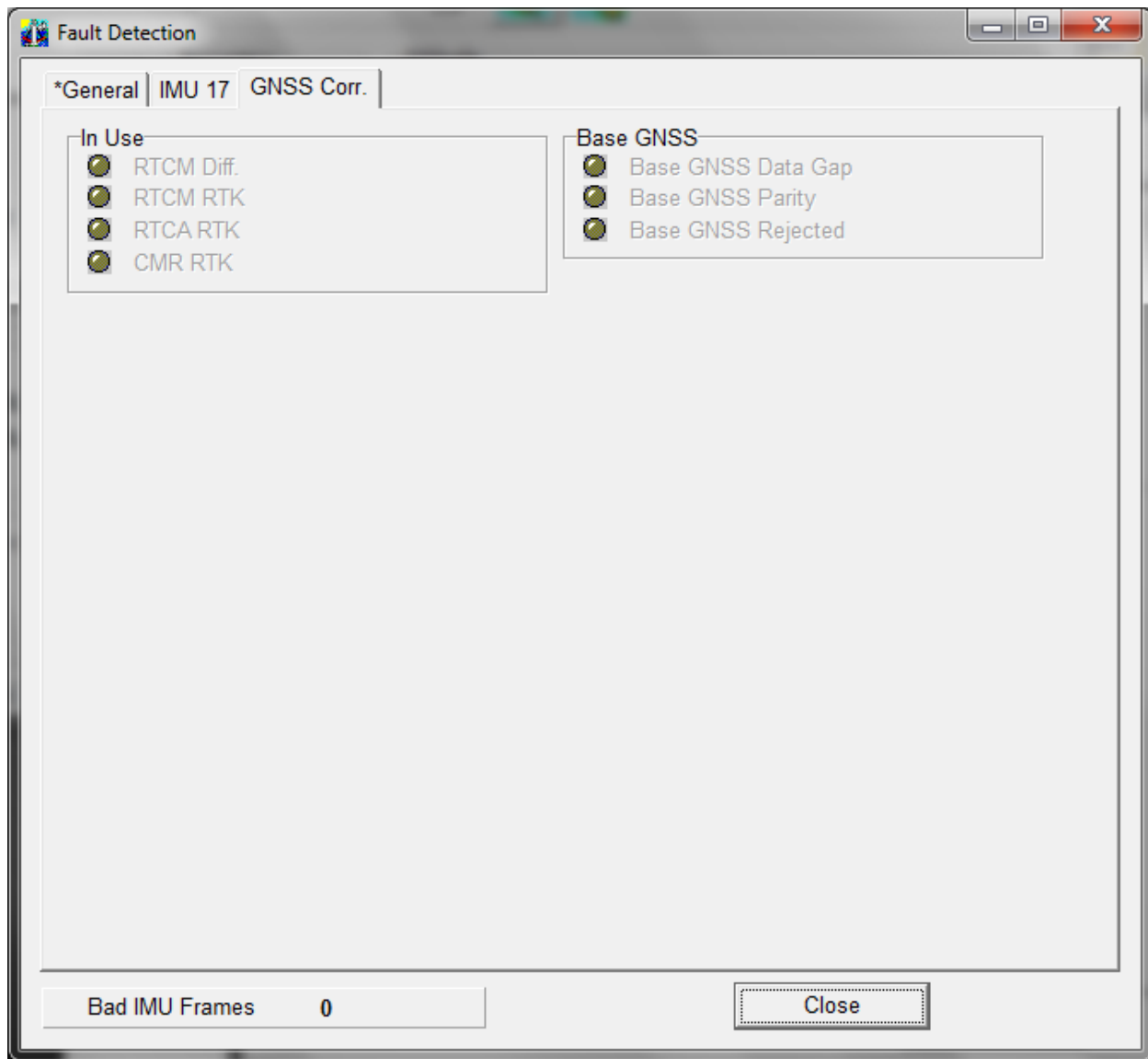


Figure 66: POSView Fault Detection - IMU and GNSS Corr. Tabs

IMU Tab

The **IMU Status** pane, Figure 64, identifies the raw status bits from the IMU. If any of these bits have a red light please contact Applanix Customer Support representative for assistance, refer to page A-1.

GNSS Corr. Tab

The **In Use** pane, Figure 64, shows the types of corrections that the navigation algorithm may use. A green light indicates the item that is currently being used.

The **Base GNSS** pane indicates the status of received data on the base GNSS COM port. A green light indicated no problems; a red light indicates a problem.

Message Log

Access the **Message Log** by selecting **View, Message Log** from the MV-POSView menu bar, see Figure 65.

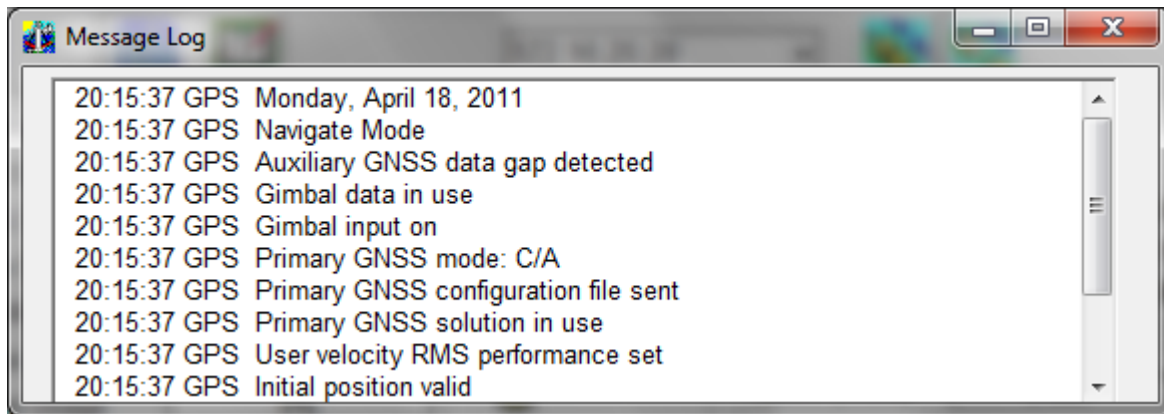


Figure 67: POSView Message Log

Table 36 contains messages that can appear in the message log. Messages marked with an asterisk (*) relate to indicators on the **Fault Detection** window.

Note: Some cases of incorrect GNSS configuration is handled automatically if the GNSS automatic reconfiguration feature is enabled (select **Enabled** in the **Auto Configuration** pane on the **GNSS Receiver Configuration** window). The automatic reconfiguration logic checks for expected messages from the GNSS receiver, and will send a configuration command to the receiver if the expected messages are not present. The contents of messages are not checked.

Table 37: Message Log Entries

Message Text	Description
*PPS data not received	Time recovery data not received
PPS data received	Flag reset
HDOP data not received	Dilution of precision data not received; receiver not configured properly; send configuration file
HDOP data received	Flag reset
*Ephemeris data gap detected	There is a gap in GNSS data; Short periods when this occurs are normal
Ephemeris data gap cleared	Flag reset

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Fault Identification

Message Text	Description
*Primary GNSS raw observable data gap detected	There is a gap in GNSS data; short periods when this occurs are normal
Primary GNSS raw observable data gap cleared	Flag reset
*Secondary GNSS raw observable data gap detected	There is a gap in GNSS data; short periods when this occurs are normal
Secondary GNSS raw observable data gap cleared	Flag reset
*Auxiliary GNSS data gap detected	There is a gap in auxiliary GNSS data
Auxiliary GNSS data gap cleared	Flag reset
Horizontal acceleration out of range	Receiver not configured properly
Horizontal acceleration out of range cleared	Flag reset
*GNSS not available for alignment	POS MV failed to receive GNSS data for > 60 s
GNSS available for alignment	Flag reset
*GNSS data gap detected	Gap in GNSS data; short periods when this occurs are normal
GNSS data gap cleared	Gap discontinued
*PPS time gap	Gap in PPS signal; short periods when this occurs are normal
PPS time gap cleared	Gap discontinued
Time recovery message <i>not</i> received	The GNSS receiver is not configured properly
Time recovery message received	Flag reset
*GNSS not in navigate mode	GNSS receiver has not entered navigate mode; still searching for satellites
GNSS in navigate mode	Receiver in navigation mode
*GNSS tracking elevation limit incorrect	GNSS receiver is not configured
GNSS tracking elevation limit corrected	Flag reset
HDOP/VDOP less than 10	GNSS receiver is not configured
HDOP/VDOP less than 10 cleared	Flag reset
GPS Time output mode is not UTC	GNSS receiver is not configured
GPS Time output mode is UTC	Flag reset
Incorrect time parameters	GNSS receiver is not configured

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Fault Identification

Message Text	Description
Incorrect time parameters cleared	Flag reset
Incorrect GNSS datum parameters	The GNSS receiver is not configured properly
Incorrect GNSS datum parameters cleared	Flag reset
Position/velocity fix error	Positions and velocities reported by the IMU and the GNSS are inconsistent; likely cause is an incorrect entry of GNSS lever arms in the installation data
Position/velocity fix error cleared	Flag reset
Incorrect differential GNSS configuration cleared	Flag reset
Incorrect SV selection parameters	The GNSS receiver is not configured properly
Incorrect SV selection parameters cleared	Flag reset
GAMS ambiguity resolution failure	The GNSS receiver is not configured properly
GAMS ambiguity resolution failure cleared	Flag reset
GNSS failure	GNSS velocity or position failure
GNSS failure cleared	Flag reset
*Speed out of range fault	Navigation algorithm speed is out of range (speed > 35 m/s); algorithm will reset itself
Speed out of range fault cleared	Flag reset
*GNSS velocity failure	GNSS reports speed > 35 m/s; problem will probably correct itself
GNSS velocity failure cleared	Flag reset
*GNSS position failure	GNSS reports horizontal position error > 1000 m; problem will eventually correct itself
GNSS position failure cleared	Flag reset
Auxiliary GNSS position failure	The GNSS receiver is not configured properly
Auxiliary GNSS position failure cleared	Flag reset

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Fault Identification

Message Text	Description
*GNSS position measurement rejected	Position reported between IMU and GNSS are inconsistent; likely GNSS Lever Arms are incorrect in installation data
GNSS position measurement reject cleared	Flag reset
*GNSS velocity measurement rejected	Velocity reported between IMU and GNSS are inconsistent; likely GNSS Lever Arms are incorrect in installation data
GNSS velocity measurement reject cleared	Flag reset
GAMS heading failure	The GNSS receiver is not configured properly
GAMS heading failure cleared	Flag reset
Aux GNSS position measurement rejection	The GNSS receiver is not configured properly
Aux GNSS position rejection cleared	Flag reset
IMU Messages - Message Log	
*Multiple consecutive IMU failures	Communications problem between IMU and PCS; check cable
Multiple consecutive IMU failures cleared	Flag reset
IMU X accelerometer failure	IMU diagnostics indicate failure of X accelerometer channel
IMU X accelerometer failure cleared	Flag reset
IMU Y accelerometer failure	IMU diagnostics indicate failure of Y accelerometer channel
IMU Y accelerometer failure cleared	Flag reset
IMU Z accelerometer failure	IMU diagnostics indicate failure of Z accelerometer channel
IMU Z accelerometer failure cleared	Flag reset
IMU X gyro failure	IMU diagnostics indicate failure of X gyro channel
IMU X gyro failure cleared	Flag reset
IMU Y gyro failure	IMU diagnostics indicate failure of Y gyro channel
IMU Y gyro failure cleared	Flag reset
IMU Z gyro failure	IMU diagnostics indicate failure of Z gyro channel

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Fault Identification

IMU Messages - Message Log	
IMU Z gyro failure cleared	Flag reset
IMU A/D converter failure	IMU diagnostics indicate failure of A/D converter
IMU A/D converter failure cleared	Flag reset
IMU pickoff test failure	IMU diagnostics indicate failure of voltage pickoff
IMU pickoff test failure cleared	Flag reset
IMU power supply failure	IMU diagnostics indicate problems in external power delivered to IMU
IMU power supply failure cleared	Flag reset
*IMU/POS checksum error	Error in data checksum between POS MV and IMU
IMU/POS checksum error cleared	Flag reset
IMU failure	IMU status test failure set by IMU sensor
IMU failure cleared	Flag reset
IMU warning	One of the IMU bias estimates is out of range
IMU warning cleared	Flag reset
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-g
X 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-g
Y 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-g
Z accelerometer bias estimate error cleared	Flag reset
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
X gyro bias estimate error cleared	Flag reset

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Fault Identification

IMU Messages - Message Log	
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
Y 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
Z gyro bias estimate error cleared	Flag reset
*These messages correspond to faults reported by the Fault Detection window.	

Status Warning Messages

POS MV provides status information on the complete system and each individual subsystem. The MV-POSView Controller program decodes some of the bits automatically and displays the relevant status information. Some examples of the faults represented by the status bits appear in Table 37.

Table 38: Status Warning Messages

IMU

The IMU can experience a communication failure between the IMU and the PCS, or a loss of calibration.

Communication Failure

The IMU can experience a permanent or intermittent communication failure. If the IMU develops a fault that causes permanent loss of communication, you will see the following symptoms:

- The IMU front panel light will show clear (off).
- The **IMU** tab on the Fault Detection window will show intermittent failures in IMU communications.
- The IMU transmits a checksum in each data frame. POS MV uses the checksum to validate the data received from the IMU. If the validation fails, then POS MV sets a bit to declare that it has detected a bad IMU frame.

Simultaneously, it increments a counter that keeps track of the number of bad IMU frames. The **Fault Detection** window shows the count of **Bad IMU Frames** in its bottom left-hand corner.

- An occurrence of several consecutive bad IMU frames will cause POS MV to reinitialize and start coarse levelling. However, due to the communications handshaking used by the IMU, bad IMU frames are highly unlikely.

IMU

If bad IMU frames do occur, their likely cause is one of the following:

- Problems in the data cable that connects the IMU to the PCS
- Problems with the IMU or the power supplied to the IMU
- Problems within the PCS

Loss of Calibration

If IMU performance falls below specification (as may happen if the IMU experiences excessive shock or vibration), the **IMU Status** field on the controller main window will indicate an IMU failure.

Refer to the **Fault Detection** and the **Message log** windows (described in Fault Identification on page 9-3 and Message Log on page 9-9) for a more detailed identification of the fault.

Note: If POS MV detects that the IMU performance is outside specification, it will alert you and continue navigation.

If POS MV detects a hardware failure in the IMU, the controller main window will display the warning message *IMU Failure*. Note any indications on the **Fault Detection** or the **Message Log** windows, and contact Applanix for advice.

GNSS

The GNSS subsystem can experience a permanent loss of satellites, or a breakdown of communication between the GNSS receiver and the PCS.

Permanent Loss of Satellites

POS MV provides continuous information on the status of the GNSS receivers. The status of the GNSS receivers may be monitored on the **GNSS Data** window; select **View, GNSS Data** from the MV-POSView menu bar. Additionally, the **GNSS Data** window includes detailed information on the satellites that the receiver is tracking and on the receiver mode (i.e. tracking, navigate, etc.).

The GNSS subsystem may experience periodic GNSS dropouts caused, for example, by antenna obstruction. The controller program indicates a GNSS dropout by displaying *GNSS Not Available* or *GNSS Data Gap* in the **GNSS Status** field on the main window. However, if a GNSS dropout occurs and persists without any apparent antenna obstruction, then one of the following problems may exist:

- A loss of GNSS receiver configuration

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Fault Identification

GNSS

- A failure in the GNSS antenna
- A failure in the GNSS antenna cable
- A failure in the GNSS receiver

The above diagnoses assume that the PCS continues to receive messages from the primary GNSS receiver. If this is true, the front panel GNSS light will behave normally for the GNSS service in use.

If the front panel GNSS light shows red, then there are no GNSS navigation solutions available to the PCS. The most likely cause of this is a loss of communication with the receiver. If this occurs, refer to the following *Loss of Communications* heading.

Correct a loss of configuration by selecting **Tools, Configure GNSS** from the MV-POSView menu bar.

The GNSS antenna is a solid-state device with a low failure rate. Faults in the GNSS subsystem are more likely to arise from damaged antenna cabling or a receiver failure. If examination of the GNSS antenna installation reveals damage to a cable, replace the cable.

If none of the above actions resolves the problem, contact Applanix for advice.

Loss of Communications

If the front panel GNSS light shows red, then there is a communications failure between the PCS and the primary GNSS receiver. Typical causes for this fault are:

- A loss of GNSS receiver configuration
- There is a failure in the internal PCS wiring harness
- There is a failure in the GNSS receiver

If Auto Configuration is enabled (select **Enabled** in the **Auto Configuration** pane on the **GNSS Receiver Configuration** window), then during the power-on sequence the PCS will establish a proper configuration for the GNSS receiver. Therefore, incorrect settings for baud rate should not be possible unless the Auto Configuration feature is disabled.

The GNSS receiver may be configured manually by sending a configuration command by selecting **Tools, Configure GNSS** from the controller menu bar.

GNSS

If proper operation is not restored within a minute, select **Tools**, **Reset GNSS** from the controller menu bar. The GNSS receiver is reset to the factory defaults. This action takes a couple of minutes. Also, if the auto configuration feature is enabled, the receiver will assume an appropriate POS configuration.

Finally, if all else fails, cycle the PCS power (off and on) to provide a hard reset of the GNSS receiver. Refer to the Power-On and Power-Off procedures on pages 4-1 and 4-28 respectively.

GAMS

The GAMS subsystem can experience a permanent loss of satellites, or a communication failure between the GNSS receiver and the PCS.

Permanent Loss of Satellites

The **GAMS Solution** window provides information on satellites being tracked and the status of GAMS; select **View, GAMS Solution** to view this window.

GAMS may experience periodic GNSS dropouts caused, for example, by an antenna obstruction. During these dropouts, GAMS is unable to compute a heading solution and the controller **Status** pane indicates *Not ready* in the **GAMS** field.

However, if a GAMS dropout occurs and persists without any apparent antenna obstruction, one of the following problems may exist:

- A loss of GNSS receiver configuration
- A failure in the GNSS antenna
- A failure in the GNSS antenna cable
- A failure in the GNSS receiver

The above diagnosis assumes that the PCS continues to receive messages from the secondary GNSS receiver. Select **View, GAMS Solution** to see the GAMS status.

GAMS Ambiguity Resolution Failures

If there is a GAMS ambiguity resolution failure, the controller **Status** pane indicates *Not ready* in the **GAMS** field. The same status is indicated when there is satellite signal loss due to an antenna obstruction.

The POS MV **Message Log** window specifically indicates GAMS ambiguity resolution failures; see Figure 65 on page 9-9.

GAMS

Occasional failures of ambiguity resolution, for example at intervals of 10 to 20 minutes, are quite common and may be the result of changes to the satellite constellation.

Repeated or continuous failures in ambiguity resolution may be the result of a poor GAMS calibration or excessive vibration at the antennas. These failures may also indicate weak signal reception from the satellites, requiring changes to the installation.

Use the following steps to further diagnose the problem:

1. Select **View, GNSS Data** and examine the L1 Signal-To-Noise Ratios (SNR) for the available satellites, see Figure 56 on page 8-2. If the L1 SNR is below 38 dB for more than one satellite, the GNSS antenna cables are introducing too much signal attenuation. To correct this fault, shorten the cables or substitute them with new low-loss cables.
2. Examine the antenna mountings; they must be rigid with respect to each other and with respect to the IMU. Make any necessary modifications to secure the antenna mounting positions so that they experience no significant twisting or movement relative to the IMU.
3. Repeat the GAMS calibration and ensure that:
 - The Positional Dilution of Precision (PDOP) is below 2.5 (preferable below 2.0)
 - The **GAMS Solution** window shows at least six Space Vehicles (SVs) in the solution

Prior to the calibration, perform a series of calibration manoeuvres and ensure the heading accuracy is better than 2.0°. Refer to the Initial GNSS Configuration description on page 4-22 for the instructions to complete this calibration procedure. Try to achieve a heading accuracy better than 1.0°.

Within the first ten minutes after calibration, GAMS uses dynamic inputs to verify the calibration. Therefore, once the calibration is completed, perform a series of dynamic and vigorous manoeuvres with the vessel for ten minutes to support this process.

GAMS

4. If the ambiguity resolution problem persists, contact Applanix for further instructions. Refer to Technical Support and Service on page A-1 for procedures.

Remove and Replace Procedures

The following paragraphs explain how to remove and replace the various components and subassemblies of the POS MV system.

ELECTRICAL HAZARD



Note: these warnings apply only to POS MV V5 PCS.



Mains electrical voltages can cause death or serious injury by electric shock.

Only a competent person who has received the relevant training and experience should perform maintenance work on electrical equipment.

Power-off and isolate the equipment from the electrical supply before you work on any equipment that uses mains voltage.

Arrange to safely discharge any power supply storage capacitors.

Observe all relevant local and national safety regulations while performing any maintenance work on electrically powered equipment.

After completing maintenance, refit all safety covers and ground connections to the equipment.

The PCS employs double pole / neutral fusing on the power receptacle. Each of the two RoHS compliant fuses are rated at:

- Rating = 250 V
- Current = 4 A
- Type = fast acting
- Case = 5.2 mm x 20 mm

WARNING: For continued protection against risk of fire, replace fuses only with fast acting* type fuses rated 250Vac, 4A

AVERTISSEMENT: Pour une protection continue contre les risques d'incendie, n'utiliser que des fusibles à action rapide* de 250V a.c., 4 A

***0.3s max at (à) 400%**

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Fault Identification

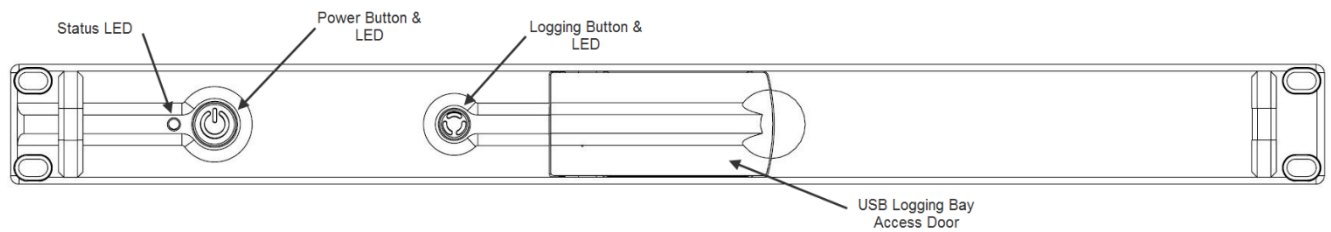


Figure 68: PCS Front Panel - POS MV V5

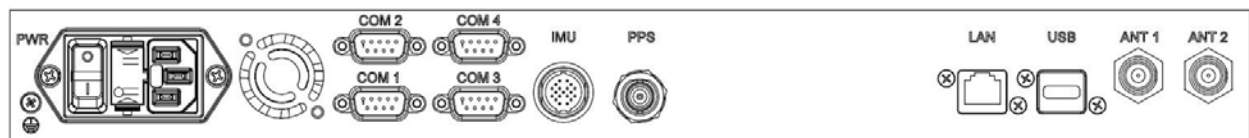


Figure 69: PCS Rear Panel - POS MV V5 – PCS-80

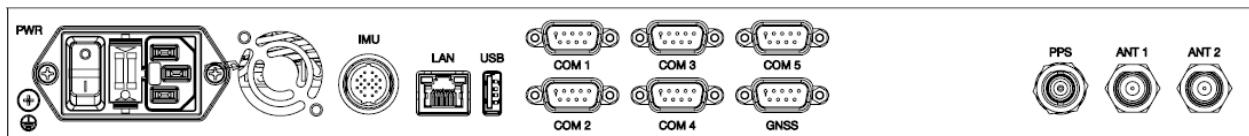


Figure 70: PCS Rear Panel - POS MV V5 – PCS-84 & PCS-100

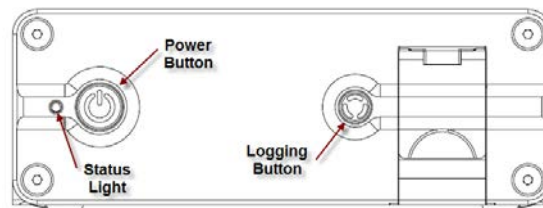


Figure 71: PCS Front Panel – POS MV V5-1

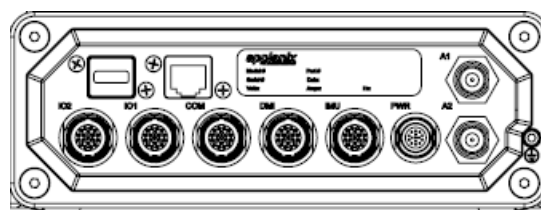


Figure 72: PCS Rear Panel – POS MV V5-1



Figure 73: PCS Front Panel – POS MV V5-2

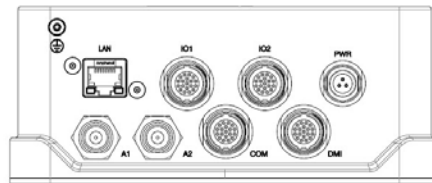


Figure 74: PCS Rear Panel – POS MV V5-2

Circular Connectors

The IMU connector on POS MV V5 and the majority of connectors on POS MV V5-1 are high quality, IP67 Lemo ® connectors. These connectors use spring loaded latches that engage when the connector is pushed fully into the socket. Once engaged the connector is very secure against shock, vibration and pulling on the cable, ensuring a reliable connection. To disengage the connector you must pull back on the outer release sleeve. Since pulling back on the release sleeve often results in some force on the entire connector body the latches can experience some friction and not retract smoothly. If possible it is better to hold the cable forward while pulling back on the release sleeve and then sliding the connector out of the socket. Applying excess force could damage the latch mechanism.

Inertial Measurement Unit



The IMU contains sensitive and expensive solid-state accelerometer and gyro components. Permanent damage to these components will result if handled roughly. To prevent irreversible damage, handle the IMU with care.

If you suspect a fault condition with the IMU please return it to Applanix for service and repair. To remove or replace the IMU complete this procedure.

Tools

- Set of metric open-end or combination wrenches appropriate to remove or secure IMU to its mounting location

POS MV V5 Installation and Operation Guide

Fault Identification

Remove

1. Observe PCS front panel power-off procedures (starting on page 4-28).
2. Remove power cable from PCS rear panel (starting page 9-20).
3. Release and disconnect power and data cable from IMU. Protect free end of power and data cable from damage or contamination.
4. If fault suspected on power and data cable, disconnect and install a new one. Refer to IMU Cable procedure on page 9-23 for details.
5. Release IMU from installed position noting orientation. Retain fixing screws or bolts.
6. Handle IMU with care and pack into original transit case.

Note: It is imperative that proper packing is used to transport IMU.

7. Contact Applanix Customer Support for shipping instructions; refer to page A-1.

Replace

Note: Each IMU is designed with alignment holes to ensure consistency in the physical mounting of the IMU (within certain tolerances); refer to Figure 5 on page 2-8. The internal accelerometers and gyros have tolerances that affect the overall alignment. Any time a repaired or new IMU is installed the calibration procedure, starting on page 2-24, should be followed. Contact Applanix Customer Support for additional information, refer to page A-1 for instructions.

1. Same location:
 - a) Place IMU in installed position noting orientation. Secure fixing screws or bolts.
 - b) Connect power and data cable to IMU. Protect free end of power and data cable from damage or contamination.
 - c) Replace power cable to PCS rear panel (starting page 9-20).
 - d) Observe PCS front panel power-on procedures (starting on page 4-1).
2. New location - Follow installation instructions for Inertial Measurement Unit starting on page 2-7.

GNSS Antenna



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

If you suspect a fault condition on the GNSS antenna, replace it with the same type and ensure its serviceability. To remove or replace the GNSS antenna complete this procedure.

Tools

- Self-amalgamating tape
- Waterproof spray
- Sharp knife or scalpel
- Set of SAE open-end or combination wrenches appropriate to remove or secure GNSS antenna

Remove

1. Observe PCS front panel power-off procedures (starting on page 4-28).
2. Remove power cable from PCS rear panel (starting page 9-20).
3. Remove waterproof sealing tape or silicone sealant protecting TNC antenna connector.
4. Disconnect TNC antenna connector. Protect free end of cable from damage or contamination.
5. Note direction of arrow on top of antenna dome.
6. Remove antenna by turning in a counter-clockwise direction.

Replace

1. Same location:
 - a) Install antenna by turning in a clockwise direction.
 - b) Note direction of arrow on top of antenna dome and align with previous installation.
 - c) Connect TNC antenna connector. Protect free end of cable from damage or contamination.
 - d) Apply waterproof sealing tape or silicone sealant to protect TNC antenna connector.
 - e) Replace power cable to PCS rear panel (starting page 9-20).
 - f) Observe PCS front panel power-on procedures (starting on page 4-1).
2. New location - Follow installation instructions for GNSS System on page 2-5.

IMU Cable

If you suspect a fault condition on the IMU power and data cable, install a new cable. To remove or replace the IMU power and data cable, complete this procedure.

Tools

No tools are required.

POS MV V5 Installation and Operation Guide

Fault Identification

Remove

1. Observe PCS front panel power-off procedures (starting on page 4-28).
2. Remove power cable from PCS rear panel (starting page 9-20).
3. Disconnect IMU power and data cable at both IMU and PCS (Figure 116 on page E-17).
4. Inspect cable and connectors for signs of damage or contamination. Perform repairs to cable as necessary. Protect free ends of cable from damage or contamination.
5. Replace cable if not repairable.

Replace

1. Connect IMU power and data cable at both IMU and PCS (Figure 116 on page E-17). Protect free ends of cable from damage or contamination.
2. Replace power cable to PCS rear panel (starting page 9-20).
3. Observe PCS front panel power-on procedures (starting on page 4-1).

GNSS Antenna Cable

If you suspect a fault condition on the GNSS antenna power and data cable, install a new cable. To remove or replace the GNSS antenna power and data cable complete this procedure.

Tools

- Self-amalgamating tape
- Waterproof spray
- Sharp knife or scalpel
- Slip joint pliers appropriate to remove or secure the GNSS antenna connector

Remove

1. Observe PCS front panel power-off procedures (starting on page 4-28).
2. Remove power cable from PCS rear panel (starting page 9-20).
3. Remove waterproof sealing tape or silicone sealant protecting TNC antenna connector.
4. Disconnect GNSS antenna power and data cable at both GNSS and PCS (Figure 116 on page E-17).
5. Inspect cable and connectors for signs of damage or contamination. Perform repairs to cable as necessary. Protect free ends of cable from damage or contamination.

6. Replace cable if not repairable.

Replace

1. Connect GNSS antenna power and data cable at both GNSS and PCS (Figure 116 on page E-17). Do not over tighten. Protect free ends of cable from damage or contamination.
2. Apply waterproof sealing tape or silicone sealant to protect TNC antenna connector.
3. Replace power cable to PCS rear panel (starting page 9-20).
4. Observe PCS front panel power-on procedures (starting on page 4-1).

POS Computer System



There are no user replaceable parts inside. Service shall be performed by trained and qualified personnel. If you suspect a fault condition with the PCS contact Applanix Customer Support, refer to page A-1 for instructions.

To remove or replace the PCS complete this procedure.

Tools

- Cross tipped screwdrivers
- Straight tipped screwdriver
- Set of SAE or metric open-end or combination wrenches appropriate to remove or secure the PCS to its mounting location

Remove

1. Observe PCS front panel power-off procedures (starting on page 4-28).
2. Remove power cable from PCS rear panel (starting page 9-20).
3. Remove PCS from mounting location.
4. Tag and remove PCS rear panel connectors.

Replace

1. Same location:
 - a) Install PCS rear panel connectors.
 - b) Install PCS in mounting location.
 - c) Replace power cable to PCS rear panel (starting page 9-20).

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Fault Identification

- d) Observe PCS front panel power-on procedures (starting on page 4-1).
2. New location - Follow installation instructions for POS MV V5-1 on page 2-13 and POS MV V5 on page 2-9.

Troubleshooting

Note: If the POS MV system fails to operate when you first try to use it after installation, check that you have installed and configured the system correctly. Contact Applanix for advice if necessary, refer to Technical Support and Service on page A-1 for procedures.

Refer to this subsection if the system develops a fault after a period of normal and successful operation, or if you experience some problems during the initial integration of POS MV into the survey suite.

The following subsections cover six categories of system failure:

- Total system failure
- Initialization failure
- GNSS Not Available
- GAMS Not Ready
- Serial communications problem
- Ethernet communications problem

Total System Failure

A total system failure is indicated by the following symptoms:

- Real-time and NMEA data communication stops
- Ethernet LAN communication stops

Use the following procedure to diagnose and isolate a total system failure:

1. Power-off PCS. Wait for thirty seconds and then power-on PCS again to reboot the system. If failure symptoms persist, continue with procedure.
2. Check IMU light, it should be solid green. If not, there is problem with IMU subsystem. Refer to Fault Identification subsection on page 9-3 for further IMU diagnostic advice.
3. Check SYS light, if red there may be a software problem. If Ethernet is functioning, select **Diagnostics, Other** from the controller menu bar, see Figure 73. Record any dead tasks and inform Applanix.

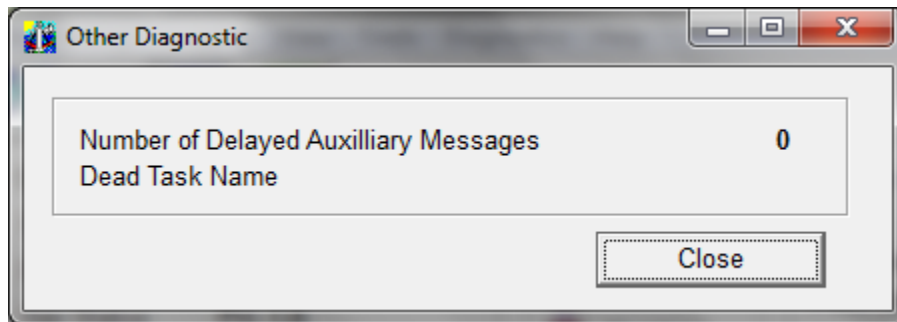


Figure 75: POSView Other Diagnostic

4. Check quality of electrical power supplied to PCS.
5. Check PCS connection to ground through ground strap to grounding screw or stud on PCS rear panel.
6. If failure still exists, system may have experienced a board failure. Substitute working PCS for failed unit.

Return the failed PCS to Applanix for repair. Provide a report of your findings with the returned PCS, refer to Technical Support and Service on page A-1.

Initialization Failure

The system Initialization procedure requires POS MV to compute the approximate tilt of the IMU relative to a locally level reference, taking into account the present position. This is called coarse levelling. If POS MV fails to complete its coarse levelling procedure, the most likely cause is the lack of GNSS aiding data.

If the system fails to complete coarse levelling, follow the instructions below to isolate the problem:

1. Check **Nav Status** on controller main window.
2. If **Nav Status** shows **DR** (Dead Reckoning), select View, GNSS Data from the controller menu bar, see Figure 74. If **Receiver Status Mode** indicates **No Nav Data** follow GNSS Not Available procedure starting on page 9-28.

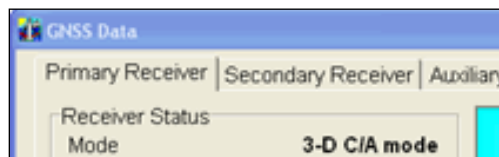


Figure 76: POSView GNSS Data - Receiver Status Pane

3. Check **IMU Status** on controller main window. If **IMU Status** shows **Failure** or **Warning**, power-off system and contact Applanix for instructions to return IMU for repair.

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4. If **IMU Status** shows **OK**, check IMU base plate is mounted in nominal horizontal orientation. If necessary, adjust installation to make base plate of IMU as close to horizontal as possible.
5. If problem still exists, contact Applanix for instructions to return POS MV system for evaluation and repair.

GNSS Not Available

When the POS MV system is powered-on, the GNSS receivers require approximately two minutes to acquire satellites and to begin computing a navigation solution. During this time, the **Nav Status** display on the controller main window shows **DR**.

If this status does not change after several minutes, or if the status changes from a valid mode to **DR** and remains unavailable, there is likely a problem with the GNSS subsystem.

There are two classes of GNSS problems associated with the POS MV:

- a) A communication fault between the receiver and the PCS
- b) The receivers are not tracking a sufficient number of satellites

Improper Communication

Note: The GNSS lights are controlled by the navigation software; the system must be in the navigate mode for the proper indication of the GNSS lights.

Follow the instructions below to identify a communications fault:

1. Examine GNSS light on PCS front panel:
 - If light shows red, there is no communication between PCS and GNSS receiver. Follow instructions relating to loss of GNSS communications in Status Warning Messages on page 9-14 and the following step below.
 - If light shows amber or green, select **View, GNSS Data** from controller menu bar; see Figure 56 on page 8-2.
 - If **GNSS Data** window shows system is tracking fewer than four satellites, go to Insufficient Satellites on page 9-29.
2. Select **Diagnostics, Primary GNSS** from controller menu bar and check that messages are being received, see Figure 75. If no, fault may be in GNSS receiver or in communications between GNSS and PCS. Please contact Applanix Customer Support, see page A-1.

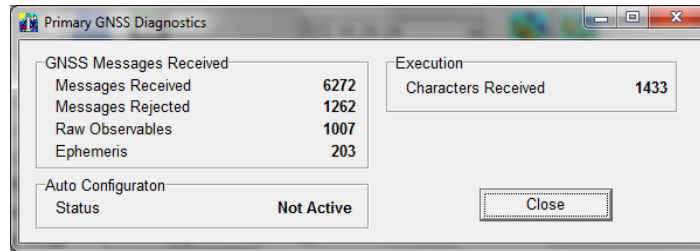


Figure 77: POSView Primary GNSS Diagnostics

Insufficient Satellites

Follow the instructions below to identify a problem caused by insufficient satellite signals:

1. From controller main window select **View, GAMS Solution** and note how many satellites appear in **SVs in Solution** field, see Figure 76.
2. If **SVs in Solution** field has fewer than four satellites, mounting location for GNSS antennas may be cause. Ensure mounting position of antennas provides unobstructed view of sky in all directions. If either antenna is moved, refer to Installation section starting on page 2-1 and System Configuration description starting on page 4-1 for instructions.

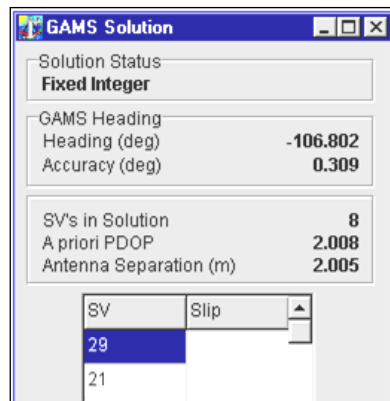


Figure 78 GAMS Solution Status Window

3. If mounting locations for both GNSS antennas are optimal and **DR** status persists, move vessel to area that has better satellite visibility.
4. If the problem persists after moving the vessel, a problem may exist with the GNSS receiver card, antenna cable or connections. Examine cable and connections for damage, degradation or contamination, e.g. moisture ingress. Use low-loss cable to replace defective cables. Ensure cable connectors are waterproofed.
5. If problem persists, contact Applanix for advice.

POS MV V5 Installation and Operation Guide

Fault Identification

GAMS Not Ready

After the POS MV system is installed, the GNSS Azimuth Measurement Subsystem (GAMS) requires calibration. Refer to the Initial GNSS Configuration description starting on page 4-22 for instructions.

Once GAMS is calibrated, it will initialize itself and deliver heading measurements automatically each time the system is powered-on and enters the navigate mode. Depending on the availability of satellites, the GAMS Initialization process may take up to five minutes.

If there is a temporary loss of satellites, e.g. caused by a signal obstruction, the **GAMS Status** may show **Not Ready** for brief periods. However, if **GAMS Status** shows **Not Ready** for an extended period after power-on, or if it transitions from **Online** to **Not Ready** and remains there, take the following steps to determine the cause.

1. Select **View, GAMS Solution** from controller menu bar. In **GAMS Solution** window, check number of SVs tracked and value displayed for PDOP. GAMS must track five SVs minimum and have PDOP value <3 before it can solve ambiguities. Wait for satellite constellation to improve or move to a location that has better satellite visibility.
2. If number of SVs tracked does not increase or if PDOP remains too high, problem may be GNSS antenna installation. Examine GNSS antennas, cables and connectors for damage or degradation.
3. GAMS may experience problems caused by invalid calibration or excessive vibration in the antennas. Check antenna installation and ensure antennas are rigid relative to each other and relative to IMU.

Serial Communications Problem

A serial communications problem may occur on any of the user configurable COM ports. Use the following steps to determine the nature of the problem.

1. Select **Settings, Input/Output Ports** from controller menu bar. Verify parameter settings; see Figure 77 and the COM Ports description starting on page 3-1.
2. Verify serial port connection.

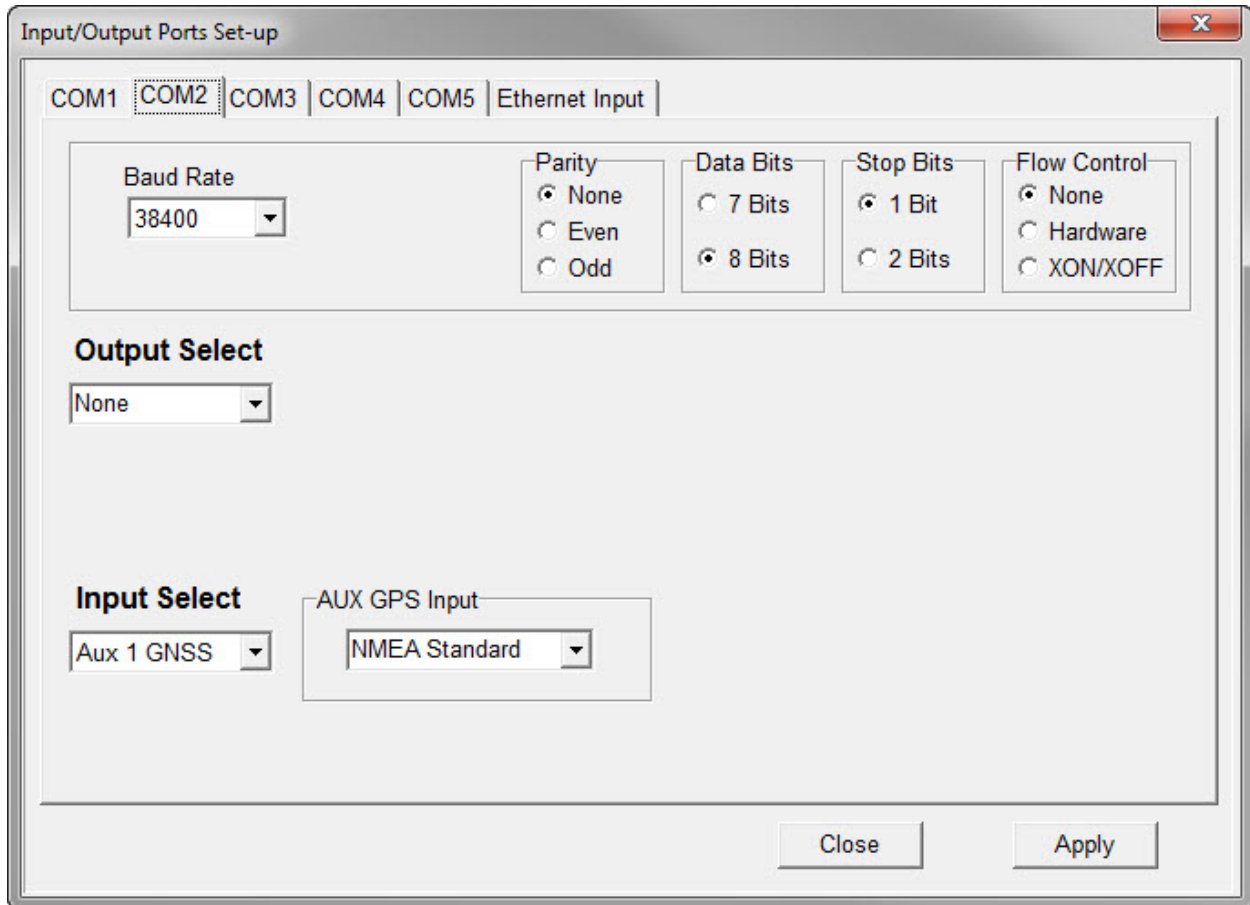


Figure 79: POSView Input/Output Port Setup

Note: Dynamically configurable COM ports add great flexibility, but can also cause problems if inadvertently reassigned.

To check the output functions (NMEA and Binary) perform the following steps:

1. Ensure that POS is navigating and is in **Degraded Nav** mode or better. Binary data is not output until this mode is reached.
2. Select **Diagnostics, NMEA & Binary Output** from controller menu bar. Verify displayed **Port#** matches selected COM port (e.g. **Port# 1 = COM 1**), see Figure 78.
3. Check **Write Failure** field. If value increases, indicates PCS hardware interface problem; try another COM port. Reassign NMEA or Binary output to unused COM port. If communications restored, note defective COM port for future reference.

POS MV V5 Installation and Operation Guide

Fault Identification

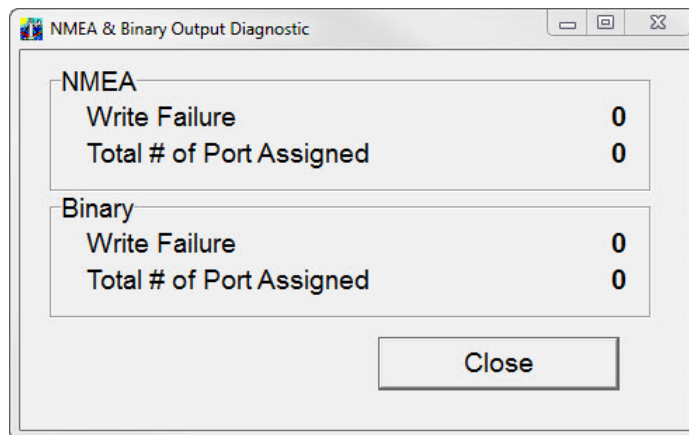


Figure 80: POSView NMEA & Binary Output Diagnostic

4. Check that baud rate is sufficient to transmit data selected.
5. Check serial cable integrity.
6. Disconnect remote end of cable from sonar or other receiving equipment and connect cable to PC running serial program (e.g. ProComm or Hyper Terminal). Adjust baud and protocol to match PCS output settings. If data received from POS, problem is receiving equipment.

To check the input functions (Base GNSS and Auxiliary GNSS) perform the following steps:

1. Select **Diagnostics, Base GNSS, Base 1** or **2**, or **Diagnostics, Aux GNSS** from controller menu bar, see Figure 79.
2. Check **Bytes Received** field. If no bytes received, may indicate PCS hardware interface problem; try another COM port. Reassign Base or Aux GNSS input to unused COM port. If communications restored, note defective COM port for future reference.
3. Check serial cable integrity.
4. Disconnect PCS end of serial cable and connect to PC running a serial program (e.g. ProComm or Hyper Terminal). Adjust baud and protocol to match Base GNSS or Aux GNSS output settings. If data received from GNSS, problem is PCS.

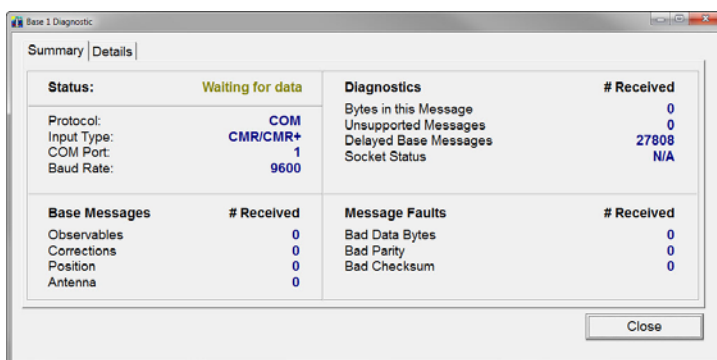


Figure 81: POSView Base 1 Diagnostic

Ethernet Communications Problem

Loss of Ethernet communications will result in the loss of communications between the PCS and the controlling PC. The MV-POSView Controller program indicates this by displaying an appropriate error message. Figures 80 and 81 provide troubleshooting procedures to identify the causes of Ethernet communications failures.

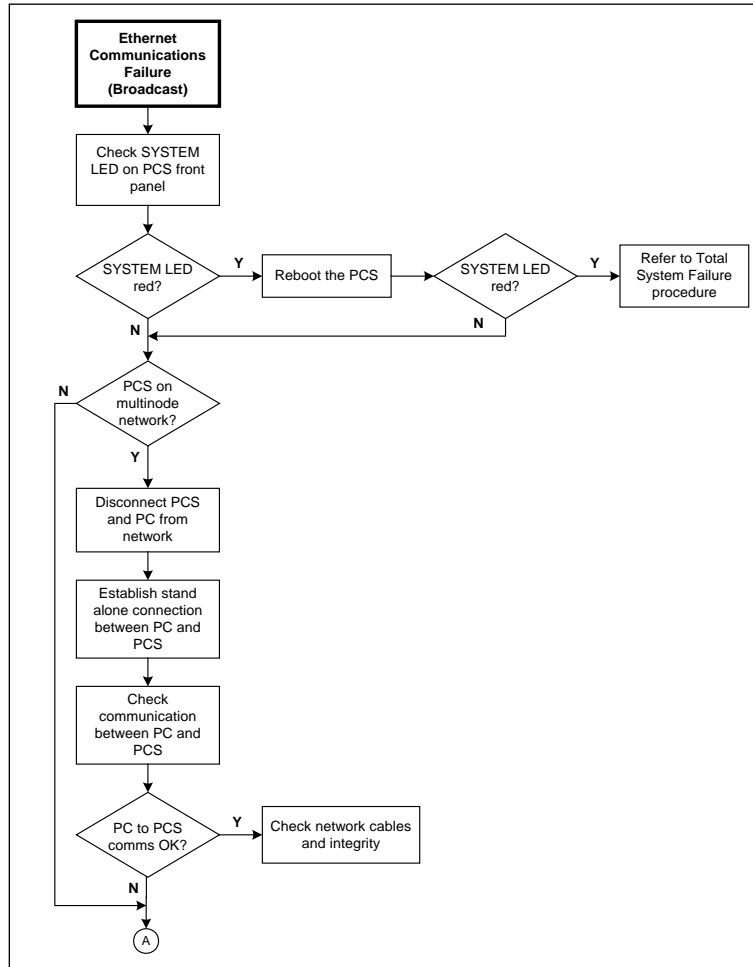


Figure 82: (1 of 2) Ethernet Communications Failure

POS MV V5 Installation and Operation Guide

Fault Identification

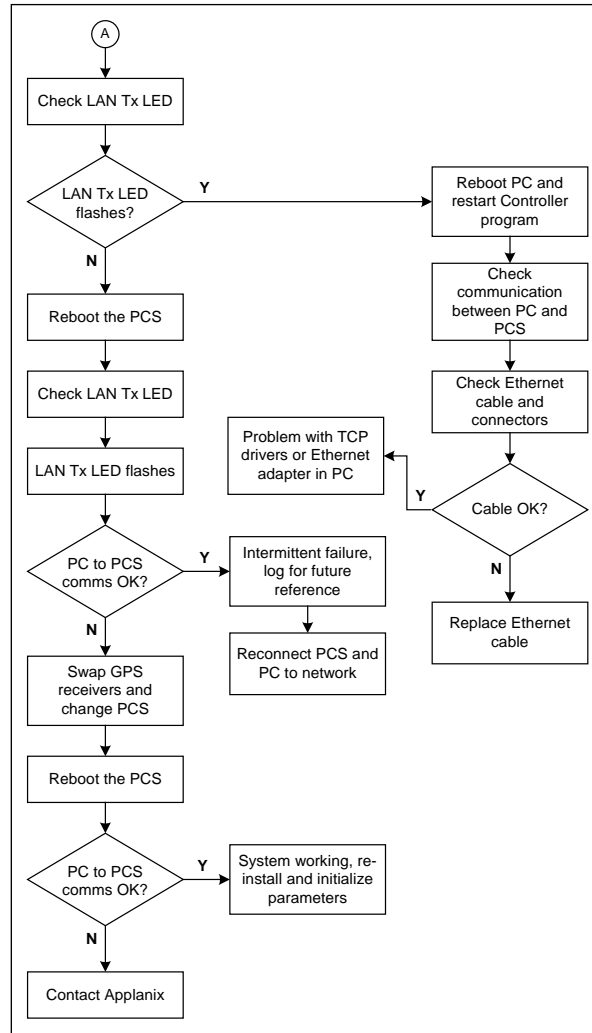


Figure 83: (2 of 2) Ethernet Communications Failure

Appendix A Technical Support and Service

Contact Applanix

Applanix Corporation	Applanix LLC	Applanix Corporation
85 Leek Crescent	15840 FM 529 Rd, Suite 316,	Forester's House
Richmond Hill, ON	Houston, Texas	Old Racecourse
L4B 3B3	77095	Oswestry, SY10 7PW
Canada	United States	UK
Tel: +1 (289) 695-6000	Tel: +1 (713) 936 2990	Tel: +44 (1691) 659359
Fax: +1 (905) 709-6027		Fax: +44 (1691) 659299

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

How to Reach Customer Support

For technical support on POS regarding installation or operation, contact Applanix customer support at the numbers listed on our [website](#). On the home page, select **Support**. If voice communication is required, select the **Contact Support** link. For general inquiries, please visit our website or call +1 (289) 695-6000.

Returns

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

1. Call your Applanix Customer Support Representative and request a Return Material Authorization (RMA) number and shipping instructions or obtain an RMA number via our [website](#).
2. Carefully disconnect and remove the part(s) to be returned.
3. Pack the part(s) to be returned in their original packing containers. Applanix will not be responsible for damage to parts during shipment, if returned in any container other than the original shipping cases. New cases are available - please contact your Customer Support Representative for details.
4. Address shipping cartons to the address listed on the packing list shipped with the system.

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

Appendix B Theory of Operation

This appendix provides a simplified explanation of the POS MV theory of operation. The explanation includes some details on each of the main techniques that the system uses to compute an integrated navigation solution.

Inertial Navigation:	An introduction to the theory of inertial navigation.
Heave Filter:	You can tune the characteristics of the heave filter to provide optimal performance of POS MV through a wide range of dynamic conditions.
GNSS Azimuth Measurement Subsystem:	GAMS uses information from two GNSS receivers to improve the accuracy of heading measurement.
Heading Measurements:	The unaided system can deliver heading measurements with reduced accuracy.
Baselines:	An explanation of the baseline definitions used throughout this appendix.
Baseline Measurement:	How the system measures the baseline vectors of the GNSS antennas and the IMU.
Carrier Phase Differential Position:	A simplified description of the process by which POS MV measures the difference in position between the two GNSS antennas.
Alignment:	How POS MV levels itself and aligns with true north in an unaided condition.
Error Sources:	How the position measurements of a free inertial navigation system would degrade with time caused by unavoidable errors in the sensing subsystems.
Aided Inertial Navigation:	POS MV uses a Kalman Filter to compensate for the effects of errors to deliver a blended navigation solution that maintains a high degree of accuracy.

Inertial Navigation

An Inertial Navigation System (INS) computes its position on the Earth by a sophisticated form of dead reckoning. In its simplest form, dead reckoning estimates the current position by measuring the speed,

direction and time of travel from a known starting point. The errors inherent in this form of navigation arise from two sources:

- Uncertainty in determining the position of the starting point. This contributes a fixed error in the dead reckoning position. The magnitude of this error is the same as the error in determining the position of the starting point.
- Inevitable inaccuracies in the measurement of speed and heading. Errors in the dead reckoning position will increase with time as the effects of these inaccuracies accumulate.

Dead reckoning requires no external support from radio navigation aids. It can be reasonably accurate if the system compensates for errors in the measurement of speed and heading, and for the effects of wind, tide and current.

To implement dead reckoning an INS contains sensitive components that include:

- Accelerometers to sense the specific forces of gravity, plus the forces that accelerate the INS with respect to the Earth.
- Gyros to sense all angular rates of rotation experienced by the INS with respect to an inertial frame of reference.

From the inertial measurements delivered by these components the INS solves Newton's equations of angular and translational motion on the approximately spherical surface of the Earth, and computes a full range of motion parameters:

- The orientation of the IMU (roll and pitch) with respect to a locally level reference plane.
- The heading of the IMU with respect to geographical north.
- The latitude, longitude and altitude of the IMU on the surface of the Earth.

In addition to these, appropriate calculations will also deliver measurements of velocity and track over the ground.

How INS Navigates

The accelerometers and gyros sense specific forces and angular rates relative to an inertial frame of reference. An inertial frame of reference is one that experiences no accelerations or angular rates of its own. Therefore, in such a reference frame, Newton's laws of motion apply without requiring corrections for accelerations or rotations of the frame.

Navigation on the Earth introduces forces and angular rates due to gravity and the rotation of the Earth. The accelerometers and gyros will sense these forces and movements, even when the INS is stationary relative to the Earth: Any object on the surface of the Earth experiences the force due to gravity. It also

has an angular rate with respect to the inertial frame of reference frame because the Earth rotates about its north-south axis at 15°/hour.

An INS that is designed to operate on the surface of the Earth must first subtract the gravitational force and Coriolis acceleration from the sensed specific forces, to obtain the acceleration of the INS with respect to the Earth.

- Gravitational acceleration - Essentially a constant over the surface of the Earth (although small variations exist from one place to another). The standard acceleration of gravity $g \cong 9.80665ms^2$. The convention used throughout this manual defines gravitational acceleration $g \cong 9.81$.
- Coriolis acceleration - The apparent tendency of a freely moving body to swing to one side when its motion is referred to a set of axis that is itself rotating in space. The magnitude of Coriolis acceleration measured by an INS moving horizontally on the surface of the Earth is:

$$\int c = 2\theta v \cdot \sin \phi$$

Where: θ = is the angular magnitude of the angular velocity of rotation of the Earth

v = is the speed of the INS

ϕ = is the latitude

The acceleration is perpendicular to the direction of v and is towards the right in the Northern Hemisphere.

The INS must also subtract the 15°/hour Earth rotation rate from the sensed angular rates to obtain the angular rate of the INS relative to the Earth.

After it has performed these functions, the INS integrates the corrected accelerations and angular rates to compute changes in velocity, position, attitude and heading relative to the Earth.

Figure 82 on page B-5 is a simplified view of inertial navigation on a spherical non-rotating Earth. The vessel is moving north at an initial velocity v_n .

The INS housing and its internal accelerometers are fixed to the vessel, forming a 'strap-down' arrangement. One accelerometer aligns with the fore-aft line of the vessel, another aligns with the vertical and a third accelerometer aligns with the port-starboard axis of the vessel. For convenience, this explanation considers only the fore-aft and the vertical accelerometers (although the INS uses all three to compute the solution).

With the vessel on a northerly course as shown, the fore-aft accelerometer also aligns with true north and therefore senses any change in the northerly velocity.

Similarly, as the vessel heaves, the vertical accelerometer senses the specific force:

$$\int_{down} = \alpha_{down} + g$$

Where: α_{down} = is the vertical motion

g = is the steady state acceleration due to gravity

This is the varying vertical acceleration experienced by the vessel caused by vertical motion, added to the steady state acceleration due to gravity.

As the vessel moves northwards, the gyro aligned with the lateral axis senses two rotations:

1. The varying short-term rotations about the pitch axis as the bow pitches up and down with the dynamic action of the vessel.
2. A slow rotation about the pitch axis as the vessel translates towards latitudes that are more northerly. This slow rotation is called the transport rate and can be determined by:

$$\delta_{east} = -\frac{v_{north}}{r}$$

Where: δ_{east} = the transport rate about the eastward axis of the INS platform

v_{north} = the northerly velocity of the vessel

r = the radius of the Earth

This is the negative of the rate at which latitude changes. Consequently, if the INS knows the starting latitude, it can compute the current latitude of the vessel as follows:

$$\lambda = \lambda_{start} - \int_0^t \delta_{east}$$

Where: δ_{east} = the transport rate about the eastward axis of the INS platform

λ_{start} = the starting latitude

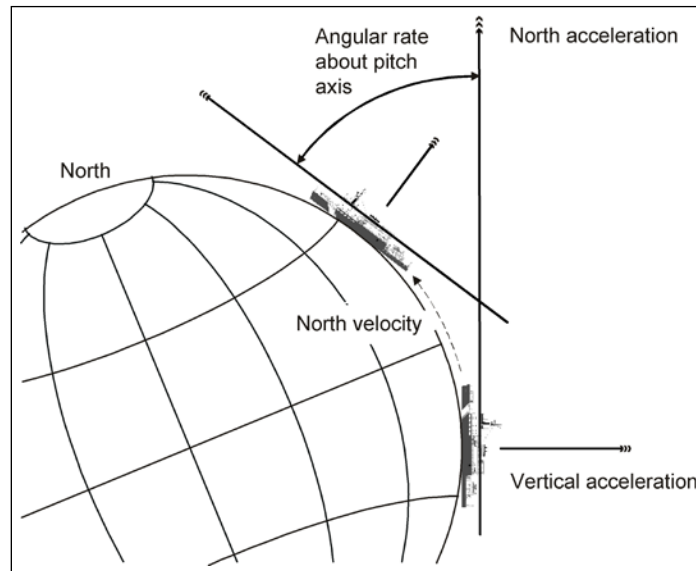


Figure 84: Example of INS Navigation on a Spherical Earth

In Figure 82, the vessel that supports the INS has no applied angles of roll or pitch, and moves along a fixed northerly heading.

Ideally, the INS platform defines a navigation frame that is both locally stable and locally level:

- A *locally stable reference frame* always maintains a constant orientation relative to the surface of the Earth at its current position.
- A *locally level reference frame* is always level relative to the surface of the Earth at its current position.

In Figure 82, the navigation frame of the vessel coincides with the geographic frame of reference.

Inertial Navigation Frames of Reference

This appendix refers to a number of different frames of reference:

- Inertial frame
- Earth frame
- Geographic navigation frame
- Body frame
- IMU body frame

For clarity, the following subsections define each of these reference frames as they apply throughout this appendix.

Inertial Frame

The inertial frame of reference is a Newtonian reference frame that experiences zero specific force and angular rate of its own. It is an absolute frame of reference and has a fixed, convenient orientation in space.

Earth Frame

The Earth co-ordinate frame is fixed to the Earth with its axis arranged as follows:

- The *x-axis* coincides with the axis of Earth rotation.
- The *z-axis* is in the equatorial plane at zero longitude (on the Greenwich meridian).
- The *y-axis* completes the right-handed orthogonal frame.

Note: This definition of the Earth frame differs from the WGS-84 definition in which the *z-axis* coincides with the Earth rotation axis and the *x-axis* coincides with the intersection of the Greenwich meridian and the equator.

The Earth frame rotates relative to the inertial frame at a nominal 15°/hr (or, more accurately, 15.04107°/hr).

Geographic Navigation Frame

The geographic navigation frame is a locally level frame of reference. The north and east axis are tangential to the Earth surface at the current latitude and longitude, and are defined by the north and east directions respectively.

The third axis of the geographic navigation frame is the down axis and is a local vertical that passes through the centre of the Earth.

Body Frame

The body frame is a co-ordinate frame fixed to the vessel with its axis arranged as follows:

- The *x-axis* coincides with the surveyed fore-aft line of the vessel.
- The *y-axis* is perpendicular to the *x-axis* and coincides with the port-starboard line of the vessel.
- The *z-axis* is perpendicular to both the *x-* and the *y-axis* and coincides with the surveyed vertical of the vessel.

IMU Body Frame

The IMU body frame uses the right-handed orthogonal co-ordinate system with its origin at the sensing centre of the IMU. These axis are fixed relative to the IMU and are marked by a label on the IMU housing.

INS Platform

An INS platform is one that has its accelerometers mounted on a mechanically gimballed platform. The platform is stabilized so that it always remains level relative to the local geographic navigation frame.

Note: POS MV does *not* use a mechanically stabilized platform of the type described in this subsection. This explanation is included because it may be easier to visualise an inertial navigation system based on a mechanical platform than one based on a strap-down INS arrangement.

Note: POS MV uses a strap-down INS of the type described in Strap-Down INS on page B-8.

Figure 83 on page B-7 represents a simplified INS platform suspended by three gimbals. The platform defines a locally level navigation frame as long as it maintains a level orientation with respect to the surface of the Earth, in spite of any motion applied externally.

Feedback systems and a servomechanism maintain platform stability in each axis of suspension:

- An arrangement of three gyros senses any angular rate of motion of the platform about each axis. The arrangement places each of the gyros orthogonally so that each responds to rotations in one axis only.

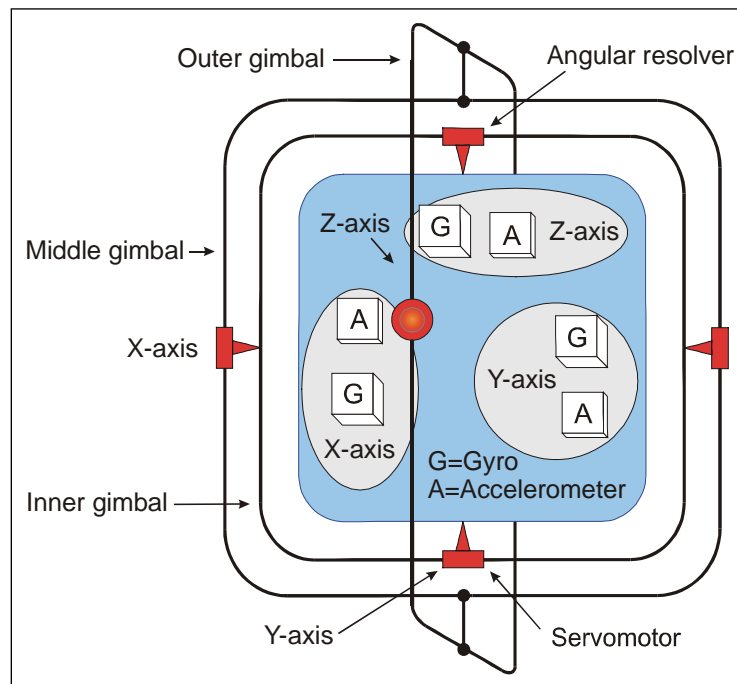


Figure 85: Gimballed INS Platform Structure

- A servomotor in each axis receives the amplified signals from its complementary gyro and rotates the gimbals axis to correct for the measured rate of rotation. In an ideally configured and compensated INS platform, the net angular rotation of the platform is almost entirely removed.

This action gives the platform stability in the *inertial reference frame*. In this condition, to an observer on the surface of the Earth the platform would appear to rotate at the Earth rate of 15°/hour relative to a locally level navigation frame.

To remove this apparent rotation, the control system makes the platform locally level by adding to the respective feedback signals, reference signals that cause the three gimbals axis to rotate at the Earth rate plus the transport rate.

- With the INS housing fixed to the vessel and the platform north aligned and locally level, the INS can measure the roll, pitch and heading of the vessel directly from the gimbals angles of the INS platform. It takes these measurements from angular resolvers in each gimbals axis.

The accelerometers are also mounted orthogonally on the platform to sense accelerations in the x, y and z directions relative to the surface of the Earth. When the platform is aligned and level with respect to the Earth surface, its x-axis points in a known direction, usually towards true north.

With the platform aligned and maintained locally both stable and level, the accelerometers align to a geographic navigation frame. In this orientation, the accelerometer array measures specific forces that the INS experiences relative to the inertial reference frame, and resolves them in the geographic navigation frame.

From these measurements, the INS computes its accelerations with respect to the surface of the Earth, also resolved in the geographic navigation frame. The INS integrates these accelerations in the navigation frame to obtain velocity and changes in position.

Strap-Down INS

A strap-down INS has its rate gyros and accelerometers fixed to the INS or IMU housing. This housing is fixed to the vessel. The inertial sensor array therefore moves and rotates with the vessel. This is the inertial navigator mechanization used by POS MV.

The accelerometers sense specific forces with respect to the inertial frame. These are resolved in the IMU body frame defined by the orthogonal accelerometer and gyro arrangement.

Similarly, the gyros sense all angular rates with respect to the inertial frame. These too are resolved in the inertial sensor frame.

The INS uses the sensed angular rates, the computed Earth rate and transport rates to update a Direction Cosine Matrix (DCM), which describes the mathematical transformation from the IMU body frame to a mathematically defined geographic navigation frame.

Following transformation of the measured specific forces into the geographic navigation frame, the navigation computations are the same as those for the INS platform.

The navigation platform, though not a physical entity as was the gimballed platform, exists in the navigation computer as an IMU-to-navigation frame DCM. For this reason, the geographic navigation frame is sometimes called the mathematical platform.

Figure 84 shows the functional architecture of a strap-down INS. The arrangement contains an inertial sensor assembly comprising a triad of accelerometers and a triad of gyros. Each of the three orthogonal axis of the IMU body frame includes one accelerometer and one gyro.

The inertial sensor processor collects the digitised accelerations and angular rates from the inertial sensor assembly and compensates these for temperature-dependent sensor errors.

Together, the inertial sensor assembly and the inertial sensor processor comprise the Inertial Measurement Unit (IMU). In POS MV, the IMU is a separate self-contained unit that interfaces to the PCS through a data interface cable.

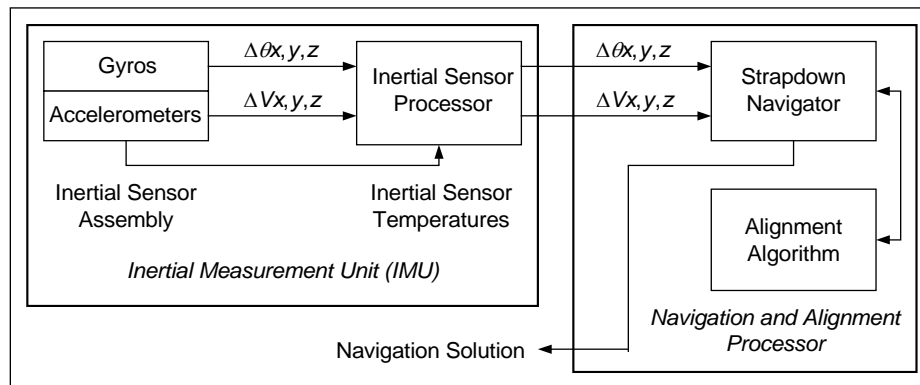


Figure 86: Strap-Down INS Generic Architecture

The compensated inertial measurements pass to the navigation and alignment processor, which implements the alignment algorithm and computes the INS navigation solution.

The alignment algorithm initializes the navigation equations, implements levelling and gyrocompassing, and obtains a mathematical platform alignment.

In POS MV, the navigation and alignment processor is located inside the PCS.

The strap-down INS 'navigates' the inertial sensors and computes the roll, pitch and heading angles of the inertial sensor assembly relative to the geographic navigation frame.

Generally, the housing of the INS (the IMU in POS MV) is assumed to be aligned with the inertial sensor frame. With the inertial sensor installed so that its x, y and z axis coincide with the forward, starboard and down directions of the vessel hull respectively, the INS will measure the vessel roll, pitch and heading directly. Otherwise, the INS must apply a constant installation offset transformation to the computed roll, pitch and heading to transform the inertial sensor assembly attitude to the hull attitude.

POS MV includes a user orientation input capability. This makes it possible to correct the orientation of the IMU so that it delivers measurements valid for an alternative reference frame, such as that of a multibeam transducer or of the vessel.

The small size and lightweight of the IMU allow it to be mounted directly on the multibeam transducer. From here, it can measure the transducer position and orientation directly.

Heave Filter

POS MV measures heave by performing a double integration on the measurements of vertical acceleration computed by the strap-down navigator, see Figure 85.

The high pass filter limits the appearance of noise in the vertical measurement channel caused by the strap-down navigator. Sources of such noise could include Schuler oscillations, GNSS noise, etc.

The performance characteristics of the heave filter are:

- Filter settling time
- Steady state heave error

Filter settling time describes the time required for a transient in the heave filter to settle to a negligible level. The filter has a transient behaviour that is stimulated by sudden changes in the filter input. This occurs when you power-on POS MV and when the vessel experiences abrupt changes in vertical displacement.

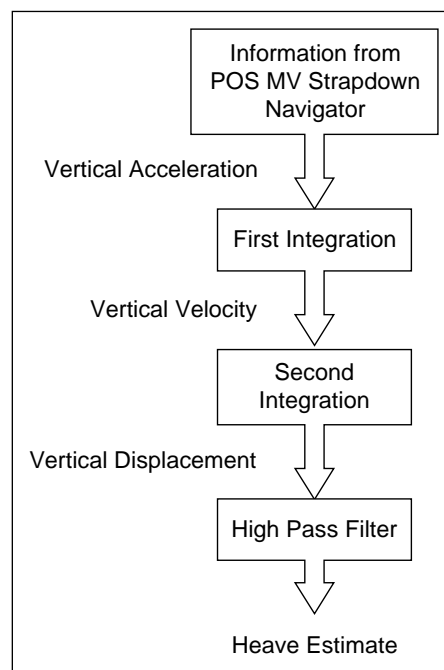


Figure 87: Heave Filter Architecture

Abrupt changes of this type can occur if the vessel experiences induced heave because of speed changes. Lighter vessels respond rapidly to changes in engine throttle settings and are therefore more likely to experience abrupt induced heave. Conversely, larger vessels that have a heavier displacement are not so responsive to changes in engine throttle settings and tend to exhibit a reduced tendency towards induced heave.

If the IMU is located close to the bow of the vessel then a significant induced heave can occur as the vessel climbs its own bow wave and pitches upwards.

Steady state heave error describes the error in measured heave after the filter transients have decayed. This error can be characterized as follows for an approximately sinusoidal heave motion with magnitude A and frequency ω :

$$\text{Steady state heave error} = |(A + \Delta A) \sin(\omega t + \phi) - A \sin(\omega t)|$$

Where: ΔA = the gain error introduced by the heave filter

ϕ = the phase error introduced by the heave filter

Steady state heave error becomes greater at lower heave frequencies in the frequency band of interest.

The high pass component of the heave filter is characterized by the following parameters, both of which are configurable through the MV-POSView Controller program:

- Heave bandwidth
- Damping ratio

The corner frequency is the lower (band reject) cut-off frequency of the high pass filter. Its setting should be at least one decade below the lowest heave frequency of interest. For example, if you require a heave measurement bandwidth of 0.05 Hz (for heave periods up to 20 seconds), then you should set the heave bandwidth to 20 seconds, and thus the corner frequency will be 0.005 Hz or lower (a heave period of 200 seconds or longer).

The damping ratio defines the transient characteristics of the heave filter and affects the steady state heave error. The largest recommended value for the damping ratio is 0.707, which causes the heave filter to be 'critically damped'. In general, this setting provides the shortest settling time among the available damping ratios for a fixed corner frequency. A smaller damping ratio causes the filter transient response to exhibit a decaying sinusoidal behaviour whose settling time is longer than the critically damped settling time.

Default Heave Filter Parameters

The default heave filter parameters are:

- Heave bandwidth = 20 seconds
- Heave damping ratio = 0.707 (critically damped)

These default values give the best compromise between settling time and steady state heave error for a vessel performing multibeam surveys in sea conditions up to sea state five.

On a different class of vessel in a different sea state, a different combination of heave filter parameters may provide better results. The following guidelines assist in selecting appropriate heave filter parameters.

Guidelines for Setting Heave Filter Parameters

The best combination of heave filter parameters will depend on the following factors:

- Survey conditions - how often does the survey vessel change speed or direction?
- The dynamic characteristics of the survey vessel, in particular the induced heave following changes to engine throttle settings.
- Significant heave amplitudes caused by the response of the survey vessel to the sea state.

You can determine empirically the correct combination of parameters for a particular survey vessel during trials. The following are guidelines for selecting appropriate values:

3. Select heave filter parameters according to the following criteria:
 - Heave bandwidth - equal to or greater than the longest heave period
 - Heave damping ratio - in the range 0.45 to 0.71
4. Calculate the maximum allowable steady state percentage error as follows:

$$\text{Maximum percentage error} = \frac{\text{Maximum heave error}}{\text{Significant heave amplitude}}$$

Choose a heave bandwidth and damping ratio to achieve the required maximum percentage error with the shortest settling time.

Usually, the maximum heave error is comparable with the resolution of the bathymetric sonar that requires heave compensation. The significant amplitude will change from one day to the next with sea state and, therefore, so will the maximum percentage error.

For example, if the heave error should be no more than 10 cm (comparable with the bathymetric sonar resolution), and the significant heave amplitude is 0.5 metres on a given day, then the maximum percentage error for that day is 20%.

5. A vessel that has a large displacement will usually exhibit more gradual changes of speed than one that has a small displacement. Since the dynamics of a large vessel will not significantly excite the transient behaviour of the filter, configure the heave filter to achieve a small percentage steady state error at the expense of a long settling time.

Table 38 describes the variations of steady state heave error and settling time with changes in damping ratio and bandwidth. Figure 86 through Figure 89 on pages B-14 through B-17 respectively show plots of steady state heave error and transient behaviour for different combinations of heave filter parameters.

Table 39: Effects of Modifying Heave Filter Parameters

Heave Filter Tuning		Steady State Error	Settling Time
Damping ratio	Increase	Increase	Decrease
	Decrease	Decrease	Increase
Heave bandwidth	Increase	Decrease	Increase
	Decrease	Increase	Decrease

Figure 86 shows a plot of the steady state heave error as a percentage of heave amplitude against heave frequency for four heave bandwidths at the default damping ratio of 0.707.

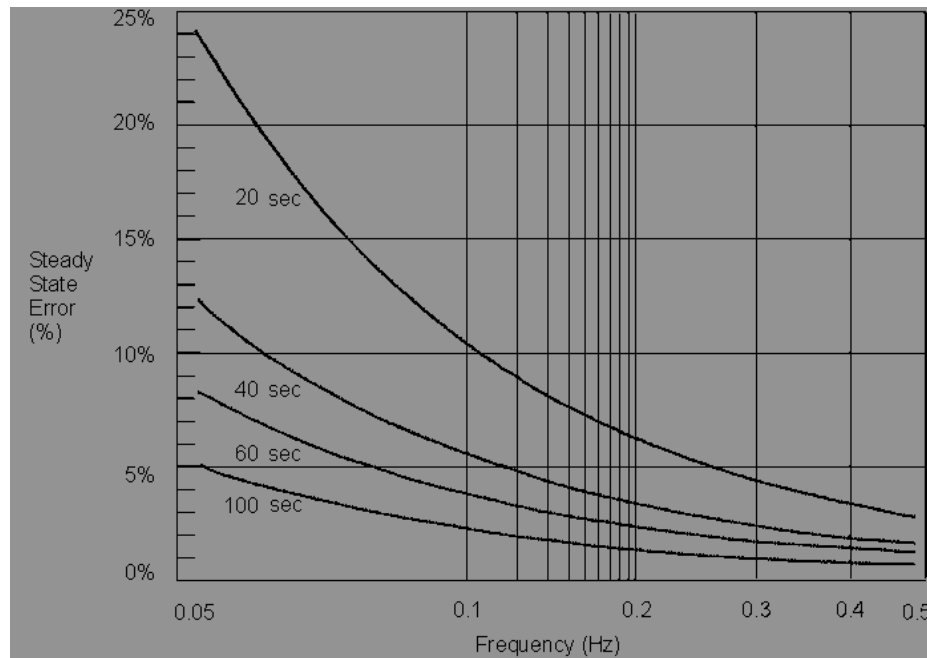


Figure 88: Percentage Steady State Error with Heave Bandwidth

Figure 87 shows a plot of steady state heave error as a percentage of heave amplitude against heave frequency for four damping ratios at the default corner heave bandwidth of 20 seconds.

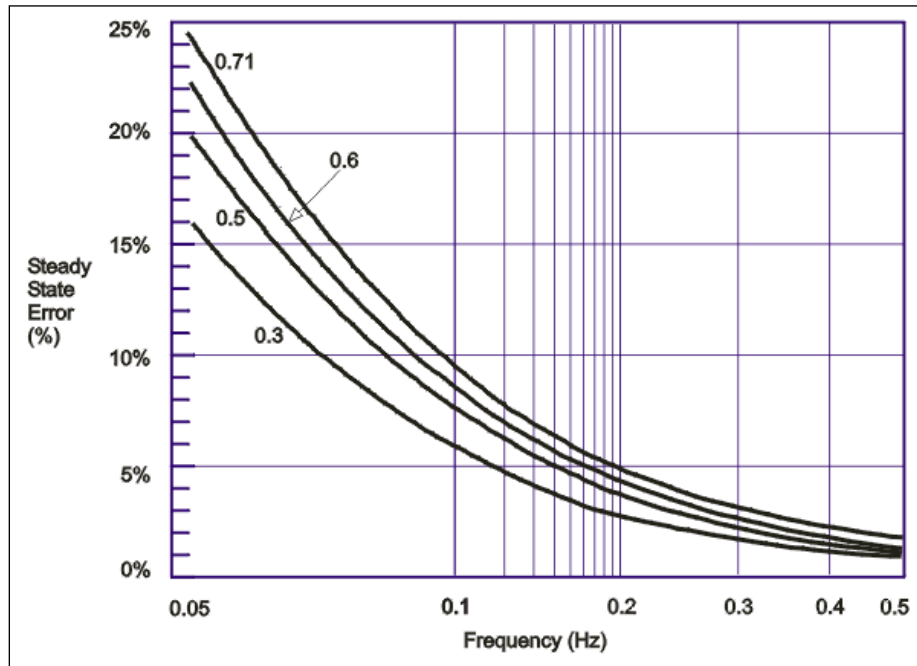


Figure 89: Percentage Steady State Error with Damping Ratio

Figure 88 shows a plot of the heave filter response against time for four heave bandwidths at the default damping ratio 0.707. The filter settling time is for the impulse response to settle to 20% of the impulse magnitude.

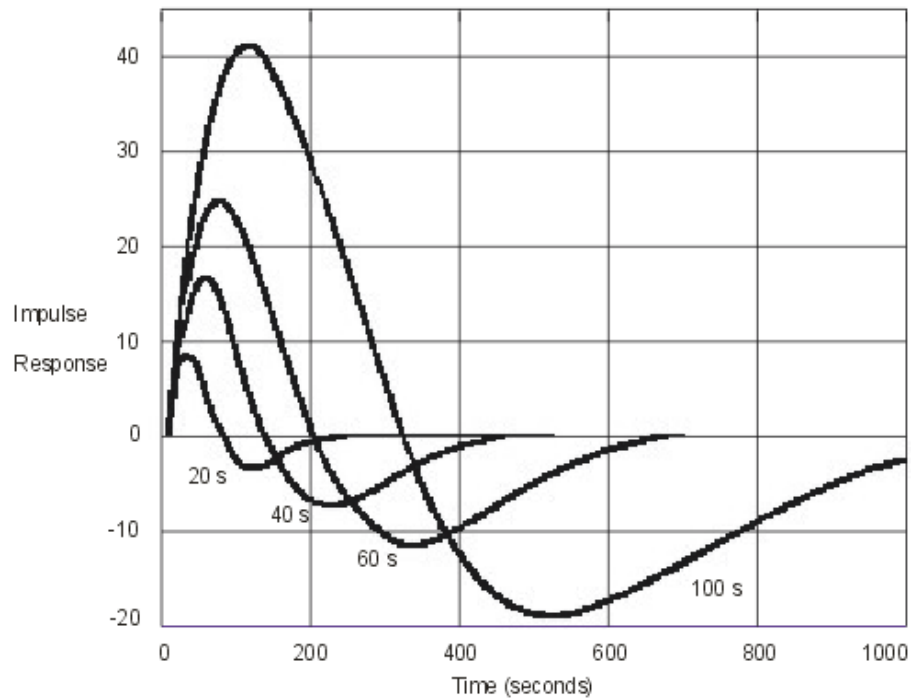


Figure 90: Heave Filter Transient Behaviour with Heave Bandwidth

Figure 89 shows a plot of the heave filter response against time for four damping ratios at the default heave bandwidth of 20 seconds. The filter settling time is for the impulse response to settle to 20% of the impulse magnitude.

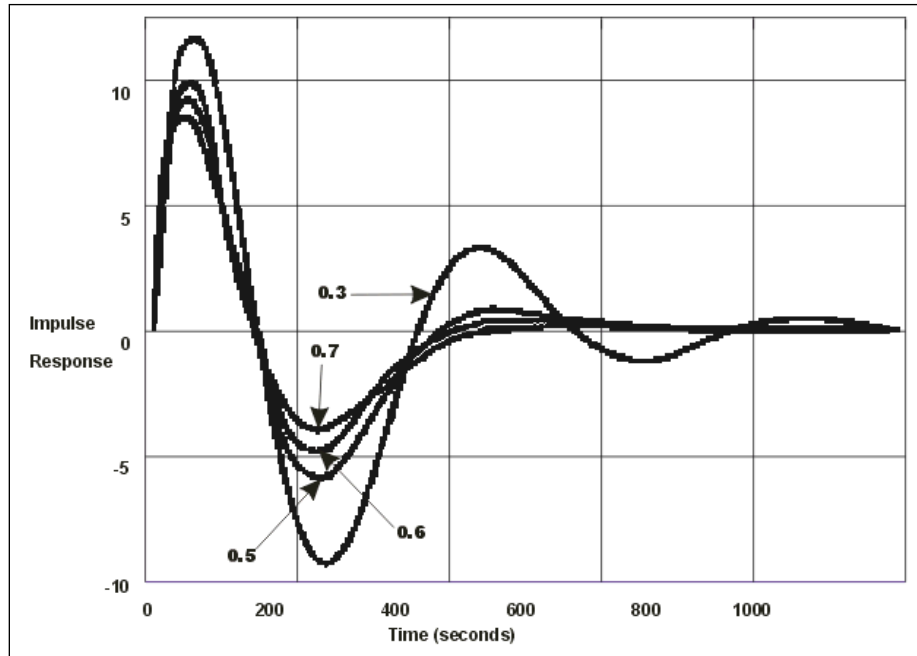


Figure 91: Heave Filter Transient Behaviour with Damping Ratio

GNSS Azimuth Measurement Subsystem

POS MV delivers heading measurements with an optimal accuracy of $\pm 0.02^\circ$. It does this by using two distinct and independent methods:

1. Dynamic Heading Alignment - A method that uses data supplied by the IMU and GNSS receivers to achieve a heading that is, at best, accurate to within 0.35° .

Dynamic heading alignment delivers its best performance when the measurement unit experiences rapid changes of direction and varying forces of acceleration. Drift will begin to appear in the heading measurements when these dynamic manoeuvres cease and the vessel follows a steady course and speed.

2. GNSS Azimuth Measurement Subsystem (GAMS) - A system that determines the geographic vector between two GNSS antennas fixed to the vessel. It does this by comparing the phase of satellite signals arriving at each antenna.

You can expect carrier phase differential measurements to deliver differential range measurements with an accuracy of between two and 10 millimetres, and heading measurements with an accuracy of between 0.1° to 0.5° RMS. These specifications are typical of multi-antenna

GNSS attitude sensors that have antenna separations of between one and three metres. They will vary according to the multipath signal environment affecting the antennas.

Each of the above heading measurement methods have advantages and disadvantages:

- An inertial navigator that undergoes dynamic heading alignment delivers heading measurements that suffer from drift but are relatively unaffected by noise.
- GAMS heading error is largely due to noise but exhibits no drift.

POS MV uses the advantages of each method to compensate for the disadvantages of the other. By blending the measurements delivered by GAMS with those delivered by the inertial navigator, POS MV averages the heading error over time and delivers blended measurements to an accuracy of between 0.02° and 0.1° RMS.

Heading Measurements

Heading measurements calculated by GAMS provide aiding data to the Kalman Filter to improve the heading estimate made by the strap-down navigator.

Baselines

Heading measurements used by POS MV are:

- The true heading of the vessel in a geographic navigation frame of reference
- The 'heading' of the IMU in a geographic frame of reference - that is, the geographic heading of the x-axis of the IMU body frame

To deliver heading measurements of the required accuracy, POS MV blends measurements made by GAMS and measurements made by the inertial navigator. A Kalman Filter performs this blending operation.

POS MV includes a primary and a secondary GNSS receiver, each with its own antenna. The GNSS System topic on page 2-5 of this manual includes instructions to install both GNSS antennas so that they are rigid relative to each other and relative to the IMU, and are separated by a distance of between one and five metres.

By using a carrier phase differential GNSS algorithm, POS MV can measure the vector between the two antennas in a geographic frame of reference. Figure 90 illustrates this situation. The Carrier Phase Differential Position topic on page B-22 explains the process of carrier phase differential GNSS measurement.

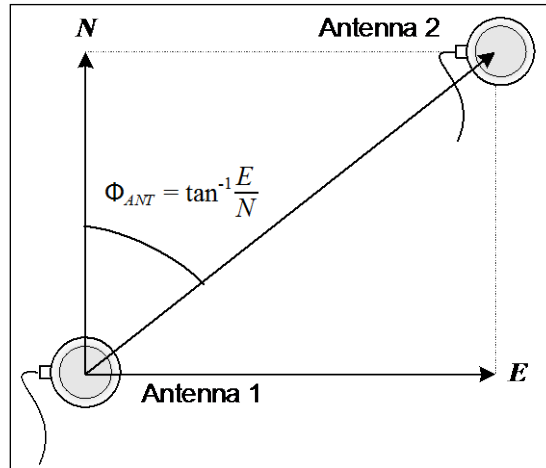


Figure 92: Geographic Antenna Baseline Vector

POS MV computes a carrier phase differential position solution in geographic co-ordinates of Antenna 2 with respect to Antenna 1. This is the geographical antenna baseline vector:

$$\Phi_{ANT} = \tan^{-1} \frac{E}{N}$$

Where: Φ_{ANT} = the geographical antenna baseline vector

E = the easterly component of the position difference between Antenna 1 and Antenna 2

N = the northerly component of the position difference between Antenna 1 and Antenna 2

Because the geographical antenna baseline vector is referenced to true north, it varies as the vessel changes course. However, the heading aiding data required by POS MV is the heading of the antenna baseline referenced to the x -axis of the IMU.

POS MV transforms the geographic antenna baseline vector Φ_{ANT} to the geographic IMU heading Φ_{IMU} using the surveyed antenna baseline vector $\Delta \vec{r}_{12}$, which is the antenna baseline vector resolved in the IMU co-ordinate frame. Figure 91 illustrates these headings and angles.

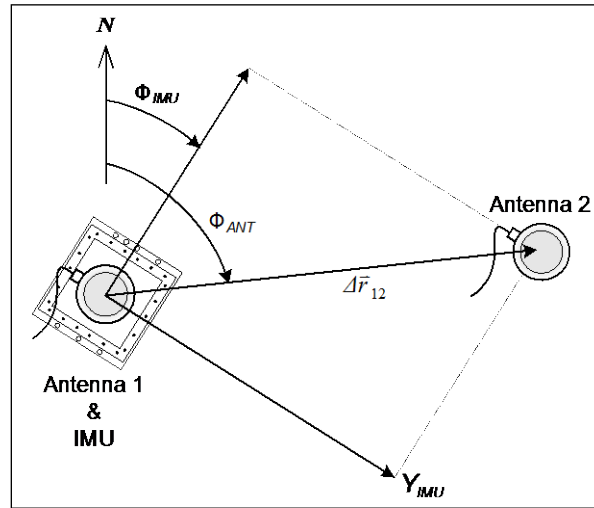


Figure 93: Baseline Comparison

- Where:
- Φ_{ANT} = geographic antenna baseline vector - the geographic vector of the line that joins the two GNSS antennas; this vector varies as the heading of the vessel changes
 - Φ_{IMU} = geographic IMU vector - the geographic heading of the IMU x-axis; this vector varies as the heading of the vessel changes
 - $\Delta \vec{r}_{12}$ = surveyed antenna baseline vector - the vector that joins the two GNSS antennas; because the IMU and the GNSS antennas are mounted rigidly on the vessel, this vector remains fixed

Note: The example shown in Figure 91 is greatly simplified. It shows only the relative yaw angles made by the baseline vectors. In practice, the transformation of one baseline vector to another may possibly involve rotations in all three axis - roll, pitch and yaw.

Baseline Measurement

Geographic Antenna Baseline Vector

To compute a highly accurate value for Φ_{ANT} based on carrier phase differential GNSS, GAMS must first resolve the phase ambiguities in the differential carrier phase observables.

The GNSS receivers in POS MV use the L1 GNSS signal, which has a carrier frequency of 1575.42 MHz and a wavelength of 19 cm. You can consider the range between each GNSS satellite and a GNSS antenna as an integer number of L1 wavelengths plus a fraction of a wavelength.

Each receiver can measure the fraction of a wavelength from each tracked satellite but cannot determine the integer number of wavelengths between the transmitting satellite and the antenna.

By using satellite pseudo-range, the receiver can reduce the uncertainty in knowing the integer number of wavelengths to less than 100. The remaining unknown integer number of wavelengths is the carrier phase ambiguity.

GAMS uses an On-the-Fly (OTF) ambiguity resolution algorithm to resolve the carrier phase ambiguities. On-the-fly implies that the algorithm resolves the phase ambiguities while the antennas are moving.

The OTF algorithm uses carrier phase measurements from five or more satellites to estimate and, eventually, to identify a set of integer phase ambiguities for each satellite being tracked by both receivers. The Carrier Phase Differential Position topic on page B-22 explains this process simply.

For the OTF algorithm to work, both receivers must track at least five common satellites to resolve the ambiguities. Preferably, they should track six or more to resolve the ambiguities within a reasonable length of time.

The GAMS OTF algorithm uses the roll, pitch and initial heading computed by POS MV (without GAMS heading aiding) to accelerate the ambiguity resolution process. Practically, if POS MV uses the IMU heading alignment process to compute the heading with an RMS accuracy of 1° or better, then ambiguity resolution is almost instantaneous and can be completed in less than ten seconds. You can achieve this degree of heading measurement accuracy without GAMS heading aiding by executing a few vessel turns after you power-on POS MV.

This facility also allows GAMS to recover very quickly following a GNSS dropout caused by a signal blockage when passing under a bridge for example.

Surveyed Antenna Baseline Vector

Figure 92 shows the geometry of the two GNSS antennas and the IMU. The antenna baseline vector is shown as $\Delta \mathbf{R}_{AB}$.

During normal operation, GAMS measures this vector resolved in the geographic or North-East-Down frame (the geographic antenna baseline vector) by using a carrier phase differential GNSS algorithm.

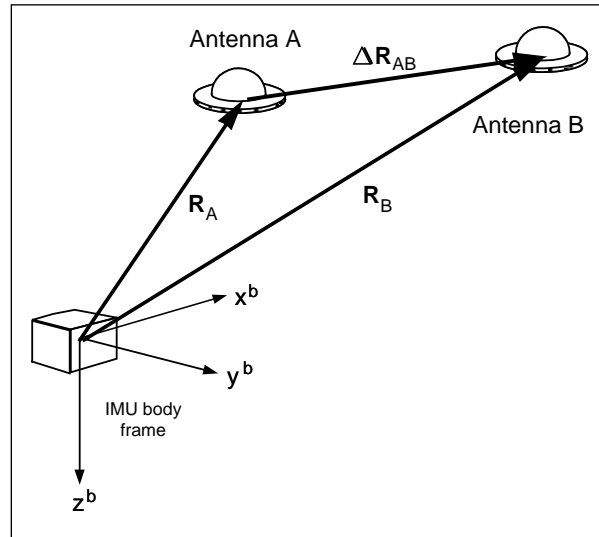


Figure 94: IMU and GNSS Antenna Geometry

To compute the heading of the IMU (that is the heading of the x -axis of the IMU body frame) GAMS must have the components of ΔR_{AB} resolved in the IMU body frame (the surveyed antenna baseline vector).

These components and the length of the vector are the GAMS installation parameters.

You can measure the GAMS installation parameters using a direct survey method, or POS MV can calibrate them automatically as part of an antenna installation calibration.

Both methods have advantages and disadvantages:

- Direct measurement of the parameters using precision survey techniques provides the best heading accuracy and allows POS MV to deliver full operational performance immediately. However, it also involves a laborious and complicated survey exercise using qualified survey personnel, special equipment and detailed engineering drawings of the vessel.
- Conversely, a POS MV installation calibration provides calibration parameters that are initially less accurate. However, the system can perform the procedure during normal survey operations without the need for any special additional equipment or personnel. You can improve the accuracy of this type of calibration by empirical methods, or by making a direct comparison with another heading instrument such as a gyrocompass.

Refer to Initial GNSS Configuration on page 4-22 for instructions to complete an installation calibration.

Carrier Phase Differential Position

GNSS measurements possess long-term stability and an accuracy that, with DGNSS, can be within a few metres. However, the measurements do not possess sufficient accuracy to allow a precise determination of the geographic antenna baseline vector.

Instead, POS MV uses carrier phase differential position measurements to determine the relative position of one GNSS antenna with respect to the other.

Using this method, the differential position computed by GAMS for the two antennas has an accuracy of between two and 10 millimetres, depending on the local multipath environment. The heading data supplied can therefore exhibit accuracy of the order 0.1° to 0.5° RMS, depending on the multipath environment and on the horizontal separation distance between the two antennas. Errors of this magnitude are typical of installations where the antenna separation distance is between one and three metres.

Figure 93 represents the signal from one satellite in the GNSS constellation received by the GNSS receiver. The drawing shows the true position of the receiver, although the receiver knows this position only to a finite limit of accuracy.

Pseudorange is the distance measured between the transmitting satellite and the receiver, based on the correlation between the transmitted code and the local reference code in the receiver. This measurement includes no correction for errors in synchronization between the satellite and the receiver clocks.

In the example in Figure 93, the predicted position is shown as calculated from the satellite pseudo-range.

GNSS signals at the L1 frequency (1575.42 MHz) have a wavelength of 0.19 metres. A GNSS receiver could compute its precise distance from a transmitting satellite if it knew two facts:

- The exact number of integer wavelengths between the transmitter and the receiving antenna
- The phase of the received signal

Although the GNSS receiver can measure the phase of the received signal, it cannot determine exactly how many integer wavelengths exist between the transmitter and the receiving antenna. It knows this value to within approximately one hundred cycles by knowing the satellite pseudo-range, but there remains some uncertainty in its precise determination.

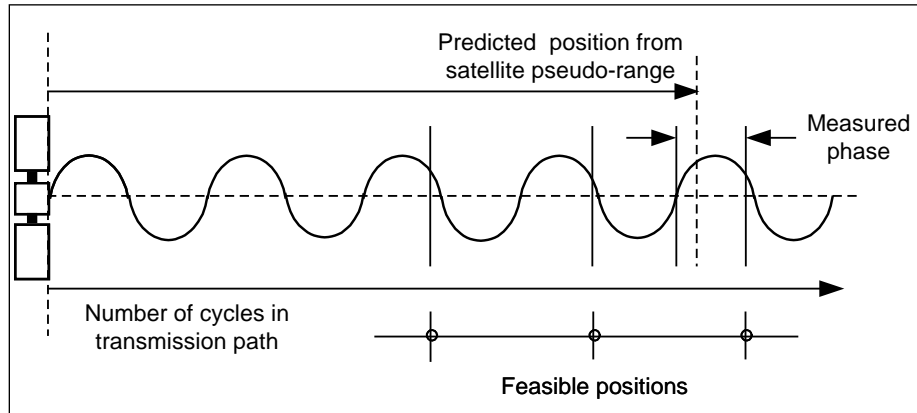


Figure 95: Carrier Phase Cycle Measurement

Because of the uncertainty in its knowledge of the number of integer wavelengths in the transmission path, the receiver has a number of feasible true positions. These all lie along the circumferences of circles, centred on the satellite and varying in radius by the signal wavelength.

The range to any satellite is very large and so, for the purposes of this explanation, the feasible positions lie along parallel straight lines. These lines are 19 cm apart and are within a circle of radius ' R ' equal to the uncertainty in the GNSS position solution. This is represented by the shaded circle in Figure 94.

The uncertainty in determining which line is the one on which the actual position lies is the carrier phase ambiguity. It can be resolved by performing the same operation using multiple satellites.

Figure 95 shows that, by performing the same operation using signals from two satellites, the range of feasible position solutions is reduced to a number of points where the lines intersect. For this to be effective, the satellites must be spaced with respect to each other so that the lines intersect at a reasonably wide angle.

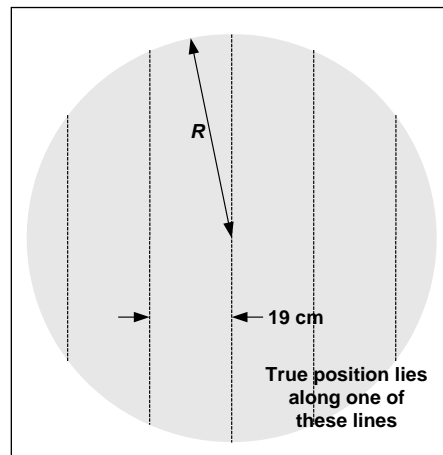


Figure 96: Feasible Position Solutions from One Satellite

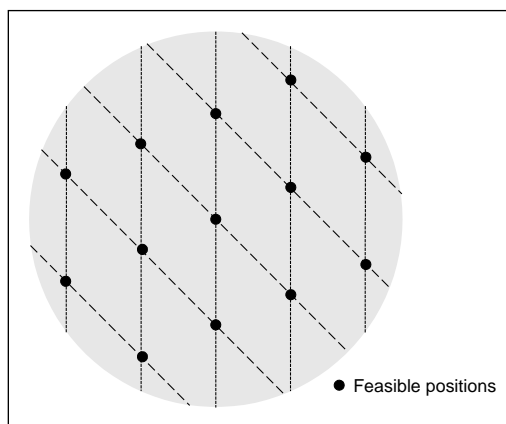


Figure 97: Feasible Position Solutions from Two Satellites

Figure 96 shows how the range of feasible position solutions reduces still further when three satellites are used to resolve the carrier phase ambiguities.

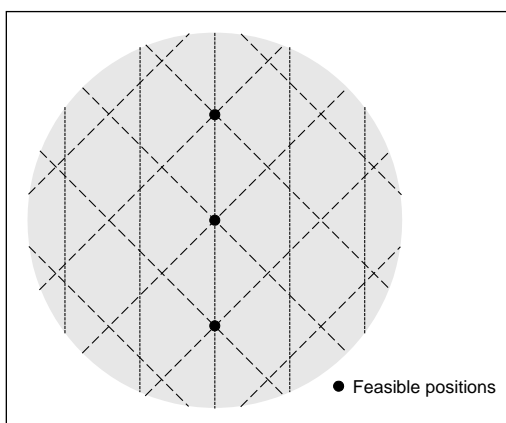


Figure 98: Feasible Position Solutions from Three Satellites

In practice, the operation is more complex than the simple explanation above. This is for the following reasons:

- The radius of the circle of uncertainty in knowing the position of the GNSS antenna is usually much larger than the simple examples shown above. There are therefore many more points within the circle that could be feasible true positions.
- Although the illustrations above show the situation in two dimensions, the actual computation performed by POS MV involves the resolution of carrier phase ambiguities in three dimensions.

In POS MV, resolution of the carrier phase ambiguities is one of the functions performed by the GNSS Azimuth Measurement Subsystem (GAMS). The process uses an aided OTF algorithm to resolve the

carrier phase ambiguities while the antennas are moving and uses the following information to reach a resolution more rapidly:

- Antenna baseline length - the distance between the two GNSS antennas. You can measure this distance with a tape measure to the required accuracy of 5 mm ($3/16$ in). The measurement allows GAMS to achieve ambiguity resolution within two to five minutes.
- Antenna baseline vector - the vector of the line joining the two GNSS antennas measured in the vessel frame of reference. You can use direct survey techniques to measure this, or POS MV can make the measurement automatically during the installation calibration (refer to the Surveyed Antenna Baseline Vector topic on page B-21). The measurement allows GAMS to achieve ambiguity resolution within 10 to 30 seconds.
- Roll, pitch and heading - information supplied by the strap-down navigator allows GAMS to achieve ambiguity resolution in one to five seconds.

GAMS uses these three sources of information to reduce the space within which the OTF algorithm searches for the correct ambiguity resolution.

The desired result of the carrier phase cycle measurement is the determination of the geographic antenna baseline vector.

Alignment

Alignment is the process by which an INS determines the down and the north directions. It does this by sensing the gravity and Earth angular rate vectors to obtain a levelled and aligned platform.

- A gimbaled INS platform (refer to the INS Platform topic on page B-7) undergoes alignment when its servomotors physically rotate the platform to make it level and oriented in a known direction, called the *wander angle*, with respect to north.
- A strap-down INS undergoes alignment when the navigation processor continuously updates the computed sensor-to-navigation Direction Cosine Matrix (DCM) until the DCM describes a transformation to a mathematical platform that is level and has a known wander angle with respect to true north.

Both these alignment mechanisms are conceptually equivalent. The explanations below therefore refer to the gimbaled platform arrangement because it is easier to visualise than the strap-down arrangement.

Levelling

A horizontally unaligned INS will have a tilted platform with respect to the true horizontal of a navigation frame of reference. This tilt causes the horizontally pointing accelerometers to sense some component of

gravity coupled by the angle of tilt, as shown in Figure 97. From this component of horizontal acceleration, the INS computes an erroneous horizontal velocity.

A platform-levelling algorithm matches the INS-computed velocity with an independent velocity reference and attributes the resulting velocity differences to platform tilt errors.

During a stationary alignment, the velocity reference is zero. Tilt estimates are then computed and applied as feedback signals to the gimbal servomotors in an INS platform, or as corrections to the sensor-to-navigation DCM in a strap-down INS. Because of these corrections, the velocity errors are nulled. The platform (whether real or mathematical) is then considered horizontally levelled.

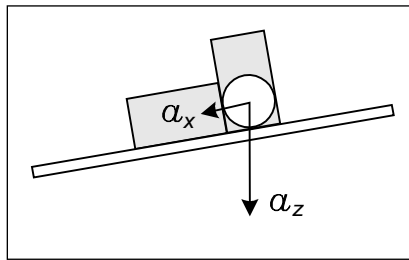


Figure 99: Horizontal Acceleration Error in a Tilted Platform

Gyrocompassing

Full alignment is complete when the platform is level and its *x-axis* points in a known direction with respect to true north. The method by which an INS seeks north during an alignment is called gyrocompassing.

A properly aligned platform will rotate about its north axis at $\Omega \cos \lambda$ and about its azimuth (yaw) axis at $-\Omega \sin \lambda$, where Ω is the Earth's rotation rate (15°/hour) and λ is the latitude. This combined motion about two axis will compensate for the rotation of the Earth so that the platform remains locally level.

If a heading error exists (i.e. the platform *x-axis* points away from north) then there will be a small component of the Earth rate appearing in the east axis that remains uncompensated by the INS. The platform will rotate slowly at the Earth rate about the east axis causing the platform to tilt away from the level at a constant rate.

This slowly increasing platform tilt causes a sensed horizontal acceleration in the north direction due to gravity coupling as shown in Figure 97. This northward acceleration error has the distinct characteristic of growing linearly with time and it is therefore clearly recognisable if there are no other large sources of acceleration error present.

In a gimballed INS platform, the ramping northward acceleration can be used as a feedback signal to a proportional-integral feedback servomechanism. This servomechanism rotates the platform about its azimuth axis and drives the heading error towards zero. The levelling mechanism already described continuously returns the platform to the level.

In a strap-down INS, the alignment algorithm separates the ramping northward acceleration due to heading error from other constant acceleration errors due to platform tilts. It then computes the correction needed by the sensor-to-navigator DCM to null the acceleration error and therefore remove the heading error.

INS operation is similar to the mechanization of a gyrocompass.

Because gravity is an observable quantity through the accelerometers, levelling occurs rapidly, usually within 30 seconds. The actual time that it takes to achieve levelling depends on the slewing rate of the gimbal motors of an INS platform, or the iteration rate of a strap-down INS algorithm.

Once levelling is complete, the ramping northward acceleration error caused by heading error becomes weakly observable against a background of acceleration transients due to vessel motion and accelerometer noise.

The alignment algorithm must filter these random disturbances in the acceleration signal. Therefore, a heading alignment will take longer to complete, typically from 10 to 30 minutes depending on latitude.

Error Sources

Once the heading alignment is complete, the INS can begin to navigate free Inertially. Free inertial navigation allows an INS to reach a navigation solution without input from any independent form of navigation aid.

The problem with this form of navigation is that it relies totally on the accuracy and stability of the inertial sensor assembly. In practice, there are a number of errors to consider, each of which contributes in some way to a deterioration in the accuracy of the navigation solution supplied by an INS:

- Alignment errors - these are errors in roll, pitch and heading measurements following the completion of an alignment. They arise from errors in the inertial sensing assembly and from motion disturbances during alignment.
- Accelerometer bias - this is a constant offset in the accelerometer output. It changes randomly each time you power-on the INS. Typical values for high quality accelerometers, as used in POS MV, are between 50 and 500 μg .
- Accelerometer scale factor - This is an error in the assumed scale factor on the accelerometer output. It results in an acceleration error proportional to the sensed acceleration. Typical values for high quality accelerometers, as used in POS MV, are 0.01 to 0.02%.
- Gyro drift - This appears as a constant output from a gyro when there is no angular rate of rotation present. The gyros used in POS MV exhibit drift rates of between 1° and 5° per hour.

- Gyro random noise -This is an uncorrelated error caused by the internal noise characteristics of the gyro. The high quality gyros used in POS MV exhibit a spectral noise density of $(0.07^\circ)^2$ per hour.

The above component-specific errors cause the following navigational errors to occur:

- Schuler oscillations having a period of 84.4 minutes (see the information on the Schuler Oscillations on page B-30)
- Space rate oscillations having a nominal period of 24 hours
- Linear position error rate

Over short navigation periods of several hours, the space rate and the linear position error rate are not separately observable and are therefore viewed together.

Because of the above sources of error, POS MV cannot perform free inertial navigation for extended periods without the introduction of an increasingly significant error.

Instead, POS MV implements an *aided* inertial navigator that controls the navigation errors and calibrates the inertial sensor errors using GNSS data as a reference.

Aided Inertial Navigation

The primary purpose of an aided inertial navigation system, also called an integrated inertial navigation system, is to compute a *blended* navigation solution. It does this by using a complementary blending algorithm to combine inertial navigation data with aiding data from another source.

In POS MV, the aiding data comes from the integral GNSS receivers. The IMU and the GNSS navigation sensors are complementary because they meet the following conditions:

- The set of navigation sensors together generate all the information required to compute a complete navigation solution.
- The navigation sensors have complementary error dynamics because all their error dynamics are observable. Each complementary sensor can calibrate the errors of the other because their respective errors are separately observable in any linear combination of their outputs.

The important characteristics of the two navigation sensors used by POS MV can be summarised:

- The INS position error grows by several nautical miles per hour in the long term (over several hours) but is smooth and dynamically accurate in the short term (over a few minutes). The output also exhibits a strongly recognisable Schuler oscillation superimposed on the growing position error.

- The GNSS position error is noisy in the short term but exhibits a constant long-term error of only a few metres (with DGNSS).

Schuler Oscillations

Schuler oscillations appear as regular oscillations about a mean position in the output of a free inertial navigator. You can also see them on the output from a gyrocompass. These oscillations have a period of 84.4 minutes, which is the theoretical period of a pendulum having a length equal to the radius of the Earth.

In a free inertial navigation system, the oscillations occur as the platform (whether mechanical or mathematical) over-corrects for small residual errors in platform levelling and alignment. These residual errors may arise because of uncorrected bias in the accelerometers or the gyros.

You can expect the best performance from the aided inertial navigation system when the advantages of one navigation sensor compensate for the disadvantages of the other.

The following is a simplified example of how navigation data from an INS and a GNSS receiver can be blended or integrated in a complementary fashion (refer to Figure 98). Note that POS MV uses a significantly more complex process involving a Kalman Filter.

1. The position solution determined by the INS includes an error that varies with time. This error comprises a drift, which increases at a linear rate with time, and the Schuler oscillations having a period of 84.4 minutes. Depending on the quality of components used in the INS, the overall combined effect of these two error sources can be considerable.
2. The DGNSS receiver delivers a position solution that is stable in the long term and includes an error of only a few metres (depending on the quality of differential correction information supplied). However, the DGNSS position solution includes short-term errors of several metres amplitude that appear as 'noise' on the position solution.
3. Calculating the difference between the INS position and the DGNSS position, and then passing this difference through a low-pass filter can determine a good estimate of the INS position error. The filter smoothes the random noise from the DGNSS solution and passes the INS position error and the small steady-state DGNSS position offset.
4. Having obtained this estimate of the INS position error, the system then subtracts it from the INS computed position. This delivers a blended solution with the long-term INS position error and the DGNSS short-term noise removed. The only remaining error is the constant position offset from the DGNSS that has passed through the filter.

The blended position solution now has the best characteristics of both the INS and the DGNSS; the position solution is smoothed like the INS solution, and has a bounded error that is less than or equal to the DGNSS solution.

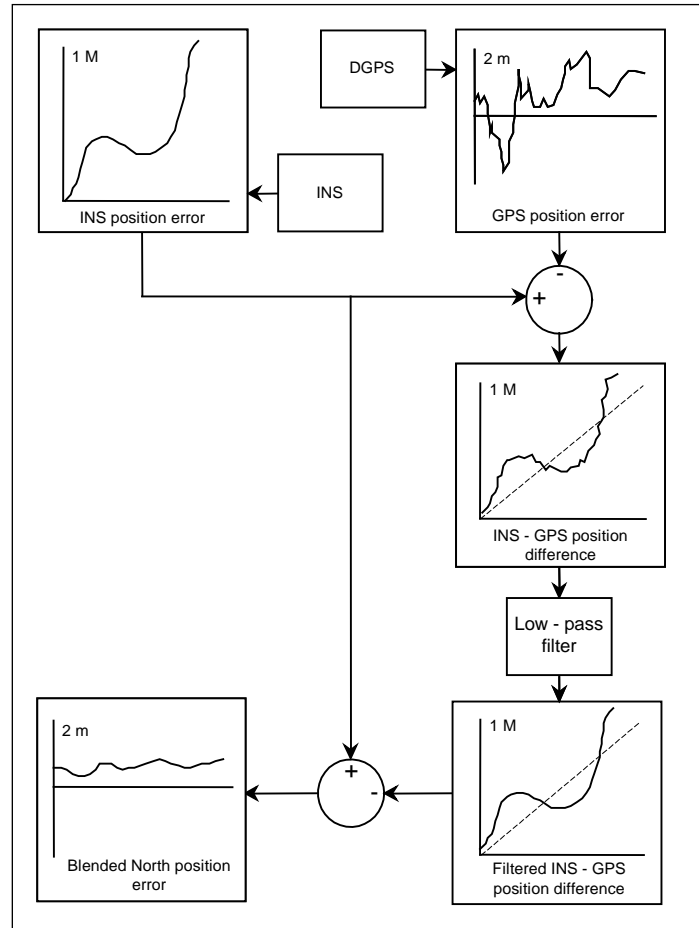


Figure 100: Example of Complementary Navigation Sensor Blending

In-Motion Alignment

The paragraphs contained under the Alignment topic on page B-26 describe how an inertial navigation platform achieves alignment under static conditions. An important feature that the integration of inertial navigation and GNSS offers is in-motion alignment of the inertial navigator.

The magnitude of Schuler oscillations in the inertial navigator depends on the quality of platform alignment. Similarly, the rate at which the position error grows depends partly on the quality of alignment and partly on the magnitude of gyro bias.

To accomplish in-motion alignment the simple low-pass filter shown in Figure 98 on page B-31 is a more sophisticated filter that has built into it a mathematical model. This mathematical model includes details of

the relationship between the quality of INS alignment, the gyro and accelerometer errors, and the respective magnitudes of the Schuler oscillations and position error growth.

Such a filter is an algorithm that combines the operations of filtering and estimation. Its main function is to estimate the internal dynamics of a system using measurements of the system outputs.

POS MV uses this 'Kalman' filter with the INS-GNSS position difference to estimate the position error, and the *cause* of the INS position error (i.e. the alignment errors and the inertial sensor errors).

- The INS uses the estimated alignment error to correct and therefore improve the alignment of the INS.
- The INS uses the estimated errors in the inertial sensors to correct and calibrate the outputs from the inertial sensors.

This process does not require the INS platform (and therefore the vessel) to be stationary. In fact, movements of the vessel actually assist the calibration process and provide a faster and more accurate inertial sensor calibration.

Appendix C Training

The POS MV Aided Inertial Navigation System is a complex assembly of interactive subsystems that delivers position and attitude measurements for use in a variety of survey applications. Those who will install, operate and maintain the system will do so more effectively after they receive training in all aspects of its operation.

In support of this philosophy, Applanix has developed a comprehensive training program for all personnel who may be involved with POS MV.

Items covered by the course include:

- POS MV Overview
- Principles of Operation - Inertial Navigation Systems, GAMS, GNSS
- Hardware Installation and Configuration
- MV-POSView Controller Program Overview
- Simple Maintenance

The course includes simplified explanations for each subject. There is no requirement for participants to be entirely familiar with electronics or computers, although it may prove easier to grasp some of the concepts if attendees possess some basic knowledge in these areas.

Appendix D Software Installation

Applanix supplies a copy of the MV-POSView Controller software, for use with a PC based Microsoft Windows® environment, with each POS MV system. This program is used to configure the POS MV once the system components have been installed and connected.

Subsequently, you can use the program to control POS MV and to view and log its data. Alternatively, for installations where the use of a controlling PC is not convenient, you can configure POS MV to run in a stand-alone mode without the need for a controlling PC.

Refer to the System Configuration and the System Operation descriptions on pages 4-1 and 5-1 respectively for instructions on how to configure and control the POS MV using the controller program.

Supplied Software	A compact disk containing POS MV software is included with each system.
Hardware and Software Requirements:	The minimum requirements of a Personal Computer (PC) running the POS MV software are listed.
MV-POSView Controller Program:	The MV-POSView Controller program must be run from the hard disk of the controlling PC. You cannot run the program from the installation Compact Disk (CD).
Firmware Upgrade:	Upgrading the POS MV embedded firmware from a PC connected through the Ethernet port.

Supplied Software

A compact disk containing POS MV software is included with each system. The following provides a brief description of the software contained on the CD.

- MV-POSView Controller - required to configure the various POS MV components, operate the system, access and display information, and to monitor system health.
- POSLoader - windows based Graphical User Interface (GUI) application that is required when upgrading the POS MV firmware; it automates firmware upgrades through an Ethernet port. The software checks the current version of POS firmware and updates the requested new firmware. POSLoader requests a password prior to operation.

- POSConfig - windows based GUI application that is required for enhancements or automating changes to the POS MV system setup (e.g. enabling software options). Pricing and enabling passwords are available from Applanix Customer Support.

Hardware and Software Requirements

Make certain the controlling PC meets or exceeds the requirements outlined in Table 39.

Table 40: Controlling PC Requirements

Item	Minimum Requirements
Processor	Intel Pentium® III or equivalent
Memory	128 MB RAM
Operating System	<i>Windows 7.1 SP1, Windows 7 Embedded, Windows 8, and Windows 10</i>
Free Disk Space	8 MB
Ethernet Card	10/100 Base-T Ethernet; IEEE 802.3 Standard

MV-POSView Controller Program

You must install the MV-POSView Controller program on the hard disk of the controlling PC. You cannot run the program directly from the installation compact disk.

This program communicates with POS MV through an Ethernet LAN port. You must have Microsoft Windows7®, Windows8® or Windows10® installed on your PC before you can install and use the controller program.

Note: Applanix recommends the removal of previous versions of the POS Controller. Keeping previous versions may result in user confusion and program instability.

To install the MV-POSView Controller program:

1. Open Windows® on controlling PC.
2. Insert Compact Disk (CD) containing POS MV software into controlling PC's CD drive.
3. Select **Start, Run** from Windows® Desktop.
4. Enter **a:setup.exe**.
5. Select **OK** to start software installation.
6. PC should display setup window with MV-POSView Controller Setup dialogue. This includes a default installation directory that can be changed to another location.

7. Select **Continue**. If controller directory does not exist, installation software will create it. During installation, program copies a number of files from compact disk to controller directory. These files include *posmv.exe* executable file; *posmv.hlp* file, a *read.me* file and a set of dynamically linked library files (*.dll).
8. Installation software prompts for creation of icons. Skip this step if default icons are preferred. Otherwise, select default program group or a new program group (either of which are created by installation software through Windows®). Also, icons may be installed into an existing program group.

This completes the installation of the MV-POSView Controller program.

Firmware Upgrade

You can upgrade the embedded software inside the PCS by connecting to the PCS through its Ethernet interface and using the POS Loader program to upload the new files.

1. Contact Applanix for an authorization code. Also, S/N of PCS is required.
2. Copy upgrade file to PC. Upgrade file is available from Applanix or may be downloaded from Internet site. Upgrade file is larger than two MB and may take a considerable time to download.
3. Once file saved to PC hard disk, run POS Loader program. Program locates PCS on your network and displays its network address. Select PCS and then continue with upgrade procedure.
4. A dialogue panel appears and lists product identification and serial number. Write these details down carefully and contact Applanix.
5. In Loader program, type authorization code into its text field and continue with upgrade.
6. Observe progress of file transfer and wait for software prompts. During reboot sequence, PCS decodes and error-checks upgrade software prior to beginning normal operation. These additional steps mean that first Initialization sequence, after installing an upgrade, will take considerably longer to complete than normal. Resulting total boot time will be approximately three to four minutes. Subsequent Initializations will proceed normally.
7. Run MV-POSView Controller program and select **View, Statistics** to verify that system is successfully upgraded. Note software revision level.

This completes the upgrade procedure.

Note: The error checking routine performed by the PCS prevents the system from overwriting the current version of firmware until it has error-checked the new version. If the PCS finds a corruption in the new file, it will abort the upgrade procedure and retain the previous version of software.

Appendix E Drawings

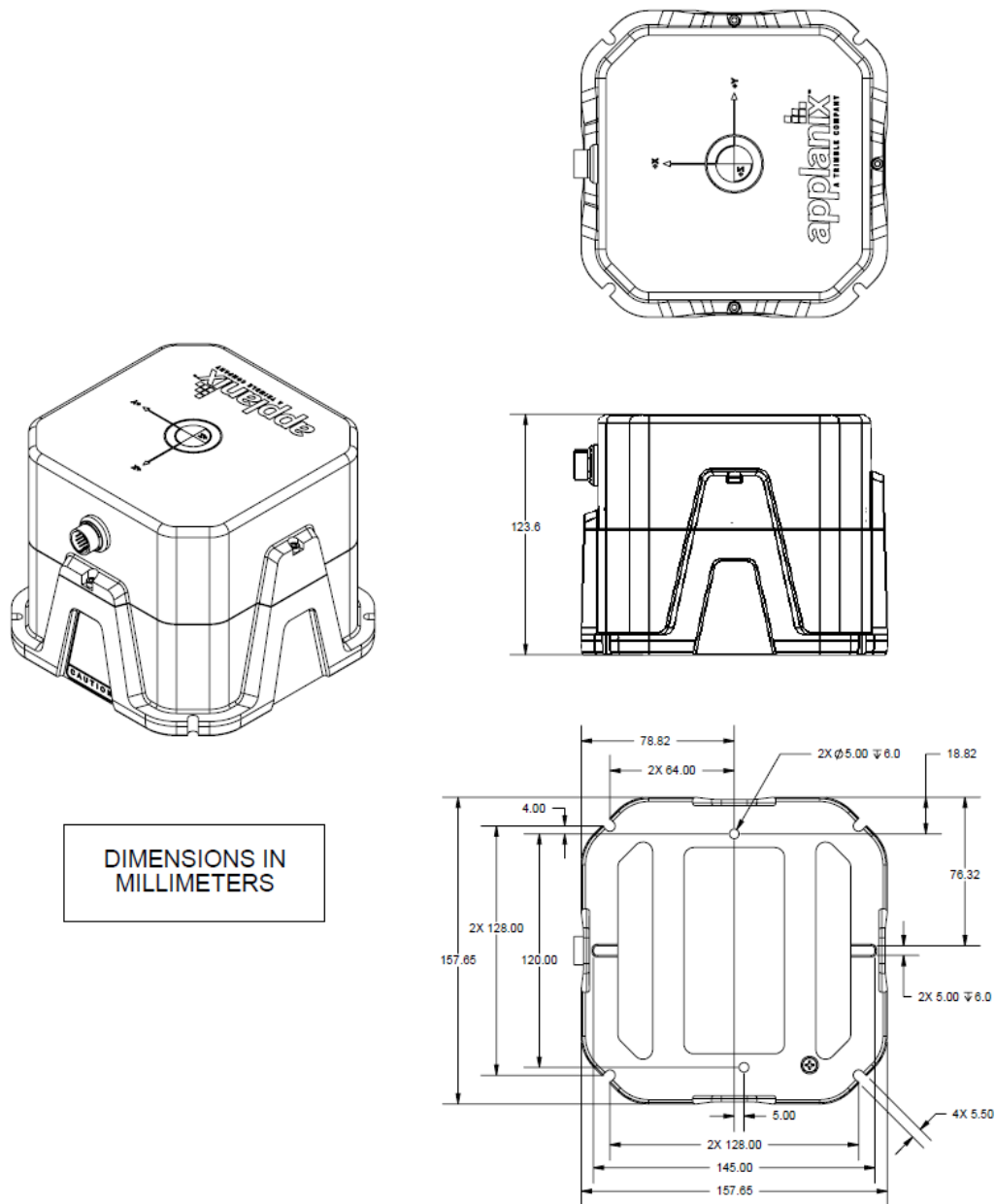


Figure 101 IMU Types 36, 37, 42, 64, 67, 82 and 89 Mechanical Interface

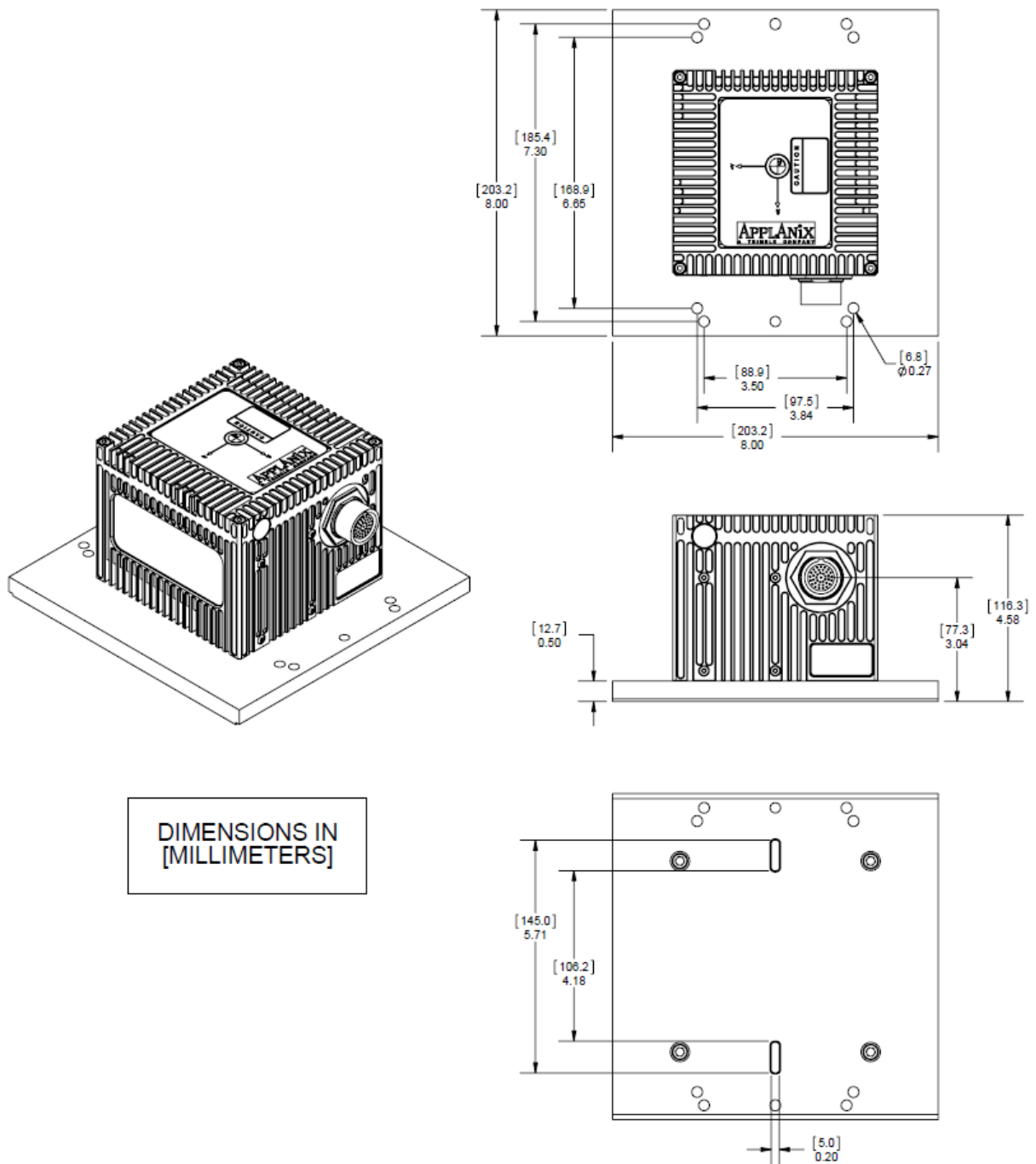
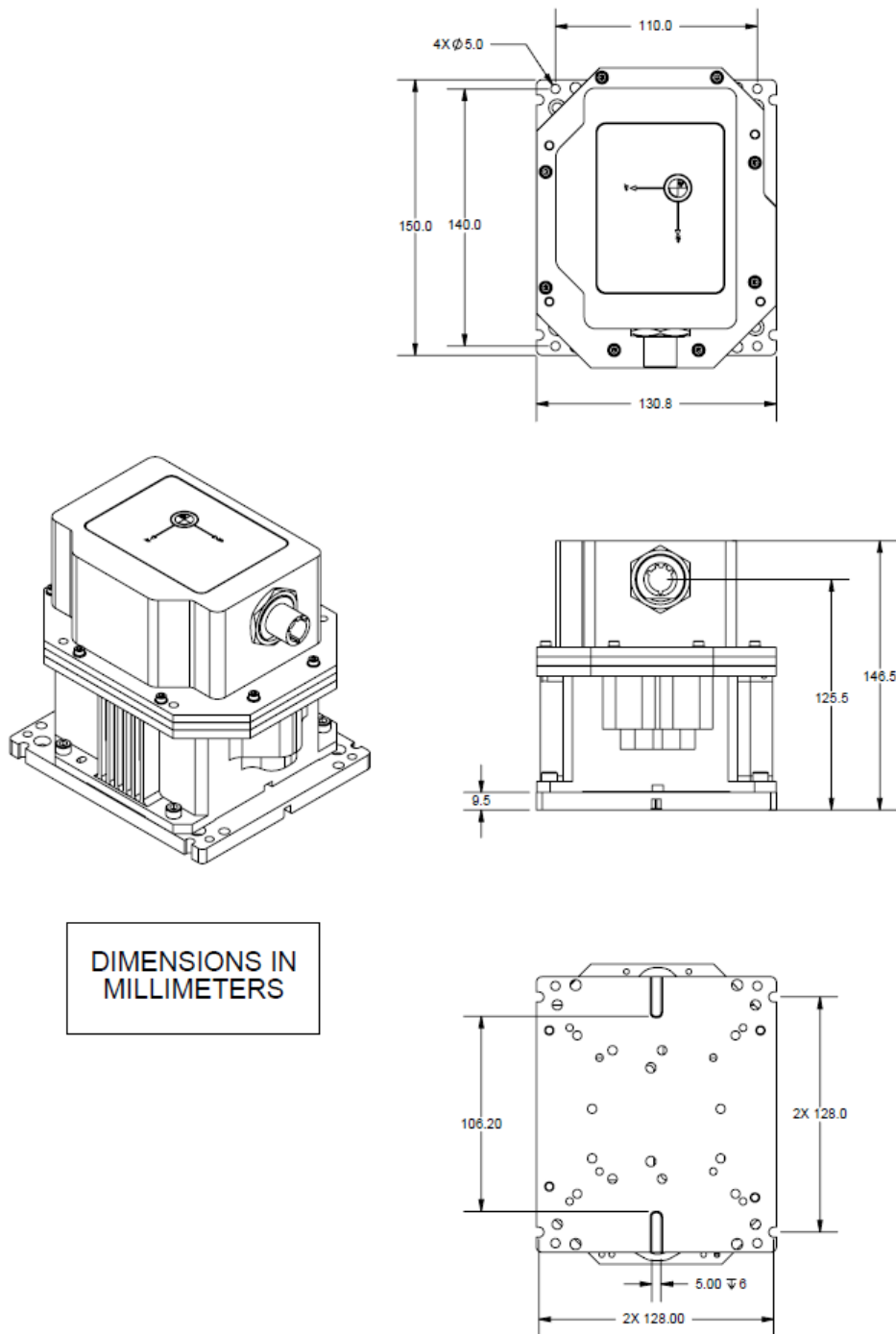


Figure 102 IMU Type 26 Mechanical Interface



IMU shown with adaptor plate 10004691. Contact Applanix for additional information.

Figure 103 IMU Type 31 and 40 Mechanical Interface

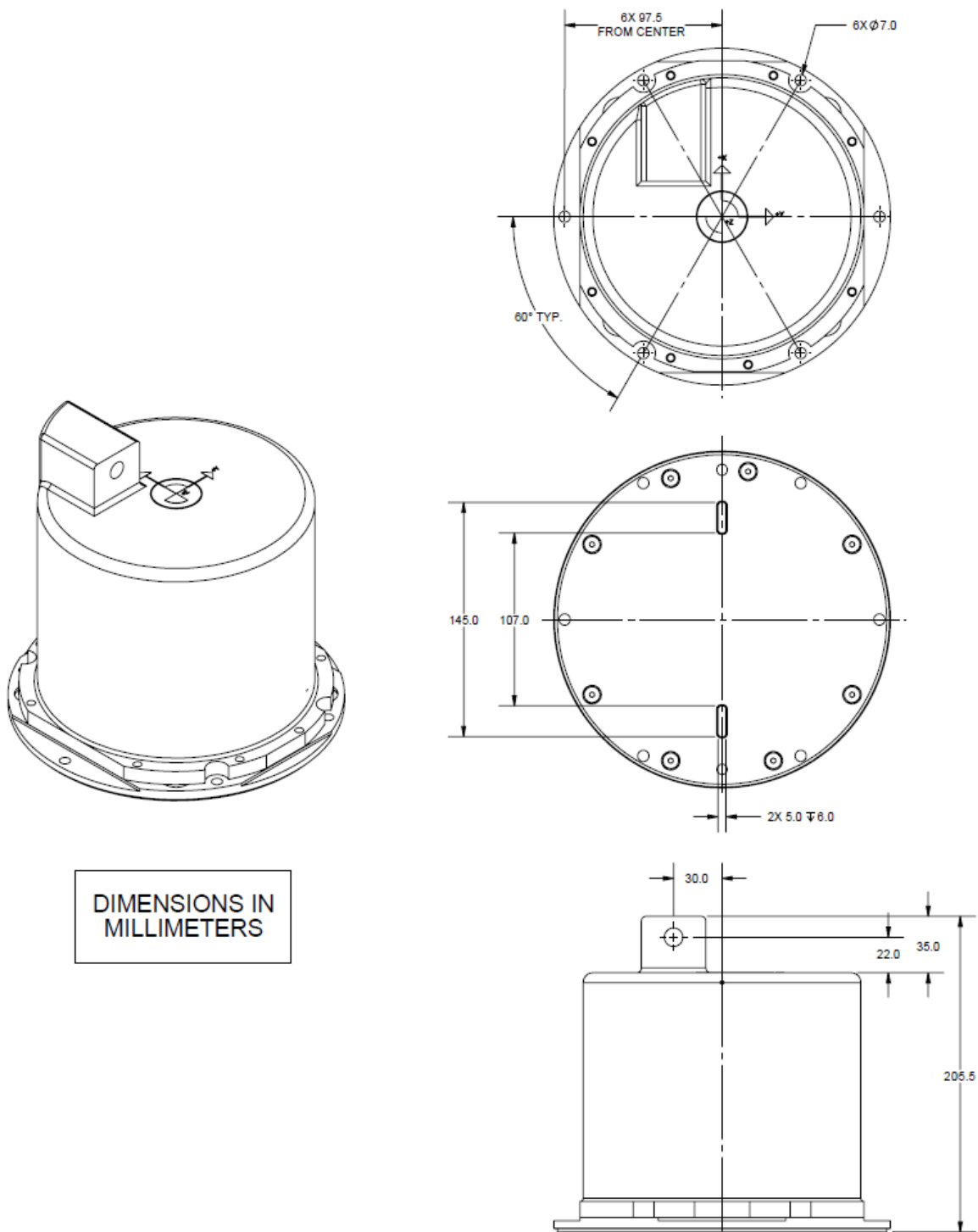


Figure 104: IMU Type 38 and 39 Mechanical Interface

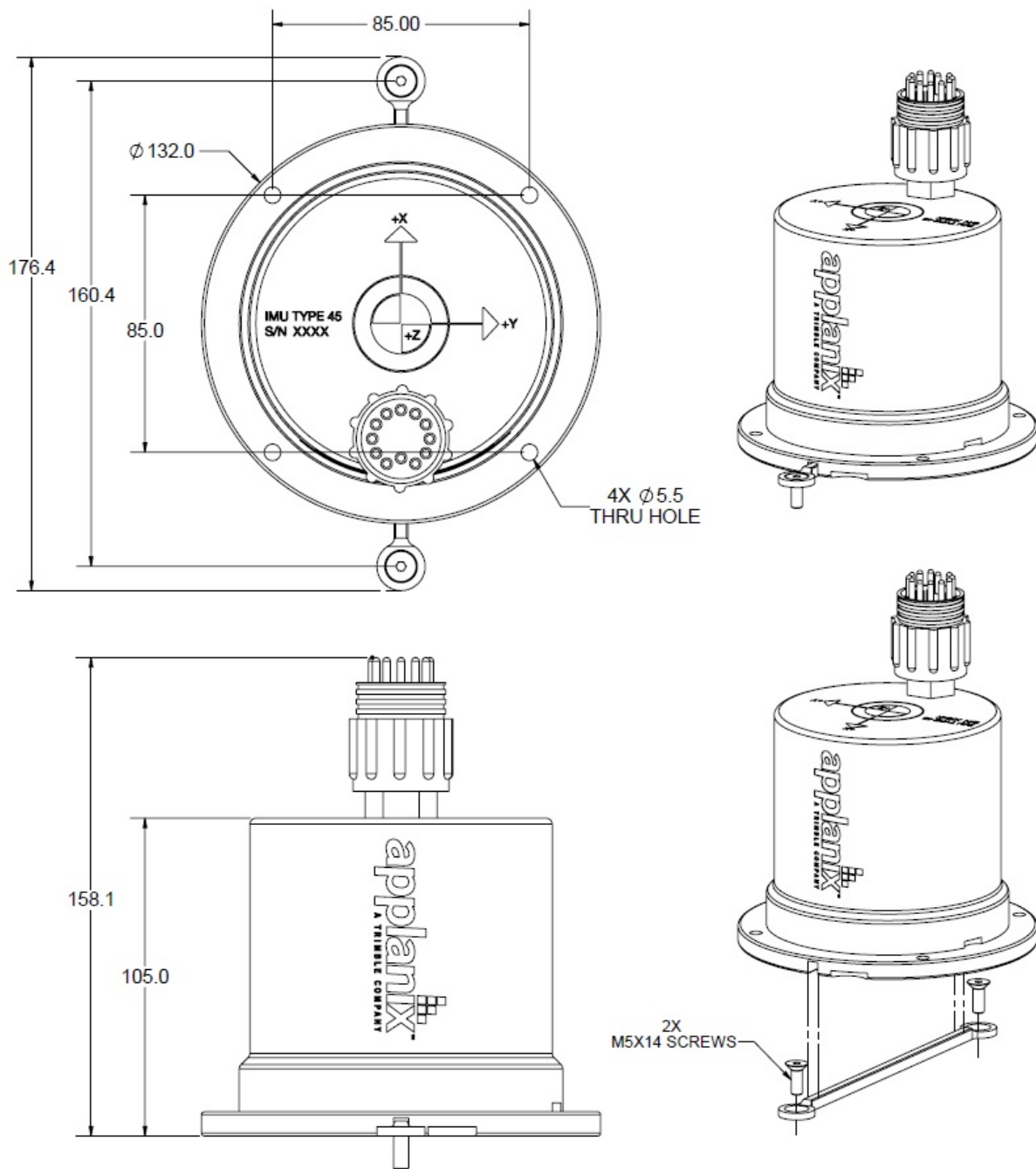


Figure 105: IMU Type 45, 65, 68, 82T and 89T Mechanical Interface

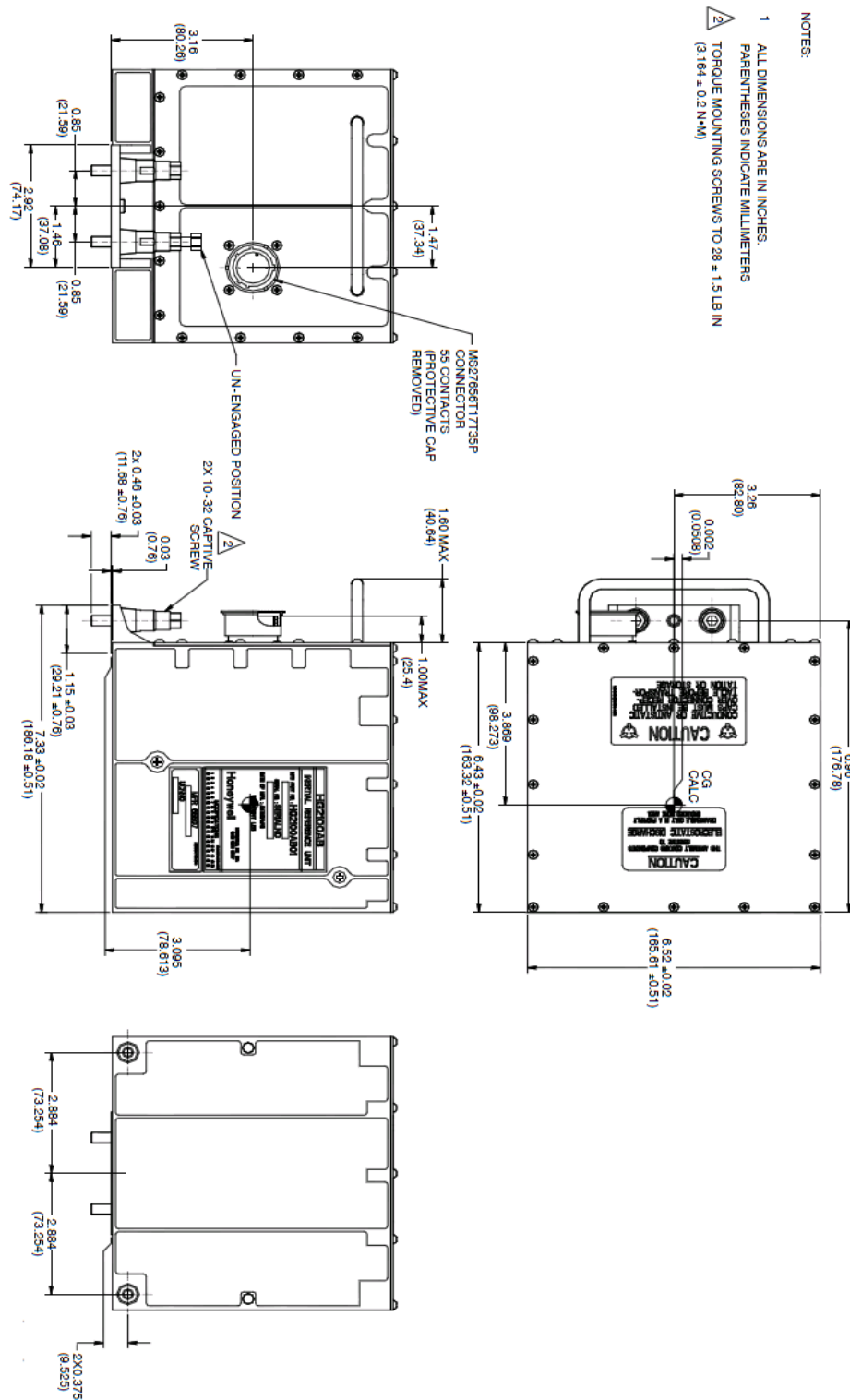


Figure 106: IMU Type 21 Mechanical Interface

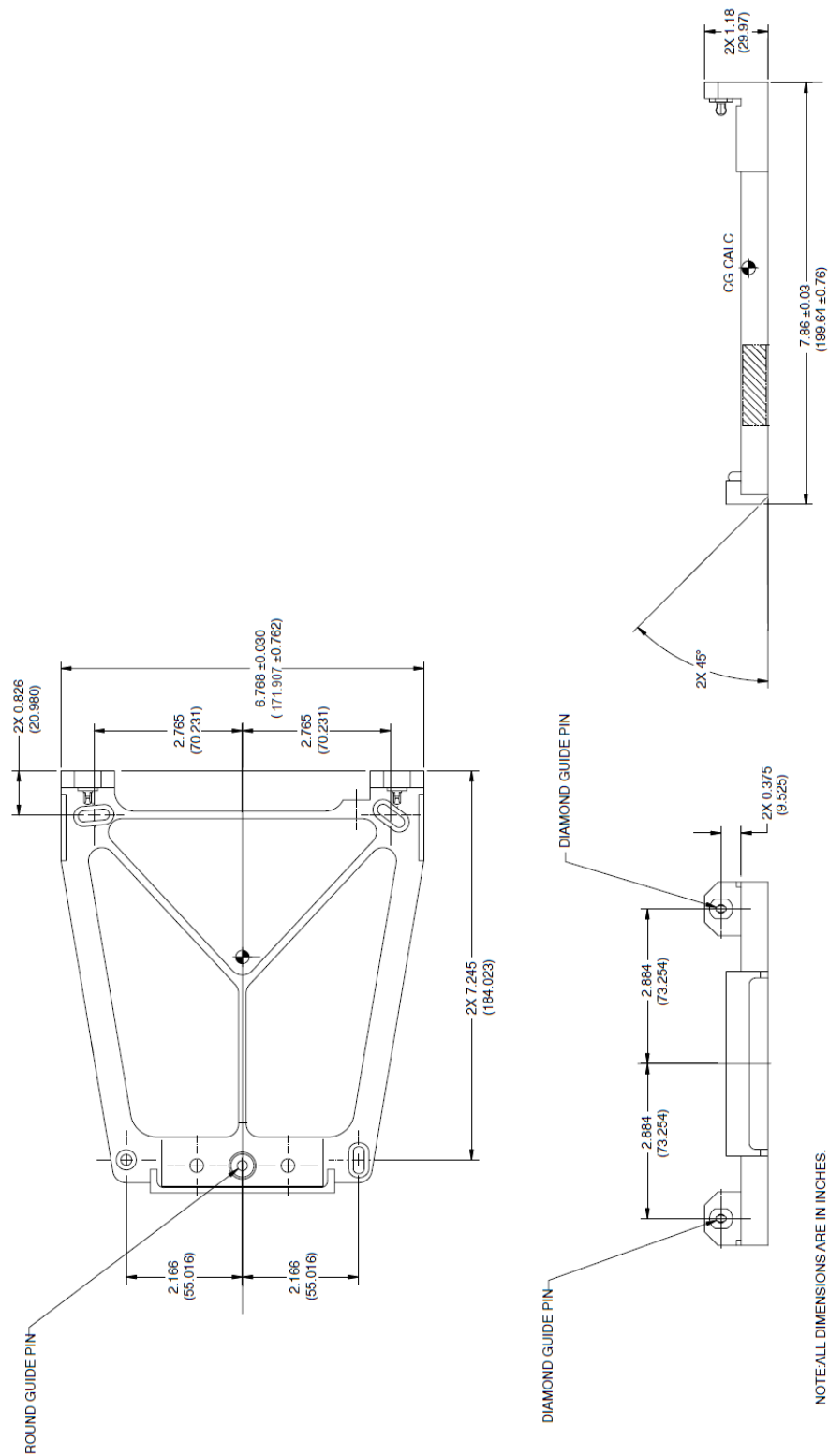


Figure 107: IMU Type 21 Mounting Tray

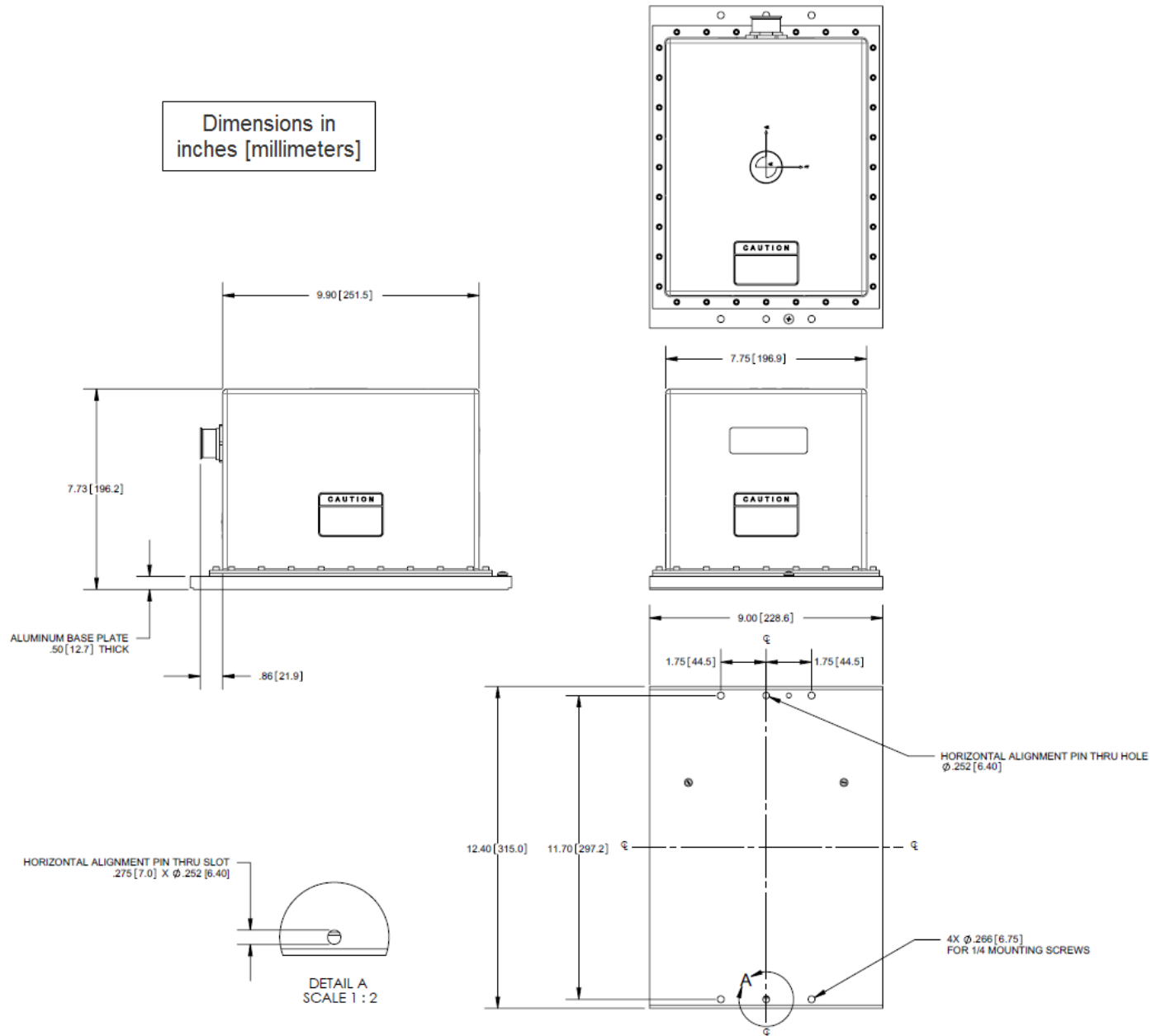


Figure 108: IMU Type 33 Mechanical Interface

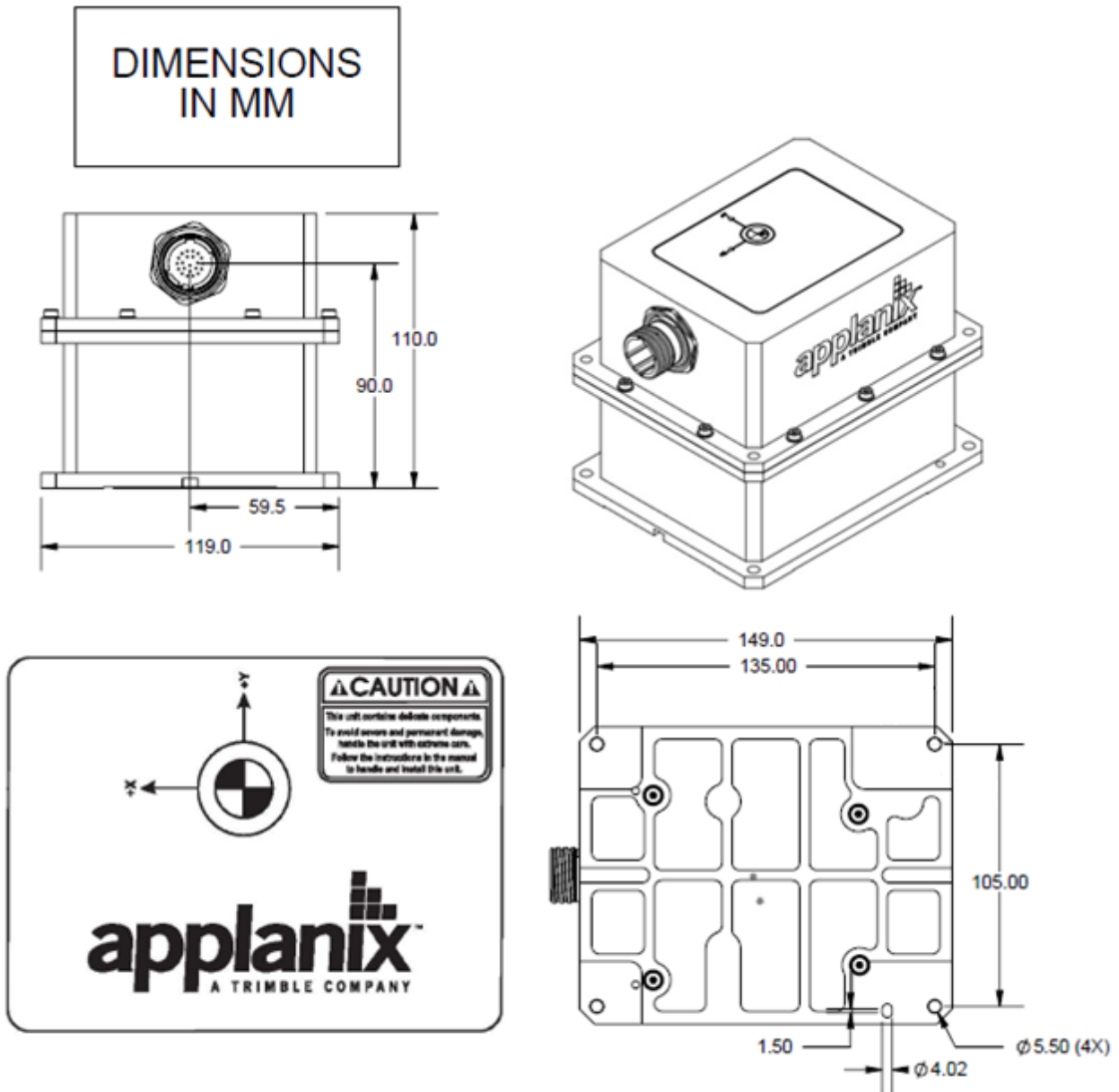


Figure 109: IMU Type 52 Mechanical Interface

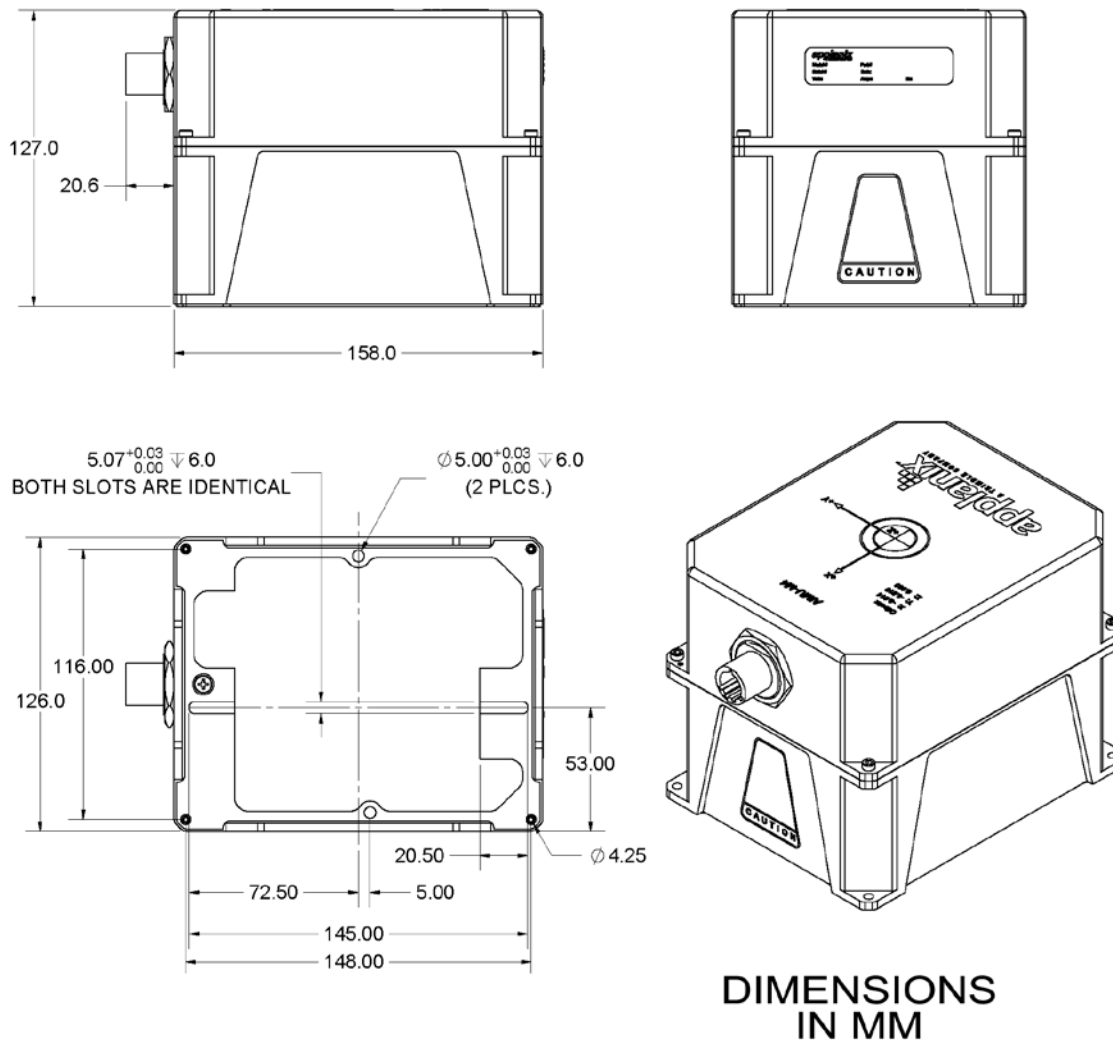


Figure 110: IMU Type 44 and 57 Mechanical Interface

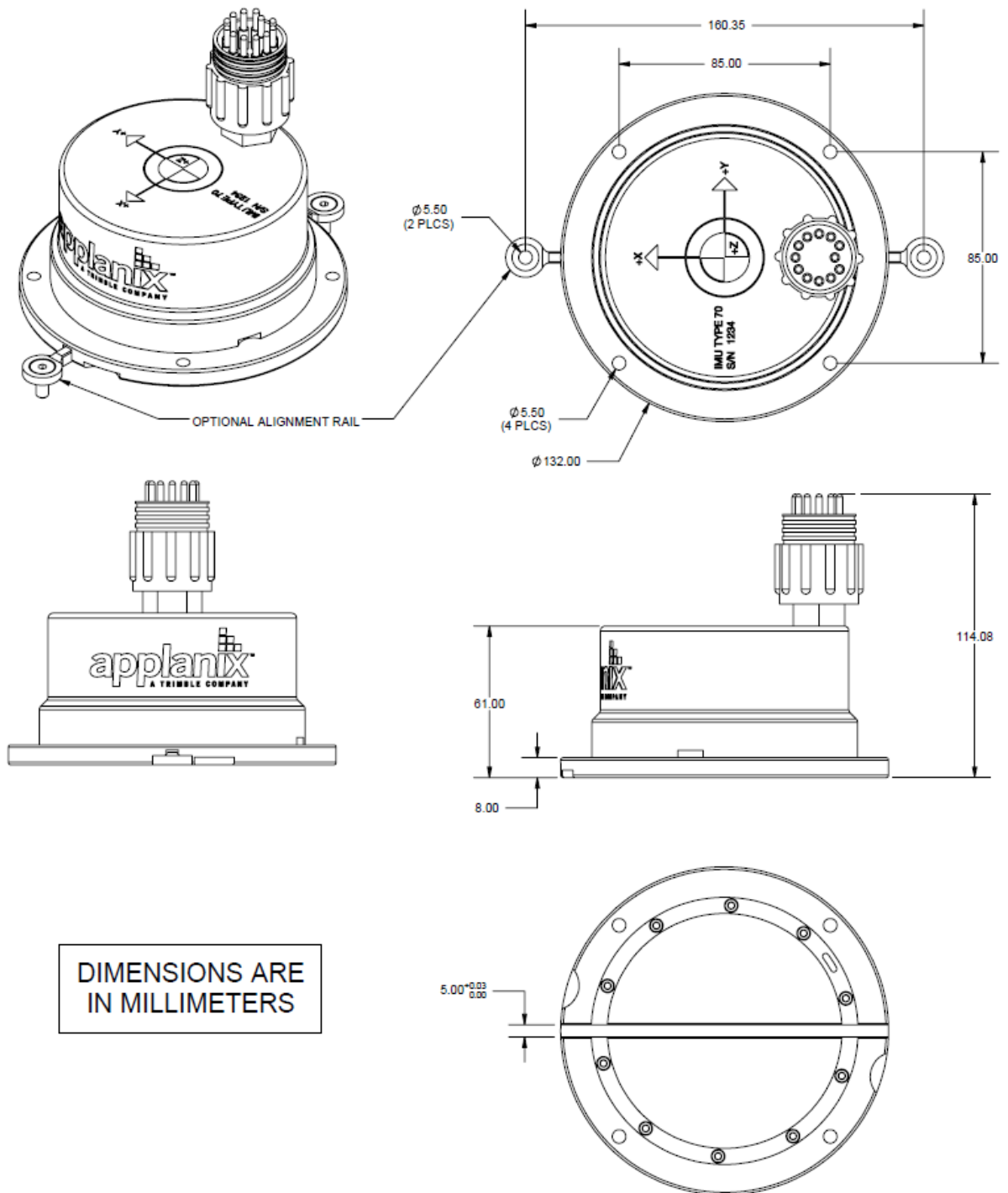


Figure 111: IMU Type 70 Mechanical Interface



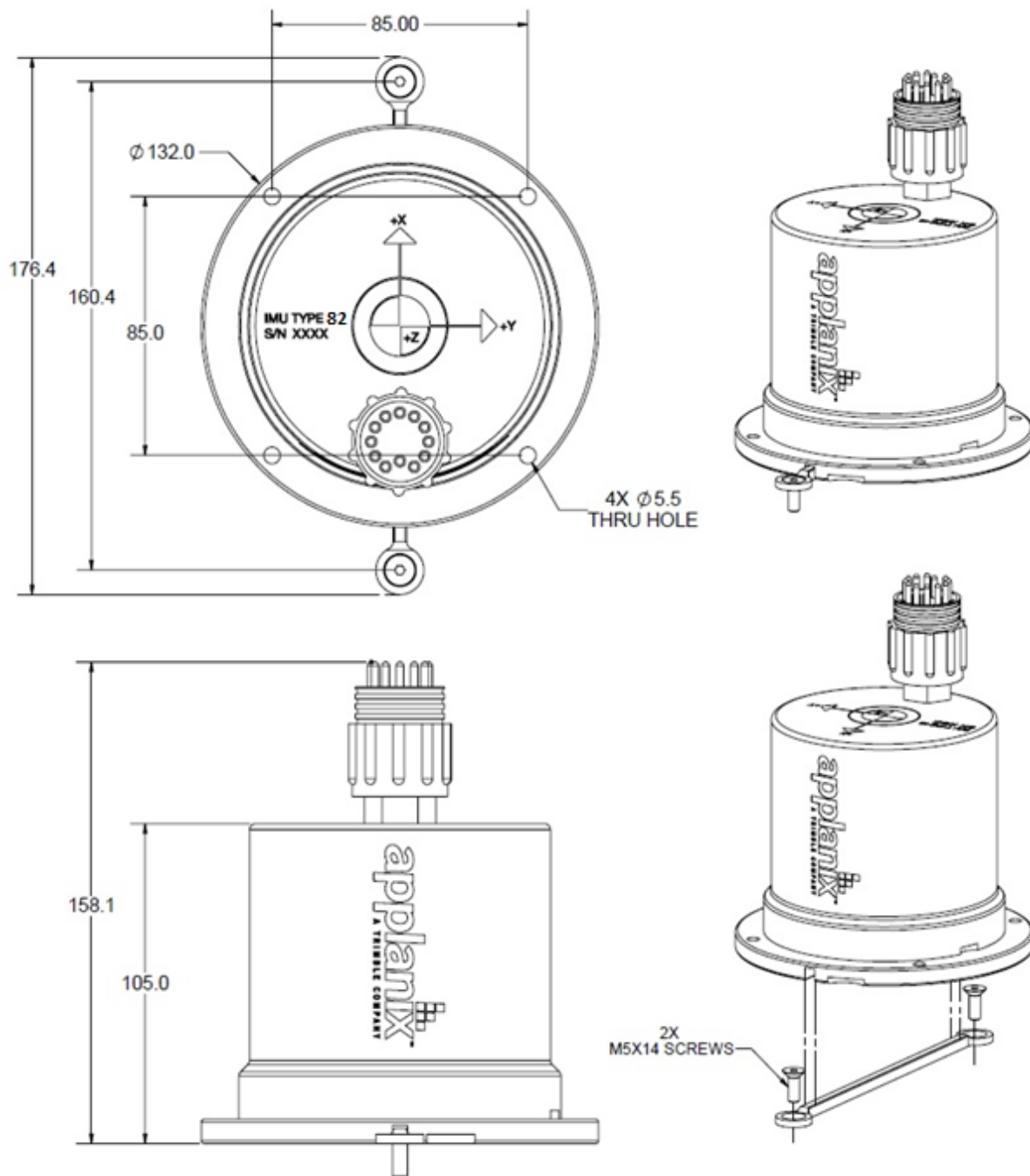


Figure 113: IMU Top-Hat Type 109 Drawing

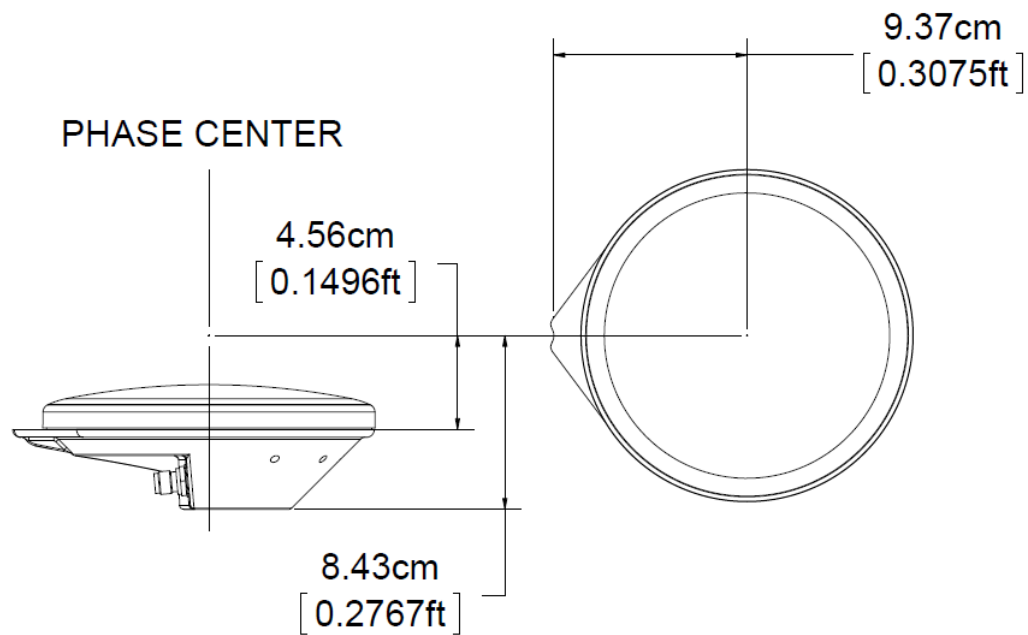
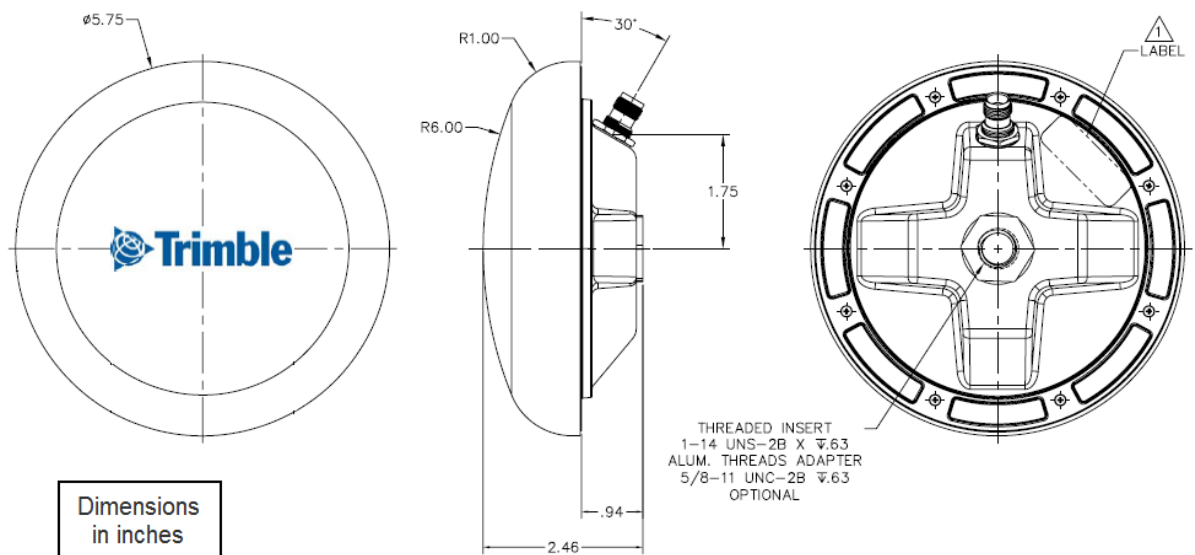
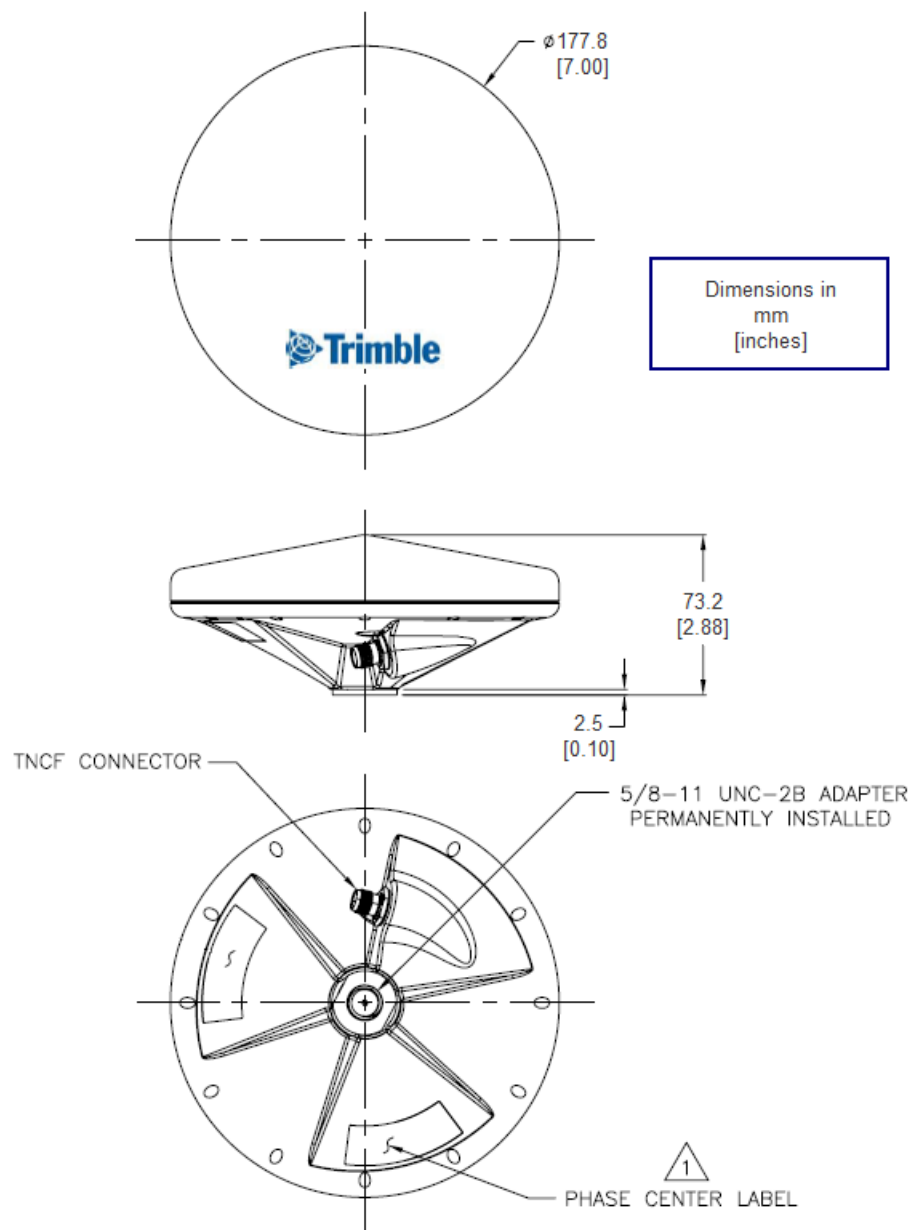


Figure 114: Trimble Zephyr II GNSS Antenna Footprint



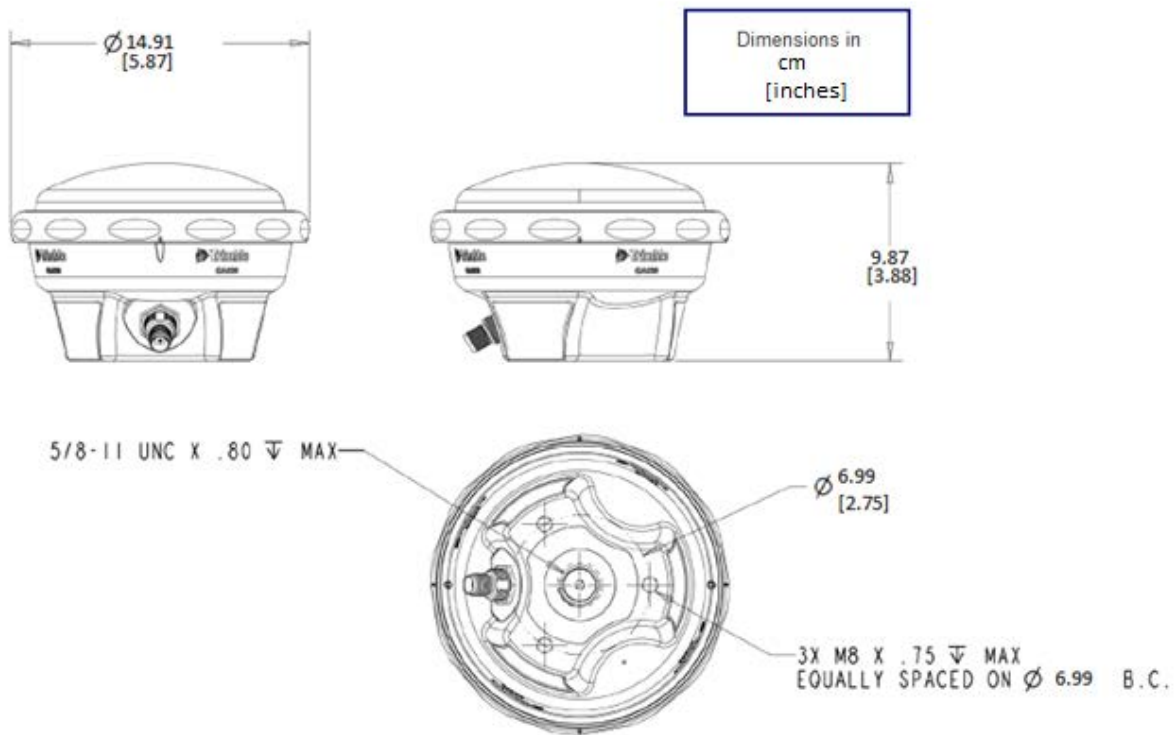
Phase centre is 66 mm above bottom of mounting thread.

Figure 115: Trimble 382AP GNSS Antenna Footprint



Note: Phase center is 58 mm above the base of the antenna.

Figure 116: Trimble 540AP GNSS Antenna Footprint



Phase centre is 8.85 cm above bottom of mounting thread.

Figure 117: Trimble GA830 GNSS Antenna Footprint

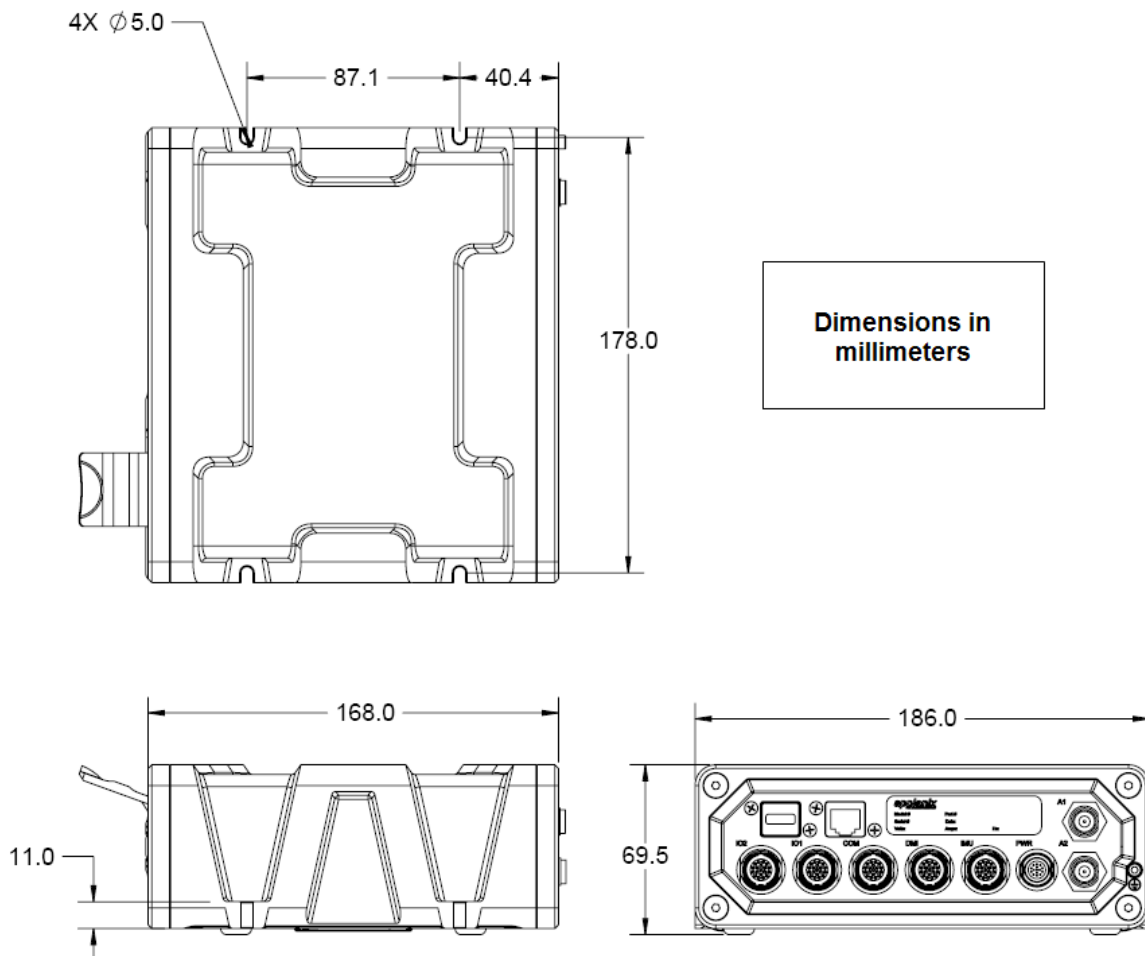


Figure 118: PCS Footprint – POS MV V5-1

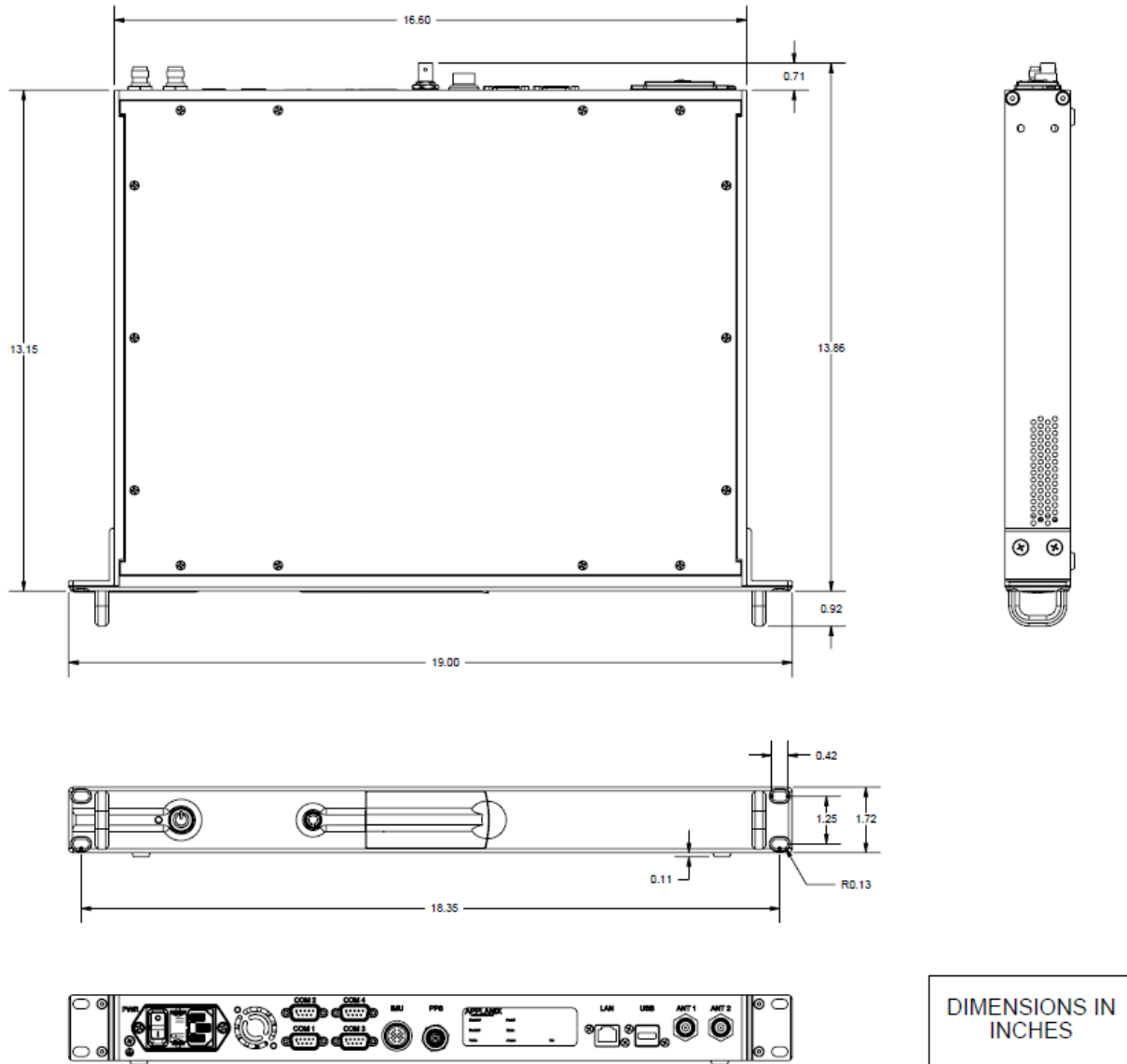


Figure 119: PCS-80 Footprint - POS MV V5

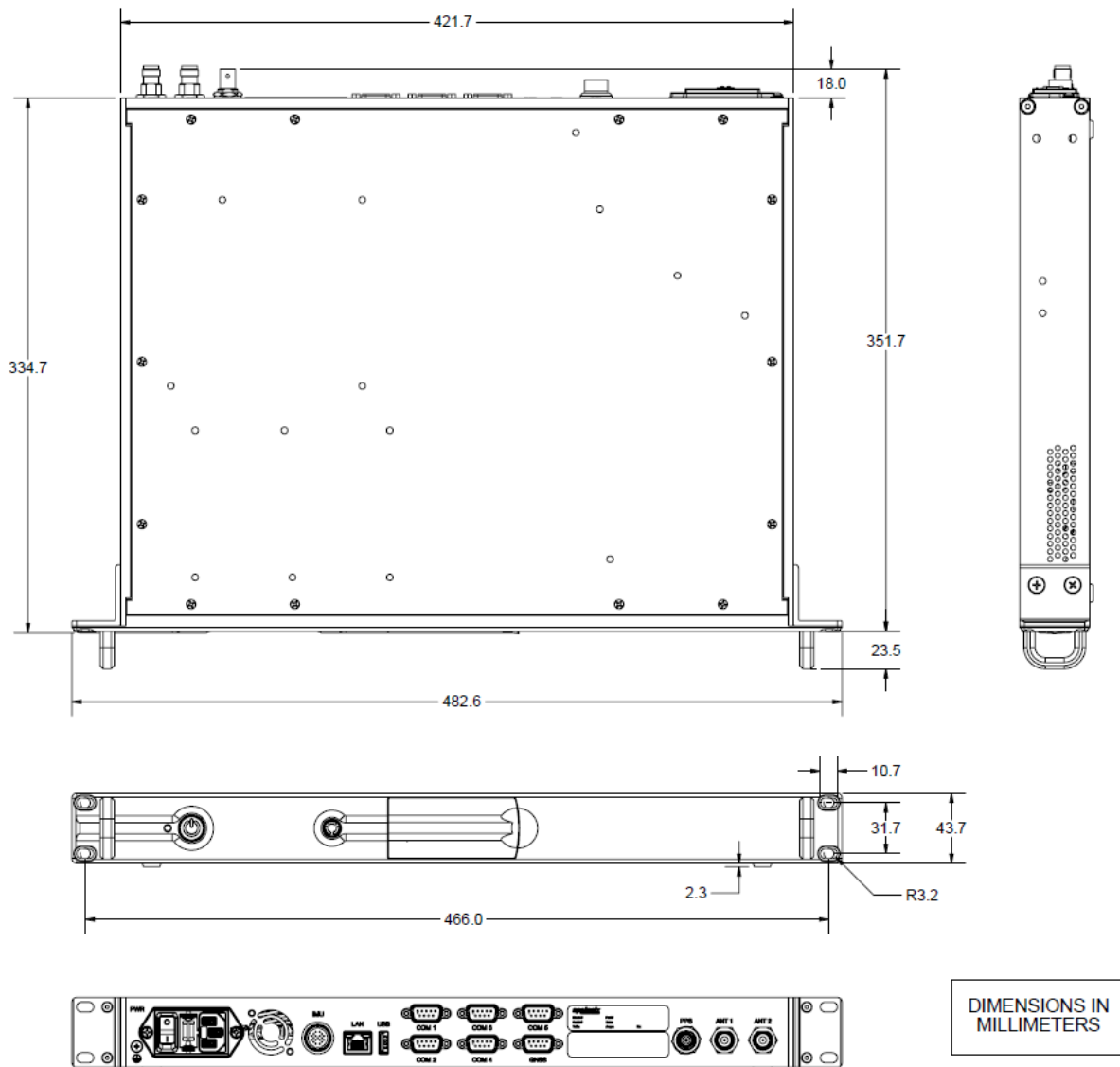


Figure 120: PCS-84 and PCS-100 Footprint - POS MV V5

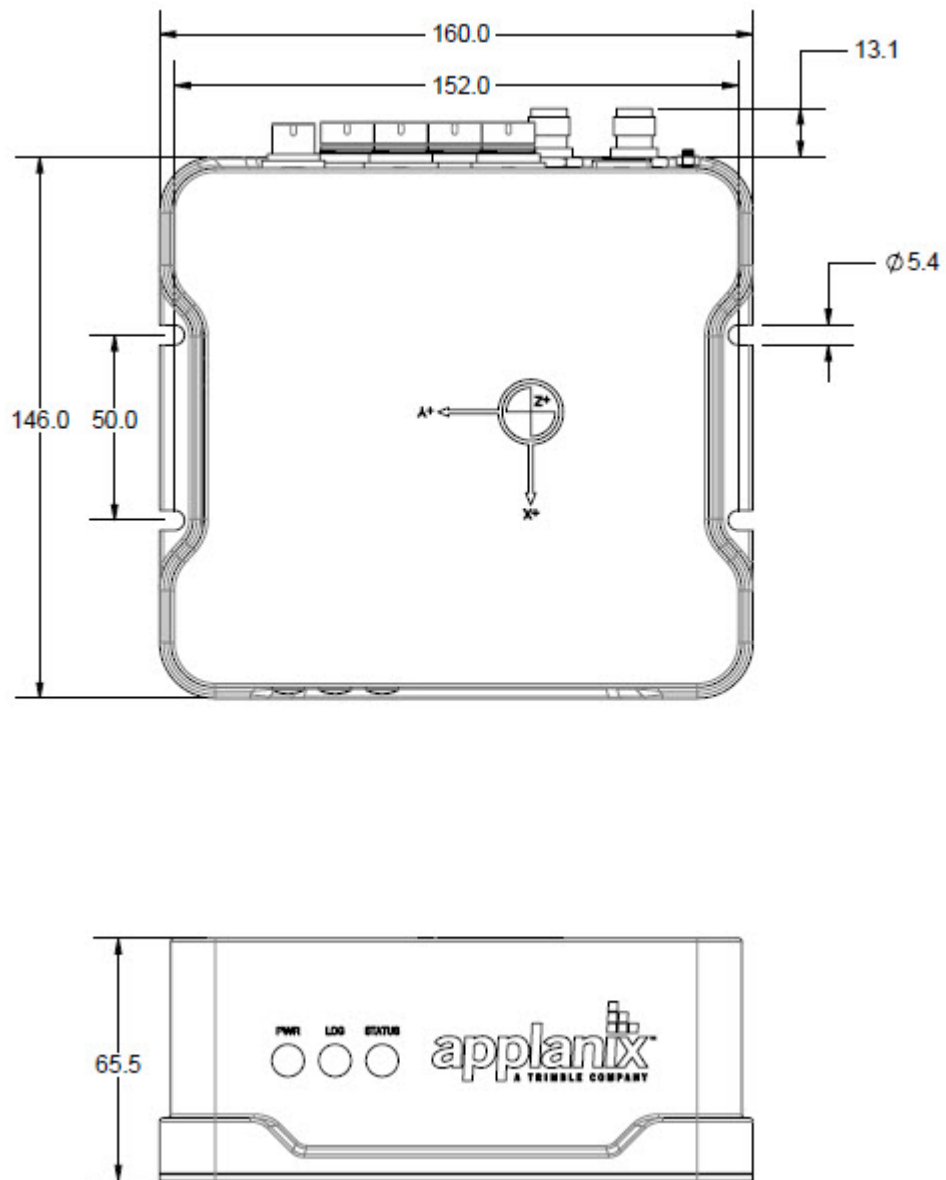


Figure 121: PCS-92 Footprint - POS MV V5-2

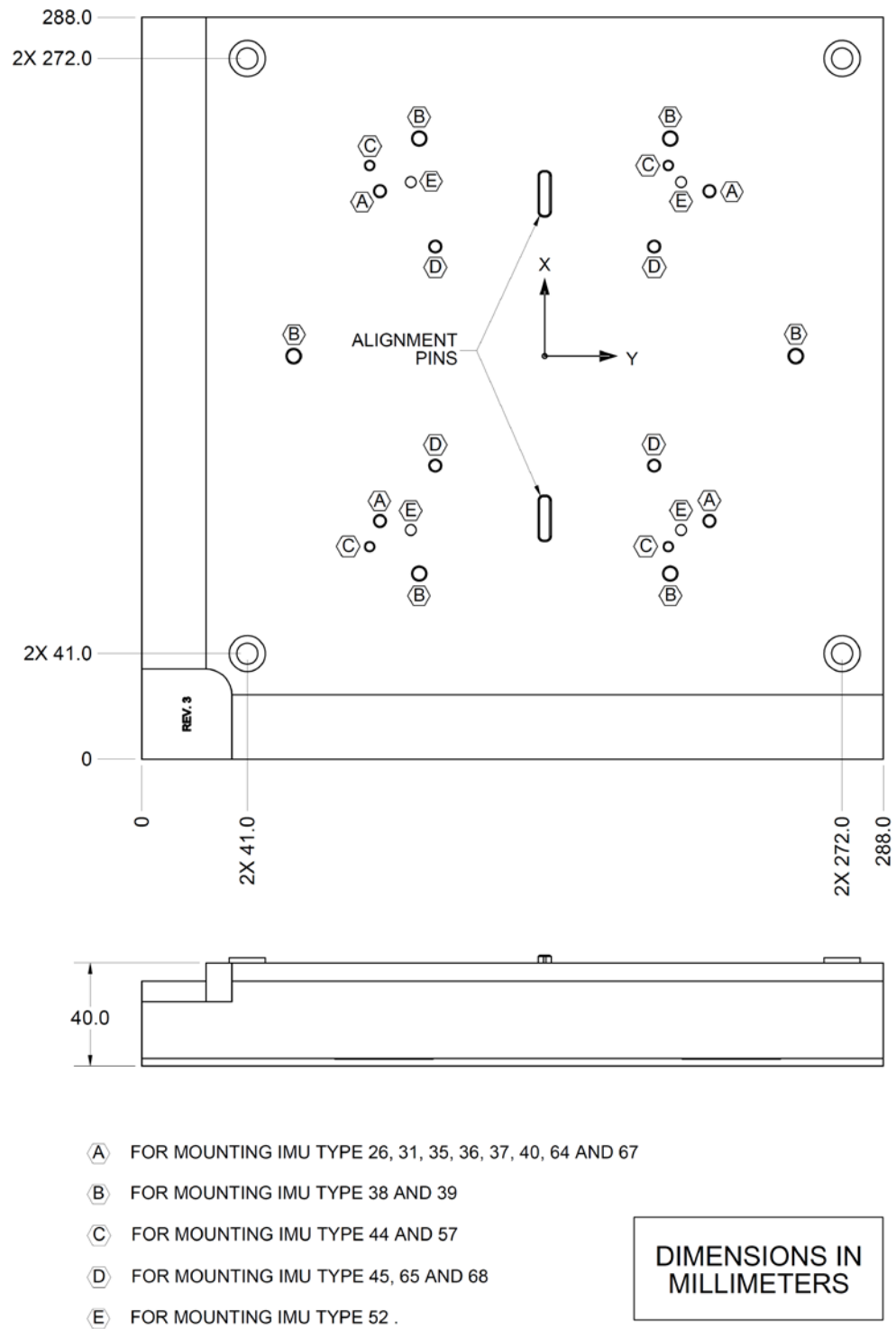


Figure 122: IMU Mounting Plate

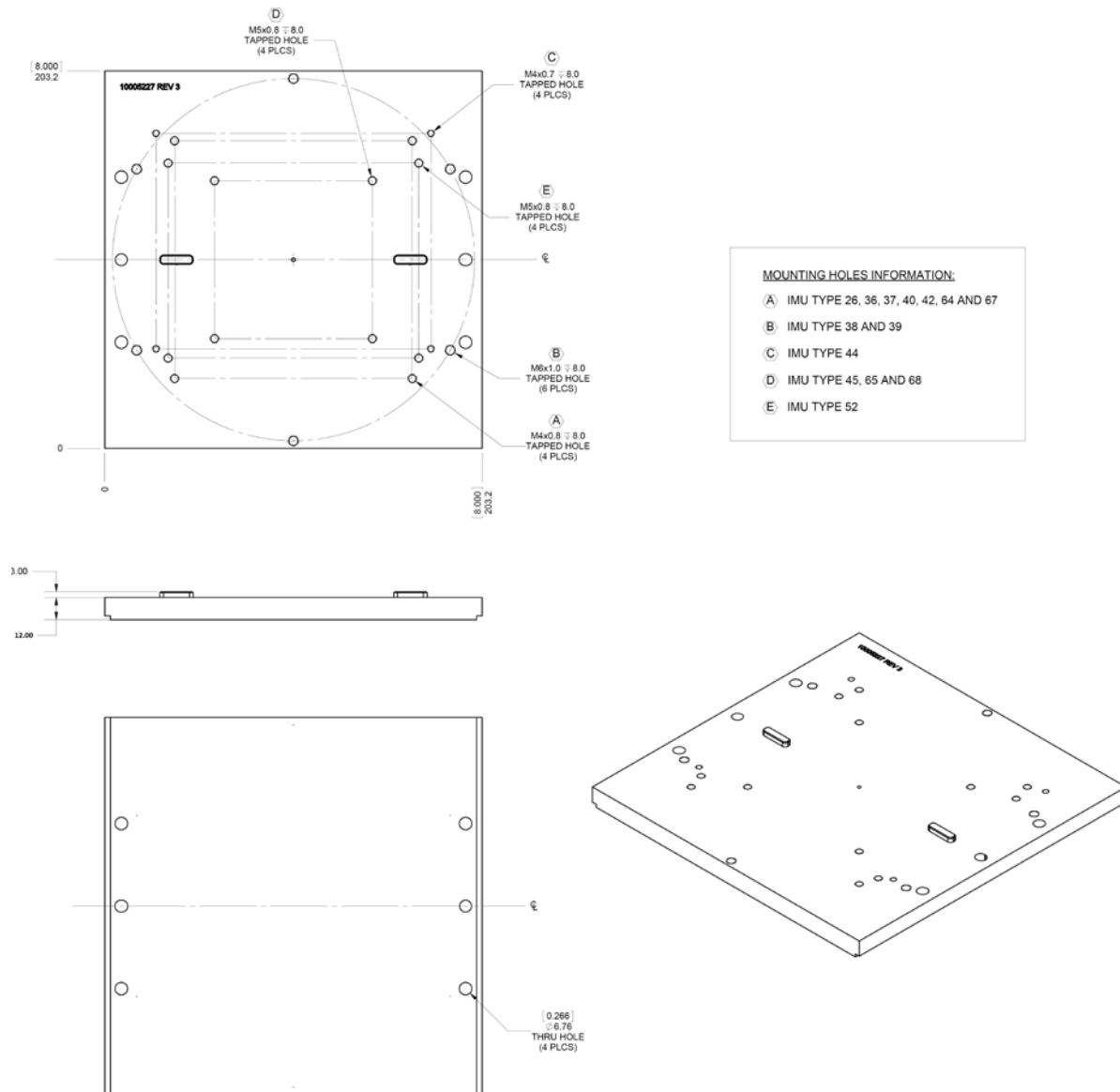


Figure 123: IMU Adaptor Plate V4-V5

Appendix F Patch Test

This appendix suggests a simple procedure for performing a patch test to remove any residual errors in the POS MV mount angle configuration. You should perform a patch test before you use POS MV data for survey purposes.

Note: The calibration procedures explained in this appendix provide generic guidance only.

Note: Specific survey sonar may require different procedures, or individual survey companies may set their own patch test procedures. You should follow the instructions in this appendix only if there are no preferred procedures already in force.

Survey Area

To complete the calibration operations detailed in this appendix successfully, the vessel should perform a series of survey lines and manoeuvres over an area of seabed that conforms closely to the following requirements:

1. There should be two distinct regions:
 - A region where the seabed is flat and level
 - A region immediately adjacent where the seabed slopes at a relatively steep angle (greater than 10°)

Figure 121 shows an ideal survey calibration area.

2. Ideally, the survey calibration area should also include a readily identifiable target object at a fixed position on the seabed. This could be a rock, a wreck or any other relatively small structure.
3. The survey calibration area should be sufficiently large so that the survey vessel can manoeuvre freely within its boundaries and can perform a series of straight survey lines approximately 300 to 500 metres long.

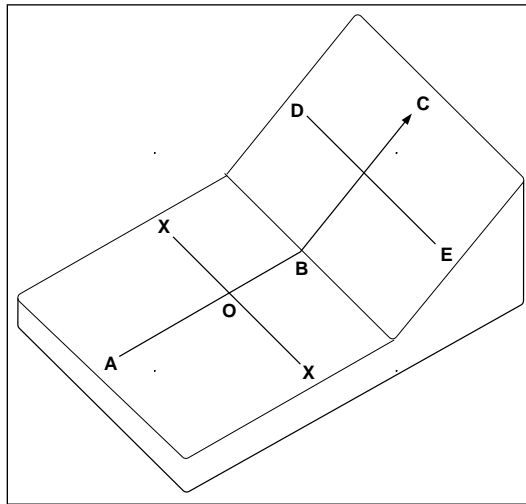


Figure 124: Ideal Survey Calibration Area

Calibration

The procedure outlined in this appendix includes a calibration check on the following parameters. Perform the following:

- Roll measurement
- Position time delay
- Gyrocompass heading
- Pitch measurement

Roll Calibration

Complete the gyrocompass calibration routine and remove any offset that may exist.

1. Sail a line to survey the flat region of the test area (A to B of Figure 121 on page F-2).
2. Turn through 180° and sail a reciprocal course along the same line. Log this line separately from the first survey line.
3. Use the multibeam software and select a single point along both survey lines (point O of Figure 121 on page F-2). Examine the profile of the seabed perpendicular to the course of the vessel at this point (the line X–X of Figure 121 on page F-2) and confirm that both survey lines show the same seabed profile. They should be substantially coincident as shown in Figure 122 on page F-3. If they are not (as shown in Figure 123 on page F-3), this indicates that there is a constant steady state roll offset in the mounting angles. Use the multibeam software to compensate for this offset.

4. Repeat the above survey tests to confirm that any adjustments you make to the multibeam software have removed the roll offset.
5. As a final check, perform a similar survey following the line D–E in Figure 121 on page F-2. At the end of the survey line, turn through 180° and repeat the survey line E–D, logging both lines separately. Check that the profiles from both survey lines coincide where they cross the line B–C.

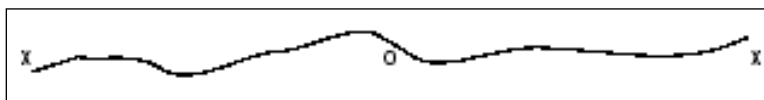


Figure 125: Correct Roll Calibration

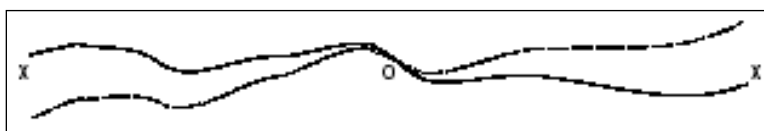


Figure 126: Incorrect Roll Calibration

Position Time Delay

1. Complete a sound velocity profile for the multibeam sonar and correct any errors that may exist.
2. Set a vessel speed of 4 knots and sail a straight line that crosses the flat and the sloping regions of the test area (line A–C in Figure 121 on page F-2). Repeat the line on a reciprocal heading and at the same speed. Log both lines separately.
3. Increase the vessel speed to 8 knots and repeat both lines. Log both lines separately.
4. Compare the two lines surveyed in the same direction but at different speeds. Any offset that appears on the seabed chart between the two runs arises from a position time delay. Use the multibeam software to correct any such error.
5. Now compare the two lines that run in opposite directions but at the same speed. Any offset that appears on the seabed chart between these two runs arises from a pitch offset in the mounting angles. Use the multibeam software to correct any such error.
6. Finally, repeat the survey lines to verify that you have removed all offsets successfully.

Gyrocompass Heading

Harbour Calibration

Ideally, you should perform the gyrocompass calibration while the vessel is in a harbour:

1. Power-on the POS MV and allow it to settle in accordance with instructions supplied by the manufacturer.

2. With the vessel tied alongside use survey techniques to determine the precise heading against a known landmark. Record this value together with the heading displayed by the gyrocompass.
3. Turn the vessel through 180° and again measure the precise heading of the vessel. Record this value together with the heading displayed by the POS MV.
4. Note any offsets that may exist between the two values for surveyed heading and the corresponding values for gyrocompass heading. Follow the instructions supplied by the sonar manufacturer to configure the system with these gyrocompass offset values.

Sea Calibration

You can use the following procedure to calibrate the gyrocompass at sea. However, this method is inherently less accurate than the preferred method detailed above and you should use it only where there are no alternatives.

1. Sail a straight course while making a calibration survey chart of the seabed. Observe the position of a target object on the chart which, ideally, should occur at about the halfway point of the survey line.
2. At the end of the first survey line, turn the vessel through 180° and repeat the survey line in the opposite direction. Again, note the position of the target object.
3. Any gyrocompass offset will appear as an apparent shift in the position of the target on the seabed.

Survey Procedure

Each operator is likely to have a standard procedure that you should follow when performing a multibeam survey. Similarly, the manufacturer of the multibeam system is likely to have a set of specific instructions detailing how to configure and use their system within such a survey. You should give precedence to any existing instructions and operating procedures over the procedures outlined in this appendix.

Generally, the following procedures should be included as part of any multibeam survey:

1. Verify the sound velocity profile.
2. Even if the system was previously calibrated, the first and the last survey lines should be sailed in both directions to enable a post-processing calibration check.
3. Finally, an extra line should be sailed perpendicular to the other survey lines. This allows detection of any changes in sound velocity or tidal action during post-processing.

Appendix G IP68 Connector Handling

Handling Instructions

- The connector should not be exposed to long term heat or sunshine.
- If this occurs, and the connectors are very dry, soak in fresh water before use.
- Ensure the connectors are lubricated - the recommended lubricant is Loctite 8021 as a spray or Molykote 44 Medium as a paste - use either sparingly.
- Any accumulation of sand or mud in the female contact should be removed with fresh water. Spraying or the application of grease could damage the the female seals; see Figure 124.
- Do not over tighten the bulkhead nuts
- Do not disconnect by pulling on the cable and avoid sharp bends at cable entry.
- When disconnecting, pull straight, not at an angle. Ensure the above points are fulfilled to get the best out of your connectors. If in doubt, please contact Applanix.

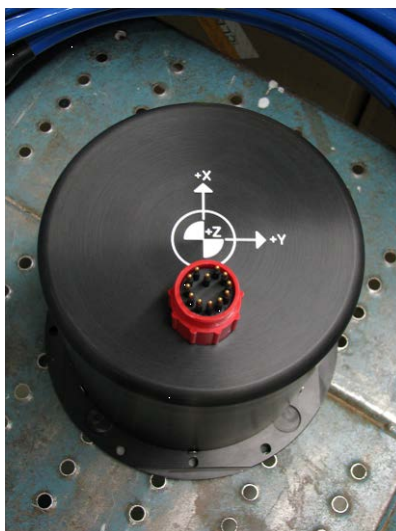


Figure 127: IP68 Connector

Appendix H 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. Local time differs from UTC by the number of hours for your time zone (plus local PC clock errors).
- UTC, 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.

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

Date	GPS to UTC Offset (sec)	Date	TAI to UTC Offset (sec)
Jan 1, 1988	5	Jan 1, 1988	24
Jan 1, 1990	6	Jan 1, 1990	25
Jan 1, 1991	7	Jan 1, 1991	26
Jul 1, 1992	8	Jul 1, 1992	27
Jul 1, 1993	9	Jul 1, 1993	28
Jul 1, 1994	10	Jul 1, 1994	29
Jan 1, 1996	11	Jan 1, 1996	30
Jul 1, 1997	12	Jul 1, 1997	31
Jan 1, 1999	13	Jan 1, 1999	32
Jan 1, 2006	14	Jan 1, 2006	33
Jan 1, 2009	15	Jan 1, 2009	34
Jul 1, 2012	16	Jul 1, 2012	35
Jul 1, 2015	17	Jul 1, 2015	36
Dec 30, 2016	18	Dec 30, 2016	37

Notes:

1. GPS and TAI are ahead of UTC time, see Figure 125.

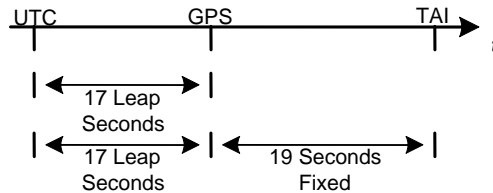


Figure 128: GPS, TAI and UTC Time

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

GNSS 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 GNSS 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 GNSS 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 GNSS 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 GNSS 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 GNSS system and the GNSS 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 GNSS system is continuously adjusted to null out timing errors.

Output Characteristics

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

Time Message

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

POS System Timing

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

Internal POS Timing

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

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

The **Events** pane on the main POSView window, see page 5-6, displays the Universal Time, Coordinated (UTC) time of the most recent PPS pulse transmitted by the primary GNSS receiver. The Count field for PPS indicates the total number of signals recorded from the GNSS receiver.

Synchronizing External Equipment to POS

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



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

The PPS pulse is present at the rear panel IO connectors and is configurable for pulse width and polarity from the POSView **Settings – Events** window. Figure 126 shows the parameters of the 1PPS signal.

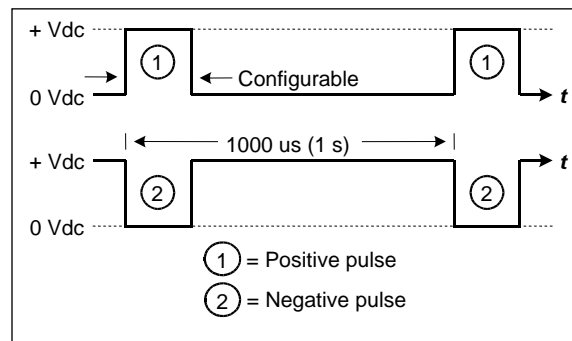


Figure 129: 1PPS Signal Characteristics

The time messages corresponding to PPS can be configured to be output on any COM port. All the various 1PPS time message outputs provide the time of the previous 1PPS signal except the UTCT

format which provides the time of the next 1PPS signal. PPS time is available from POS in either a NMEA message (ZDA or PPS) or Binary output message (PPS or TM1B). Refer to COM Ports starting on page 3-1 for message format details.

Synchronizing POS to External Equipment

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

To synchronize POS with external equipment time (User Time), the external equipment must read and record the 1PPS signal from POS and transmit its User Time to POS on the Ethernet port. Refer to the description of the Ethernet Connector on page 2-21.

'Message 55 - User Time Recovery' (Table 40) is extracted from Applanix document *PUBS-ICD-004089*. 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 any time at a maximum rate of once per second.

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

Table 41: 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	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
User PPS time	8	Double	[0,) default = 0.0	seconds
User Time conversion factor	8	Double	[0,) default = 1.0	•/seconds
Pad	2	Short	0	N/A
Checksum	2	Ushort	N/A	N/A
Message end	2	Char	\$#	N/A

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

Time Tagging of Output Data

POS formats data into ICD groups as described in *PUBS-MAN-004089*. The ICD groups are output in real-time on the Display Port and Data Port, are logged on the removable media and internal flash drive and are output on the Ethernet logging port. Which groups are output on which port are under user control.

All ICD groups have the same basic structure as shown in Table 41 (extracted from Applanix document *PUBS-ICD-004089*). The selections of the time and distance types are made from the POSView **Settings** – **Installation – Tags, Multipath & Autostart** window. To ensure the POS data are useful for post-processing using POSpac, set Time Tag 1 to UTC time.

Table 42: Common ICD Group Structure

Item	Bytes	Format	Value	Units
Group start	4	Char	\$GRP	N/A
Group ID	2	Ushort	Group specific	N/A
Byte count	2	Ushort	Group specific	bytes
Time 1	8	Double	N/A	sec
Time 2	8	Double	N/A	sec
Distance tag	8	Double	N/A	m
Time types	1	Byte	<u>Time 1 Select Value: bits 0-3</u> Time 1: POS time 0 Time 1: GPS time 1 (default) Time 1: UTC time 2 <u>Time 2 Select Value: bits 4-7</u> 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	<u>Distance select Value</u> N/A 0 POS distance 1 (default) DMI distance 2	
Group specific data fields				
Pad	0-3	Byte	0	N/A
Checksum	2	Ushort	N/A	N/A
Group end	2	Char	\$#	N/A

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

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

Event Time Tagging

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

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

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

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:

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

ASCII

American Standard Code for Information Interchange. A code in which each alphanumeric character is represented as a number from 0 to 127, translated into a 7-bit binary code for the computer.

Attitude

Attitude determination is the process of estimating the orientation of a vehicle (space, air, marine or land) by using known reference points and vehicle attitude. Vehicle attitude sensors supply roll, pitch, and yaw data to a computer for processing with navigational data (reference points).

Baseline Vector

X, Y and Z components of the displacement from the Primary to secondary GNSS antenna phase centre. The baseline vector is resolved in the Vehicle body frame.

Baud Rate

Baud Rate, in computer science, is commonly a reference to the speed at which a modem can transmit data. Often incorrectly assumed to indicate the number of bits per second (bps) transmitted, baud rate actually measures the number of events, or signal changes, that occur in one second. Because one event can actually encode more than one bit in high-speed digital communications, baud rate and bits per second are not always synonymous, and the latter is the more accurate term to apply to modems. For example, a so-called 9600-baud modem that encodes four bits per event actually operates at 2400 baud but transmits 9600 bits per second (2400 events times 4 bits per event) and thus should be called a 9600 bps modem.

Bit

The smallest element of computer storage, the bit is a single digit in a binary number (0 or 1). Groups of bits make up storage units in the computer, called "characters," "bytes," or "words," which are

manipulated as a group. The most common is the byte, made up of eight bits and equivalent to one alphanumeric character.

Bits are widely used as a measurement for transmission. Ten megabits (Mb) per second means that ten million pulses are transmitted every second. Measurements for storage devices such as disks, files and databases are given in bytes rather than bits.

Byte

The common unit of computer storage from micro to mainframe, the byte is made up of eight binary digits (bits). A ninth bit may be used in the memory circuits as a parity bit for error checking. The term was originally coined to mean the smallest addressable group of bits in a computer (has not always been eight).

C/A

The coarse/acquisition or clear/acquisition code modulated onto the GNSS L1 signal. This code is a sequence of 1023 pseudorandom binary bi-phase modulations on the GNSS 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".

Control Port

Accessed via the LAN connector, the Control Port is designed to receive and acknowledge setup and control commands from MV-POSView Controller. The Control port is not a physical port. Rather, it is a subset of the Ethernet Interface.

Data Port

Accessed via the LAN connector, the Data Port is designed to broadcast high rate navigation and raw sensor data. The Data port is not a physical port. Rather, it is a subset of the Ethernet Interface.

DGNSS

Differential GNSS. A technique used to improve positioning or navigation accuracy by determining the positioning error at a known location and subsequently incorporating a corrective factor (by real-time transmission of corrections or by post-processing) into the position calculations of another receiver operating in the same area and simultaneously tracking the same satellites.

Dilution of Precision

Dilution of Precision (DOP) is a dimensionless number that accounts for the purely geometric contribution of the position of the satellites to the uncertainty in a position fix. Standard terms for the GNSS application are: GDOP-Geometric Dilution of Precision (three position coordinates plus clock offset in the solution); PDOP-Position Dilution of Precision (three coordinates); HDOP-Horizontal Dilution of Precision (two horizontal coordinates); VDOP-Vertical Dilution of Precision (height only); TDOP-Time Dilution of Precision (clock offset only); RDOP-Relative Dilution of Precision (normalized to 60 seconds).

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 MV-POSView Controller. The display port is not a physical port; it is a subset of the Ethernet Interface.

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} .

GNSS

Global Navigation Satellite System. A constellation of 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.

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.

NMEA

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

Point of Validity

The Point of Validity defines the geographical location to which a particular set of data applies.

Post-Processing

Non real-time navigation solution computation from previously collected and recorded raw sensor data.

Pound

The pound (avoirdupois) or international pound is the mass unit defined as exactly 0.45359237 kilograms (or 453.59237 grams). It is part of the avoirdupois system of mass units. There are 16 ounces in a pound (avoirdupois). The pound is equal to exactly 7000 grains, where a grain is officially defined as exactly 0.06479891 gram. The legal definition of the pound in the United Kingdom and Canada are the same as in the United States, and were unified to their current value in 1960.

PPS Mode

Precise Positioning Service capable GNSS 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 GNSS second.

Pseudo-range

A GNSS distance measurement that has not been corrected for differences in synchronization between the satellite and receiver clocks.

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.

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

Coordinated Universal Time is a precise atomic time system, offset from GPS Time by an integer number of seconds. Also known as Greenwich Mean Time (GMT).

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