
POS MV V4 Installation and Operation Guide

Congratulations on your purchase of a POS MV system.

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

PUBS-MAN-000047

Revision 1

General Notice

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This manual describes the POS MV™ 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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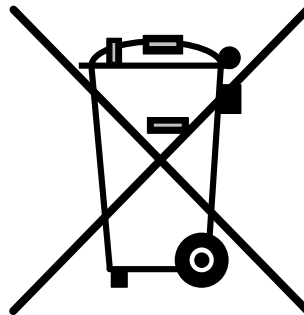
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For Our European Union Customers A New Recycling Program

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

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



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

About This Document







Text Conventions

The following text conventions are used in this manual:

- Emphasize a term - italic font (e.g. “An *Inertial Frame* is a”)
- Referring to another manual, or to a file name - italic font (e.g. “read *Power Requirements*” or “locate the *start.exe* file”)
- Referring to a placard label - regular font (e.g. “the COM connector”)
- Referring to a window label - bold font (e.g. “select the **Add, Remove Programs** from”)
- Path statement - bold font (e.g. “select directory **C:\My Computer\Working Files**”)
- Menu statement - bold font (e.g. “select **Insert, AutoText, Closing** window menu”)
- 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

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References

PUBS-MAN-000050, Remote Analog Unit User Guide

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List of Abbreviations, Synonyms and Symbols

°	Degree (plane angle)
°C	Degree Celsius
°F	Degree Fahrenheit
µs	Microsecond
A	Ampere
ac	Alternating Current
ASCII	American Standard Code for Information Interchange
att	Attitude
BNC	Bayonet Neil-Concelman (British Naval Connector)
bps	Bits Per Second
C/A	Coarse Acquisition
CD	Compact Disk
CD-ROM	Compact Disk - Read Only Memory
cg	Centre of Gravity
cm	Centimetre
CPU	Central Processing Unit
CTS	Clear to Send
DAC	Digital to Analog Converter
dB	Decibel
dc	Direct Current
DCM	Direction Cosine Matrix

deg	Degree (plane angle)
DGPS	Differential Global Positioning System
dia	Diameter
DIN	Deutsche Industrinorm
DIO	Data I/O
DOP	Dilution of Position
dpi	Dots Per Inch
EMI	Electromagnetic Interference
ERR	Error
ESD	Electrostatic Discharge
FDIR	Fault Detection, Isolation and Reconfiguration
FOG	Fibre Optic Gyro
FOM	Figure of Merit
ft	Foot
FTP	File Transfer Protocol
g	Gravity (acceleration due to gravity)
GAMS	GPS Azimuth Measurement Subsystem
GB	Gigabyte
GMT	Greenwich Mean Time
GND	Ground
gnd	Ground
GPS	Global Positioning 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
ISA	Industry Standard Architecture
kb	Kilobit
kB	Kilobyte
kbps	Kilobits Per Second
kHz	Kilohertz
LAN	Local Area Network
lat	Latitude
lb	Pound (weight)
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LOF	List of Figures
long	Longitude
LWH	Length, Width, Height
m	Metre

mA	Milliampere
Mb	Megabit
MB	Megabyte
MHz	Megahertz
min	Minute (time interval)
mm	Millimetre
mPOS	Mini POS
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
PCI	Peripheral Component Interconnect
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
PPS	Precise Positioning Service
pwr	Power

QC	Quality Control
qty	Quantity
rad	Radian
RAM	Random Access Memory
RAU	Remote Analog Unit
rcvr	Receiver
RD	Receive Data
REF	Drawing Reference Designation
RFI	Radio Frequency Interference
RH	Relative Humidity
RMS	Root Mean Square
ROM	Read Only Memory
RTCM	Radio Technical Commission for Maritime Services
RTK	Real-Time Kinematic
RTS	Ready to Sent
RU	Rack Unit (see U)
RX	Receive Data
s	Second (time interval)
SAE	Society of Automotive Engineers
SCSI	Small Computer System Interface
SDRAM	Synchronous Dynamic Random Access Memory
SGRAM	Synchronous Graphics Random Access Memory
SNR	Signal-To-Noise Ratio
SOSR	Sum of Squared Residuals
Std	Standard

SV	Space Vehicle
sync	Synchronous
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TDM	Time Division Multiplex
TNC	Threaded-Neill-Concelman (Threaded Navy Connector)
TOV	Time of Validity
TR	Terminal Ready
TTL	Transistor-Transistor Logic
U	Rack Unit (see RU)
UDP	Universal Datagram Protocol
UNC	Unified National Coarse
UPS	Uninterrupted Power Supply
UTC	Universal Time Coordinated (or Coordinated Universal Time)
UTP	Unshielded Twisted Pair
TX	Transmit Data
Vac	Volt Alternating Current
Vdc	Volt Direct Current
VDOP	Vertical Dilution of Precision
W	Watt

POS MV V4 Installation and Operation Guide

Introduction

1.0 Introduction

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

This manual contains full installation and operating instructions and is an important part of POS MV. 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.

Manual Contents

For your convenience, this manual includes several sections, each of which describes specific features of POS MV:

Note: Read sections one to three before you attempt to install POS MV.

Section 1.0: Contains introductory notes and describes POS MV and its subsystems.

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Section 2.0: Describes the physical and electrical installation of POS MV. This section also explains how to select the best location to install the Inertial Measurement Unit (IMU).

Section 3.0: Explains the data formats for each of the interface ports located on the rear panel of the POS Computer System (PCS).

Note: Read sections four to seven before you use POS MV.

Section 4.0: Describes how to power-on and configure the POS MV after you have installed it.

Section 5.0: Describes how to operate the POS MV during a survey.

Section 6.0: Describes how to operate the POS MV TrueHeave feature.

Section 7.0: Provides detailed specifications for the POS MV.

Note: Read sections eight and nine if POS MV fails to operate normally due to a suspected fault condition:

Section 8.0: Describes the diagnostic functions available from POS MV and suggests some basic maintenance procedures.

Section 9.0 Describes the function of the various PCS components and suggests procedures to help you identify, find and clear a suspected fault condition.

Note: For reference, this manual also contains Appendices that provide additional information about POS MV.

Appendix A: Technical support and service instructions.

Appendix B: Includes a simplified theory of operation.

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Appendix C: Provides details of the Applanix training programme available for anyone involved with POS MV.

Appendix D: Explains how to install the MV-POSView Controller software on a PC.

Appendix E: Provides dimensioned mechanical drawings of the POS MV system.

Appendix F: Provides a suggested 'Patch Test' procedure.

Appendix G: Provides an overview of the POS-GPS timing conventions.

This manual uses a number of specialized terms and abbreviations. Refer to the Glossary, located at the end of the Tables of Contents, for an explanation of these terms and abbreviations as used in the context of this manual.

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

System Description and Overview

POS MV consists of a rack mountable POS Computer System (PCS), a separate Inertial Measurement Unit (IMU) and two GPS receivers. Three sensors, the IMU and the two Global Positioning System (GPS) receivers deliver an accurate and comprehensive data set, including:

- Geographic position (latitude, longitude and altitude)
- Heading
- Attitude (roll and pitch)
- Vertical displacement (heave)

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- Velocity
- Acceleration
- Angular rate of turn
- Performance metrics
- Fault detection and reporting

POS MV combines the IMU and GPS sensor data into an integrated navigation solution. There are two navigation algorithm designs incorporated into the system, namely *tightly coupled* and *loosely coupled* inertial/GPS integration. Tightly coupled inertial/GPS integration involves the processing of GPS pseudorange, phase and Doppler observables. In this case, the GPS receiver is strictly a sensor of the GPS observables and the navigation functions in the GPS receiver are not used. With loosely coupled inertial/GPS integration, the GPS 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 GPS signal reception. Previous POS MV systems only employed a loosely coupled integration design. Depending on the availability and relative quality of sensor inputs such as primary GPS, auxiliary GPS and base station GPS 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.

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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 $\pm 0.02^\circ$ 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 POS MV, you can use this program to configure the system and monitor its status during operation.

After you have configured 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

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Area Network (LAN) can receive the data or Transmission Control Protocol (TCP) so that only a single computer can receive the data.

- 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, GPS 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 POS MV with AutoStart enabled.

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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 two GPS receiver cards. The following paragraphs describe these individually and Figure 1 shows these major components.

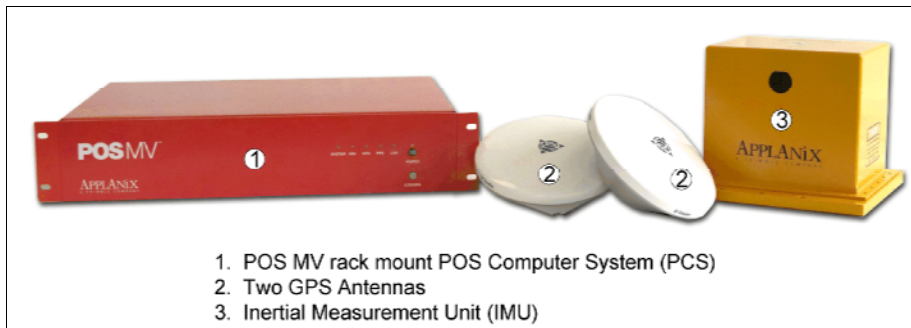


Figure 1: POS MV Components

POS Computer System

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

POS MV V4 Installation and Operation Guide

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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

During manufacture, the IMU housing is purged with nitrogen gas that removes moisture and dust to protect the sensitive electronics. 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 on page B-1 for a more detailed explanation of the POS MV operating theory.

GPS Receivers

POS MV includes two GPS receiver cards:

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

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The system includes two identical antennas with 15 metre (~49 ¼ feet) long connection cables. You must connect each receiver to a GPS antenna to receive GPS signals from the orbiting constellation of satellites.

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

GPS Azimuth Measurement Subsystem

GPS 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 GPS receivers and antennas to determine a GPS-based heading that is accurate to 0.02° or better (using a two-metre [~6 ½ feet] antenna baseline) when blended with the inertial navigation solution. POS MV uses this heading information as aiding data together with the position, velocity and raw observations information supplied by the primary GPS receiver.

GAMS provides heading aiding to 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, the vessel, and the multi-beam transducer. 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.

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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° (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 2-30 to measure the mounting angles of the IMU, vessel and multi-beam transducer relative to the reference frame that you have defined. Refer to the POS MV Configuration description on page 4-11 for instructions to configure POS MV with these important parameters.

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

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Operation without GAMS

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

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

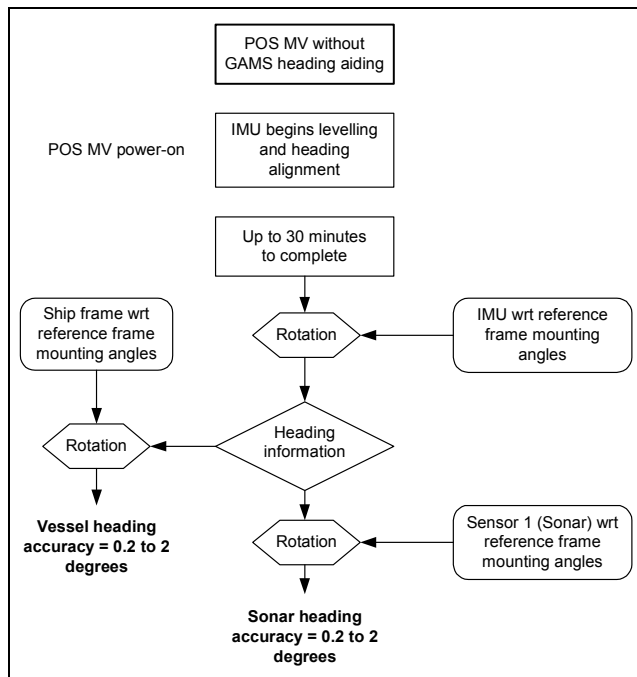


Figure 2: Heading Measurement without GAMS

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.

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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. 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 multi-beam 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 initialisation 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.

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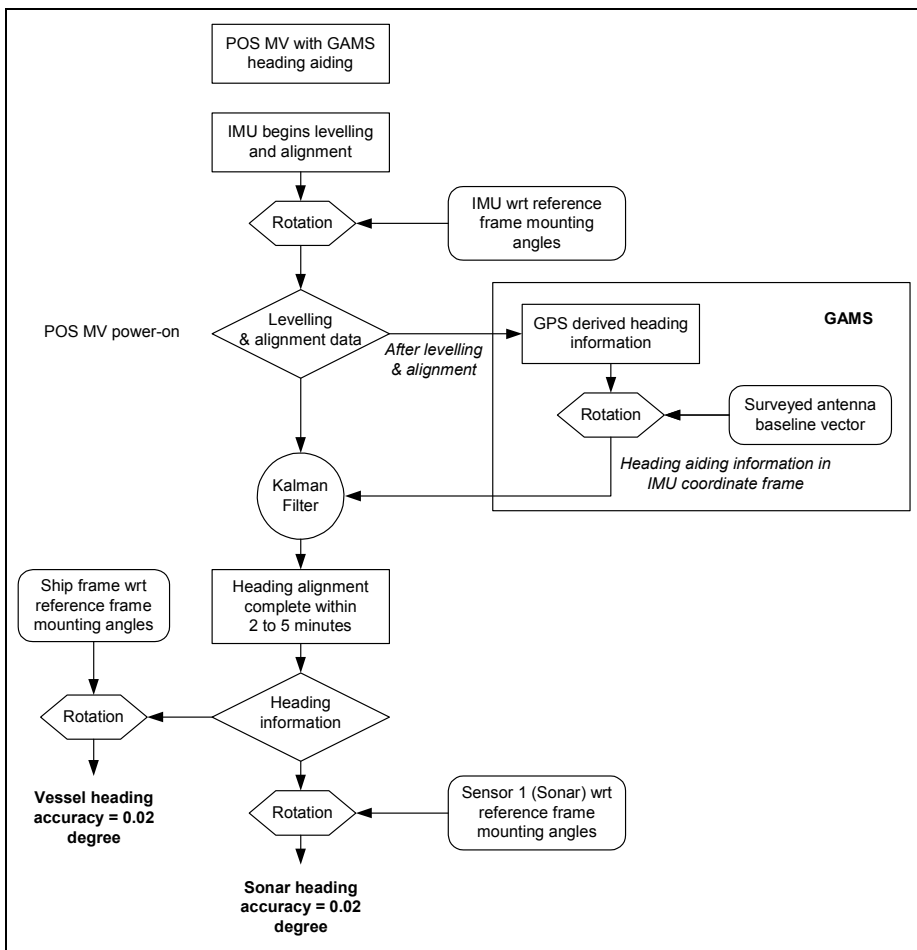


Figure 3: Heading Measurement with GAMS

GAMS heading error is largely due to GPS 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 or better.

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

After alignment, the IMU delivers measurements of vessel heading relative to true north. These possess an accuracy of 0.02° RMS or better, independent of vessel manoeuvres or latitude.

After alignment, the IMU delivers measurements of multi-beam 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 GPS carrier phase differential position measurement, levelling, gyrocompassing and the Kalman Filter.

Refer to the Lever Arm Distances, page 2-34, and the Antenna Separation, page 2-39, descriptions for instructions to measure the mounting angles of the IMU, multi-beam 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)
- Analog interface (hardware option)
- Position and velocity measurement
- AutoRecovery and fault detection, isolation and reconfiguration
- AutoStart

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- Ethernet Data logging
- Internal Data logging (hardware and software option)
- 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 multi-beam sonar. The system also estimates and displays the accuracy of its attitude and heading measurements.

TrueHeave

TrueHeave software option (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 POS MV 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.

As a non-standard option, TrueHeave must be enabled before use. Contact your Applanix Customer Support representative for the appropriate authorization code; refer to page A-1.

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Refer to the TrueHeave Operation description on page 6-1 for a full description of the data formats used by POS MV to output these parameters.

Analog Interface

The analog interface hardware option delivers motion measurements (roll, pitch and heave) for use by external equipment such as an echo-sonar. Contact your Applanix Customer Support representative for the details; refer to page A-1).

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.

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Fault Detection, Isolation and Reconfiguration (FDIR) allow POS MV to combine data from the GPS 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, multi-beam transducer and the primary GPS antenna, to your chosen reference point
- The sensor mounting angles of the IMU and the multi-beam 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 initialises 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.

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.

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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).

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 multi-beam sonar systems. Contact Applanix for more information on POSpac.

Ethernet Real-Time Logging

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

Internal Data Logging

This hardware and software option uses a one-Gigabyte (1 GB) internal memory device for logging data. The logging function is controlled from the front panel LOGGING switch or from the MV-POSView menu bar. Contact Applanix for more information on the internal data logging option.

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

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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 Transistor-Transistor Logic (TTL) level pulse. You can configure POS MV for a positive edge trigger or a negative edge trigger. Connect the TTL signal to an event line described in the EVENT Interface paragraph on page 2-23.

You must also provide a reference ground on one of the ground lines.

Event time tagging occurs when the 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 or for internal logging. 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 multi-beam sonar in use.

In some cases, a multi-beam sonar can accept data in more than one format (for example analog or digital). 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 multi-beam sonar. You must consider this when you select the communications interface used to supply position, attitude and motion

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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
- Ethernet
- Analog (*optional*)

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.

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 1-17.

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.

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Installation

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 Positioning System (GPS) antennas should only take a few hours.

This section of the POS MV 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: | POS MV includes a number of assemblies that have special handling requirements. |
| Unpacking and Storage: | Applanix tests the system thoroughly before shipping. Special packing cases protect the system from impact, shock and vibration during normal transit conditions. Store the assemblies in their packing cases until you need to install them. |
| Site Preparation: | Pre-plan the location and layout of the POS MV assemblies. By preparing the installation site carefully, you will improve the overall performance of the system. |
| Installation: | You can reduce the time that it takes the system to perform its initial configuration procedure by installing the POS MV assemblies correctly. By taking sufficient care as you install the POS MV you will allow the system to deliver an accurate position and orientation solution. |

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Installation

Installation Parameters: After you have installed the POS MV assemblies, you must configure the system with a series of installation parameters. POS MV stores these important parameters in non-volatile memory for immediate use when you power-on the system.

Installation Checklist: This subsection includes a simple installation checklist. Verify each aspect of system installation to ensure you have installed the POS MV with minimal disruption to the vessel or its crew. The list will also help you to install the system in a way that provides the best possible performance.

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 GPS 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.

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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.

GPS Antennas

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

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

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IMPORTANT

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

Applanix supplies two transit cases when shipping the POS MV equipment:

- The first transit case contains the IMU, GPS receiver software and manuals, MV-POSView Controller program, POS MV Installation and Operation Manual and all cables.
- The second transit case contains the POS Computer System and the GPS antennas.

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 and excessive humidity (maximum 95% non-condensing) or temperature extremes (below -25 °C or above +85 °C).
- Protect the PCS and IMU from accidental damage by storing in their original shipping cases.

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- 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 2-8 and 5-28 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

Applanix strongly recommends that you arrange to supply electrical power to the PCS 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:

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POS Computer System

Voltage: 210 to 250 Vac (50 Hz) or
105 to 125 Vac (60 Hz)

Maximum power: 80 W

GPS Antennas

Voltage: Supplied by the GPS receiver
via the antenna coaxial cable

IMU

Voltage: Supplied by the PCS via the
IMU cable

Environmental Requirements

GPS Antennas

To receive GPS satellite signals without interruption, the GPS 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 GPS System paragraphs on page 2-8 to install the GPS antennas.

Although the antennas are tolerant of an exposed mounting position, please observe the following environmental limits when installing these components:

- Operating temperature: -40 to +70 °C
- Operating relative humidity: 0 to 100%

Inertial Measurement Unit

The IMU has an enamel coated 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.

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Follow the installation instructions listed on page 2-11, Inertial Measurement Unit, to select a suitable mounting location for the IMU. Observe the following environmental limits when selecting a mounting location for the IMU:

- Operating temperature: -40 to +60 °C
- Operating relative humidity: 0 to 100%
- Although the IMU has a sealed nitrogen-filled housing, it has an Ingress Protection (IP) rating of 65 (defined in the International Electrotechnical Commission [IEC] standard 60529) and is *not* depth-rated; do not mount the IMU where it can become immersed in water

POS Computer System

Applanix ships the PCS in a protective transit case that must be removed prior to operation. The PCS is installed in a 19-in (48.3 cm) instrument rack that provides isolation against shock and vibration. Follow the instructions in the POS Computer System paragraphs on 2-15 to install the PCS in an instrument rack.

Observe the following environmental limits when installing the PCS:

- Operating temperature: 0 to +55 °C
- Operating relative humidity: 10 to 80%, non-condensing
- Do not expose the PCS to temperatures below -25 °C (-13 °F) or above +85 °C (+185 °F), or to rapid temperature changes

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Installation

GPS System



Do not connect any input to the PPS OUT port. Connecting a signal input to this port will damage the PCS interface circuitry.

The PCS includes a primary and a secondary GPS receiver for operation with the POS MV.

Multipath reflections of the received GPS signals are the dominant source of measurement errors in the heading aiding information computed by the GPS Azimuth Measurement Subsystem (GAMS). Reflectors can include flat surfaces on the vessel and the surface of the sea.

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

- Observe the environmental limitations specified on page 2-6, GPS Antennas.
- Avoid GPS antenna locations that may experience multipath satellite signals caused by reflections off nearby structures.
- Avoid mounting the GPS 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 GPS antennas closer than 0.5 m (~20 in) to any radar, UHF, satellite communications or other communications antennas or transmitters.
- Avoid mounting the GPS antennas in areas that may experience high levels of vibration, shock or electrical noise.

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- 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 GPS 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 (~1/4 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 GPS antennas. Install these so that they have less than 5 m (~16 1/2 ft) separation distance between them. The antenna separation distance must be more than 1 m (~3 1/4 ft) in the horizontal vector, but it is recommended that the antennas be at least 2 m (~6 1/2 ft) apart.
- 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 GPS 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.

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Installation

Install GPS Antennas

The following instructions refer to the GPS 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:

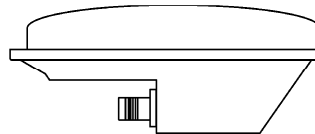


Figure 4: GPS Antenna

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

Note: POS MV includes two low-loss antenna cables with connectors at each end. These cables are standard length of 15 m (~49 ¼ ft). Applanix can supply longer GPS antenna cables on request, up to a maximum allowable length of 50 m (~164 ft) with a maximum signal loss of eight 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 Threaded-Neill-Concelman (TNC) cable connector to the GPS 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. Avoid subjecting the cable to sharp bends or other mechanical stresses; minimum bend radius of LMR 400 cable is one inch (25.4 mm). Use cable clips to secure the cable at regular

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Installation

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. 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 GPS antenna to generate a navigation solution.

Once the GPS antennas are installed, measure the antenna separation distance. POS MV can calculate this distance 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 distance between the antenna phase centres to an accuracy of ± 5 mm ($\pm \frac{1}{4}$ in). The GPS antenna footprint is shown in Figure 79 on page E-3.

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.

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The IMU footprint is shown in Figures 77 and 78 on pages E-1 and E-2 respectively.

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 2-6, 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 (~164 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.
- 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 multi-beam transducer. The chosen location must provide rigid support so that the IMU does not move relative to the GPS antennas; see GPS System on page 2-8.

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- 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 4-11.
- 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 multi-beam transducer. Instead, measure the mounting angles, save them in the PCS when you first power-on and configure the system.
- Two holes are predrilled in the base to accept 0.25 in (6.35 mm) diameter alignment pins. These holes maintain IMU alignment when the unit is replaced, see Figure 5.

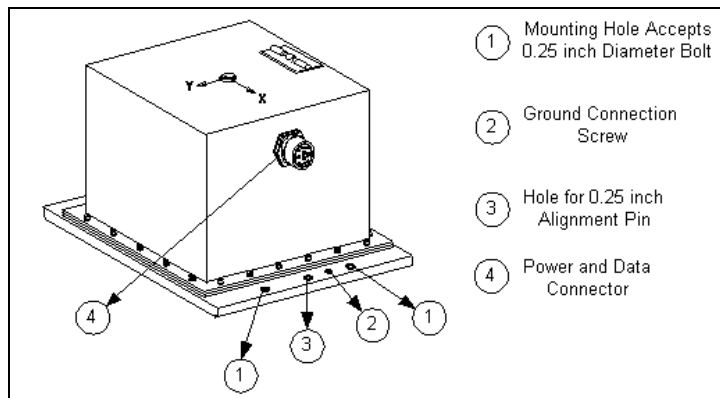


Figure 5: IMU Mounting Features

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Installation

Install the IMU

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

1. Attach the IMU to the mounting location using four 0.25 in (6.35 mm) 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.
2. Tighten the mounting bolts in a uniform manner, exercising care not to over torque. Avoid warping the IMU base plate.
3. If it is impractical to electrically isolate the IMU from the vessel, attach a ground strap between the IMU ground connection screw and the hull of the vessel to ensure adequate electrical noise protection.
4. Attach the IMU connection cable to the IMU connector and tighten the locking collar by hand. 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. Tighten the locking collar by hand.
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 2-30, Installation Parameters for details of these parameters.

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Installation

POS Computer System

The PCS is the heart of POS MV and is based on an Intel Pentium processor. The PCS footprint is shown in Figure 81 on page E-5.

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 in (48.3 cm) instrument rack where it occupies two rack units 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 specified on page 2-7, POS Computer System.
- 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 two rack units of space in a 19-inch (48.3 centimetre) instrument rack.
- 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 cabinet for cable connection and ventilation. Do not restrict the airflow intakes located on each side of the cabinet. If necessary, provide

POS MV V4 Installation and Operation Guide

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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. Connector interface requirements are described on page 2-19, Interfaces.

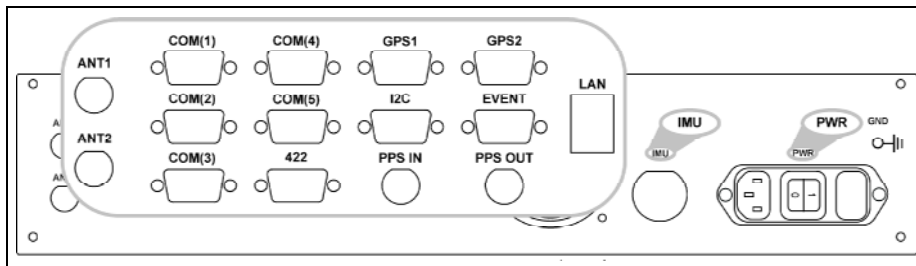


Figure 6: PCS Rear Panel

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

Table 2: Connector/Cable Summary

Connector	Cable	Description
PWR, 3-pin male	Standard 3-pin connector cable	The internal power supply is auto-switching between: <ul style="list-style-type: none"> • Nominal 110 Vac 60 Hz (range 105-125 V) • Nominal 220 Vac 50 Hz (range 210-250 V)
IMU, 12-pin male	Double-shielded cable	<ul style="list-style-type: none"> • RS-422 serial data • Supplies dc power and data to/from IMU

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Table 2: Connector/Cable Summary

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 OUT, BNC female	75 ohm coaxial cable (RG59/U)	<ul style="list-style-type: none"> A TTL strobe at one pulse per second is active low for 1 ms Falling edge of pulse is coincident with exact GPS second Provides synchronization with GPS time <p>Note: Do <i>not</i> connect an input signal to the PPS OUT port; otherwise, damage to the PCS interface circuitry may result.</p>
PPS IN, BNC female	75 ohm coaxial cable (RG59/U)	<ul style="list-style-type: none"> A TTL strobe of one pulse per second for synchronization with GPS time Only effective if external GPS option is enabled through POS Config
EVENT, DB-9S	Single-shielded cable	<ul style="list-style-type: none"> 2 digital I/P ports, TTL signal level Events 1 through 2 time tagging
I2C, DB-9S	Single-shielded cable	Connects to the analog interface hardware option, refer to page 2-24, I2C and RAU Interface
GPS1 (primary GPS receiver), DB-9P	Single-shielded cable	<ul style="list-style-type: none"> RS-232 Serial I/O port (digital) I/P primary GPS receiver software upgrade - contact Applanix Customer Support for details

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Table 2: Connector/Cable Summary

Connector	Cable	Description
GPS2 (secondary GPS receiver), DB-9P	Single- shielded cable	<ul style="list-style-type: none">• RS-232 Serial I/P port (digital)• I/P secondary GPS receiver software upgrade - contact Applanix Customer Support for details
422, DB-9P	Single- shielded cable	Not implemented
COM(1), DB-9P	Single- shielded cable	RS-232 Serial I/O port (digital)
COM(2), DB-9P	Single- shielded cable	RS-232 Serial I/O port (digital)
COM(3), DB-9P	Single- shielded cable	RS-232 Serial I/O port (digital)
COM(4), DB-9P	Single- shielded cable	RS-232 Serial I/O port (digital)
COM(5), DB-9P	Single- shielded cable	RS-232 Serial I/O port (digital)
ANT1, TNC female	50 ohm coaxial cable (RG303/U)	Supplies dc power to and receives signals from primary GPS antenna
ANT2, TNC female	50 ohm coaxial cable (RG303/U)	supplies dc power to and receives signals from secondary GPS antenna

If the POS MV 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 2-5 for details. Good grounding practices are essential for proper operation of the POS MV system.

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Note: If the analog interface hardware option is in use, ensure that the PCS and the multi-beam sonar are grounded at the same point.

Interfaces

Applanix ships the POS MV with the following cables:

- PWR cable
- IMU data and power cable
- LAN (Ethernet) cable
- GPS1 and GPS2 cables
- ANT1 and ANT2 (one with each GPS antenna)

Cables not included with each POS MV:

- PPS IN or PPS OUT cables
- EVENT cable
- I2C to POS INTF and ANALOG I/O cables (part of the analog interface hardware option)
- COM(1) through COM(5) cables

The following paragraphs provide cable and interface details for the active ports on the PCS rear panel, refer to Table 2 on page 2-16.

IMU Interface

The IMU port on the PCS rear panel accepts the data and power cable from the Inertial Measurement Unit. The port supplies power for IMU operation and receives inertial measurements from the IMU.

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Connection is through a double-shielded RS-422 data cable that has three twisted pairs and three power conductors; it uses KPT07E14-12P, 12-pin connectors at both ends. The standard IMU data and power cable is 8 m (~26 ¼ ft) long; longer cables can be ordered from Applanix for special installations.

Figure 7 and Table 3 illustrate and list the pin arrangements of the Type 2 IMU power and data cable. The twisted pairs are on pins A/B, C/D, E/F and J/K.

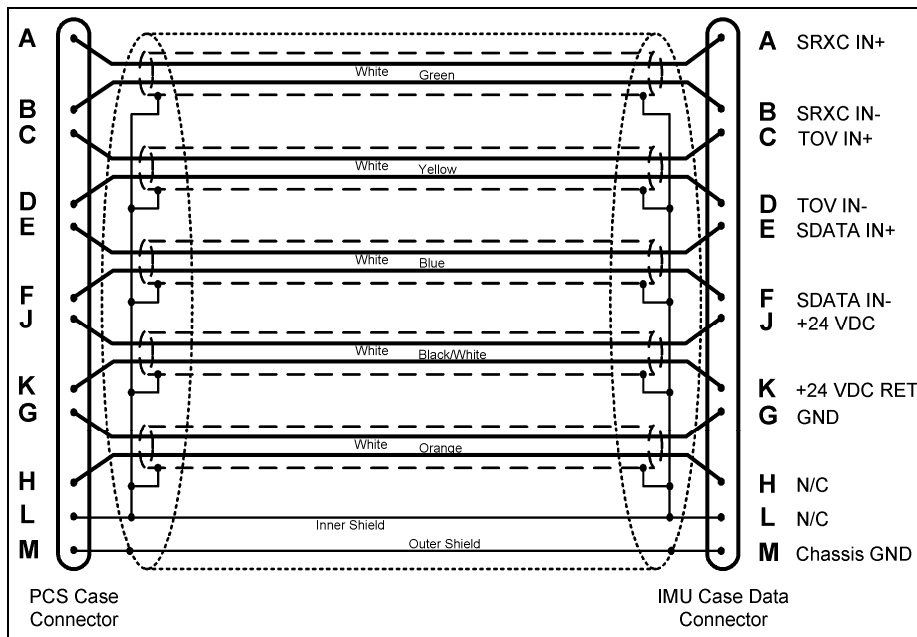


Figure 7: Type 2 IMU Power and Data Cable

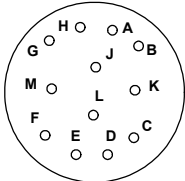
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Table 3: IMU Connector Pin Assignment

PIN	Pin Description	Signal Type	Signal Direction
A	Serial Data Clock Receive + (SRXC IN+)	RS422	Input
B	Serial Data Clock Receive - (SRXC IN-)	RS422	Input
C	TOV + (TOV IN+)	RS422	Input
D	TOV - (TOV IN-)	RS422	Input
E	Serial Data + (SDATA IN+)	RS422	Input
F	Serial Data - (SDATA IN-)	RS422	Input
G	GND	N/A	N/A
H	N/C	N/A	N/A
J	+24 Vdc (+24 VDC)	N/A	N/A
K	24 Vdc Return (+24 VDC RET)	N/A	N/A
L	N/C	N/A	N/A
M	Chassis GND	N/A	N/A

POS MV Rear Panel
KPT06F14-12P
12 Pin Male Connector



LAN (Ethernet) Interface

Applanix supplies a MV-POSView Controller program with the system that runs on an IBM compatible PC under Microsoft Windows® 2000, NT 4 or XP. The controller program is not compatible with Microsoft Windows® 3.1 or 3.11.

The link between POS MV and the PC uses a 10/100BaseT Ethernet interface connected to the LAN port on the PCS rear panel. This interface

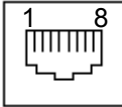
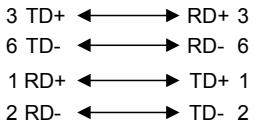
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conforms to the Institute of Electrical and Electronics Engineers (IEEE) standard 802.3. Table 4 provides a LAN port pin assignment, as well as pin associations for a crossover and a straight through cable.

Table 4: LAN Connector Pin Assignment

Pin	Pin Description	Signal Type	Signal Direction
1	TX +	Analog	Bidirectional
2	TX -	Analog	Bidirectional
3	RX +	Analog	Bidirectional
4/5	N/C	N/A	N/A
6	RX -	Analog	Bidirectional
7/8	N/C	N/A	N/A

POS MV Rear Panel RJ-45 Female Connector		
Pin out for a straight through cable		Pin out for a crossover cable

PPS Interfaces

The PCS requires the one Pulse Per Second (PPS) signal for internal timing requirements. This signal is obtained from the primary GPS receiver, either internal or external. In addition, the PPS OUT port will duplicate the 1PPS signal from the selected source. The input signal (PPS IN port) is only effective if the external GPS option is enabled through the POS Config menu selection in MV-POSView. Figure 8 provides a functional diagram.

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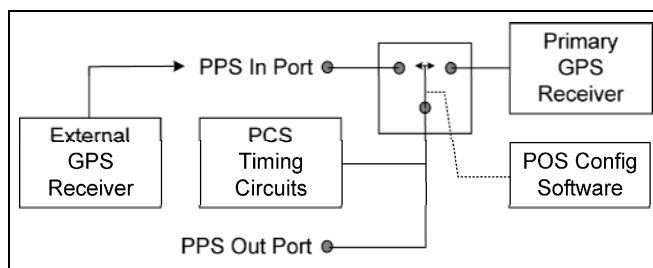


Figure 8: PPS Port Signal Sources - Functional Diagram

Note: A cable must be constructed and installed to couple the 1PPS signals to other equipment.



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 (input or output) is an active 'LOW' Transistor-Transistor Logic (TTL) level strobe that occurs at a 1 Hz rate. The leading edge of the strobe is coincident with the exact GPS second. The corresponding GPS time message that specifies the Universal Time Coordinated (UTC) time of the 1PPS is output on the GPS 1 port; refer to the GPS Interfaces description on page 2-27 and to the GPS Timing Basics description starting on page G-3 for more information.

EVENT Interface

The EVENT port permits access to the POS MV timing facility; refer to page 1-18, Event Tagging, for a detailed description of this function.

To time tag an event with Universal Time Coordinated (UTC) or GPS time, supply a TTL level pulse whose rising/falling edge (configurable) corresponds to the exact time when the event occurs. Connect the TTL signal to an event in pin and its associated return pin; refer to Table 5.

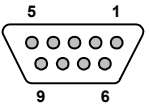
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Table 5: EVENT Connector Pin Assignment

Pin	Pin Description	Signal Type	Signal Direction
1	N/C	N/A	N/A
2	Event 1 In	TTL	Input
3	Event 2 In	TTL	Input
4	N/C	N/A	N/A
5	N/C	N/A	N/A
6	N/C	N/A	N/A
7	Event 1 Return	N/A	N/A
8	Event 2 Return	N/A	N/A
9	N/C	N/A	N/A

POS MV Rear Panel
DB-9S Female Connector



I2C and RAU Interface

The analog interface hardware option delivers motion measurements (roll, pitch and heave) for use by external equipment such as an echo-sonar. Contact your Applanix Customer Support representative for the details; refer to page A-1.

Figure 9 provides a block diagram of the Applanix proprietary option. The Remote Analog Unit (RAU) converts the digitally encoded roll, pitch and heave data from the PCS to analog data useable by other equipment. The customer interface is at the ANALOG I/O connector located on the RAU; Table 6 provides a connector pin assignment. Operating power for the RAU is supplied by the PCS using the I2C to POS INF port cable.

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Applanix supplies the following for the analog interface hardware option:

- One Remote Analog Unit (RAU)
- One I2C to POS INTF port cable, 3 m (~9 ¾ ft) long
- One analog output cable (open tails at one end and an ANALOG I/O connector at the other end), 1 m (~3 ¼ ft) long

Note: The analog output cable should not be extended by the customer beyond a maximum length of 5 m (~16 ft); and then only with consideration of the connection load.

Note: Longer I2C to POS INTF port cables are available from Applanix.

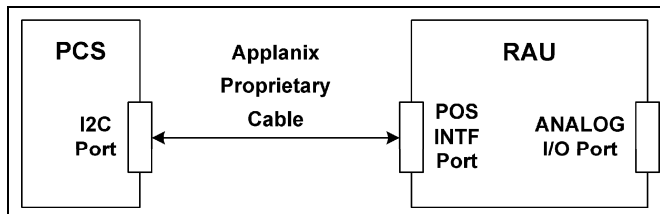


Figure 9: Analog Interface Hardware Option - Block Diagram

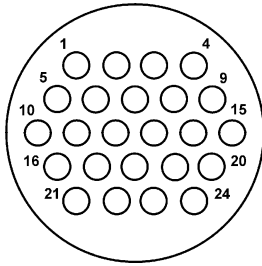
Table 6: RAU Analog I/O Connector Pin Assignment

Pin	Pin Description	Signal Type	Signal Direction
11	Chassis GND (roll, pitch & heave shields)	N/A	N/A
16	DAC 3 (heave)	Analog	Output
18	GND (DAC 3 return)	N/A	N/A
21	DAC 1 (roll)	Analog	Output
22	GND (DAC 1 return)	N/A	N/A
23	GND (DAC 2 return)	N/A	N/A

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Table 6: RAU Analog I/O Connector Pin Assignment

Pin	Pin Description	Signal Type	Signal Direction
24	DAC 2 (pitch)	Analog	Output
1 to 10, 12 to 15, 17, 19, 20	N/C	N/A	N/A
<div style="display: flex; align-items: center;"> <div style="flex: 1;"> <p>Plug Assembly: 213851-1 Cable Clamp Body: 206510-1 Socket Assembly: 66105-1 24 Pin Male Connector</p> </div> <div style="flex: 1; text-align: center;">  </div> </div>			

Four indicators (see Figure 10) provide an indication of the operational status of the RAU. A description of their function follows:

- ERR (error) light - Indicates an under run error. This type of error occurs when the host system commands a read request when there is no data in the transmit memory. The error condition is cleared upon subsequent commands issued by the host.
- CAL (calibration) light - Indicates the initialization of the calibration coefficients and the thermal drift processing functions. The light is illuminated during normal operation.
- COM (communications) light - Indicates communication with the host. The light illuminates with each communications packet commanded by the host system.

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- RDY (ready) light - Indicates the completion of the internal initialization sequence and that all functions within the RAU are operational. The light is illuminated during normal operation.

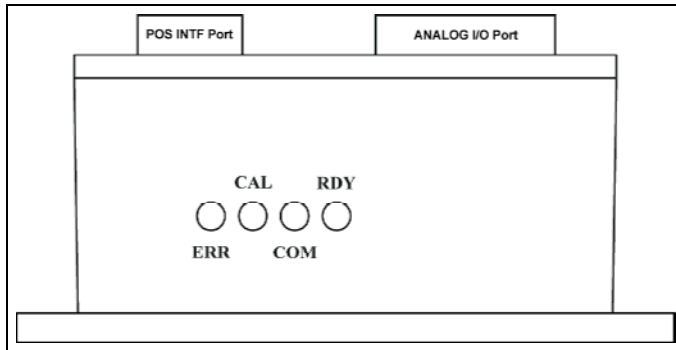


Figure 10: Remote Analog Unit

GPS Interfaces

The serial digital port for each GPS receiver (GPS1 and GPS2) provides access for receiver upgrading of its firmware; upgrade kits are available from Applanix.

Applanix does not supply a cable with the POS MV cable set to make this connection. Refer to Table 7 to construct a suitable cable.

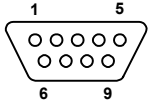
Table 7: GPS Connectors Pin Assignment

Pin	Pin Description		Signal Type	Signal Direction
	GPS 1	GPS 2		
2	RX 1	RX 2	RS-232	Input
3	TX 1	TX 2	RS-232	Output
5	GND	GND	N/A	N/A
1, 4, 6,7,8,9	N/C	N/C	N/A	N/A

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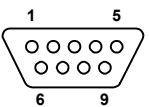
Table 7: GPS Connectors Pin Assignment

Pin	Pin Description		Signal Type	Signal Direction
	GPS 1	GPS 2		
POS MV Rear Panel DB-9P Male Connector				

COM Interfaces

Serial cables for the COM ports cannot 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 8 provides connector pin assignments.

Table 8: COM Connectors Pin Assignment

Pin	Pin Description	Signal Type	Signal Direction
1	N/C (port 1 through 5)	N/A	N/A
2	RX (port 1 through 5)	RS-232	Input
3	TX (port 1 through 5)	RS-232	Output
4	DTR (port 1 through 5)	RS-232	Output
5	GND (port 1 through 5)	N/A	N/A
6	DSR (port 1 through 5)	RS-232	Input
7	RTS (port 1 through 5)	RS-232	Output
8	CTS (port 1 through 5)	RS-232	Input
9	N/C (port 1 through 5)	N/A	N/A
POS MV Rear Panel DB-9P Male Connector			

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ANT Interfaces

Refer to the GPS System description on page 2-8 for instructions on the installation of the GPS antennas. Connection between each GPS antenna and its respective receiver is through 50 ohm coaxial cables (RG303/U).

Two identical 15 m (~49 ¼ ft) coaxial cables are supplied with POS MV system. Applanix can supply alternative lengths on request. The maximum allowable length depends on cable quality:

- The antenna cable must provide excellent shielding
- Attenuation between the antenna and the PCS must be <8 dB

Both of the GPS antenna coaxial cables have male TNC connectors fitted to each end. The ANT1 (primary GPS) and ANT2 (secondary GPS) ports located on the PCS rear panel have female TNC connectors.

Ancillary Equipment Interfaces

AUXILIARY GPS RECEIVER

Any of the five COM ports may be used for connecting an auxiliary GPS receiver to the PCS. The output of the auxiliary GPS receiver must be manually configured before it can be used by the POS MV. The PCS will only use this receiver if its quality is better than the primary GPS receiver. The state of the auxiliary GPS receiver input is displayed in the **GPS Data** window, see Figure 43 on page 8-3.

Applanix does not supply a cable with the POS MV cable set to make this connection. Construct a cable and connector to suit the particular requirements of the RTK GPS receiver in use. Refer to Table 8 on page 2-28 for the connector pin assignments of the COM ports.

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SONAR

Any of the five COM ports may be used for connecting the sonar to the PCS. The standard POS MV cable set includes two identical data cables. Each is three metres long and has DB-9P connector at one end and a DB-9S connector at the other.

The cables may be extended up to a maximum length of 15 m (~49 ¼ ft) as defined by the RS-232 specification.

If you use a data cable that has not been included with the POS MV data set, observe the following recommendations:

- Use a high quality data cable.
- Ensure that the cable has an overall Belden foil shield, which is connect to chassis ground at the PCS and at the multi-beam sonar.
- Use shielded connectors throughout to prevent data corruption from Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI).

ECHO-SONAR (ANALOG)

The analog interface feature for the POS MV is a hardware option. Refer to the I2C and RAU Interface description on page 2-24 and Table 6 on page 2-25 for more information.

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. Record all measurements for later use; see POS MV Configuration on page 4-11.

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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 data 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.

- Reference to IMU - measure to an accuracy of ± 0.05 m ($\sim \pm 2$ in)
- Reference to primary GPS antenna:
 - Single frequency - measure to an accuracy of ± 0.2 m ($\sim \pm 8$ in)
 - Dual frequency - (RTK GPS) measure to an accuracy of ± 0.02 m ($\sim \pm \frac{3}{4}$ in)
- Reference to vessel - measure to the same accuracy as the *Reference to primary GPS antenna* to prevent a bias in the position output by POS
- Reference to sensor 1 and sensor 2 - measure to an accuracy of ± 0.05 m ($\sim \pm 2$ in)
- Reference to auxiliary GPS antenna:
 - Single frequency - measure to an accuracy of ± 0.1 m ($\sim \pm 4$ in)
 - Dual frequency - (RTK GPS) measured to an accuracy of ± 0.02 m ($\sim \pm \frac{3}{4}$ in)

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- Reference to heave measurement location - measure to an accuracy of ± 0.05 m ($\sim \pm 2$ in)

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 scalar antenna separation distance should be measured to an accuracy of 5 mm ($\sim \frac{1}{4}$ in). You can allow POS MV to measure the antenna separation distance automatically during its calibration routine; this process will extend the time it takes the calibration to complete its task successfully.

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 GPS antenna, the multi-beam 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 31, page 5-5) 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

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- 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 the POS MV of the relative orientations of the IMU and the multi-beam transducer (sensor 1) by relating them all to a common reference frame that has been defined. It may be convenient to define the reference frame to be coincident with the multi-beam 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 multi-beam 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 multi-beam 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 multi-beam sonar. Additionally, some multi-beam sonar may calculate the beam forming parameters incorrectly.
- Perform a 'patch test' to determine whether there is any uncorrected misalignment between the multi-beam sonar and the POS MV. Many operators have a defined procedure to complete a patch test to refine

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the accuracy of the POS MV and multi-beam 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 axis. The reference point must be fixed and rigid relative to the IMU, the GPS antennas and the multi-beam 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)

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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, make these measurements to an accuracy of ± 0.05 m ($\sim \pm 2$ in):

- 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 GPS Lever Arm

Measure and record the distance from your reference point to the centre of the primary GPS antenna. Make these measurements to an accuracy of ± 0.2 m ($\sim \pm 8$ in) for a single frequency unit and to an accuracy of ± 0.02 m ($\sim \pm \frac{3}{4}$ in) for a dual frequency (RTK) unit:

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

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datum. Make these measurements to the same accuracy as the *Reference to Primary GPS Lever Arm* to prevent a bias in the position output by POS:

- 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 the multi-beam transducer. Measure and record the distance from your reference point to the sensing centre of the multi-beam transducer array. Make these measurements to an accuracy of ± 0.05 m ($\sim \pm 2$ in):

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

Reference to Sensor 2 Lever Arm

Measure and record the distance from your reference point to the second sensor. Make these measurements to an accuracy of ± 0.05 m ($\sim \pm 2$ in):

- 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

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- 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 GPS Lever Arm

The auxiliary GPS supplies DGPS, P-Code or RTK measurements to the POS MV. Measure and record the distance from your reference point to the auxiliary GPS antenna. For a DGPS or P-Code receiver used as an auxiliary unit, make these measurements to an accuracy of ± 0.1 m ($\sim \pm 4$ in). For an RTK receiver used as an auxiliary unit, make these measurements to the same accuracy as the *Reference to Primary GPS Lever Arm* to prevent a bias in the position output by POS.

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

Note: If your application does not include an auxiliary GPS 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.

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Under the influence of these, vertical movements experienced by the multi-beam 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 multi-beam 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.

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Measure and record the distance from your reference point to the vessel centre of rotation. Make these measurements to an accuracy of ± 0.05 m ($\sim \pm 2$ in):

- 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 Separation

The scalar distance measured between the two GPS antennas.

POS MV can calculate this distance automatically during the installation calibration routine, although this will mean the routine will take longer to complete. If you make a manual measurement, record the distance between the antennas to an accuracy of ± 5 mm ($\sim 1/4$ in).

To measure the antenna separation distance manually, use one of the following methods:

- Use a tape measure to measure the separation distance between the geometric centres of the antennas; that is between the centres of both antenna domes.
- Stretch a non-elastic string or wire between the GPS antennas. Mark the string or wire where it crosses the centres of the antenna domes. Remove the string or wire and measure the distance between the marks.

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Note: Both methods assume there is a straight unobstructed vector between both antennas.

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 Tate-Bryant sequence of rotations is used.

Tate-Bryant Rotation Sequence

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

- 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.

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

By convention, POS MV uses the right-hand orthogonal coordinate system, with its origin at the sensing centre of the multi-beam 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 11 shows an example of a frame centred on the vessel and aligned with its surveyed fore-aft, port-starboard and vertical axis.

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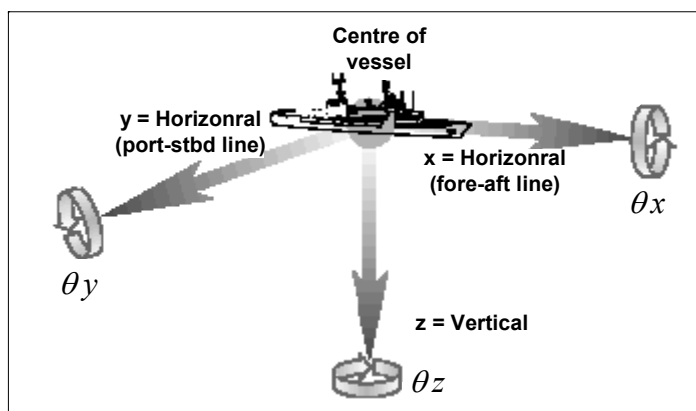


Figure 11: Right-Hand Orthogonal System

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.

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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° for the IMU with respect to reference frame z mounting angle
- +2° 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° for the IMU with respect to reference frame z mounting angle
- +2° for the IMU with respect to reference frame y mounting angle
- -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 Tate-Bryant sequence explained above, to align your chosen reference frame with the IMU reference frame.

Sensor 1 with respect to Reference Frame

Sensor 1 is the multi-beam transducer. Measure and record the rotations that you must apply, using the Tate-Bryant sequence explained above, to align the sensor 1 frame with your chosen reference frame.

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Sensor 2 with respect to Reference Frame

Measure and record the rotations that you must apply, using the Tate-Bryant sequence explained above, to align the second sensor frame with your chosen reference 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 multi-beam 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 2-6 for storage and operation.

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- 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 GPS antenna to the ANT1 port.
 - Connect the secondary GPS antenna to the ANT2 port
 - If necessary, connect the Differential GPS corrections to a COM port.
 - Connect the IMU data and power cable to the IMU port.
 - Connect an electrical supply of nominal voltage either 120 V or 220 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.
- c) GPS Antenna Positioning:
- Ensure there is a horizontal separation distance of between 1.0 and 5.0 m ($\sim 3 \frac{1}{4}$ and $\sim 16 \frac{1}{2}$ ft) between the primary and the secondary GPS 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 GPS antennas within 0.5 m ($\sim \pm 19 \frac{3}{4}$ 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.

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2. Offset Measurements

- Measure the lever arm distances and mounting angles, as instructed in Lever Arm Distances on page 2-34 and Mounting Angles on page 2-40. Be as careful and accurate as possible.
- Measure the GPS antenna separation distance, as instructed in Antenna Separation on page 2-39. 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.

- Arrange a clean, stable electrical supply in the range 210 to 250 Vac (50 Hz) or 105 to 125 Vac (60 Hz) 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.

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Interfaces and Data Formats

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 10/100BaseT Ethernet interface is used to configure the system, monitor its status during operation and log data.
- I2C (Analog) Data: Roll, pitch and heave information are supplied by the analog interface option in a format that matches the input requirements of several types of multi-beam sonar.
- COM Ports: The serial interface ports allow POS MV to communicate NMEA formatted position and attitude data, and binary attitude data to external equipment; to receive Real-Time Kinematic (RTK) Global Positioning System (GPS) data from an auxiliary GPS receiver; and to receive base station GPS corrections.
- GPS Ports: The serial digital port for each GPS receiver provides access for receiver upgrading of its firmware.

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.

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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 the same information as the display port, but at a higher update rate for use by other computers on a shared Ethernet LAN
- Logging data port - provides the same information as the display port, but is buffered for robust logging by other computers on a shared Ethernet LAN

POS MV broadcasts information from the display and real-time data port using the Universal Datagram Protocol (UDP) protocol, and the logging data port using the Transmission Control Protocol (TCP) protocol. 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.

I2C (Analog) Data

Note: The I2C analog interface hardware feature of POS MV is an option. The following details apply only if you have this option fitted to the PCS.

The analog interface provides roll, pitch and heave information (at the ANALOG I/O connector of the RAU) in a format that matches the input

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requirements of several types of multi-beam sonar. See page 2-24, I2C and RAU Interface, for a full description of the hardware option.

Three Digital-to-Analog Converters (DAC) generate the independent analog outputs, which operate in the range of ± 10 volts. The MV-POSView Controller program may be used to change the polarity and scale factors for each of the analog output lines.

The analog representations that the user can select are: Tate-Bryant Linear, Tate-Bryant Trigonometric (Trig), TSS Linear, TSS Trig, RPH (roll, pitch, heading); the last one is heading instead of heave. POS MV does not compensate for internal processing delays and at best, the latency is comparable to that on the binary (real-time) data port.

Note: POS MV updates all three analog output lines simultaneously at a rate of 200 times per second.

COM Ports

The five RS-232 serial ports, COM(1) through COM(5), allow communication between the PCS and external equipment. Since all the COM ports are assignable, it is possible to assign more than one output or input to the same port. In this case, the last assigned function prevails. The following identifies the available port assignments:

- NMEA sentence types
- Binary data formats
- Base 1 and 2 GPS outputs
- Base 1 and 2 GPS inputs
- Auxiliary 1 and 2 GPS inputs

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Interfaces and Data Formats

Table 9 identifies the default COM port settings.

Table 9: COM Port Settings

Input/Output Ports Setup Tab	Default Settings										
	Port Number	Baud Rate	Flow Control	Parity	Data Bits	Stop Bits	Line	Update Rate	Roll Pos Sense	Pitch Pos Sense	Heave Pos Sense
NMEA Output	No	9600	None	None	8	1		1 Hz	Port Up	Bow Up	Heave Up
Binary Output	No	9600	None	None	8	1		1 Hz	Port Up	Bow Up	Heave Up
Base 1 GPS Output	No	9600	None	None	8	1					
Base 2 GPS Output	No	9600	None	None	8	1					
Base 1 GPS Input	No	9600	None	None	8	1	Serial				
Base 2 GPS Input	No	9600	None	None	8	1	Serial				
Aux 1 GPS Input	No	9600	None	None	8	1					
Aux 2 GPS Input	No	9600	None	None	8	1					

Note: Baud rates may differ from the default settings for the transmission of various sentence formats.

NMEA Data Formats

The PCS uses any one of the five COM ports to output data using the National Marine Electronics Association (NMEA) 0183 format at rates up to fifty sentences per second. POS MV makes eleven different sentence formats available:

1. \$INGGA: global system position fix data
2. \$INGGK: time, position, position type and DOP values

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3. \$INHDT: heading - true data
4. \$INVTG: course over ground and ground speed data
5. \$INGST: GPS pseudorange noise statistics
6. a) \$PASHR: attitude data
b) \$PASHR-TSS: attitude data (TSS indicates the use of the TSS standard instead of the Tate-Bryant standard, see page 4-19 for a description)
7. a) \$PRDID: attitude data
b) \$PRDID-TSS: attitude data (TSS indicates the use of the TSS standard instead of the Tate-Bryant standard, see page 4-19 for a description)
8. \$INZDA: time and date
9. \$UTC: time and date
10. \$INPPS: time and offset

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

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

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NMEA Sentence Formats

1. *\$INGGA: 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.

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

Table 10: \$INGGA Sentence Format

Item	Definition	Value	Units (If Applicable)
\$INGGA	Header	\$INGGA	
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
IIII.IIIII	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	

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

Table 10: \$INGGA Sentence Format

Item	Definition	Value	Units (If Applicable)
t	GPS quality indicator	0 = fix not available or invalid 1 = C/A standard GPS; fix valid 2 = DGPS mode; fix valid 3 = GPS 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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\$INGGA,hhmmss.sss,IIII.IIIII,a,yyyyy.yyyyy,b,t,nn,v.v,xxxxx.xx,M,,,ccc,rrrr*hh<CRLF>

Table 10: \$INGGA Sentence Format

Item	Definition	Value	Units (If Applicable)
rrrr	DGPS 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.

2. **\$INGGK: Time, Position, Position Type and DOP Values**

The message string is shown below.

\$INGGK,hhmmss.ss,mmddy,IIII.IIIIIII,a,yyyyy.yyyyyyy,b,t,nn,v.v,x.xxx,M*hh<CRLF>

Table 11: \$INGGK Sentence Format

Item	Definition	Value	Units (If Applicable)
\$INGGK	Header	\$INGGK	
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
mmddy	UTC date of position	N/A	month day year 2 fixed digits for month 2 fixed digits for day 2 fixed digits for year

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\$INGGK,hhmmss.ss,mmdyy,IIII.IIIIII,a,yyyy.yyyyyyy,b,t,nn,v.v,x.xxx,M*hh<CRLF>

Table 11: \$INGGK Sentence Format

Item	Definition	Value	Units (If Applicable)
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
a	Direction of latitude	N or S	
yyyy.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	
t	GPS quality indicator	0 = fix not available or invalid 1 = C/A standard GPS; fix valid 2 = RTK float 3 = RTK fixed 4 = DGPS mode; fix valid 5 = free inertial	
nn	Number of satellites used in GPS 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

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\$INGGK,hhmmss.ss,mmdyy,IIII.IIIIII,a,yyyy.yyyyyyy,b,t,nn,v.v,x.xxx,M*hh<CRLF>

Table 11: \$INGGK Sentence Format

Item	Definition	Value	Units (If Applicable)
M	Ellipsoid height	N/A	metres
*hh	Checksum		
<CRLF>	Carriage return and line feed	<CRLF>	

3. \$INHDT: Heading - True Data

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

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

Table 12: \$INHDT Sentence Format

Item	Definition	Value	Units (If Applicable)
\$INHDT	Header	\$INHDT	
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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4. **\$INVTG: 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.

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

Table 13: \$INVTG Sentence Format

Item	Definition	Value	Units (If Applicable)
\$INVTG	Header	\$INVTG	
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.

5. **\$INGST: GPS Pseudorange Noise Statistics**

GPS pseudorange noise statistics indicate the quality of the position solution delivered by the integrated navigation solution. POS MV

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supplies information in the following ASCII NMEA 0183 sentence format.

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

Table 14: \$INGST Sentence Format

Item	Definition	Value	Units (If Applicable)
\$INGST	Header	\$INGST	
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

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

Table 14: \$INGST Sentence Format

Item	Definition	Value	Units (If Applicable)
a.a	Standard deviation of altitude	N/A	metres
*hh	Checksum	N/A	
<CRLF>	Carriage return and line feed	<CRLF>	

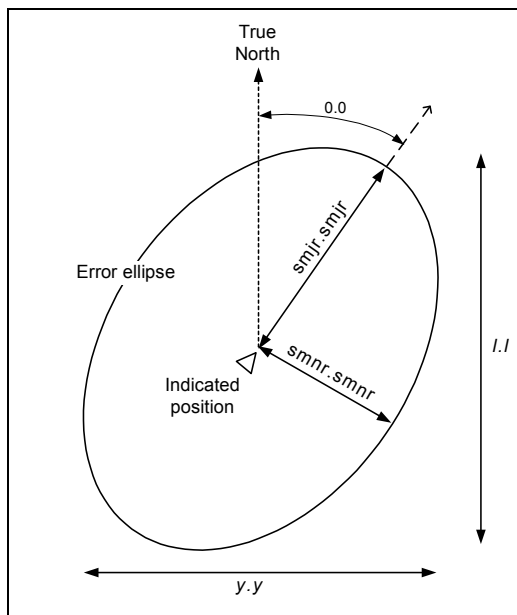


Figure 12: \$INGST Sentence Nomenclature

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6. \$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 15: \$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 <ul style="list-style-type: none"> • 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

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

Table 15: \$PASHR Sentence Format

Item	Definition	Value	Units (If Applicable)
d	Flag - accuracy heading	0, 1, 2	0 = no aiding 1 = GPS aiding 2 = GPS & 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 Tate-Bryant angles and the other uses TSS angles. Use the MV-POSView Controller program to set the required angle convention. Refer to COM Ports Configuration on page 4-17 for instructions and for a definition of the Tate-Bryant and the TSS formulas. The information is valid in the vessel frame, except for heave, which is valid in the sensor 1 frame.

7. \$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 16: \$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

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

Table 16: \$PRDID Sentence Format

Item	Definition	Value	Units (If Applicable)
*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 Tate-Bryant angles and the other uses TSS angles. Use the MV-POSView Controller program to set the required angle convention. Refer to COM Ports Configuration on page 4-17 for instructions and for a definition of the Tate-Bryant and the TSS formulas. The information is valid at the sensor 1 location.

8. **\$INZDA: Time and Date**

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

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

Table 17: \$INZDA Sentence Format

Item	Definition	Value	Units (If Applicable)
\$INZDA	Header	\$INZDA	
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		

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

Table 17: \$INZDA Sentence Format

Item	Definition	Value	Units (If Applicable)
Null	Null		
*hh	Checksum	N/A	
<CRLF>	Carriage return and line feed	<CRLF>	

Note: Commas separate all items.

9. \$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 18: \$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.

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10. \$INPPS: Time and Offset

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

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

Table 19: \$INPPS Sentence Format

Item	Definition	Value	Units (If Applicable)
\$INPPS	Header	\$INPPS	
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
d	Offset day ^{N1}	0 to 6	
www	GPS week number	0000 to 9999	
uu.uu	Offset of GPS time from UTC time ^{N2}	00.00 to 99.99	seconds decimal seconds • 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.

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NMEA Update Rate

POS MV outputs NMEA sentences from the COM ports at a settable rate from one to 50 times per second. You can choose to output only one of the sentences or any combination of those available.

Binary Data Formats

The PCS outputs attitude data using any of the following output string formats:

1. TSS1 format
2. Simrad 1000 format using Tate-Bryant or TSS angles
3. Simrad 3000 format using Tate-Bryant or TSS angles
4. TSM 5265 format using Tate-Bryant 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.

Information supplied through the COM port is valid for the point described by the reference to sensor 1 lever arms and by the reference to sensor 1 mounting angles.

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1. 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.

:XXAAAASMHHHQMRRRRSMPPPP<CRLF>

Table 20: 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 = GPS aided mode - settled condition g = GPS 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	

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:XAAAASMHQHQMRRRRSMPPPP<CRLF>

Table 20: TSS1 Output Format

Field	Definition	Value	Units (If Applicable)
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.

2. Simrad 1000 Format

You can use this format with the Simrad 1000 multi-beam sonar. The MV-POSView Controller program is used to select the TSS or the Tate-Bryant convention of rotations for the attitude measurement. Refer to COM Ports Configuration on page 4-17 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 21.

Table 21: Simrad 1000 Digital Output Format

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

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.

3. Simrad 3000 Format

You can use this format with the Simrad 3000 multi-beam sonar. The MV-POSView Controller program is used to select the TSS or the Tate-Bryant convention of rotations for the attitude measurement. Refer to COM Ports Configuration on page 4-17 for an explanation of these conventions.

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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 22.

Table 22: Simrad 3000 Digital Output Format

Item	Byte	Value	Units (If Applicable)
Header LSB	0	0x00	N/A
Header MSB	1	0x90	
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		

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Table 22: Simrad 3000 Digital Output Format

Item	Byte	Value	Units (If Applicable)
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.

4. TSM 5265 Format

You can use this format with the Thompson TSM 5265 multi-beam 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

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- 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 Tate-Bryant convention of rotations for the attitude measurement. Refer to subsection COM Ports Configuration on page 4-17 for instructions to do this and for an explanation of the TSS and Tate-Bryant 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 23.

Table 23: 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

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Table 23: TSM 5265 Digital Output Format

Item	Byte	Value	Units (If Applicable)
Roll LSB	10	±180°	0.01°
Roll MSB	11		
Pitch LSB	12	±180°	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		

5. 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°/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.

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DLERrPpHhQDLE

Table 24: 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 = GPS aided mode - settled condition 3 = GPS 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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6. PPS Format

Table 25: PPS Digital Output Format

Item	Byte	Value	Units (If Applicable)
Header LBS	0	0x00	N/A
Header MSB	1	0x99	
PPS time (GPS seconds into the week, coincident with PPS strobe [GPS time])	2 to 9		seconds
Week (GPS 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

7. Time of PPS Format (copy of Novatel TM1B)

Table 26: 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 (GPS week number)	12 to 15		N/A
PPS time (GPS seconds into the week, coincident with PPS strobe [PCS time])	16 to 23		seconds

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Table 26: Time of PPS Digital Output Format

Item	Byte	Value	Units (If Applicable)
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
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

GPS Ports

The PCS configures the primary and secondary GPS receiver cards automatically for its own use.

Physical Interface

The serial digital port for each GPS receiver (GPS1 and GPS2) provides access for receiver upgrading of its firmware; upgrade kits are available from Applanix. Table 27 lists the factory port settings and Table 7 on page 2-27 lists the details of the pin arrangements.

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Table 27: GPS1 and 2 Port Settings

Setting	Default Value
GPS Output Rate	1 Hz
Auto Configuration	Enabled
Baud Rate	9600
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 2-30 for instructions on how to measure the installation parameters.

Once the POS MV is configured using the installation parameters, save the data to non-volatile memory 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 POS MV system is installed, the PCS is powered-on and connected to a separate PC using the Ethernet Local Area Network (LAN) port. The controller program is then used to configure the POS MV. Front panel lights indicated the progress of the POS MV power-on sequence.

POS MV Configuration: The successful operation of the POS MV is achieved only after system installation and software configuration using the installation parameter data.

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Power-Off: Although the POS MV system is normally left powered-on, situations may arise that require the power to be removed.

Making Changes: Installation and configuration changes may be saved to non-volatile memory at any time.

Power-On

Once the system is installed and configured, the POS MV is ready for operation in a stand-alone mode. This feature allows the 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 system is applied to the PCS rear panel PWR connector, refer to Figure 13. 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 Mini POS (mPOS) and the Inertial Measurement Unit (IMU); refer to Figure 14. The mPOS 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, located above the switch, illuminates indicating that the PCS is

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powered-on. To power-off, press and hold the POWER switch until the light starts blinking, then release the switch.

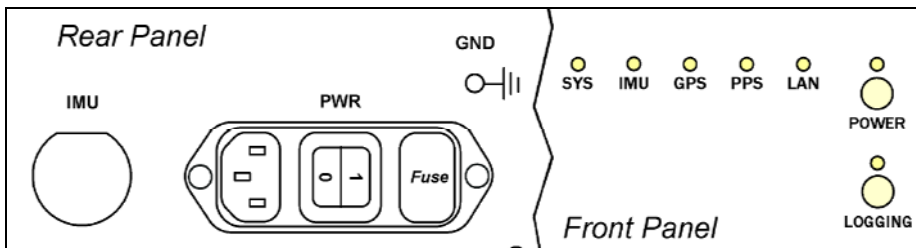


Figure 13: PCS Front and Rear Panels - Switches and Indicators

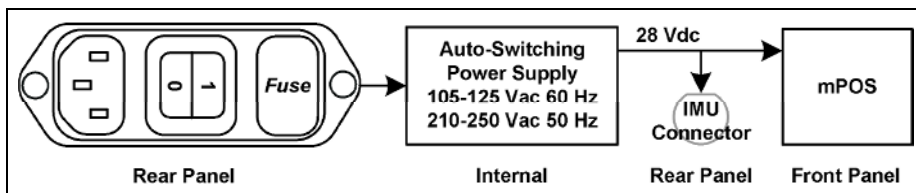


Figure 14: PCS Internal Power Distribution - Block Diagram

To power-on the POS MV system, perform and observe the following:

1. Ensure PCS rear panel PWR switch is enabled.
2. Press PCS front panel POWER switch and ensure that:
 - Front panel POWER light illuminates
 - Various front panel lights illuminate, refer to next step
3. Check status of PCS front panel lights, see Table 28:

Front panel indicators have three different colours (red, amber and green) and three states (flashing, steady-on and steady-off).

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Table 28: PCS Front Panel Indicators - Power-On

SYS 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.

A solid red indication while all the other lights behave normally indicates a fault in PCS.

If a fault occurs, do not power-off PCS. Refer to **Fault Detection** window of controller program, described in Faults and Messages on page 5-12 and Fault Detection on page 9-8.

If light frequently shows red during operation, PCS may be receiving poor quality electrical power. Applanix recommends a UPS to power POS MV installation.

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.

IMU light - indicates status of IMU:

Steady green: Receiving IMU data and TOV.

Steady red: IMU down, disconnected or an internal hardware failure.

GPS light - indicates GPS reception in loosely coupled mode or navigation status in tightly coupled mode:

Steady red: No GPS solution is available.

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Steady amber: GPS receiver is delivering a C/A or P-Code GPS solution.

Steady green: GPS receiver is delivering a DGPS or RTK solution.

PPS light - flashes green once per second to indicate reception of GPS 1PPS signal.

LAN light - indicates transmit and receive local area network activity:

Flashing green: Activity on Ethernet LAN.

Steady red: A LAN fault (e.g. a break in Ethernet line).

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 2-30.

Use the MV-POSView Controller program to enter this information. Save these parameters to non-volatile memory 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 description on page 4-11 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.

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

MV-POSView will connect automatically and start 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 non-volatile memory. Only one MV-POSView Controller program can operate in the control mode at any time.

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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 4-37 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 **129.100.1.231**.

Initially, to communicate with the PCS, you must give the controlling PC a unique address within the same subnet. Applanix recommends using address **129.100.1.230**.

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 31 on page 5-5) 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 illuminated.

System Addresses

POS MV has a number of different addresses:

- The default subnet mask address is **255.255.000.000**.

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- The factory default IP address for the PCS is always **129.100.1.231**. You should change this address to make it suitable for use with the specific network in which you will install the PCS. The following instructions tell you how to do this and to save the new address to memory.
- Port addresses for the Ethernet display, control, and real-time and logging data ports on the PCS are 5600, 5601, 5602 and 5603 respectively. They are set at the factory to be compatible with the PCS and should never be changed.

IP Addresses

IP addresses consist of four sets of numbers separated by full stops (e.g. 129.100.0.220). 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, 129.100.0 are the default value for the PCS network IP address and 220 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.

Changing Addresses

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.

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- 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.
- 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 all versions of Windows™, except 2000 - 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 15. The new address must be valid for the network on which you will operate the PCS. Press the **OK** button.

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- 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.

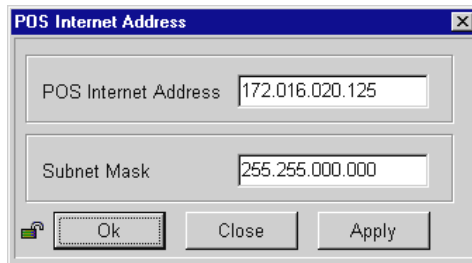


Figure 15: POSView POS Internet Address

- 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

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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 Controller 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 16 outlines the configuration data refinement process.

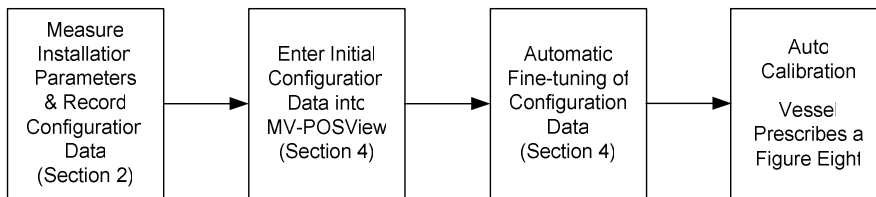


Figure 16: Configuration Data Refinement

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 GPS measurement is presently available, other automatic measurements will be available in the future.

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

- a) 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 Addresses description on page 4-8 for instructions on IP addressing.
- b) Power-on the PCS and the controlling PC, and start Microsoft Windows™; from windows, launch the MV-POSView Controller program.
- c) 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 2-30 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 17). 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 GPS Lever Arm** panes. This basic information allows the system to supply useful data to the multi-beam sonar.

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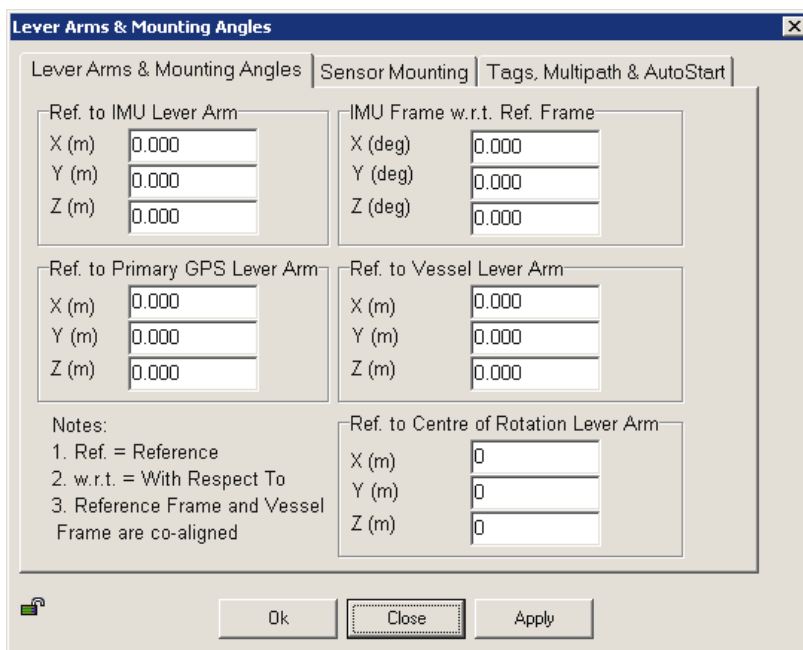


Figure 17: POSView Lever Arms & Mounting Angles Tab

Next, select the **Sensor Mounting** tab (Figure 18) 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 initialise using these installation parameters whenever the PCS is powered-on.

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

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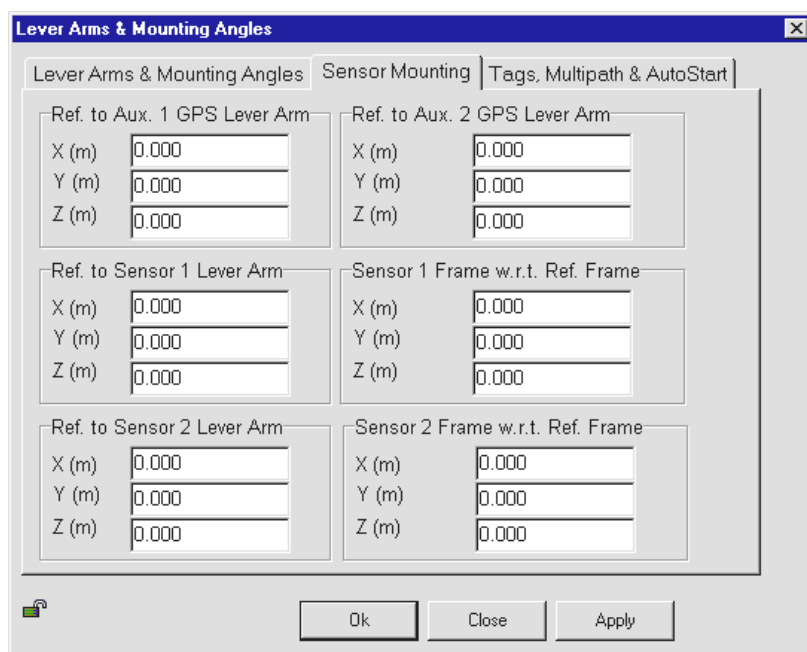


Figure 18: POSView Sensor Mounting Tab

Configuration - Automatic

Note: Perform a GPS Azimuth Measurement Subsystem (GAMS) calibration prior to running this procedure, see Antenna Installation Calibration on page 4-24.

Note: The integrated navigation solution should be delivering a RTK solution; may be tightly coupled or using an auxiliary RTK GPS receiver. The Nav Status (MV-POSView Status pane) indicates FLOAT RTK or FIXED RTK, see page 5-6.

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 19).

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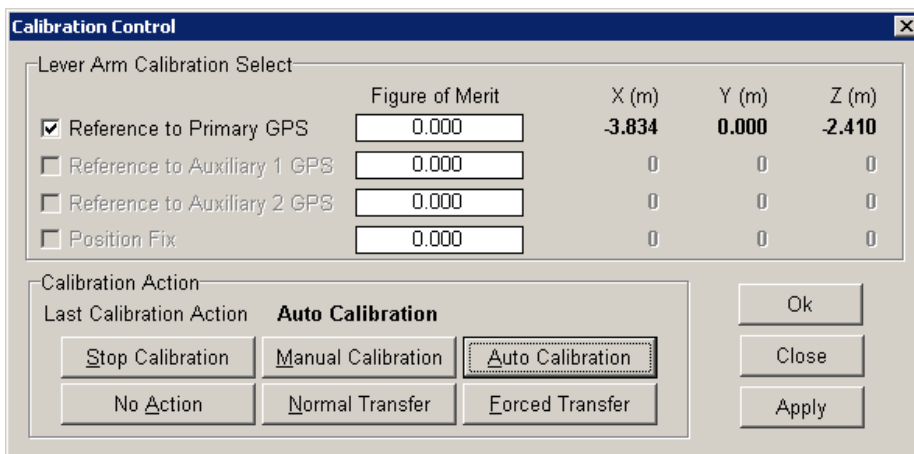


Figure 19: Calibration Control Screen

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 GPS 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 GPS check box - select to compute corrected values

Reference to Auxiliary 1 GPS check box - not enabled

Reference to Auxiliary 2 GPS check box - not enabled

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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

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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

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. Select the **OK** button to accept the change.

Note: The AutoStart configuration change must be saved to non-volatile memory to retain its new setting when the POS MV is power-on again; refer to the Save Settings description on page 4-23 for instructions.

COM Ports Configuration

Select **Settings, Input/Output Ports** to display the window shown in Figure 20. This window allows you to change the configuration of the five

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COM ports for use with various applications. The COM Ports description starting on page 3-3 provides port settings and data format information.

Changes made to the sense parameters of roll, pitch or heave will affect the output to the multi-beam sonar. Changes to these settings will not affect the polarity displayed by the controller program for the relevant channel.

Note: Save the settings to non-volatile memory so that they will be effective next time the POS MV is powered-up. Refer to the Save Settings topic on page 4-23 for instructions. Settings become active once the **OK** or the **Apply** button is pressed.

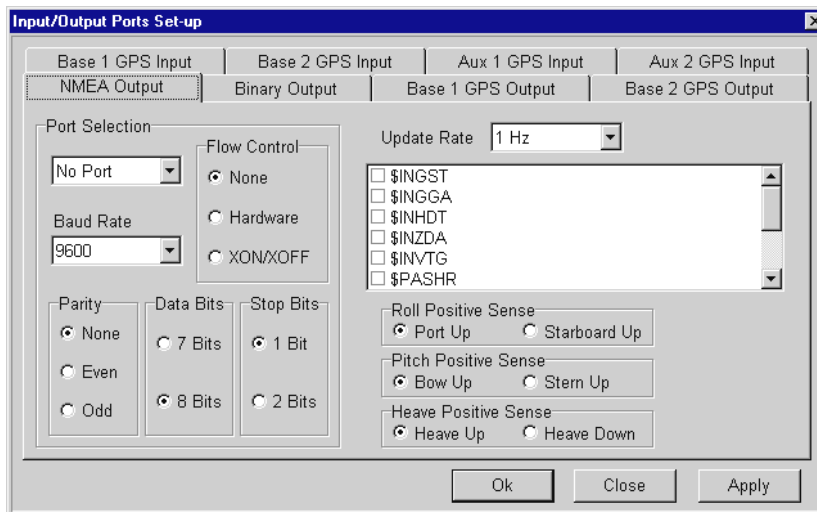


Figure 20: POSView Input/Output Port Setup

ANALOG I/O Port (RAU) Configuration

The analog interface hardware option delivers motion measurements (roll, pitch and heave) for use by an external multi-beam sonar equipment. Contact your Applenix Customer Support representative for the details, see page A-1.

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Refer to the I2C and RAU Interface description on page 2-24 and Table 6 on page 2-25 for more information on this option.

Select **Settings, Analog Port** from the MV-POSView menu bar to display the window shown in Figure 21. This window allows you to change the configuration of the ANALOG I/O port for use with multi-beam sonar equipment.

Changes to the **Scale Factors** pane or any of the sense settings will not appear on the main window **Attitude** pane because they apply only to the ANALOG I/O port.

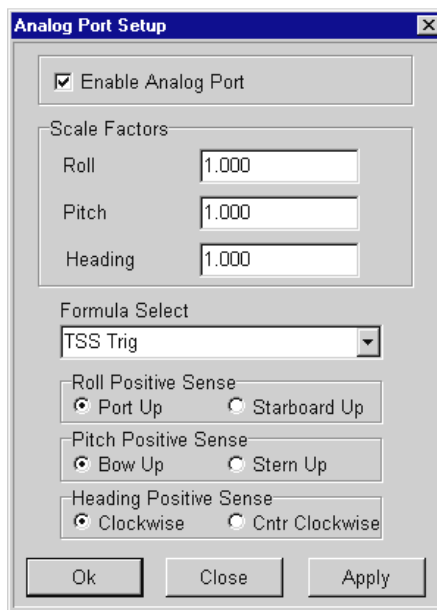


Figure 21: POSView Analog Port Setup

The Tate-Bryant or the TSS conventions (each defines the roll angle differently) follow linear or trigonometric relationships; Table 29 provides a comparison between the different definition formulas.

- The TSS convention defines roll relative to a locally level frame of reference.
- The Tate-Bryant convention defines roll relative to a plane made by the deck of the vessel after it has included the pitch angle of the vessel.

The relationship between the two definitions is:

$$\text{Roll}_{\text{TSS}} = \sin^{-1}(\sin \text{Roll}_{\text{TB}} \cos \text{Pitch}_{\text{TB}})$$

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Table 29: Formula Type Definition		
	Analog Formula	Digital (RS-232) Formula
Tate-Bryant Linear	$Roll_{out} = F_{roll} \times Roll_{TB}$ $Pitch_{out} = F_{pitch} \times Pitch$ $Heave_{out} = F_{heave} \times Heave$	N/A
Tate-Bryant Trig	$Roll_{out} = F_{roll} \times 10\sin Roll_{TB}$ $Pitch_{out} = F_{pitch} \times 10\sin Pitch$ $Heave_{out} = F_{heave} \times Heave$	N/A
TSS Linear	$Roll_{out} = F_{roll} \times Roll_{TSS}$ $Pitch_{out} = F_{pitch} \times Pitch$ $Heave_{out} = F_{heave} \times Heave$	N/A
TSS Trig	$Roll_{out} = F_{roll} \times 10\sin Roll_{TSS}$ $Pitch_{out} = F_{pitch} \times 10\sin Pitch$ $Heave_{out} = F_{heave} \times Heave$	N/A
Tate-Bryant	N/A	$Roll_{out} = Roll_{TB}$ $Pitch_{out} = Pitch$ $Heave_{out} = Heave$
TSS	N/A	$Roll_{out} = Roll_{TSS}$ $Pitch_{out} = Pitch$ $Heave_{out} = Heave$
Roll _{out}	= the roll output on an analog or digital channel	
Pitch _{out}	= the pitch output on an analog or digital channel	
Heave _{out}	= the heave output on an analog or digital channel	
F _{roll}	= roll scale factor	
F _{pitch}	= pitch scale factor	
F _{heave}	= heave scale factor	
Roll _{TB}	= roll angle defined using the Tate-Bryant convention	
Roll _{TSS}	= roll angle defined using the TSS convention	

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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 22. 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.

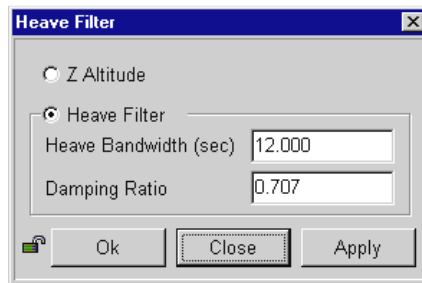


Figure 22: POSView Heave Filter

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.

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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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 non-volatile memory so that they will be effective next time the POS MV is powered-up. Refer to the Save Settings topic on page 4-23 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 2-37 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.

GPS Receiver

Select **Settings, Installation, GPS Receiver** from the MV-POSView menu bar to display the **GPS Receiver Configuration** window, refer to Figure 23.

The PCS can assess the GPS receiver configuration and, if necessary, can reconfigure the receiver automatically to establish appropriate settings. You

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can disable the automatic reconfiguration feature through the GPS receiver window by selecting **Enabled** or **Disabled** in the **Auto Configuration** pane.

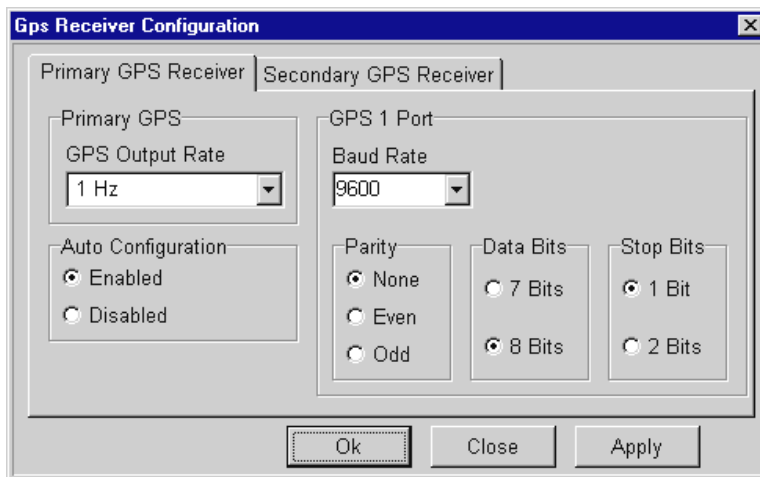


Figure 23: POSView GPS Receiver Configuration

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 non-volatile memory.

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 non-volatile memory, select **Settings, Save Settings** from the MV-POSView menu bar.

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

Initial GPS Configuration

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

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

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

Antenna Installation Calibration

A successful antenna installation calibration depends upon the GPS 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 GPS 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

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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 Figure 31 on page 5-5.
2. Select **Tools, Configuration** from the MV-POSView menu bar to open the **Navigator Configuration** window, refer to Figure 24.

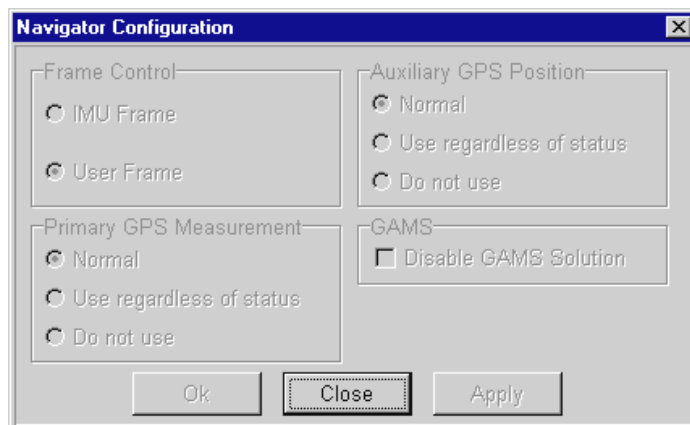


Figure 24: POSView Navigator Configuration

3. In the **GAMS** pane, ensure the **Disable GAMS Solution** option is not selected. This permits POS MV to use GAMS heading aiding in its antenna calibration solution.
4. Select **View, GAMS Solution** from the menu bar to open POS MV **GAMS Solution** window shown in Figure 25.
5. Transition the system to standby mode by selecting the **Standby** icon from the controller tool bar.

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6. Select **Settings, Installation, GAMS Parameter Setup** from the menu bar to open the **GAMS Parameter Setup** window shown in Figure 26.
7. In the **GAMS Parameter Setup** window, enter a value between 0.5 and 5.0° in the **Heading Calibration Threshold** field. Select the **OK** button.

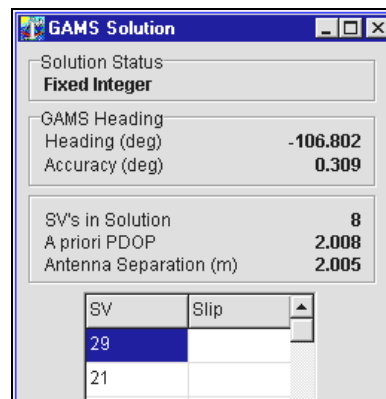


Figure 25: POSView GAMS Solution

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 0.5°) 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.
8. Perform the following in the **GAMS Parameter Setup** window:
 - a) In most cases, this value is entered as '0'. Only if you are able to measure the antenna separation to 1 mm accuracy should you enter a value here.

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Refer to the Installation Checklist on page 2-44 for instructions on how to measure the antenna separation distance.

- b) In each of the component fields in the **Baseline Vector** pane, enter '0'. Select the **Apply** and **OK** buttons.

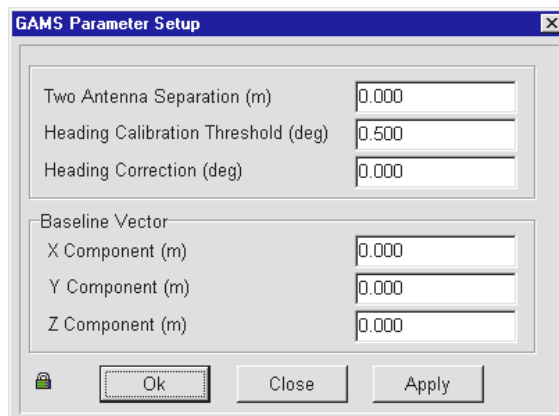


Figure 26: POSView GAMS Parameters Setup

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. Next, perform either the auto-start calibration (steps 11 and 12) or the manual calibration procedure (steps 13 and 14).

AUTO-START CALIBRATION PROCEDURE

11. Select **Settings, GAMS Calibration Control, Start** from the MV-POSView menu bar (Figure 27, page 4-30). The **Status** pane for **GAMS** indicates **CAL Requested** (Figure 27, page 4-30).

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

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calibration process will start automatically when the POS MV RMS heading error falls below the value that you set for the **Heading Calibration Threshold** field in step 7 above.

12. 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 27, page 4-30). When the value displayed falls below the setting for the **Heading Calibration Threshold** field (Figure 26), 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 Completed**. This condition lasts for approximately five seconds and then changes to **Online**.

See Options starting with step 15.

MANUAL CALIBRATION PROCEDURE

Note: Before proceeding ensure the **GAMS Parameters Setup** window displays the values that you entered in step 7 above.

13. When GAMS has resolved the carrier phase ambiguities, the **Status** pane for **GAMS** indicates **Ready Offline** (Figure 27, page 4-30). You can start the calibration manually at any time.

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If possible, 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** on the MV-POSView main window **Attitude** pane (Figure 27, page 4-30). Ideally, the heading accuracy displayed should be as small as possible.

Wait until the heading error becomes as small as possible before starting the calibration. Simple manoeuvres of the vessel, such as a change of course, will cause the heading accuracy to improve.

14. To start the manual calibration, select **Settings, GAMS Calibration Control, Force** from the MV-POSView menu bar (Figure 27, page 4-30). This commands an immediate start of the calibration process.

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

See Options starting with step 15.

OPTIONS

15. Suspend calibration while in progress: Select **Settings, GAMS Calibration Control, Suspend**. The displayed **GAMS** status then becomes **CAL Suspended**.

The system suspends the partially completed calibration process until you resume it. To resume the calibration process select **Settings, GAMS Calibration Control, Start**.

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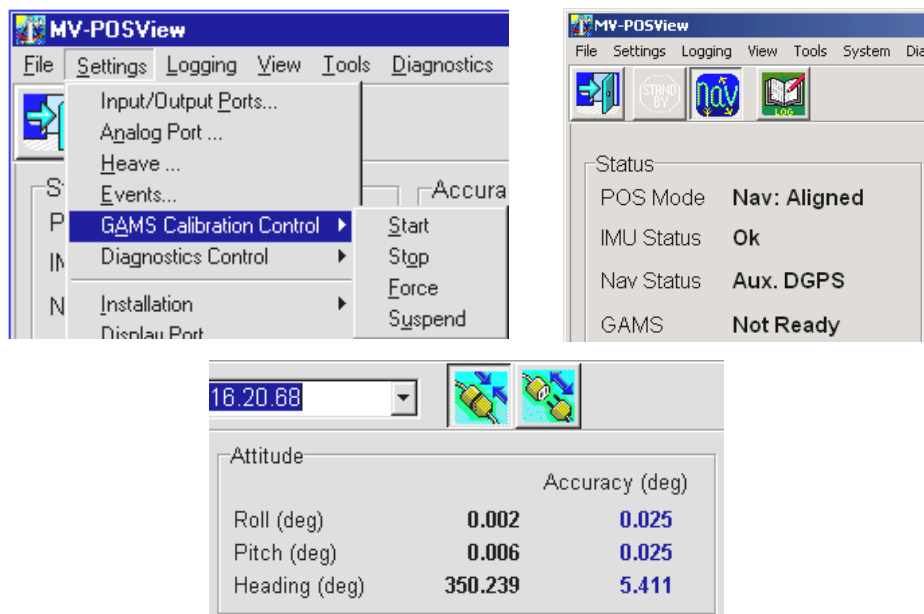


Figure 27: POSView Settings Menu, Status and Attitude Panes

16. Stop calibration while in progress: Select **Settings, GAMS Calibration Control, Stop**. The displayed **GAMS** status then becomes **Ready Offline**. The system cancels the partially completed calibration process.
17. 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.
18. 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**.

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- The **Altitude** pane **Heading Accuracy** field drops slowly to less than 0.15° and eventually settles to a value of 0.02° in a low multipath environment. The actual value that it settles to depends on the current setting for the multipath environment.

If the calibration was successful and no GPS 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.

19. Record data: If the installation parameters appear to be correct, select **Settings, Installation, GAMS Parameter Setup** from the menu bar (Figure 26, page 4-27) 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 5-20 for a description of how GAMS uses the GAMS installation parameters to aid the 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 initialisation sequences.
- There may be an azimuth error similar in size to the displayed heading accuracy that existed during the calibration process. This

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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 26 on page 4-27. Select the **OK** button to install the new antenna separation distance.

Begin a new calibration procedure, see Antenna Installation Calibration on page 4-24.

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 26 on page 4-27. 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.

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 2-30 and 4-12 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 non-volatile memory.

Whenever changes are made to the POS MV installation parameters or its configuration, they must be saved to non-volatile memory 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 non-volatile memory. 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 non-volatile memory. Refer to the Save Settings description on page 4-35 for more information.

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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, refer to Figure 28.
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. Refer to the Manage Multiple Configurations description on page 4-36 for more information.

POS MV Power-Off

Power for the POS MV system is applied to the PCS rear panel PWR connector, refer to Figure 28. 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 4-2 for more information.

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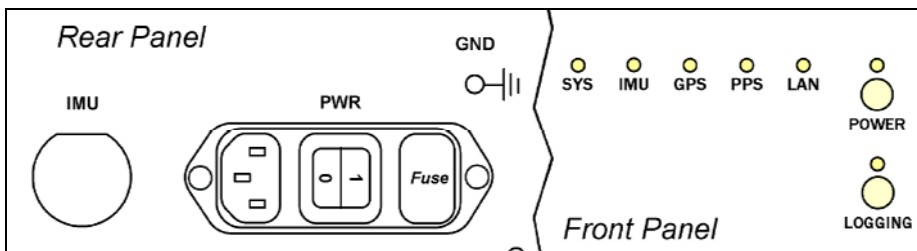


Figure 28: PCS Front and Rear Panels - Switches and Indicators

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.

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

Note: Applanix recommends the use of a UPS to power the POS MV. Following this recommendation will eliminate the need to power-off the system while switching on board generators.

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

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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 non-volatile memory 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 non-volatile memory. 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.

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System Configuration

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:

- 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
- Tools, Configuration - Navigator Configuration window

Each of the above windows has an icon in the lower left corner. They are either all locked (password protected) or all unlocked (no password).




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

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System Configuration

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 29 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 29 right
- Reset the password to the default setting (pcsPasswd) by:
 - Acquire an authorization code, from Applanix Customer Support or the MV Product Manager, 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 the 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)

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System Configuration

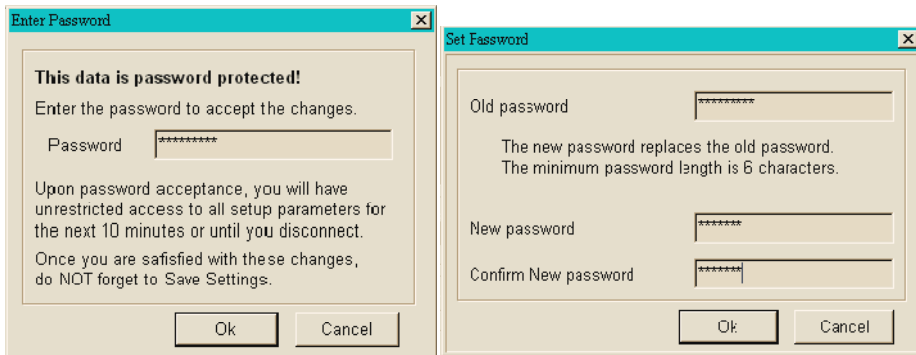


Figure 29: POSView Controller Password Protection

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.

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 4-17 for instructions.

If necessary, refer to the following instructions for assistance:

- LAN (Ethernet) Interface starting on page 2-21
- System Configuration starting on page 4-1
- Power-On starting on page 4-2
- System Addresses starting on page 4-7
- AutoStart starting on page 4-17
- Power-Off starting on page 4-33

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System Operation

- Password Protection starting on page 4-37
- Software Installation starting on page D-1

The following identifies the key elements of Section 5.0.

MV-POSView Controller Program: Use the controller program, which runs under MS-Windows™, to configure and operate the system.

Monitoring POS MV: The controller program allows you to display the measurements and navigation solutions generated by the system.

Data Logging: Data may be logged by the POS MV over the Ethernet LAN to a PC hard drive, or as an option, internally.

Operation with GAMS: Operation with GPS Azimuth Measurement Subsystem (GAMS) allows POS MV to deliver heading measurements with exceptional accuracy.

Stand-Alone Operation: You can configure POS MV to begin operation without the need of a controlling PC.

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

POS MV V4 Installation and Operation Guide

System Operation

data simultaneously. If a window is open but the corresponding group is not selected for output in the **Display Port Control** window, then the data are not displayed, see Figure 30.

- 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 non-volatile memory. Only one MV-POSView Controller program can operate in control mode on the LAN 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. Alternatively, specific groups may be enabled or disabled from the **Display Port Control** window, see Figure 30.

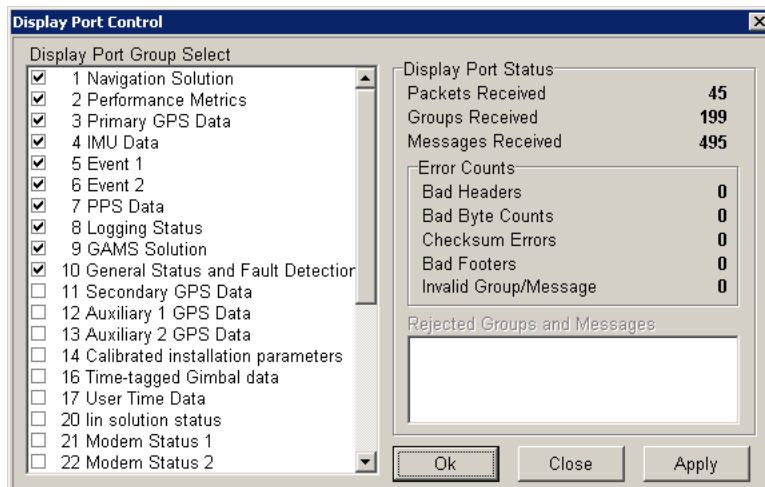


Figure 30: POSView Display Port Control

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PCS Ethernet Connection

Refer to Figure 31 on page 5-5 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 31 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 Positioning System (GPS) 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) |

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- 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

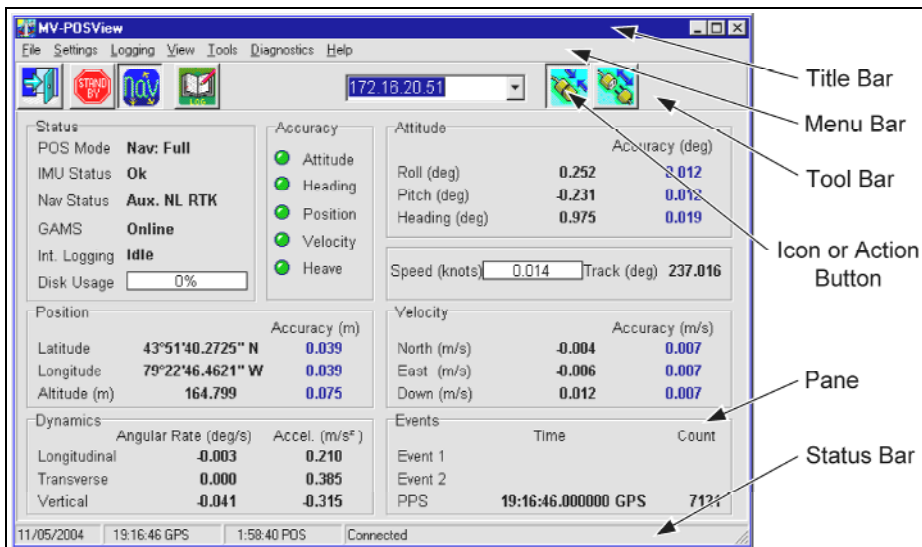


Figure 31: POSView Controller Main Window

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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

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 5-12. Contact Applanix for advice if necessary.

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

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

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

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

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FLOAT RTK	Navigator is tightly coupled using the primary GPS raw observables plus base GPS 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 GPS position data in C/A mode
Pri. DGPS	Navigator is loosely coupled using the primary GPS position data in DGPS mode
Pri. P	Navigator is loosely coupled using the primary GPS position data in P-CODE mode
Aux. DGPS	Navigator is loosely coupled using the auxiliary GPS position data in DGPS mode
Aux. Float RTK	Navigator is loosely coupled using the auxiliary GPS position data in Float RTK mode
Aux. WL RTK	Navigator is loosely coupled using the auxiliary GPS position data in Wide Lane RTK mode
Aux. NL RTK	Navigator is loosely coupled using the auxiliary GPS 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**.

Int. Logging - displays the status of the internal data logging drive (hardware and software option). This field displays **Device Full**, **Write Error**, **Writing**, **Buffering** and **Idle**.

Disk Usage - indicates the percentage of the internal data logging drive that contains data (hardware and software option).

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.

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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/s^2) 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.

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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.

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 32. Click the **OK** button to accept.

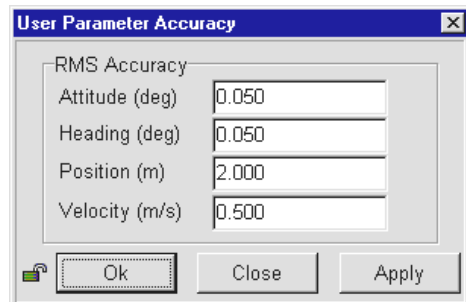


Figure 32: POSView User Parameter Accuracy

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.

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 GPS receiver, the number of satellites tracked and whether DGPS corrections are available to the navigation algorithm. It also depends on the level of motion that POS MV

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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 33, 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 multi-beam transducer or other equipment. Refer to the Installation Parameters description starting on page 2-30 when assigning lever arms and mounting angles.

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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.

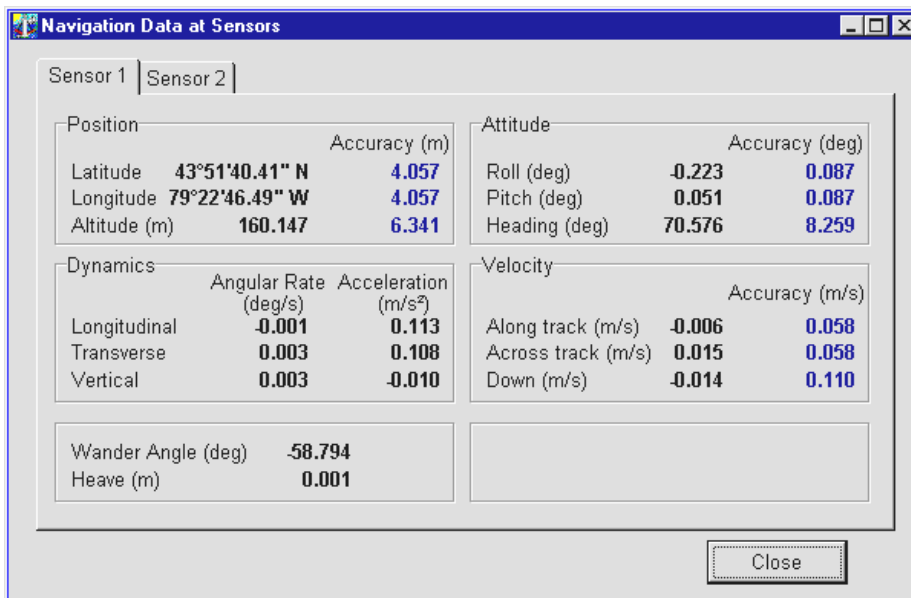


Figure 33: POSView Navigation Data at Sensors

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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.

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's orientation is with respect to North.

Heave Field

Heave is the filtered vertical motion plus the pitch-derived heave at the heave location.

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 34. Two other tabs on the window show IMU and GPS Correction fault status. Three light conditions may occur where; *green* indicates an acceptable condition, *red* indicates an unacceptable condition and *greyed* is not

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applicable. Access to the **Fault Detection** window is from the MV-POSView menu bar, select **View, Faults**.



Figure 34: POSView Fault Detection

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System Operation

Note: Some fields may display a red indicator (intermittently) during initialisation 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 35) select **View, Message Log** from the MV-POSView menu bar.

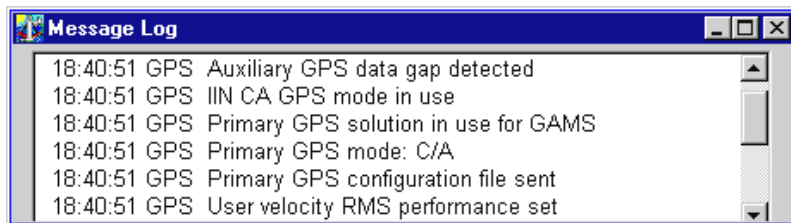


Figure 35: POSView Message Log

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 GPS and IMU to offer the best navigation solution for the current data quality.

For more information on AutoRecovery and FDIR refer to page 1-16.

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System Operation

Data Logging

POS MV can log mission data internally (hardware and software option) or externally to a PC.

Internal Logging

With this option, see page 1-18, the PCS has a one-Gigabyte (1 GB) internal memory device for logging data that is not physically accessible. The logging function is controlled from the front panel LOGGING switch or from the MV-POSView menu bar.

Internal logging activity is indicated three ways; refer to Figure 36:

- Illumination of the LOGGING light, located above its related switch
- **Int. Logging** field display on the MV-POSView **Status** pane
- **Disk Usage** percentage bar on the MV-POSView **Status** pane

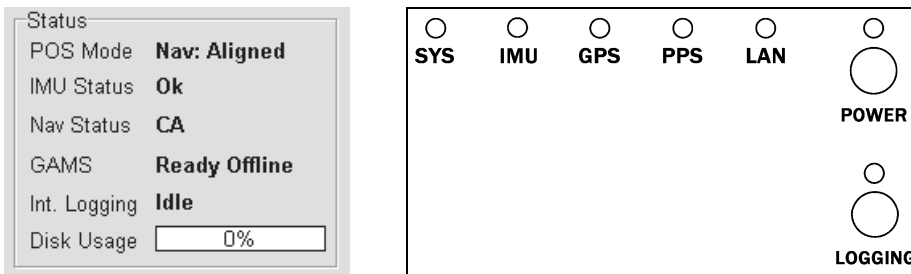


Figure 36: Internal Logging Activity Indicators

Access the internal logged data by connecting to the PCS using File Transfer Protocol (FTP), log on as *anonymous* and use *ftp* as the password. The default directory contains the logged data files. Transfer the data files from the PCS, verify the transfer and then delete the source files (on the PCS).

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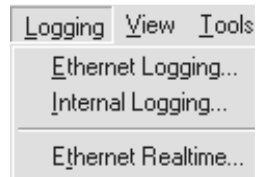
System Operation

Ethernet Logging

High rate logging using the Transmission Control Protocol (TCP) connection to the PCS data port logs mission data through the Ethernet LAN port to a disk on a PC running the MV-POSView Controller program. Only one computer on the Ethernet LAN can connect and receive data.

You can stop and restart logging as often as required. With Ethernet logging, the data file is closed each time you stop logging, and appended or overwritten when you start logging again using the same filename.

Logging commands are accessed from the MV-POSView menu bar. **Ethernet Logging** is intended for data logging or a delayed processing application where data loss cannot be tolerated. This selection implements a very large storage buffer to minimize the risk of data loss.



Ethernet Real-Time Logging

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

Data Logging Control

Figure 37 shows the logging control windows. Selecting **Logging, Internal Logging** from the menu bar displays the top window (hardware and software option), whereas selecting either of the two remaining Ethernet logging menu items will display the bottom window. The following paragraphs describe the window parameter options.

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Logging Group Select Field

Identifies the groups selected for logging. Ensure that you have selected all the desired groups. (All logging windows)

POSPac button (all) - selects the groups that POSPac processes

Deselect All button (all) - removes all selections

Media Status Pane

Displays the dynamic status of the dedicated internal memory device.
(Internal logging window)

Logging Control Pane

Auto Log option (internal) - PCS automatically starts logging after power-up; previously, the option must be selected and saved to NVM (**Settings, Save Settings**)

Group 1 Output Rate field (all) - sets the data rate of group 1 to the internal memory device or to the Ethernet; other groups are logged at the rate at which they are generated, refer to *POS MV Model 320 V4 Ethernet & SCSI Interface Control Document (ICD)*

Filename field (internal) - enter a file name; this becomes the core file name and the PCS appends a three-digit number that is incremented each time a new file is started; if logging is stopped and restarted with the same file name, the appended number is incremented

Log data to File option

Selecting this option causes the controller to save the data to the file specified in the **Log File** pane; if this option is not selected, then

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clicking the **OK** or **Apply** button causes the PCS to output the selected groups to the data port but controller does not log the data

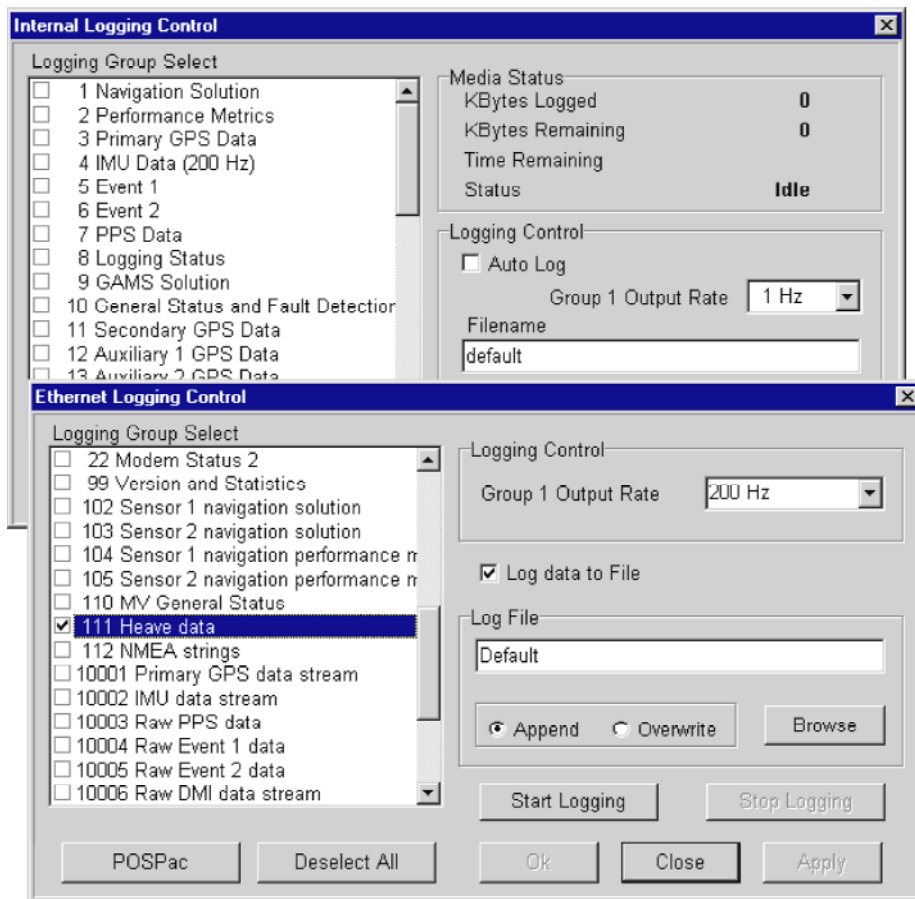


Figure 37: POSView Data Logging Control

Log File Pane

File name field (Ethernet) - choose a location on the PC (**Browse** button) and a filename to store the logged data

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Append, Overwrite options (Ethernet) - choosing a filename that already exists enables these two options; you can append new data to the existing file or you can overwrite the existing file with new information

Command Buttons

Start Logging button (all) - starts logging data; the window stays open

Stop Logging button (all) - stops logging data and closes the file; the window stays open

OK button (all) - enables all window parameter settings and closes the window, logging does not start

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

Apply button (all) - enables all window parameter settings, but does not close the window, logging does not start

If you want the changes to become active when the PCS is next powered-on, select **Installation, Save Settings** to save them to non-volatile memory.

The configuration for the Ethernet (LAN) data port affects only the PCS output. Ethernet data logging is a function of the controlling PC and the MV-POSView Controller program.

A change to the logged data groups may be made at any time, even when logging is already in progress. The changes will take effect immediately when you choose **OK** or **Apply** buttons on the **Ethernet Logging Control** window.

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System Operation

Operation with GAMS

Normal Operation

If POS MV has valid installation parameters stored in non-volatile memory then it is ready to operate with GAMS heading aiding.

- a) Follow the instructions in the Power-On topic on page 4-2 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 38) to follow the GAMS initialisation 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 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.
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 GPS receivers. **GAMS** status displays **Not Ready**.

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System Operation

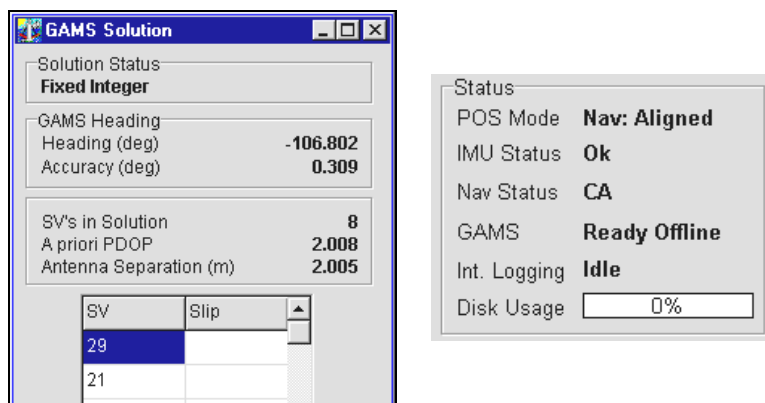


Figure 38: POSView GAMS Solution and Status Pane

- 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**.
- 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° .

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.

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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 GPS data dropout occurs in either/both GPS 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 GPS 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.

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- 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 GPS data gap occurs and lasts for longer than two seconds. This can be caused by a blockage of the GPS 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, GPS signal masking, or unexpected changes in IMU or GPS antenna geometry.

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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 GPS antennas move with respect to the IMU by more than a few centimetres or if the IMU has moved with respect to the GPS 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 2-30) and re-configure the POS MV installation parameters (POS MV Configuration on page 4-11).

2. ***Cause - Multipath Environment*** - A temporarily high multipath environment may occur if the vessel passes near a large reflecting surface such as a large ship or a building. SNR degradation for low elevation satellites may occur in either/both GPS 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.

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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, see Figure 24 on page 4-25.

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-initialise 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 GPS 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-initialise POS MV and GAMS.

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System Operation

3. **Cause - Low SNR** - GAMS uses one or more satellite observables with a tracking SNR that is consistently below 32 dB from either/both GPS receivers. This can arise from:

- Partial masking of a GPS 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)
- GPS 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 34 on page 5-13, **Fault Detection** window (by selecting **View, Faults**), to check the GPS receiver status and to determine whether either receiver has reported a fault.

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System Operation

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.

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-initialise 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.

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System Operation

This may also occur if you experience degraded signal reception in either/both GPS 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 GPS 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 GPS signal degradation while it continues to maintain an acceptable heading accuracy.

Once you have removed the vessel from the source of GPS signal degradation, **GAMS** status should become **Online**.

Installation Parameters

Figure 39 shows the **GAMS Parameter Setup** window. Refer to Antenna Installation Calibration on page 4-24 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. It is unlikely you will ever need to modify these parameters again unless you move either/both GPS antennas or the IMU.

POS MV V4 Installation and Operation Guide

System Operation

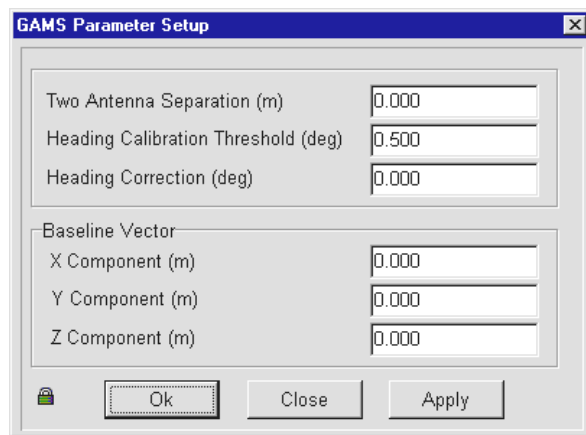


Figure 39: POSView GAMS Parameters Setup

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.

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System Operation

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 GPS 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.

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 4-17 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 4-2 to power-on the POS MV. The system will initialise using the configuration parameters that it holds in non-volatile memory. 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.

POS MV V4 Installation and Operation Guide

System Operation

Once the system is initialised, it will begin to output data across the enabled ports.

Refer to the Data Logging instructions page 5-15 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 lights on the PCS continue to provide an indication of the system status as described in the Power-On instructions on page 4-2.

In stand-alone mode, whichever outputs you enabled and saved to the non-volatile memory will be available from the PCS. Data output will begin when the SYS light, 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 SYS light begins to flash green, at which time the PCS will start to broadcast all the selected output groups.

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 5 Hz (30 to 0.2 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 40 illustrates the relationship of the TrueHeave solution to the current real-time approach and shows how it is computed and applied.

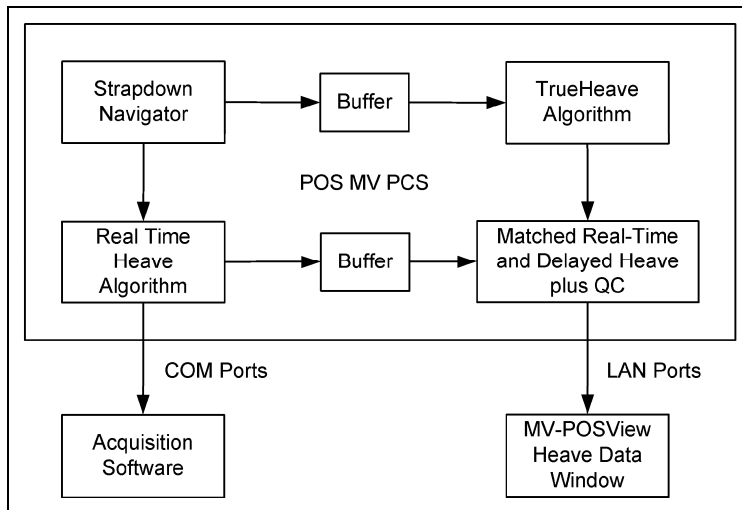


Figure 40: TrueHeave Functional Block Diagram

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TrueHeave Operation

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 Model 320 V4 Ethernet & SCSI Interface Control Document (ICD)*. 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 111 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 41. 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.

POS MV V4 Installation and Operation Guide

TrueHeave Operation

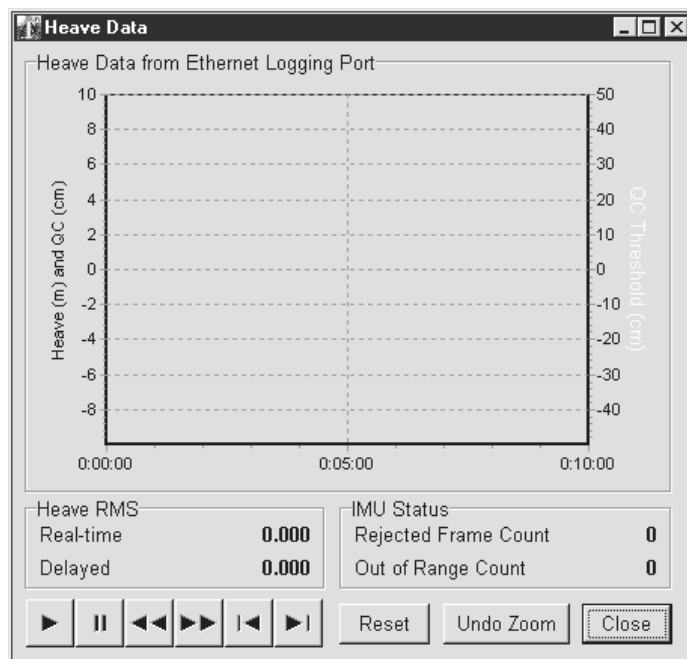


Figure 41: POSView Heave Data

TrueHeave Procedure

As a non-standard option, TrueHeave must be enabled before use. Contact your Applanix Customer Support representative for the appropriate authorization code (refer to page A-1).

1. Initialise 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 42.

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TrueHeave Operation

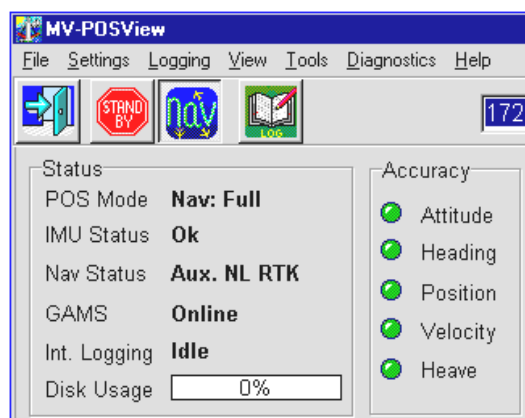


Figure 42: POSView Status and Accuracy Panes

2. View real-time heave and TrueHeave data by selecting **View, Heave Plot**, see Figure 41. Due to the delay inherent in creating the TrueHeave solution, the heave data plot remains blank for the first three minutes after initialization.
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 5-15 and to Figure 37 on page 5-18 noting the following points:
 - a) Select the 111 Heave check box 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

POS MV V4 Installation and Operation Guide

TrueHeave Operation

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.

POS MV V4 Installation and Operation Guide

Specifications

7.0 Specifications

POS MV 320 Main Specifications (with Differential Corrections)

Roll, Pitch accuracy:	0.02° (1 sigma with GPS or DGPS) 0.01° (1 sigma with RTK)
Heave Accuracy:	5 cm or 5% (whichever is greater) for periods of 20 seconds or less
Heading Accuracy:	0.02° (1 sigma) with 2 m antenna baseline, 0.01° (1 sigma) with 4 m baseline
Position Accuracy:	0.5 - 2 m (1 sigma) depending on quality of differential corrections 0.02 - 0.10 m (RTK) with input from auxiliary RTK or optional internal RTK receiver
Velocity Accuracy:	0.03 m/s horizontal

POS MV 320 during GPS 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 < 60s)
Position accuracy degradation:	2.5 m (1 sigma) for 30 s outages <6 m (1 sigma) for 60 s outages

POS MV 220 Main Specifications (with Differential Corrections)

Roll, Pitch accuracy:	0.05° (1 sigma with GPS or DGPS) <0.05° (1 sigma with RTK)
Heave Accuracy:	5 cm or 5% (whichever is greater) for periods of 20 seconds or less
Heading Accuracy:	0.1° (1 sigma) with 2 m antenna baseline, 0.05° (1 sigma) with 4 m baseline

POS MV V4 Installation and Operation Guide

Specifications

POS MV 220 Main Specifications (with Differential Corrections)

Position Accuracy:	0.5 - 4 m (1 sigma) depending on quality of differential corrections
	0.02 – 0.10 m (RTK) with input from auxiliary RTK or optional internal RTK receiver
Velocity Accuracy:	0.05 m/s horizontal DPGS, .03 m/s horizontal RTK

POS MV 220 during GPS Outages

Roll, Pitch accuracy:	0.05° (1 sigma)
Heave accuracy:	5 cm or 5% (whichever is greater) for wave periods of 18s or less
Heading accuracy:	Drift less than 3° per hour (negligible for outages < 60s)
Position accuracy degradation:	2.5 m (1 sigma) for 30 s outages <6 m (1 sigma) for 60 s outages

Physical Characteristics

Size

IMU:	204 mm X 204 mm X 168 mm	7.95 in X 7.95 in X 6.55 in
PCS:	432 mm X 89 mm X 356 mm	17.00 in X 3.50 in X 14.05 in
	2.0U 19 in rack mount	
GPS Antenna (x2):	187 mm Ø X 53 mm	7.4 in Ø X 2.1 in

Weight

IMU:	3.5 kg	7.7 lb (international)
Processor:	5 kg	11.0 lb (international)
GPS Antenna:	<0.5 kg	<1.1 lb (international)

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Specifications

Power

Processor:	110/230 Vac, 50/60 Hz, auto-switching 80 Watt	
IMU:	Power provided by PCS	
GPS Antennas:	Power provided by PCS	

Environmental

Temperature Range (Operating)

IMU:	-40 °C to +60 °C	-40 °F to +140 °F
Processor:	0 °C to +55 °C	+32 °F to +131 °F
GPS Antenna:	-40 °C to +70 °C	-40 °F to +158 °F

Temperature Range (storage)

IMU:	-40 °C to +60 °C	-40 °F to +140 °F
Processor:	-25 °C to +85 °C	-13 °F to +185 °F
GPS Antenna:	-50 °C to +70 °C	-58 °F to +158 °F

Humidity

IMU:	10 - 80% RH, Ingress Protection of 65
Processor:	10 - 80% RH, non-condensing
GPS Antenna:	0 - 100% RH

Shock & Vibration (IMU)

Operating:	90 g, 6 ms terminal saw tooth
Non-Operating:	220 g, 5 ms half-sine

POS MV V4 Installation and Operation Guide

Tools and Diagnostics

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.

GPS Configuration: The system can configure the Global Positioning System (GPS) receivers automatically for its own use. If necessary, the GPS receivers may be configured manually.

GPS Reset: If a condition develops that prevents the operation of the GPS receivers, the system provides a GPS reset function that commands the receivers to reinitialise.

Control Diagnostics: POS MV provides a diagnostic mode that may be used to set the output ports to specific values. This function assists when installing the system as part of an extended suite of survey equipment.

Display Diagnostics: POS MV provides diagnostic data, via the Ethernet ports, that may be viewed on the MV-POSView Controller to troubleshoot system problems.

Regular Maintenance: Following the simple maintenance procedures listed in this subsection ensures that the system operates at peak performance throughout its lifetime.

Technical Support: Applanix provides a comprehensive technical support service managed by trained and experienced engineers.

POS MV V4 Installation and Operation Guide

Tools and Diagnostics

GPS Configuration

Upon installation the POS MV configures the GPS 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 GPS configuration message to the GPS receivers manually by selecting **Tools, Configure GPS** from the MV-POSView menu bar.

GPS Reset

The MV-POSView Controller program allows you to send a reset command to the GPS receivers. To do this, select **Tools, Reset GPS** from the MV-POSView menu bar.

Once the reset command is initiated, the GPS receivers will take approximately two minutes before they return to the navigation mode and POS MV can use their data.

Use the GPS 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 GPS reset feature, verify that you cannot attribute the cause to faults in cables or connectors.

GPS Data

Select **View, GPS Data** from the MV-POSView menu bar to view the **GPS Data** window shown in Figure 43.

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Tools and Diagnostics

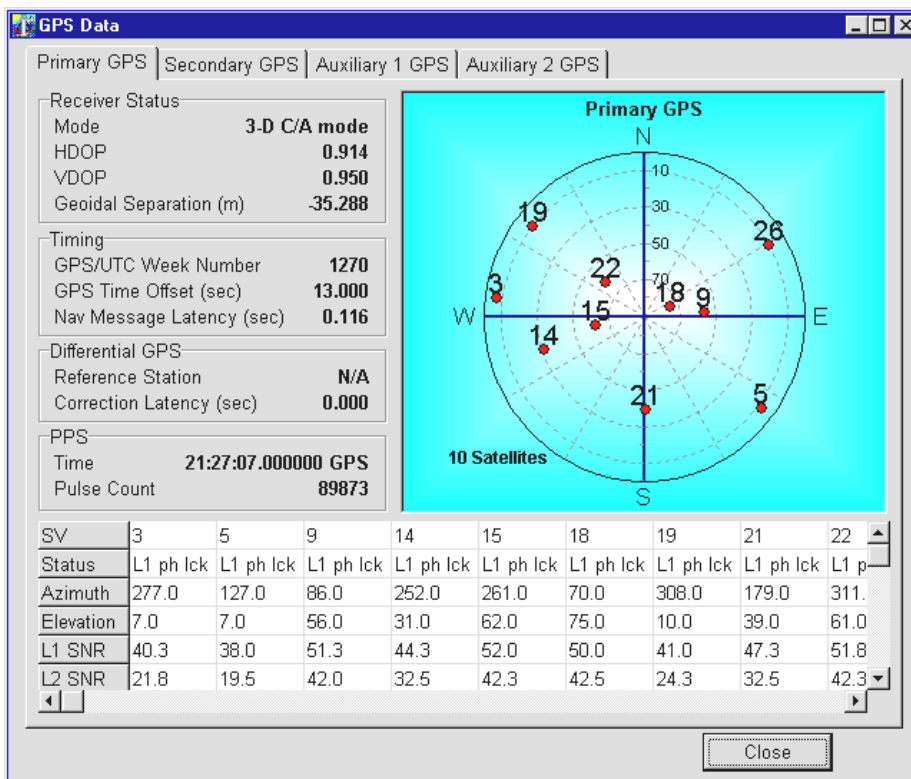


Figure 43: POSView GPS Data

The **GPS Data** window shows the GPS 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

POS MV V4 Installation and Operation Guide

Tools and Diagnostics

deterioration in the quality of the GPS antenna cable. The window will show the L2 SNR for L1/L2 GPS, if fitted.

Diagnostics

POS MV provides both control and display diagnostic functions. The control functions permit the selection and setting of various binary and analog 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 or analog 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 44.

1. On the MV-POSView menu bar, select **Settings, Diagnostics Control, Binary/Analog** to open the **Binary/Analog 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.

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Tools and Diagnostics

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

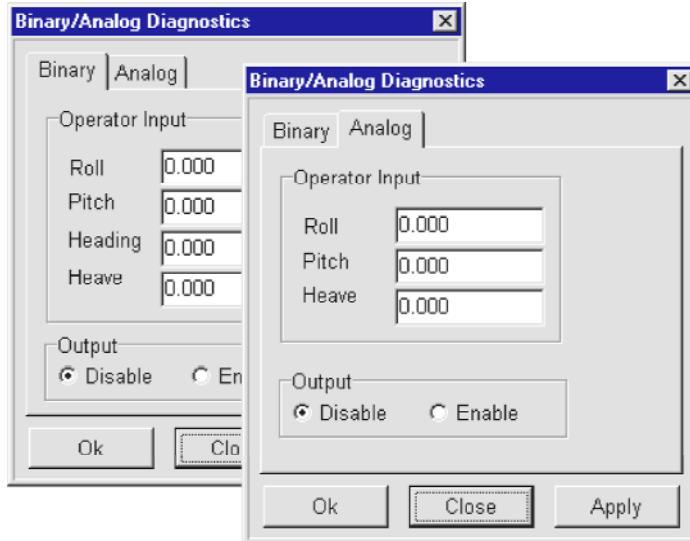


Figure 44: POSView Binary/Analog Diagnostics

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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 GPS
- Secondary GPS
- Base GPS (Base 1 and Base 2)
- Aux GPS
- Control Port
- Display, Data & NVM
- Time & Pulses
- IMU
- NMEA & Binary Output
- Other

Contact Applanix Customer Support for assistance, see page A-1

Regular Maintenance

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 or removal of the gas purge screws will void the warranty. The IMU is a sealed, nitrogen-filled unit that contains no user serviceable parts and does not require internal maintenance.

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Tools and Diagnostics

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.

GPS 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.

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Tools and Diagnostics

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

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.

Component Description: The POS MV components are described in the context of fault identification.

Fault Identification: The various fault diagnostic methods available to the operator are Identified. Such as automatic fault identification, front panel indicators, fault windows and log messages.

Remove and Replace Procedures: Remove and replace procedures for various components and subassemblies of the POS MV system are described.

Troubleshooting: Refer to this subsection if your 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 your survey suite.

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.

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Fault Identification

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 Positioning System (GPS) antennas

POS MV V4 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 2-2 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 2-2 for instructions pertaining to IMU handling and care.

GPS Antennas



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

The GPS 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

POS MV V4 Installation and Operation Guide

Fault Identification

operation. Follow the steps outlined in the GPS 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 GPS 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 comprises the following subsystem modules:

- An auto-switching power supply
- An Mini POS (mPOS) module
- Two Trimble GPS receiver cards

The following paragraphs describe the functions of these modules.

Power Supply

The PCS uses an auto-switching power supply that operates from a 110 Vac or a 220 Vac nominal electrical supply. The module senses the input electrical voltage and configures itself automatically to accept it. Both the mPOS and the IMU receive their operating power from the power supply.

mPOS

Heart of the PCS, the mPOS is powered by an Intel central processing unit and support circuitry, an optional one-gigabyte internal memory for logging, an IMU interface card and two GPS receivers. The module interfaces directly with the PCS front panel switches and indicators. The mPOS is not field repairable.

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Fault Identification

Trimble GPS Receiver Cards

The mPOS includes two GPS receivers, primary and secondary, where each card is an L1, 24-channel module. These single-frequency RTK GPS receivers boast horizontal accuracies of 20 mm and vertical accuracies of 30 mm.

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, including the power supply, mPOS and the internal PCS wiring harnesses
- GPS subsystem, including the GPS antennas, GPS antenna cables and GPS receivers

If POS MV detects a failure condition in either the GPS 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)

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Fault Identification

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, the IMU, the one pulse per second signal and the LAN connection. The GPS light indirectly indicates the status of the GPS receivers; refer to Figure 45. To isolate faults on any of these subsystems, follow the advice and instructions provided in Table 30.

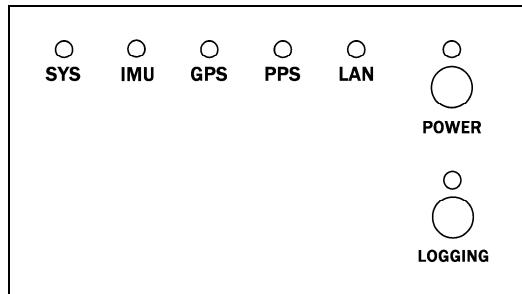


Figure 45: PCS Front Panel - Switches and Indicators

Table 30: PCS Front Panel Indicators - Fault Identification

SYS 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.

A solid red indication while all the other lights behave normally indicates a fault in PCS.

If a fault occurs, do not power-off PCS. Refer to Fault Detection window of controller program, described in Faults and Messages on page 5-12 and Fault Detection on page 9-8.

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Fault Identification

If light frequently shows red during operation, PCS may be receiving poor quality electrical power. Applanix recommends a UPS to power POS MV installation.

- 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.

IMU light - indicates status of Inertial Measurement Unit (IMU):

- Steady green: Receiving IMU data and TOV.
- Steady red: IMU down, disconnected or an internal hardware failure.

GPS light - indicates GPS reception in loosely coupled mode or navigation status in tightly coupled mode:

- Steady red: No GPS solution is available.
- Steady amber: GPS receiver is delivering a Coarse Acquisition (C/A) or P-Code GPS solution.
- Steady green: GPS receiver is delivering a Differential Global Positioning System (DGPS) or Real-Time Kinematic (RTK) solution.

PPS light - flashes green once per second to indicate reception of GPS One Pulse Per Second (1PPS) signal.

LAN light - indicates transmit and receive local area network activity:

- Flashing green: Indicates activity on Ethernet Local Area Network (LAN).
- Steady red: Indicates a LAN fault, such as a break in Ethernet line.

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Fault Identification

Fault Detection

To access the **Fault Detection** window select **View, Faults** from the MV-POSVIEW menu bar. This window, shown in Figure 46, 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 GPS 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 9-11 lists the possible messages that may appear in the message log. Of interest, at this point, are the items in Figure 46. 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 GPS** pane, Figure 46, shows the status of the primary GPS receiver and any faults reported by it. If this pane reports any persistent faults, they could be caused by a faulty GPS antenna or its cable.

The **Secondary GPS** pane monitors the data gaps from the secondary GPS receiver. A persistent loss of secondary GPS information will prevent GPS Azimuth Measurement Subsystem (GAMS) from performing carrier phase differential measurements to determine the heading. Investigate the secondary GPS antenna and its cable as a possible cause of persistent data gaps.

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Fault Identification



Figure 46: POSView Fault Detection

Data gaps experienced by both GPS 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.

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Fault Identification

The **Auxiliary GPS** pane reports the status of navigation solutions supplied from any auxiliary GPS receiver connected to the PCS.

The **IMU** pane reports the status of the IMU, with additional information appearing on the **IMU** tab shown in Figure 47. 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 reinitialise and start coarse levelling.

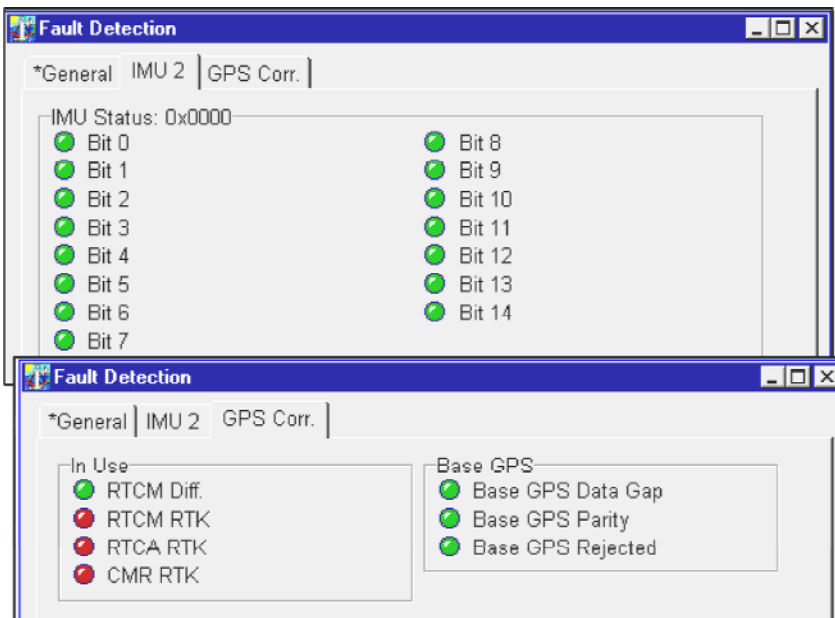


Figure 47: POSView Fault Detection - IMU and GPS Corr. Tabs

IMU Tab

The **IMU Status** pane, Figure 47, 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.

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Fault Identification

GPS Corr. Tab

The **In Use** pane, Figure 47, shows the types of corrections that the navigation algorithm may use. A green light indicates the item that is currently being used.

The **Base GPS** pane indicates the status of received data on the base GPS 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 48.

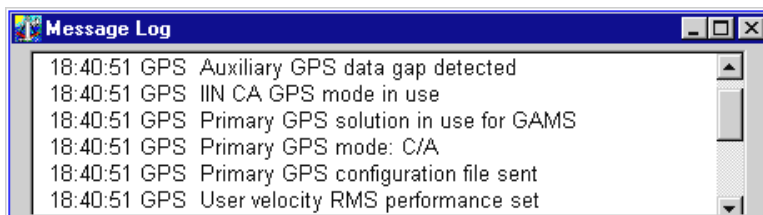


Figure 48: POSView Message Log

Table 31 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 GPS configuration is handled automatically if the GPS automatic reconfiguration feature is enabled; refer to the GPS Receiver topic on page 4-22 and Figure 23 on page 4-23. The automatic reconfiguration logic checks for expected messages from the GPS receiver, and will send a configuration command to the receiver if the expected messages are not present. The contents of messages are not checked.

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Fault Identification

Table 31: 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 GPS data; Short periods when this occurs are normal
Ephemeris data gap cleared	Flag reset
*Primary GPS raw observable data gap detected	There is a gap in GPS data; short periods when this occurs are normal
Primary GPS raw observable data gap cleared	Flag reset
*Secondary GPS raw observable data gap detected	There is a gap in GPS data; short periods when this occurs are normal
Secondary GPS raw observable data gap cleared	Flag reset
*Auxiliary GPS data gap detected	There is a gap in auxiliary GPS data
Auxiliary GPS data gap cleared	Flag reset
Horizontal acceleration out of range	Receiver not configured properly
Horizontal acceleration out of range cleared	Flag reset
*GPS not available for alignment	POS MV failed to receive GPS data for > 60 s
GPS available for alignment	Flag reset
*GPS data gap detected	Gap in GPS data; short periods when this occurs are normal
GPS data gap cleared	Gap discontinued

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Fault Identification

Message Text	Description
*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 GPS receiver is not configured properly
Time recovery message received	Flag reset
*GPS not in navigate mode	GPS receiver has not entered navigate mode; still searching for satellites
GPS in navigate mode	Receiver in navigation mode
*GPS tracking elevation limit incorrect	GPS receiver is not configured
GPS tracking elevation limit corrected	Flag reset
HDOP/VDOP less than 10	GPS receiver is not configured
HDOP/VDOP less than 10 cleared	Flag reset
GPS time output mode is not UTC	GPS receiver is not configured
GPS time output mode is UTC	Flag reset
Incorrect time parameters	GPS receiver is not configured
Incorrect time parameters cleared	Flag reset
Incorrect GPS datum parameters	The GPS receiver is not configured properly
Incorrect GPS datum parameters cleared	Flag reset
Position/velocity fix error	Positions and velocities reported by the IMU and the GPS are inconsistent; likely cause is an incorrect entry of GPS lever arms in the installation data
Position/velocity fix error cleared	Flag reset

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Message Text	Description
Incorrect differential GPS configuration cleared	Flag reset
Incorrect SV selection parameters	The GPS receiver is not configured properly
Incorrect SV selection parameters cleared	Flag reset
GAMS ambiguity resolution failure	The GPS receiver is not configured properly
GAMS ambiguity resolution failure cleared	Flag reset
GPS failure	GPS velocity or position failure
GPS 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
*GPS velocity failure	GPS reports speed > 35 m/s; problem will probably correct itself
GPS velocity failure cleared	Flag reset
*GPS position failure	GPS reports horizontal position error > 1000 m; problem will eventually correct itself
GPS position failure cleared	Flag reset
Auxiliary GPS position failure	The GPS receiver is not configured properly
Auxiliary GPS position failure cleared	Flag reset

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Fault Identification

Message Text	Description
*GPS position measurement rejected	Position reported between IMU and GPS are inconsistent; likely GPS Lever Arms are incorrect in installation data
GPS position measurement reject cleared	Flag reset
*GPS velocity measurement rejected	Velocity reported between IMU and GPS are inconsistent; likely GPS Lever Arms are incorrect in installation data
GPS velocity measurement reject cleared	Flag reset
GAMS heading failure	The GPS receiver is not configured properly
GAMS heading failure cleared	Flag reset
Aux GPS position measurement rejection	The GPS receiver is not configured properly
Aux GPS 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

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IMU Messages - Message Log	
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
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

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IMU Messages - Message Log	
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
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.	

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Fault Identification

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 32.

Table 32: 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 reinitialise and start coarse levelling. However, due to the communications handshaking used by the IMU, bad IMU frames are highly unlikely.

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Fault Identification

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 Detection on page 9-8 and Message Log on page 9-11) 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.

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Fault Identification

GPS

The GPS subsystem can experience a permanent loss of satellites, or a breakdown of communication between the GPS receiver and the PCS.

Permanent Loss of Satellites

POS MV provides continuous information on the status of the GPS receivers. The status of the GPS receivers may be monitored on the **GPS Data** window; select **View, GPS Data** from the MV-POSView menu bar. Additionally, the **GPS Data** window includes detailed information on the satellites that the receiver is tracking and on the receiver mode (i.e. tracking, navigate, etc).

The GPS subsystem may experience periodic GPS dropouts caused, for example, by antenna obstruction. The controller program indicates a GPS dropout by displaying *GPS Not Available* or *GPS Data Gap* in the **GPS Status** field on the main window. However, if a GPS dropout occurs and persists without any apparent antenna obstruction, then one of the following problems may exist:

- A loss of GPS receiver configuration
- A failure in the GPS antenna
- A failure in the GPS antenna cable
- A failure in the GPS receiver

The above diagnoses assume that the PCS continues to receive messages from the primary GPS receiver. If this is true, the front panel GPS light will behave normally for the GPS service in use.

If the front panel GPS light shows red, then there are no GPS 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.

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Fault Identification

GPS

Correct a loss of configuration by selecting **Tools, Configure GPS** from the MV-POSView menu bar.

The GPS antenna is a solid-state device with a low failure rate. Faults in the GPS subsystem are more likely to arise from damaged antenna cabling or a receiver failure. If examination of the GPS 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 GPS light shows red, then there is a communications failure between the PCS and the primary GPS receiver. Typical causes for this fault are:

- A loss of GPS receiver configuration
- There is a failure in the internal PCS wiring harness
- There is a failure in the GPS receiver

If Auto Configuration is enabled (select **Enabled** in the **Auto Configuration** pane on the **Gps Receiver Configuration** window), then during the power-on sequence the PCS will establish a proper configuration for the GPS receiver. Therefore, incorrect settings for baud rate should not be possible unless the Auto Configuration feature is disabled.

The GPS receiver may be configured manually by sending a configuration command by selecting **Tools, Configure GPS** from the controller menu bar.

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Fault Identification

GPS

If proper operation is not restored within a minute, select **Tools, Reset GPS** from the controller menu bar. The GPS 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 GPS receiver. Refer to the Power-On and Power-Off procedures on pages 4-2 and 4-33 respectively.

GAMS

The GAMS subsystem can experience a permanent loss of satellites, or a communication failure between the GPS 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 or see Figure 38 on page 5-21.

GAMS may experience periodic GPS 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 GPS receiver configuration
- A failure in the GPS antenna
- A failure in the GPS antenna cable
- A failure in the GPS receiver

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Fault Identification

GAMS

The above diagnosis assumes that the PCS continues to receive messages from the secondary GPS 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 48 on page 9-11.

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, GPS Data** and examine the L1 Signal-To-Noise Ratios (SNR) for the available satellites, see Figure 43 on page 8-3. If the L1 SNR is below 38 dB for more than one satellite, the GPS antenna cables are introducing too much signal attenuation. To correct this fault, shorten the cables or substitute them with new low-loss cables.

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Fault Identification

GAMS

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 (see Figure 38 on page 5-21) 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 GPS Configuration description on page 4-24 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.

4. If the ambiguity resolution problem persists, contact Applanix for further instructions. Refer to Technical Support and Service on page A-1 for procedures.

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Fault Identification

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



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.

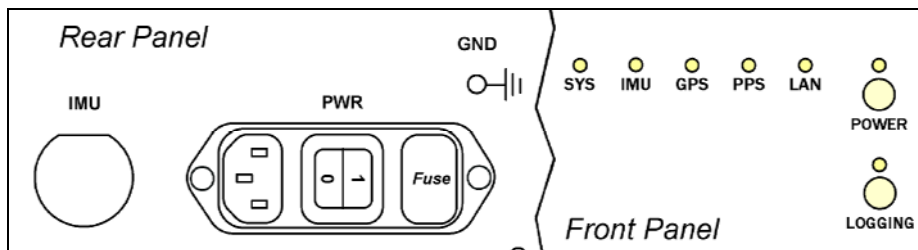


Figure 49: PCS Front and Rear Panels - Switches and Indicators

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Fault Identification

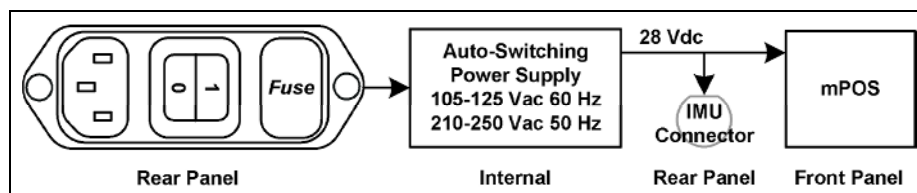


Figure 50: PCS Internal Power Distribution - Block Diagram

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

Remove

1. Observe PCS front panel power-off procedures (refer to Power-Off on page 4-33).
2. Power-off PCS from rear panel (see Figures 49 and 50).
3. Remove power cable from PCS rear panel (see Figures 49 and 50).
4. Release and disconnect power and data cable from IMU (see Figures 77 and 78 on pages E-1 and E-2 respectively). Protect free end of power and data cable from damage or contamination.
5. If fault suspected on power and data cable, disconnect and install a new one. Refer to IMU Cable procedure on page 9-29 for details.

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Fault Identification

6. Release IMU from installed position noting orientation. Retain fixing screws or bolts.
7. Handle IMU with care and pack into original transit case.

Note: It is imperative that proper packing is used to transport IMU.

8. Contact Applanix Customer Support for shipping instructions; refer to page A-1.

Replace

1. Same location:
 - a) Place IMU in installed position noting orientation. Secure fixing screws or bolts.
 - b) Connect power and data cable to IMU (see Figures 77 and 78 on pages E-1 and E-2 respectively). Protect free end of power and data cable from damage or contamination.
 - c) Replace power cable to PCS rear panel (see Figures 49 and 50).
 - d) Power-on PCS from rear panel (see Figures 49 and 50).
 - e) Observe PCS front panel power-on procedures (refer to Power-On on page 4-2).
2. New location - Follow installation instructions for Inertial Measurement Unit on page 2-11.

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Fault Identification

GPS Antenna



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

If you suspect a fault condition on the GPS antenna, replace it with the same type and ensure its serviceability. To remove or replace the GPS 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 GPS antenna

Remove

1. Observe PCS front panel power-off procedures (refer to Power-Off on page 4-33).
2. Power-off PCS from rear panel (see Figures 49 and 50).
3. Remove power cable from PCS rear panel (see Figures 49 and 50).
4. Remove waterproof sealing tape or silicone sealant protecting TNC antenna connector (see Figure 79 on page E-3).
5. Disconnect TNC antenna connector. Protect free end of cable from damage or contamination.
6. Note direction of arrow on top of antenna dome.
7. Remove antenna by turning in a counter-clockwise direction.

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Fault Identification

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 (see Figure 79 on page E-3).
 - e) Replace power cable to PCS rear panel (see Figures 49 and 50).
 - f) Power-on PCS from rear panel (see Figures 49 and 50).
 - g) Observe PCS front panel power-on procedures (refer to Power-On on page 4-2).
2. New location - Follow installation instructions for GPS System on page 2-8.

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.

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Fault Identification

Remove

1. Observe PCS front panel power-off procedures (refer to Power-Off on page 4-33).
2. Power-off PCS from rear panel (see Figures 49 and 50).
3. Remove power cable from PCS rear panel (see Figures 49 and 50).
4. Disconnect IMU power and data cable at both IMU (Figure 77 on page E-1) and PCS (Figure 81 on page E-5).
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 IMU power and data cable at both IMU (Figure 77 on page E-1) and PCS (Figure 81 on page E-5). Protect free ends of cable from damage or contamination.
2. Replace power cable to PCS rear panel (see Figures 49 and 50).
3. Power-on PCS from rear panel (see Figures 49 and 50).
4. Observe PCS front panel power-on procedures (refer to Power-On on page 4-2).

GPS Antenna Cable

If you suspect a fault condition on the GPS antenna power and data cable, install a new cable. To remove or replace the GPS antenna power and data cable complete this procedure.

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Fault Identification

Tools

- Self-amalgamating tape
- Waterproof spray
- Sharp knife or scalpel
- Slip joint pliers appropriate to remove or secure the GPS antenna connector

Remove

1. Observe PCS front panel power-off procedures (refer to Power-Off on page 4-33).
2. Power-off PCS from rear panel (see Figures 49 and 50).
3. Remove power cable from PCS rear panel (see Figures 49 and 50).
4. Remove waterproof sealing tape or silicone sealant protecting TNC antenna connector (see Figure 79 on page E-3).
5. Disconnect GPS antenna power and data cable at both GPS and PCS (Figure 81 on page E-5).
6. 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.
7. Replace cable if not repairable.

Replace

1. Connect GPS antenna power and data cable at both GPS (see Figure 79 on page E-3) and PCS (Figure 81 on page E-5). Do not

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Fault Identification

over tighten. 6 pmProtect free ends of cable from damage or contamination.

2. Apply waterproof sealing tape or silicone sealant to protect TNC antenna connector (see Figure 79 on page E-3).
3. Replace power cable to PCS rear panel (see Figures 49 and 50).
4. Power-on PCS from rear panel (see Figures 49 and 50).
5. Observe PCS front panel power-on procedures (refer to Power-On on page 4-2).

POS Computer System

Note: There are no user replaceable components inside the PCS. 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 (refer to Power-Off on page 4-33).
2. Power-off PCS from rear panel (see Figures 49 and 50).
3. Remove power cable from PCS rear panel (see Figures 49 and 50).

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Fault Identification



Do not hang PCS from loose panel mounting hardware. Support PCS weight from underneath while removing cables.

4. Remove PCS from equipment rack.
5. Tag and remove PCS rear panel connectors.

Replace

1. Same location:



Do not hang PCS from loose panel mounting hardware. Support PCS weight from underneath while connecting cables.

- a) Install PCS rear panel connectors.
 - b) Install PCS in equipment rack.
 - c) Replace power cable to PCS rear panel (see Figures 49 and 50).
 - d) Power-on PCS from rear panel (see Figures 49 and 50).
 - e) Observe PCS front panel power-on procedures (refer to Power-On on page 4-2).
2. New location - Follow installation instructions for Install the PCS on page 2-15.

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.

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Fault Identification

The following subsections cover six categories of system failure:

- Total system failure
- Initialisation failure
- GPS 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 9-5 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 51. Record any dead tasks and inform Applanix.
4. Check quality of electrical power supplied to PCS. PCS can tolerate fluctuations of $\pm 5\%$ maximum and minor variations in supply

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Fault Identification

frequency. If noisy or intermittent electrical power suspected, provide UPS and line conditioner to improve electrical supply quality.



Figure 51: POSView Other Diagnostic

5. Check PCS connection to ground through electrical supply cable. If necessary, connect separate ground strap to grounding lug 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.

Initialisation Failure

The system initialisation 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 GPS 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.

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Fault Identification

2. If **Nav Status** shows **DR** (Dead Reckoning), select View, GPS Data from the controller menu bar, see Figure 52. If **Receiver Status Mode** indicates **No Nav Data** follow GPS Not Available procedure starting on page 9-36.

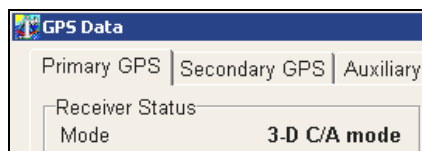


Figure 52: POSView GPS Data - Receiver Status Pane

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.
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.

GPS Not Available

When the POS MV system is powered-on , the GPS 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 GPS subsystem.

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Fault Identification

There are two classes of GPS 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

a) **Improper Communication**

Follow the instructions below to identify a communications fault:

1. Examine GPS light on PCS front panel:
 - If light shows red, there is no communication between PCS and GPS receiver. Follow instructions relating to loss of GPS communications in Status Warning Messages on page 9-18 and the following step below.
 - If light shows amber or green, select **View, GPS Data** from controller menu bar; see Figure 43 on page 8-3.
 - If **GPS Data** window shows system is tracking fewer than four satellites, go to Insufficient Satellites on page 9-38.
2. Select **Diagnostics, Primary GPS** from controller menu bar and check that messages are being received, see Figure 53. If no, fault may be in GPS receiver or in communications between GPS and PCS. Please contact Applanix Customer Support, see page A-1.

POS MV V4 Installation and Operation Guide

Fault Identification

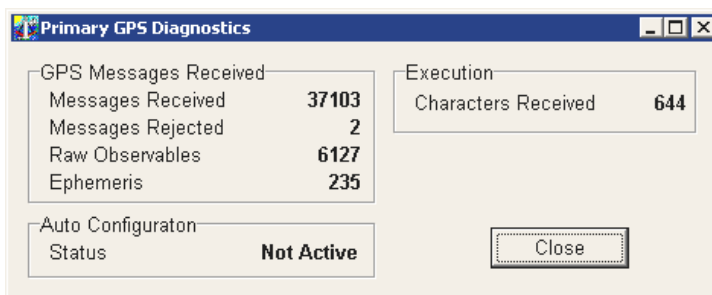


Figure 53: POSView Primary GPS Diagnostics

b) 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 54.
2. If **SVs in Solution** field has fewer than four satellites, mounting location for GPS 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.
3. If mounting locations for both GPS antennas are optimal and **DR** status persists, move vessel to area that has better satellite visibility.

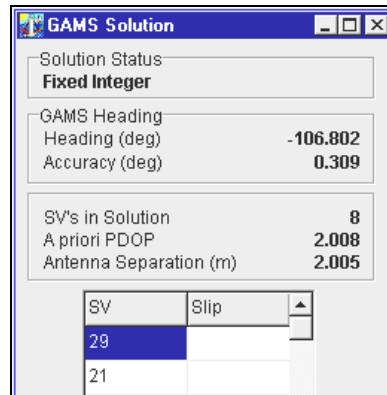


Figure 54: POSView GAMS Solution

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Fault Identification

4. If problem persists after moving vessel, problem exists with GPS 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.

GAMS Not Ready

After the POS MV system is installed, the GPS Azimuth Measurement Subsystem (GAMS) requires calibration. Refer to the Initial GPS Configuration description starting on page 4-24 for instructions.

Once GAMS is calibrated, it will initialise itself and deliver heading measurements automatically each time the system is powered-on and enters navigate mode. Depending on the availability of satellites, the GAMS initialisation 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, see Figure 54 on page 9-38. 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.

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Fault Identification

2. If number of SVs tracked does not increase or if PDOP remains too high, problem may be GPS antenna installation. Examine GPS 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 55 and the COM Ports description starting on page 3-3.
2. Verify serial port connection.

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 56.

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Fault Identification

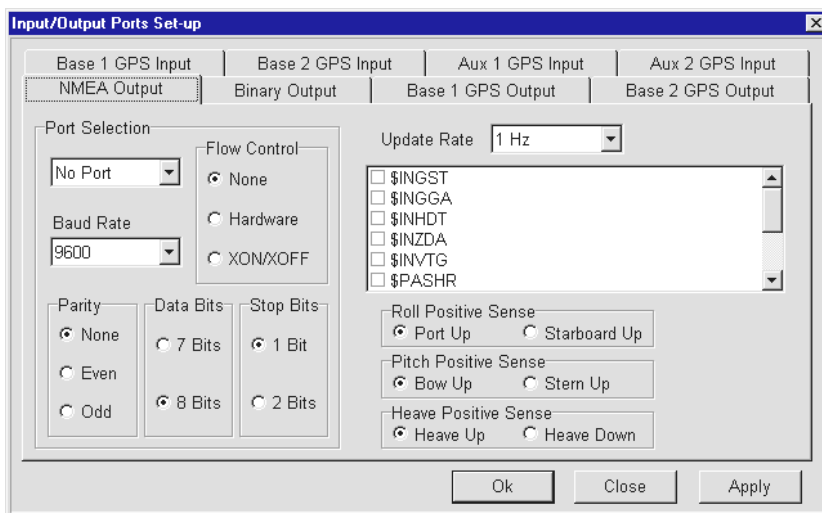


Figure 55: POSView Input/Output Port Setup

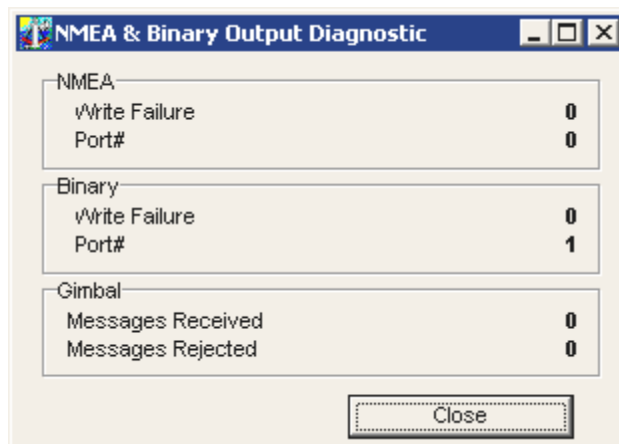


Figure 56: POSView NMEA & Binary Output Diagnostic

3. Check **Write Failure** field. If value increases, indicates PCS hardware interface problem; try another COM port. Reassign NMEA or Binary

POS MV V4 Installation and Operation Guide

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output to unused COM port. If communications restored, note defective COM port for future reference.

4. Check serial cable integrity.
5. 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 GPS and Auxiliary GPS) perform the following steps:

1. Select **Diagnostics, Base GPS, Base 1** or **2**, or **Diagnostics, Aux GPS** from controller menu bar, see Figure 57.
2. Check **Bytes Received** field. If no bytes received, may indicate PCS hardware interface problem; try another COM port. Reassign Base or Aux GPS input to unused COM port. If communications restored, note defective COM port for future reference.
3. Check serial cable integrity.

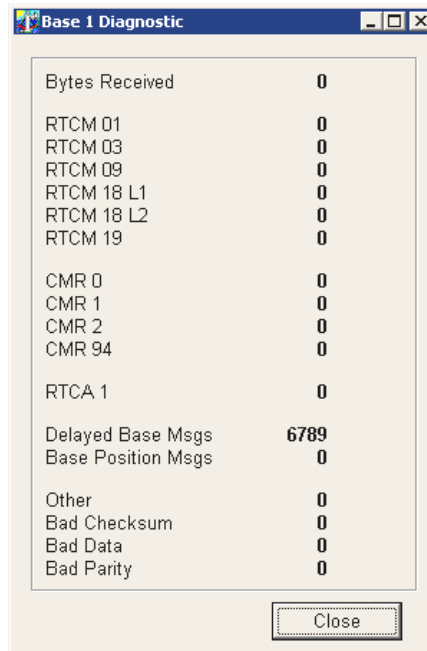


Figure 57: POSView Base 1 Diagnostic

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Fault Identification

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 GPS or Aux GPS output settings. If data received from GPS, problem is PCS.

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 58 and 59 provide troubleshooting procedures to identify the causes of Ethernet communications failures.

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Fault Identification

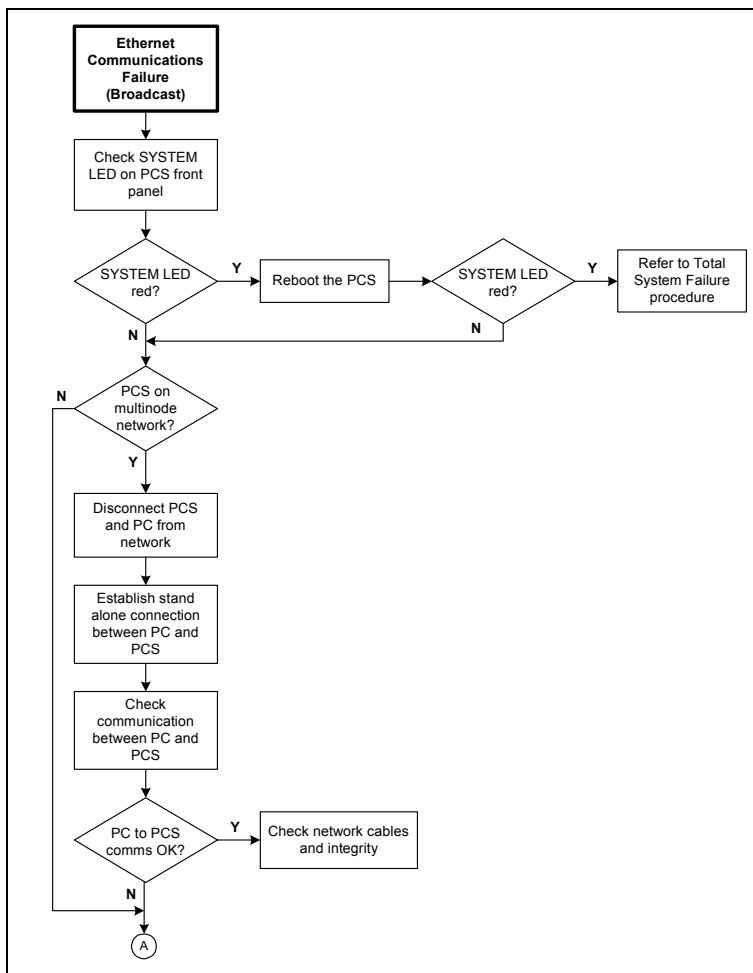


Figure 58: (1 of 2) Ethernet Communications Failure

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Fault Identification

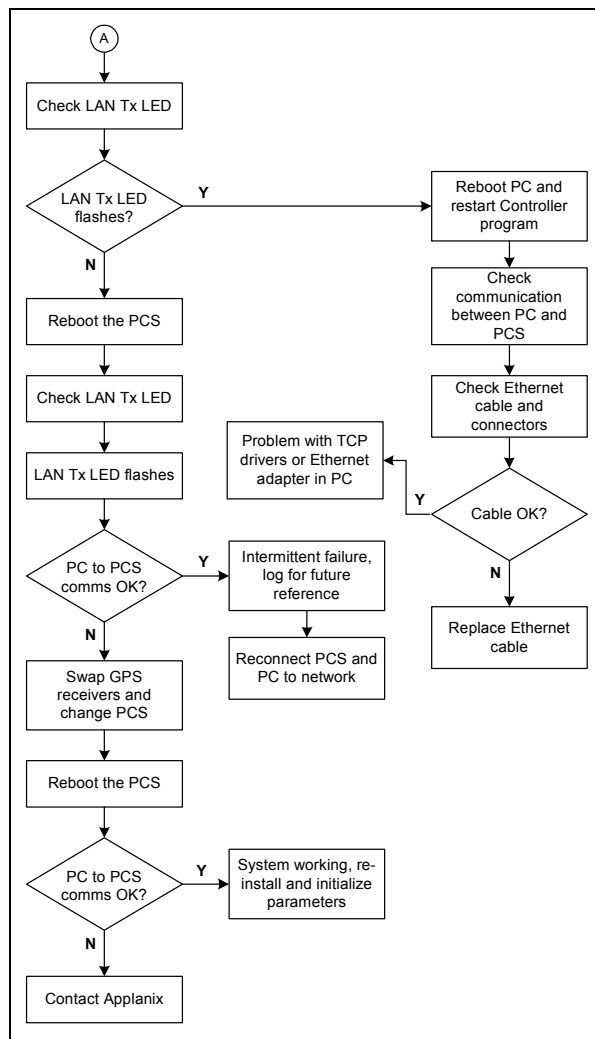


Figure 59: (2 of 2) Ethernet Communications Failure



APPENDICES

POS MV V4 Installation and Operation Guide

Technical Support and Service

Appendix A Technical Support and Service

Contact Applanix

Applanix LLC	Applanix Corporation	Applanix Corporation
17461 Village Green Drive	85 Leek Crescent	Forester's House
Houston, TX 77040	Richmond Hill, ON L4B 3B3	Old Racecourse
USA	Canada	Oswestry, SY10 7PW
		UK
Tel: (713) 896-9900	Tel: (905) 709-4600	Tel: +44 (1691) 659359
Fax: (713) 896-9919	Fax: (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 Web site. On the home page, select **Support**. If voice communication is required, select the **Contact Support** link. For general inquiries, please visit our Web site or call (905) 709-4600.

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Technical Support and Service

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.
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.

GPS Azimuth Measurement Subsystem: GAMS uses information from two GPS 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 GPS 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 GPS antennas.

Alignment: How POS MV levels itself and aligns with true north in an unaided condition.

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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.

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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

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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 $g \cong 9.80665 \text{ ms}^{-2}$. 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.

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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 60 on page B-7 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.

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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

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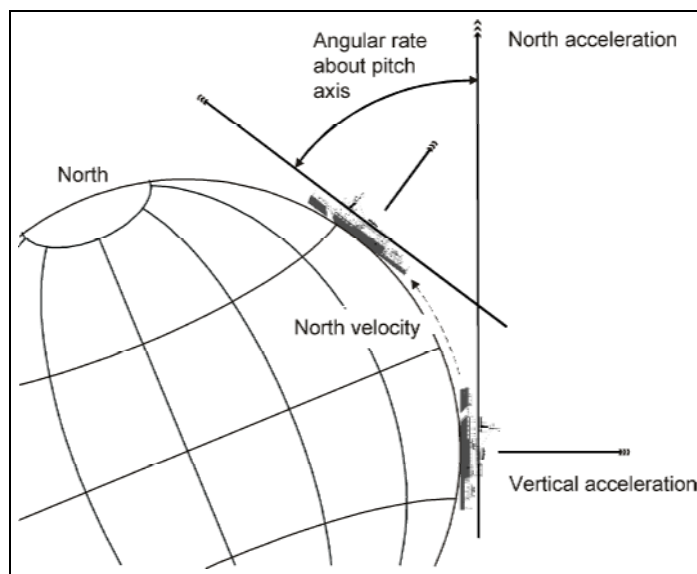


Figure 60: Example of INS Navigation on a Spherical Earth

In Figure 60, 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 60, the navigation frame of the vessel coincides with the geographic frame of reference.

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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.

a) 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.

b) 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

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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 $15^\circ/\text{hr}$ (or, more accurately, $15.04107^\circ/\text{hr}$).

c) 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.

d) 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.

e) 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.

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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-12.

Figure 61 on page B-11 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.

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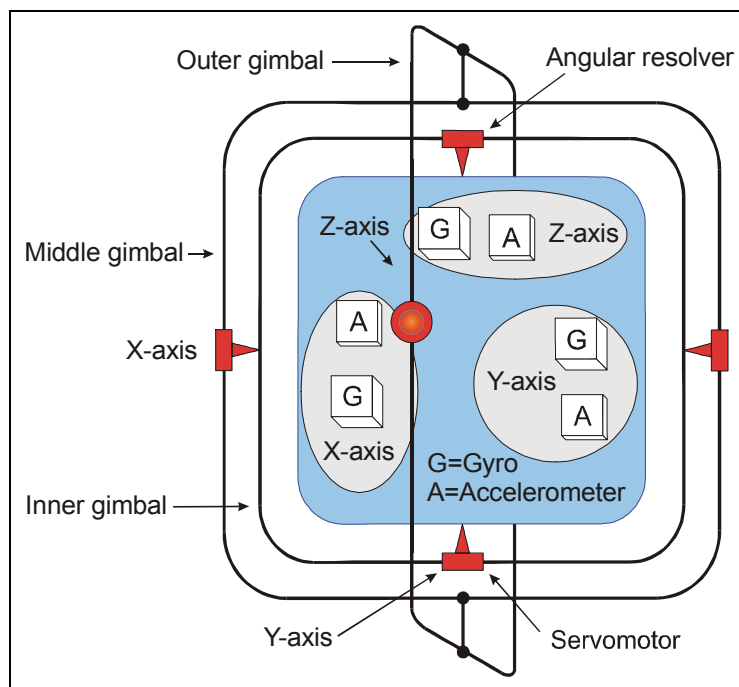


Figure 61: Gimbaled INS Platform Structure

- 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 $15^\circ/\text{hour}$ 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,

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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.

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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 62 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

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separate self-contained unit that interfaces to the PCS through a data interface cable.

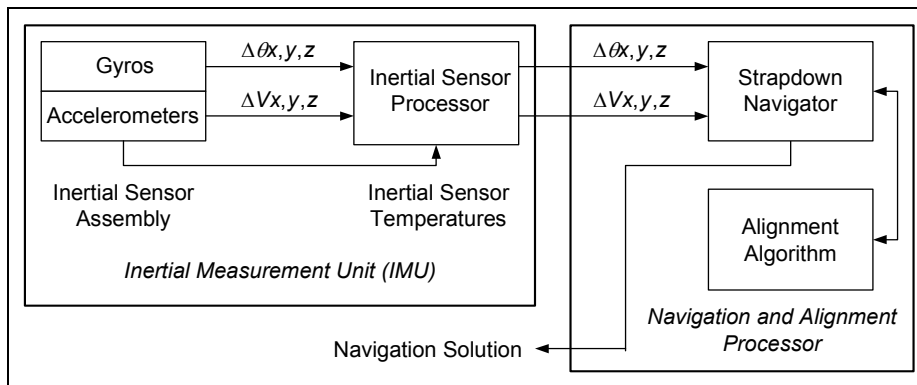


Figure 62: Strap-Down INS Generic Architecture

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 initialises 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

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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 multi-beam transducer or of the vessel.

The small size and lightweight of the IMU allow it to be mounted directly on the multi-beam 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 63.

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, GPS 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-

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on POS MV and when the vessel experiences abrupt changes in vertical displacement.

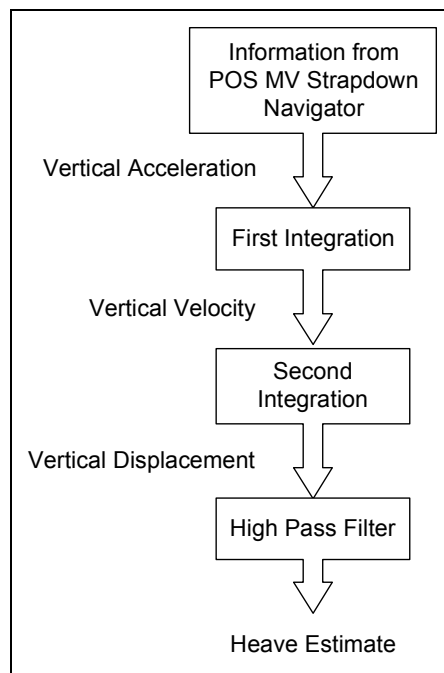


Figure 63: Heave Filter Architecture

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.

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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

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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 multi-beam 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.

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You can determine empirically the correct combination of parameters for a particular survey vessel during trials. The following are guidelines for selecting appropriate values:

1. 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
2. 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%.

3. 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

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small percentage steady state error at the expense of a long settling time.

Table 33 describes the variations of steady state heave error and settling time with changes in damping ratio and bandwidth. Figure 64 through Figure 67 on pages B-21 through B-24 respectively show plots of steady state heave error and transient behaviour for different combinations of heave filter parameters.

Table 33: 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

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Figure 64 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.

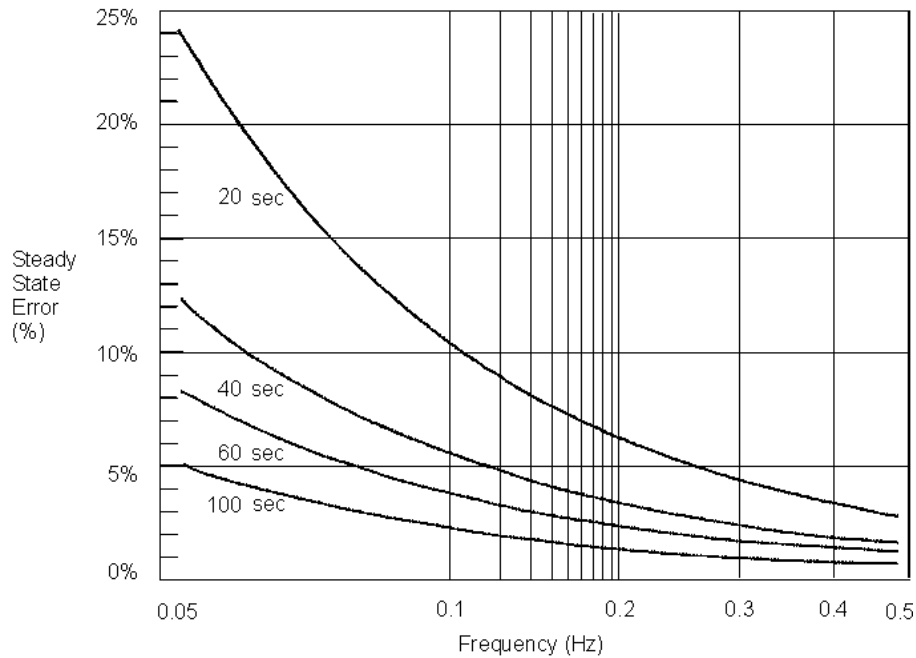


Figure 64: Percentage Steady State Error with Heave Bandwidth

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Figure 65 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.

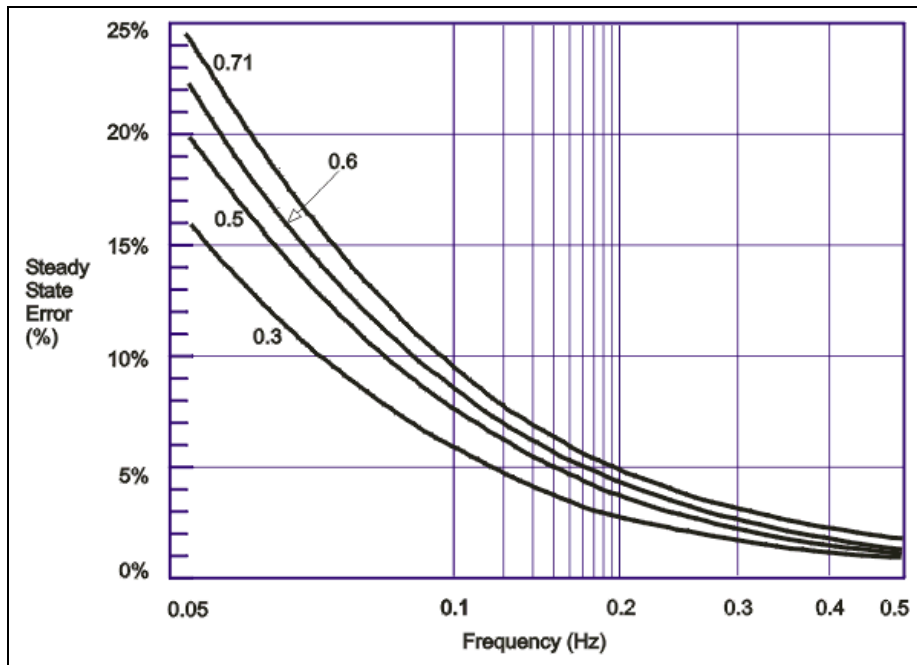


Figure 65: Percentage Steady State Error with Damping Ratio

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Figure 66 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.

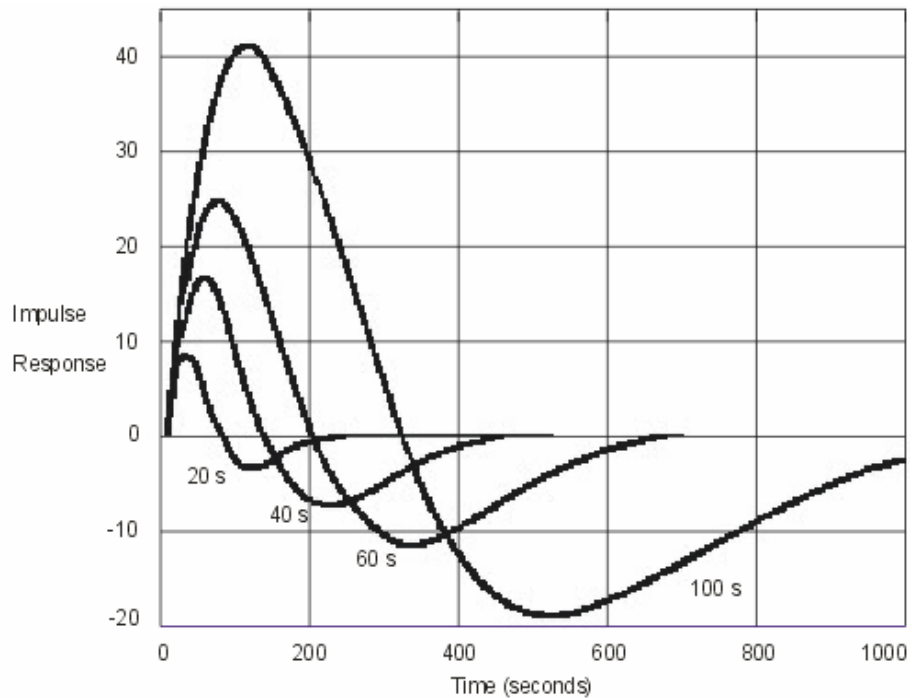


Figure 66: Heave Filter Transient Behaviour with Heave Bandwidth

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Figure 67 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.

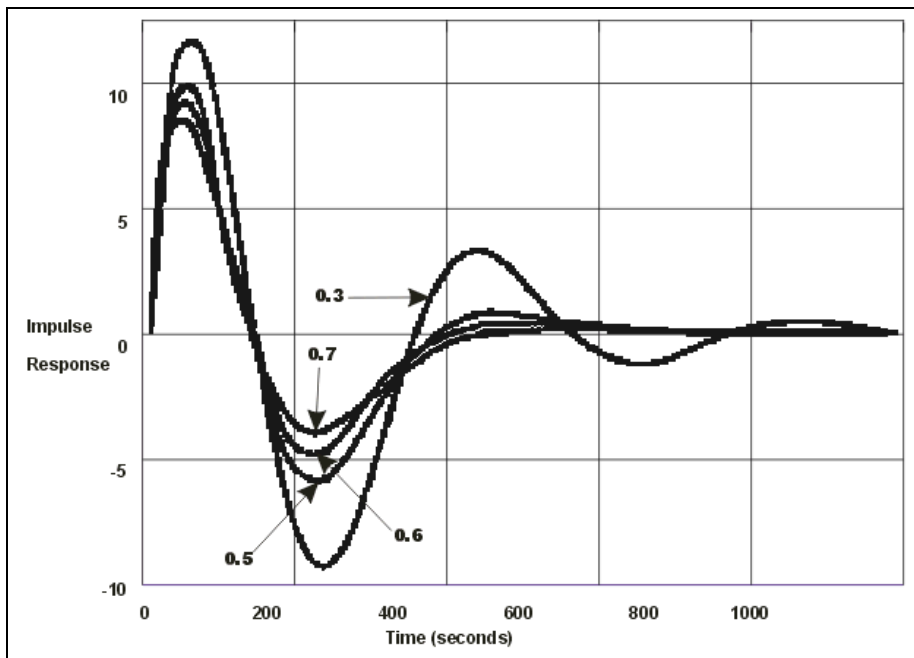


Figure 67: Heave Filter Transient Behaviour with Damping Ratio

GPS 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 GPS receivers to achieve a heading that is, at best, accurate to within 0.35° .

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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. GPS Azimuth Measurement Subsystem (GAMS) - A system that determines the geographic vector between two GPS 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 GPS 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

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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 GPS receiver, each with its own antenna. The GPS System topic on page 2-8 of this manual includes instructions to install both GPS 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 GPS algorithm, POS MV can measure the vector between the two antennas in a geographic frame of reference.

Figure 68 illustrates this situation. The Carrier Phase Differential Position

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topic on page B-32 explains the process of carrier phase differential GPS measurement.

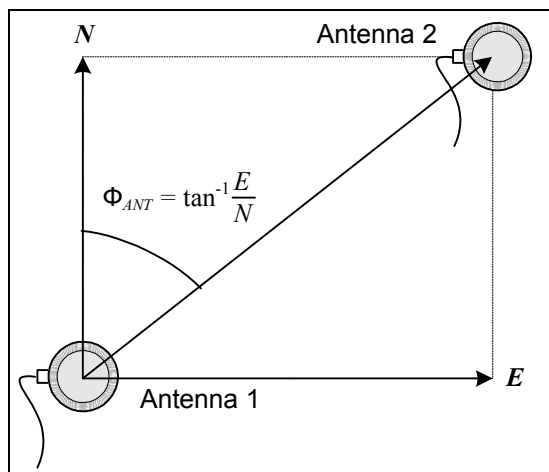


Figure 68: Geographic Antenna Baseline Vector

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

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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 69 illustrates these headings and angles.

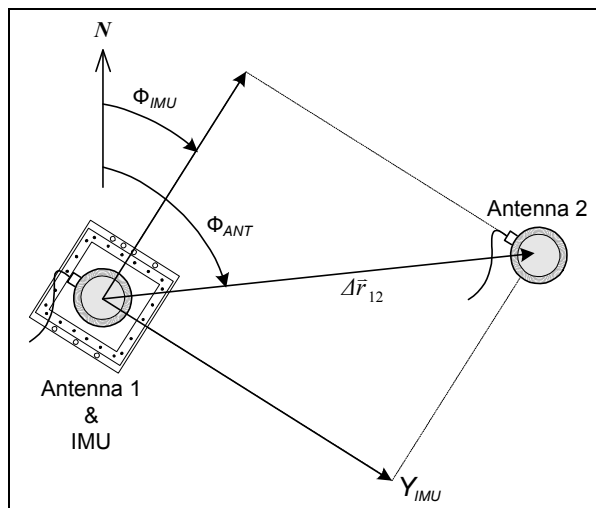


Figure 69: Baseline Comparison

- Where:
- Φ_{ANT} = geographic antenna baseline vector - the geographic vector of the line that joins the two GPS 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

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$\Delta\vec{r}_{12}$ = surveyed antenna baseline vector - the vector that joins the two GPS antennas; because the IMU and the GPS antennas are mounted rigidly on the vessel, this vector remains fixed

Note: The example shown in Figure 69 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 GPS, GAMS must first resolve the phase ambiguities in the differential carrier phase observables.

The GPS receivers in POS MV use the L1 GPS signal, which has a carrier frequency of 1575.42 MHz and a wavelength of 19 cm. You can consider the range between each GPS satellite and a GPS 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.

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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-32 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 GPS dropout caused by a signal blockage when passing under a bridge for example.

Surveyed Antenna Baseline Vector

Figure 70 shows the geometry of the two GPS antennas and the IMU. The antenna baseline vector is shown as ΔR_{AB} .

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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 GPS algorithm.

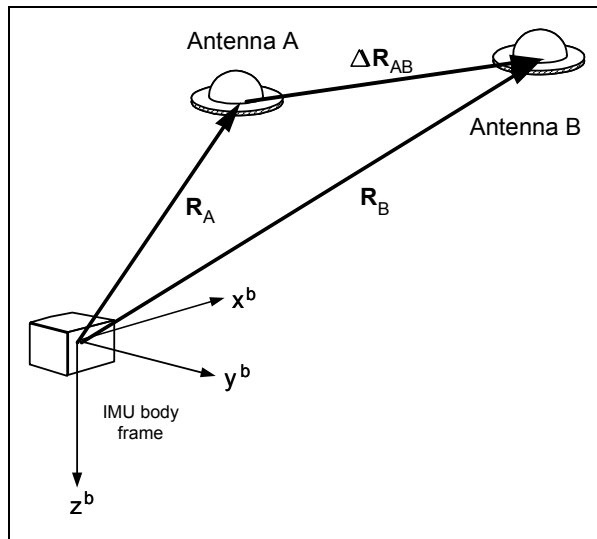


Figure 70: IMU and GPS Antenna Geometry

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.

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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 GPS Configuration on page 4-24 for instructions to complete an installation calibration.

Carrier Phase Differential Position

GPS measurements possess long-term stability and an accuracy that, with DGPS, 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 GPS 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

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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 71 represents the signal from one satellite in the GPS constellation received by the GPS 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 71, the predicted position is shown as calculated from the satellite pseudo-range.

GPS signals at the L1 frequency (1575.42 MHz) have a wavelength of 0.19 metres. A GPS 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 GPS 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.

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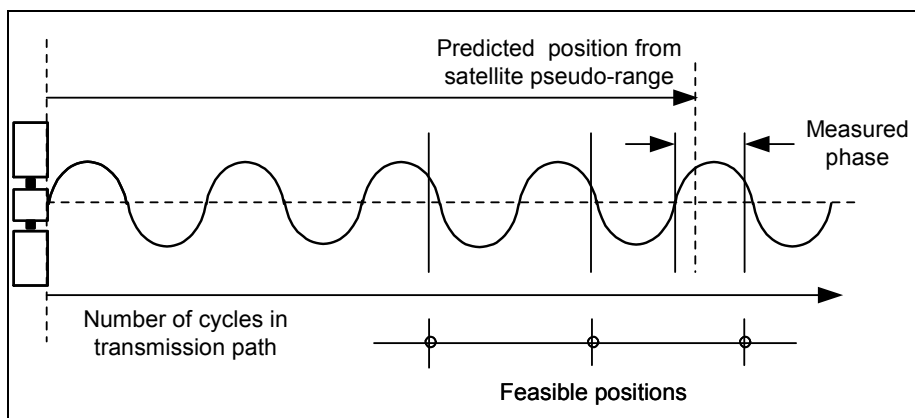


Figure 71: Carrier Phase Cycle Measurement

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 GPS position solution. This is represented by the shaded circle in Figure 72.

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 73 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

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be spaced with respect to each other so that the lines intersect at a reasonably wide angle.

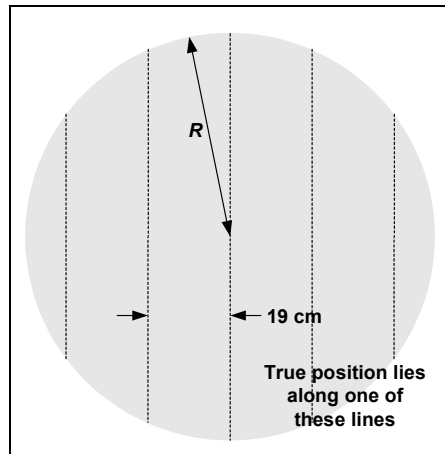


Figure 72: Feasible Position Solutions from One Satellite

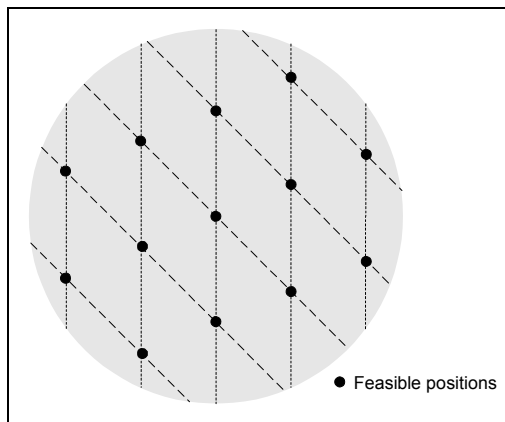


Figure 73: Feasible Position Solutions from Two Satellites

Figure 74 shows how the range of feasible position solutions reduces still further when three satellites are used to resolve the carrier phase ambiguities.

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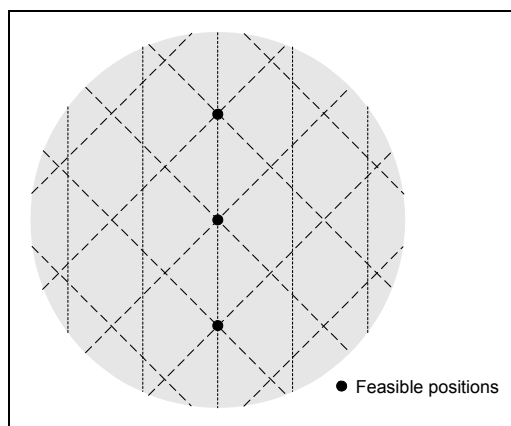


Figure 74: Feasible Position Solutions from Three Satellites

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 GPS 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 GPS 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 GPS antennas. You can measure this distance with a tape measure to the

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required accuracy of 5 mm ($\frac{3}{16}$ 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 GPS 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-30). 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-10) 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.

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- 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 gimballed 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 75. 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 a 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.

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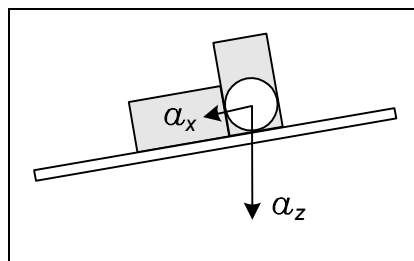


Figure 75: Horizontal Acceleration Error in a Tilted Platform

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 ($15^\circ/\text{hour}$) 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 75. 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.

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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 a 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.

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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-43)

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- 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 GPS 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 GPS receivers. The IMU and the GPS 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.

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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 GPS position error is noisy in the short term but exhibits a constant long-term error of only a few metres (with DGPS).

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 GPS receiver can be blended or integrated in a complementary fashion

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(refer to Figure 76). 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 DGPS 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 DGPS 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 DGPS 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 DGPS solution and passes the INS position error and the small steady-state DGPS 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 DGPS short-term noise removed. The only remaining error is the constant position offset from the DGPS that has passed through the filter.

The blended position solution now has the best characteristics of both the INS and the DGPS; the position solution is smoothed like the INS solution, and has a bounded error that is less than or equal to the DGPS solution.

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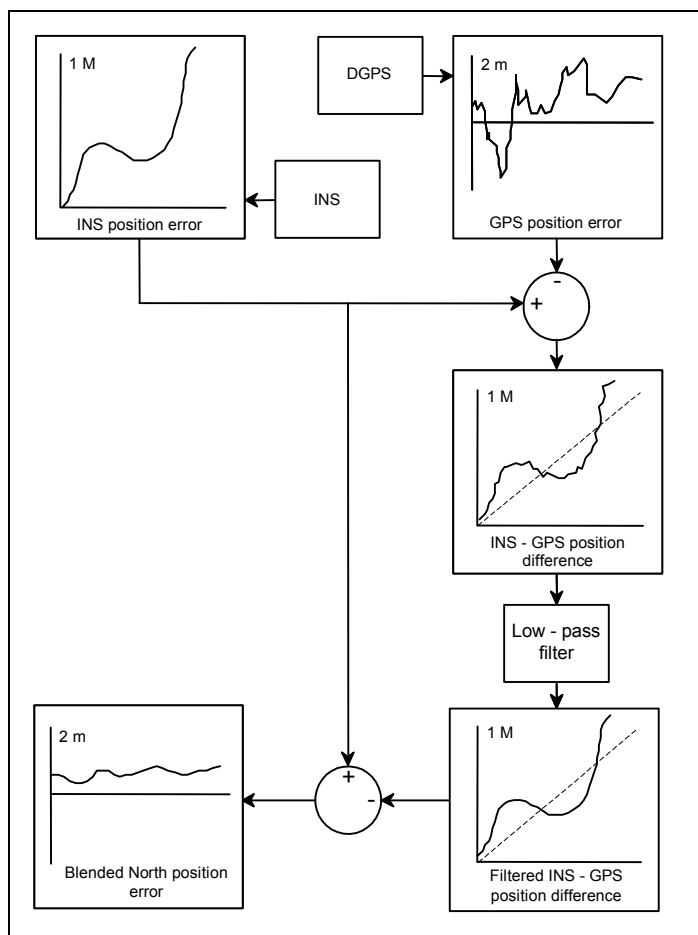


Figure 76: Example of Complementary Navigation Sensor Blending

In-Motion Alignment

The paragraphs contained under the Alignment topic on page B-37 describe how an inertial navigation platform achieves alignment under static conditions. An important feature that the integration of inertial navigation and GPS offers is in-motion alignment of the inertial navigator.

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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 76 on page B-45 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-GPS 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, GPS
- 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.

POS MV V4 Installation and Operation Guide

Software Installation

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).

POS MV V4 Installation and Operation Guide

Software Installation

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. The software checks the current version of POS firmware and updates the requested new firmware. POSLoader requests a password prior to operation and may be used through an Ethernet port.
- POSConfig - windows based GUI application that is required for enhancements or automating changes to the POS MV system setup (e.g. enabling the TrueHeave software option). 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 34.

POS MV V4 Installation and Operation Guide

Software Installation

Table 34: Controlling PC Requirements

Item	Minimum Requirements
Processor	Intel Pentium® III or equivalent
Memory	128 MB RAM
Operating System	Microsoft Windows® 2000 or XP
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 Windows™ 2000, XP or NT 4 installed on your PC before you can install and use the controller program.

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.

POS MV V4 Installation and Operation Guide

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 MV 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.

POS MV V4 Installation and Operation Guide

Software Installation

3. Once file saved to PC hard disk, run POS MV 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 initialisation 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 initialisations 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

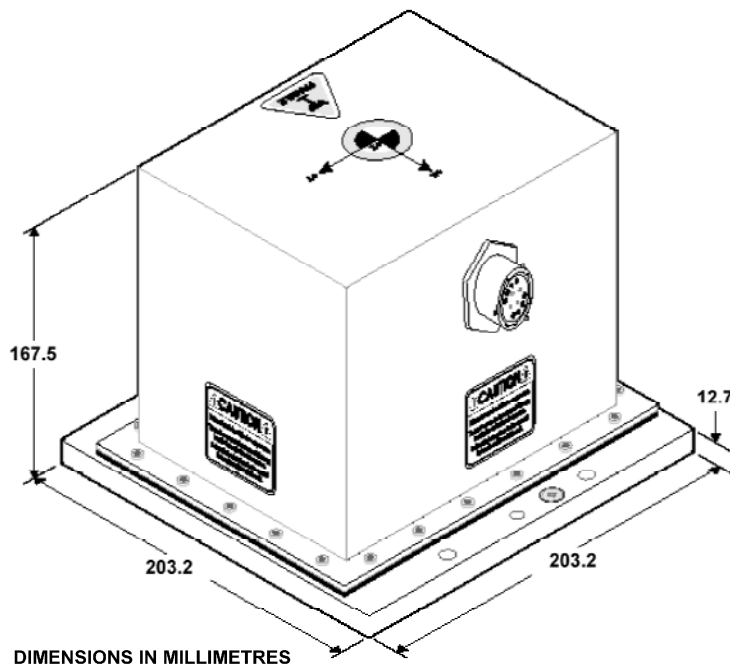
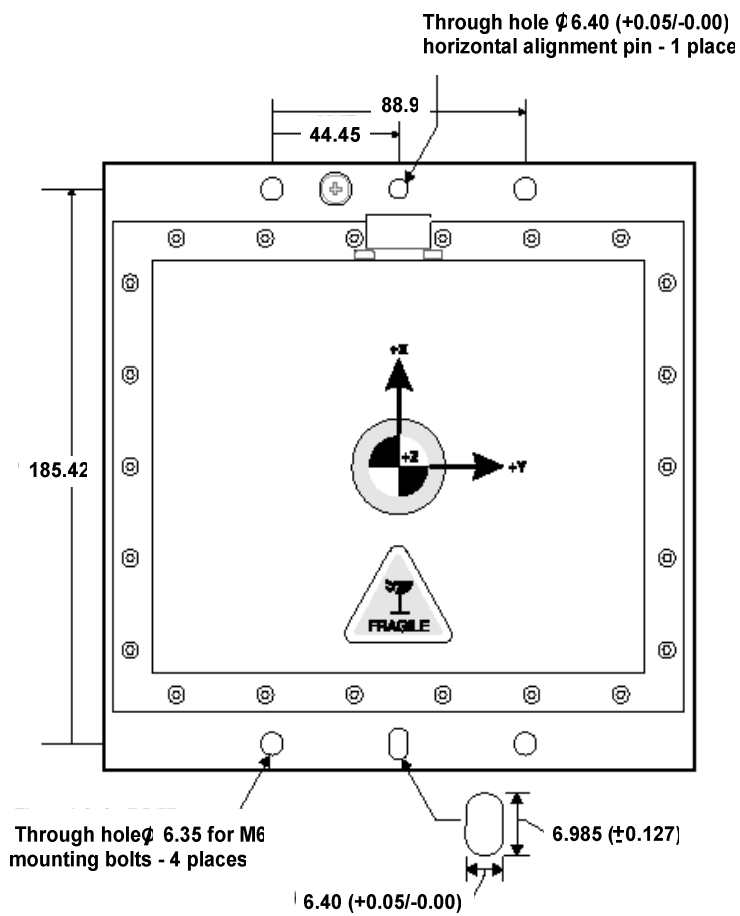


Figure 77: IMU Footprint

POS MV V4 Installation and Operation Guide

Drawings



DIMENSIONS IN MILLIMETRES

Figure 78: IMU Base Plate Footprint

POS MV V4 Installation and Operation Guide

Drawings

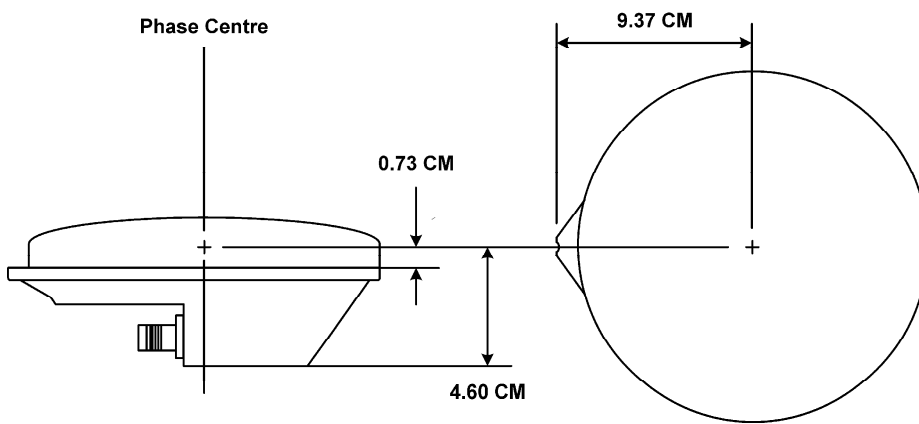


Figure 79: GPS Antenna Footprint

POS MV V4 Installation and Operation Guide

Drawings

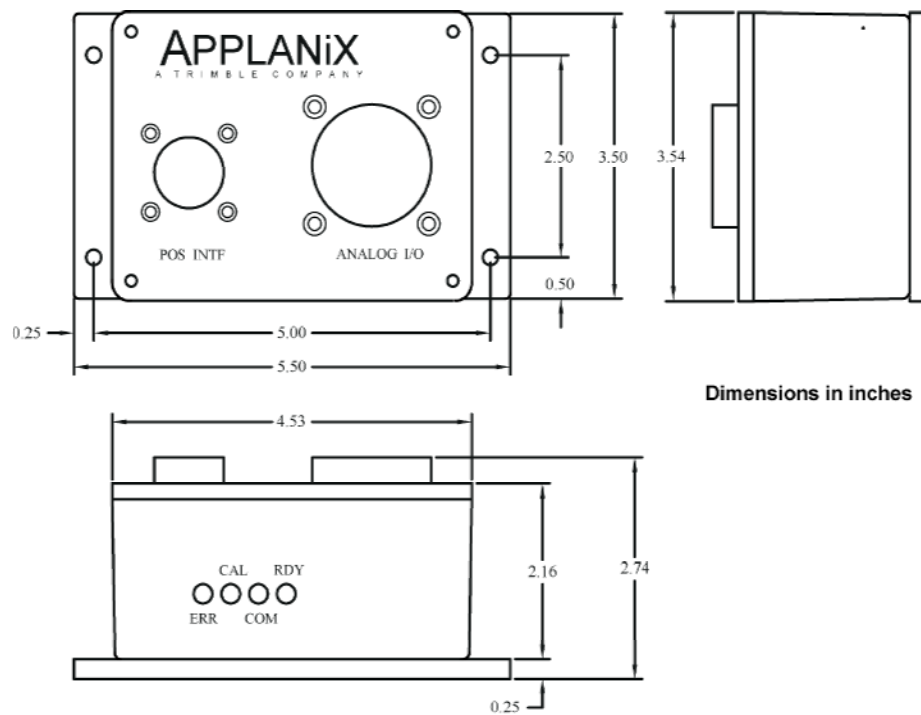
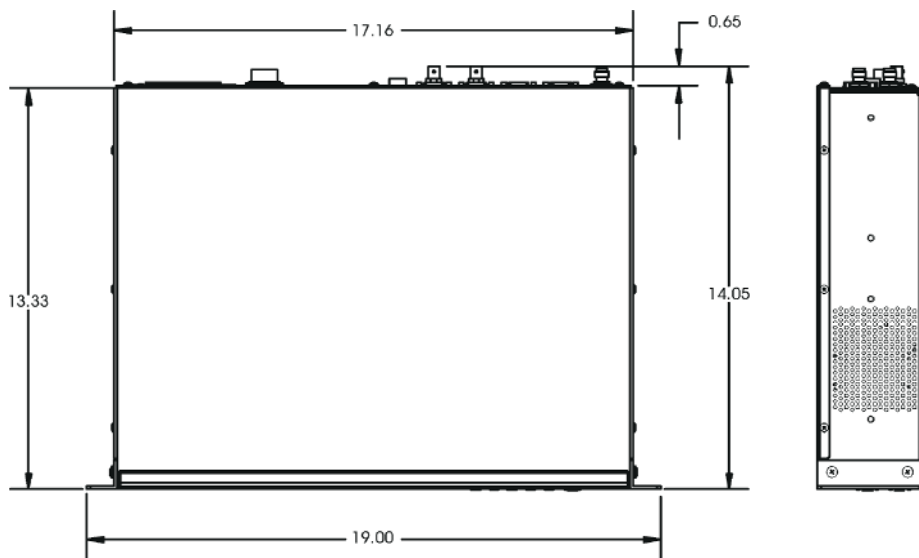


Figure 80: Remote Analog Unit (RAU) Footprint

POS MV V4 Installation and Operation Guide

Drawings



Dimensions in inches

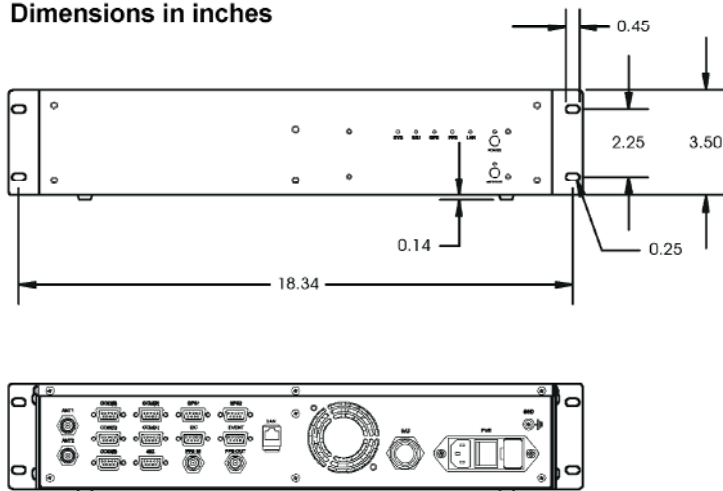


Figure 81: PCS Footprint

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 82 shows an ideal survey calibration area.

POS MV V4 Installation and Operation Guide

Patch Test

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.

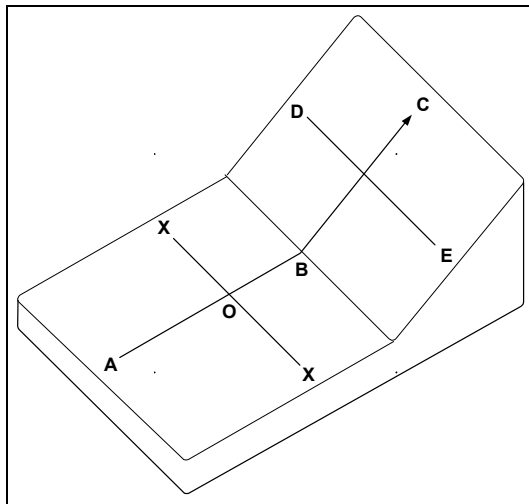


Figure 82: Ideal Survey Calibration Area

Calibration

The procedure outlined in this appendix includes a calibration check on the following parameters. Perform the following:

- Roll measurement
- Position time delay

POS MV V4 Installation and Operation Guide

Patch Test

- 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 82 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 multi-beam software and select a single point along both survey lines (point O of Figure 82 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 82 on page F-2) and confirm that both survey lines show the same seabed profile. They should be substantially coincident as shown in Figure 83 on page F-4. If they are not (as shown in Figure 84 on page F-4), this indicates that there is a constant steady state roll offset in the mounting angles. Use the multi-beam software to compensate for this offset.
4. Repeat the above survey tests to confirm that any adjustments you make to the multi-beam software have removed the roll offset.
5. As a final check, perform a similar survey following the line D–E in Figure 82 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.

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Patch Test

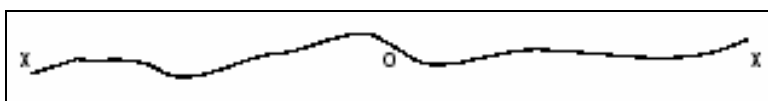


Figure 83: Correct Roll Calibration

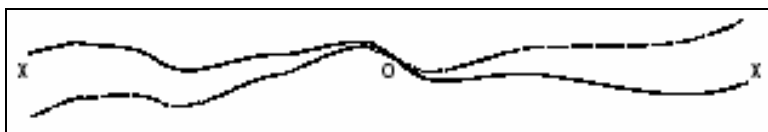


Figure 84: Incorrect Roll Calibration

Position Time Delay

1. Complete a sound velocity profile for the multi-beam 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 82 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 multi-beam 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 multi-beam software to correct any such error.

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Patch Test

6. Finally, repeat the survey lines to verify that you have removed all offsets successfully.

Gyrocompass Heading

a) 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.

b) 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.

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Patch Test

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 multi-beam survey. Similarly, the manufacturer of the multi-beam 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 multi-beam 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

POS-GPS Timing

Background

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

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

The following identify a few of the many time standards:

- Local time is the date/time reported by your PC (as seen by your web browser). Local time differs from UTC by the number of hours for your time zone (plus local PC clock errors).
- UTC, popularly known as GMT (Greenwich Mean Time), or Zulu time.

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POS-GPS Timing

- 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
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

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POS-GPS Timing

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

Notes:

1. GPS and TAI are ahead of UTC time, see Figure 85.

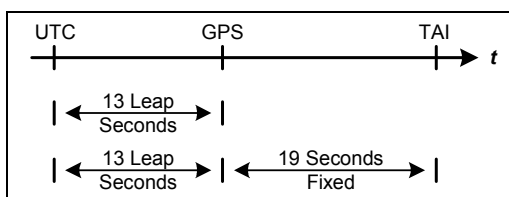


Figure 85: GPS, TAI and UTC Time

2. There was no leap second at the end of June 2002.
3. No leap second will be introduced at the end of December 2002.
4. Consult the International Earth Rotation Service (IERS) web pages for more quantitative information.

GPS Timing Basics

One Pulse Per Second

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

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POS-GPS Timing

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

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

Timing Accuracy

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

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

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

Output Characteristics

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

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POS-GPS Timing

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

To synchronize external equipment time with received GPS time, the external equipment reads and records the occurrence of the 1PPS signal (present at the rear panel PPS OUT port at a rate of 1 Hz) in user time. Figure 86 shows the parameters of the 1PPS signal. With the time differential known, the external device calculates the GPS time.

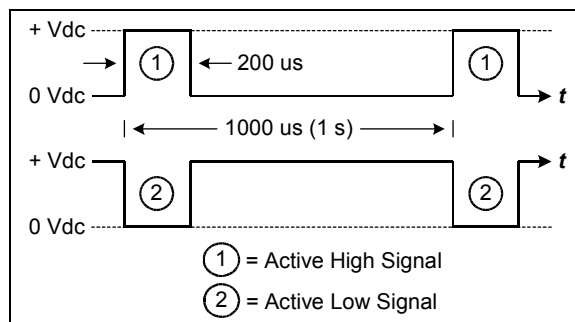


Figure 86: 1PPS Signal Characteristics

The **Events** pane in MV-POSView, see Figure 87, displays the UTC time of the two most recent signals (known as events) from sources external to the Position and Orientation System (POS) system. In addition, the PPS field displays the UTC time of the most recent PPS pulse transmitted by the primary GPS receiver. The Count field for PPS indicates the total number of

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POS-GPS Timing

signals recorded from the GPS receiver, while the Count fields for Events 1 and 2 indicate the number of event pulses recorded.

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

Figure 87: Events Group

1PPS Timing

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

If the PPS signal is an active low TTL strobe, the falling edge is coincident with the exact GPS second. Depending upon the GPS card manufacturer, the GPS Time Message timing and its contents may vary; refer to Figure 88.

Note: There are two NMEA time messages that convey timing, \$UTC and \$INZDA; refer to the NMEA Data Formats description on page 3-4. Both messages are synchronized to the 1PPS signal. The NMEA messages may be output on any of the COM ports.

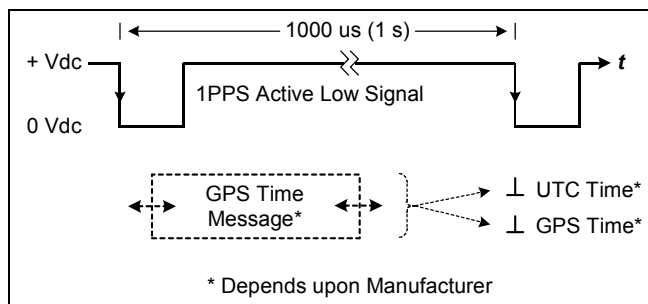


Figure 88: 1PPS Time Synchronization

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POS-GPS Timing

Time and Distance Tags

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

EVENT TAGS

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

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 GPS antenna phase centre. The baseline vector is resolved in the Vehicle body frame.

Baud Rate

Baud Rate, in computer science, is commonly a reference to the speed at which a modem can transmit data. Often incorrectly assumed to indicate the number of bits per second (bps) transmitted, baud rate actually measures the number of events, or signal changes, that occur in one second. Because one event can actually encode more than one bit in high-speed digital communications, baud rate and bits per second are not always synonymous, and the latter is the more accurate term to apply to modems. For example, a so-called 9600-baud modem that encodes four bits per event actually operates at 2400 baud but transmits 9600 bits per second (2400 events times 4 bits per event) and thus should be called a 9600 bps modem.

Bit

The smallest element of computer storage, the bit is a single digit in a binary number (0 or 1). Groups of bits make up storage units in the computer, called "characters," "bytes," or "words," which are manipulated as a group. The most common is the byte, made up of eight bits and equivalent to one alphanumeric character.

Bits are widely used as a measurement for transmission. Ten megabits (Mb) per second means that ten million pulses are transmitted every second. Measurements for storage devices such as disks, files and databases are given in bytes rather than bits.

Byte

The common unit of computer storage from micro to mainframe, the byte is made up of eight binary digits (bits). A ninth bit may be used in the memory circuits as a parity bit for error checking. The term was originally coined to mean the smallest addressable group of bits in a computer (has not always been eight).

C/A

The coarse/acquisition or clear/acquisition code modulated onto the GPS L1 signal. This code is a sequence of 1023 pseudorandom binary bi-phase modulations on the GPS carrier at a chipping rate of 1.023 MHz, thus having a code repetition period of one millisecond. The code was selected to provide good acquisition properties. Also known as the "civilian code".

Choke Ring

An optional ring mounted around a GPS antenna, designed to minimize multipath signal reception.

Control Port

Accessed via the LAN connector, the Control Port is designed to receive and acknowledge 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.

DGPS

Differential GPS. A technique used to improve positioning or navigation accuracy by determining the positioning error at a known location and subsequently incorporating a corrective factor (by real-time transmission of corrections or by post-processing) into the position calculations of another receiver operating in the same area and simultaneously tracking the same satellites.

Dilution of Precision

Dilution of Precision (DOP) is a dimensionless number that accounts for the purely geometric contribution of the position of the satellites to the uncertainty in a position fix. Standard terms for the GPS application are: GDOP-Geometric Dilution of Precision (three position coordinates plus clock offset in the solution); PDOP-Position Dilution of Precision (three coordinates); HDOP-Horizontal Dilution of Precision (two horizontal coordinates); VDOP-Vertical Dilution of Precision (height only); TDOP-Time Dilution of Precision (clock offset only); RDOP-Relative Dilution of Precision (normalized to 60 seconds).

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.

Distance Pulse

A TTL level signal generated by the DMI that represents a fractional revolution of the Instrumented Wheel.

Dropout

Loss of signal.

Ephemeris

The predictions of current satellite positions transmitted to the user in the data message. A list of accurate positions or locations of a celestial object as a function of time. Available as "broadcast ephemeris" or as post-processed "precise ephemeris."

Force of Gravity

Gravity is a force that exists between the Earth and objects which near it. All objects on Earth experience this force and is represented it by the symbol F_{grav} .

GPS

Global Positioning system. A constellation of 24 satellites that allows precise determination of position by analysis of satellite signals.

GPS Time

Highly accurate time system with units of Weeks and Seconds. GPS time is offset from UTC time by an integer number of seconds.

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 GPS receivers have higher accuracy than C/A code receivers, but are currently only available for military use.

PPS Strobe

The Pulse per Second Strobe is a TTL-level signal; generated once per second, whose falling edge is coincident with the GPS second.

Pseudo-range

A GPS distance measurement that has not been corrected for differences in synchronization between the satellite and receiver clocks.

Rack Unit

Rack Unit is a vertical measurement equal to 1.75 in (4.44 cm) for rack-mounted equipment.

TCP/IP

TCP/IP is a routable protocol, and the TCP part provides transport functions, which ensures that the total amount of bytes sent is received correctly at the other end. It is widely used for real-time voice and video transmissions where erroneous packets are not retransmitted.

The IP part of TCP/IP provides the routing capability. In a routable protocol, all messages contain not only the address of the destination

station, but the address of a destination network. This allows TCP/IP messages to be sent to multiple networks within an organization or around the world, hence its use in the worldwide Internet. Every client and server in a TCP/IP network requires an IP address that is either permanently assigned or dynamically assigned at start-up.

Time of Validity

Time of Validity defines the exact time at which a particular set of data are current.

TTL Level Signal

TTL Level Signals are DC signals interpreted in a discrete fashion. A signal below 0.8V is interpreted as a LOW, and a signal above 3.3V is interpreted as a HIGH. TTL signals can be likened to a binary system, where LOW is equivalent to 0, and HIGH is equivalent to 1.

UDP

UDP is a collection of protocols similar to TCP/IP. Most notable among the differences is that data broadcast in UDP can be read by any computer on the network. In contrast, TCP/IP messages are directed at particular computer.

UTC

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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