



POS MV V4 User ICD

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1 Scope

This document presents the functional specification of the POS MV Control, Display and Data Ports and data structures used by the POS Computer System (PCS) to communicate with the user over its Control, Display and Data Ports. The document is separated into specifications of output data groups and input and output control messages that are relevant to the user.

This document describes the data structures that are implemented in the V4 system version of POS MV. POS MV V4 shall hereafter be referred to as POS MV or simply POS.

2 Ethernet and Data Acquisition Interfaces

The POS MV provides a mechanism for control and data exchange in the form of control messages and data groups. Control messages direct POS MV to execute a well-defined action such as mode transition, or start or stop of data acquisition. Data groups contain the data output by the POS MV for the purpose of display on a control computer, recording to a mass storage device, or for real-time processing by another subsystem. POS MV exchanges all control messages with a user via the POS's Control Port. It outputs all data groups on the Display and Data Logging Ports.

Applanix provides a program called *MV POSView* with the POS MV to run on the user's PC-compatible computer running Microsoft Windows 2000 or XP. The user's PC is called the *client computer* and is used to both control the system and allow the user to view POS data via the control messages and data groups specified in this document. The user can create custom control and display software that implements similar functionality. In either case, the program that provides the control and display functions on the client computer will hereafter be referred to as the *POS Controller*.

POS MV provides one physical Ethernet interface that has four logical communications ports called the *Display Port*, the *Control Port*, the *Real-Time Data Port* and the *Logging Data Port*.

POS MV outputs data in specified group formats defined in the body of this document. Messages are used to both change and describe the system configuration. Both message and group data are output on three ports: Display, Real-Time Data and Logging Data. Messages are input on the Control Port.

The **Display Port** is a *low rate* UDP output port that is designed to broadcast low rate data and status information for display. The *POS Controller* reads the message and group data from this port for display purposes. POS MV is designed to allow multiple *POS Controller* programs running on different computers to receive and display data from the PCS. However, only one *POS Controller* at any time can be designated as the master controller and be capable of sending commands to the PCS via the Control Port. This arrangement prevents conflicting controller information from being received by the PCS.

The port address for the Display Port is 5600. The subnet mask is 255.255.255.255.

The **Real-Time Data Port** is a *high rate* UDP output port that is designed to output multiple data

groups at high data rates with minimal latency. Since there is no handshaking implemented in UDP there is a possibility that the client may not receive all data packets. The Real-Time Data Port design emphasizes real-time delivery of the data without the overhead of ensuring totally reliable data transfer. To receive data from the Real-Time Data Port, a computer must listen to the port using the UDP socket protocol. Several computers may be connected to the Real-Time Data Port at any one time. MV POSView uses this port to obtain some higher rate data from POS MV that is required for display plots.

The **Logging Data Port** is a *high rate* TCP/IP output port that is designed to output multiple data groups at high data rates. The emphasis is on reliable and efficient data transfer to the client computer. The Logging Data Port implements several buffers to store data in the event the TCP/IP connection between POS and the client computer becomes bogged down or requires retransmission of packets. To receive data from the Logging Data Port, a computer must connect to it using the TCP/IP socket protocol. Only one computer may be connected to the Logging Data Port at any one time. MV POSView can log this data to the client computer's hard drive.

The port address for the Real-Time Data Port is 5602 and 5603 for the Logging Data Port. The IP subnet mask is 255.255.255.255.

The user is able to select, from several different options, the data required for output. Each port can be configured to output different data than the other ports. POS MV accepts changes to the output options of the Display, Data and Logging ports at any time. MV POSView automatically sends the Display Port control message to output the data groups that it requires to populate the display windows as the user opens them.

The **Control Port** is designed to receive set-up and control commands from the *POS Controller* and to acknowledge the commands to indicate successful reception of each message. The Control Port is bi-directional and uses the TCP/IP protocol to communicate with the *POS Controller*.

The port address for the Control Port is 5601. The IP subnet mask is 255.255.255.255.

3 Output Groups

3.1 Introduction

POS MV organizes the data going to the Display and Data ports into output groups. Each group contains a block of related data at a specified group rate. The user directs POS MV via Control Port messages generated by the POS Controller to include a group or groups containing data items of interest in the Display and Data port data streams. The output groups have been designed to allow simple parsing and decoding of the output data streams into the selected groups. All groups are framed by ASCII delimiters and have identifiers that uniquely identify each group.

The output data rate on the Display Port is typically once per second or less. This output is intended for updating the POS Controller display; hence a higher data output rate is not required. The output data rate on the Data Ports is group dependent and has a range from 1Hz to an IMU rate. For certain output groups, it is possible to select, from several options, the output data rate of choice on the Data ports.

3.2 Output Group Specification

3.2.1 Group Data Rates

There are several output groups defined for the Display and Data ports. The user can select any of these groups and *may select different groups* for the Display Port, Real-Time Data Port and Logging Data Port. The Standby and Navigate modes shown in Table 1 are defined in POS MV V4 User Guide.

3.2.2 Group Classification and Numbering Convention

All POS products use the following group numbering convention. POS MV outputs the group categories shown. Reserved group numbers are assigned to other products.

0 - 99	POS Core User data groups
100 - 199	POS MV User data groups
200 - 299	POS AV User data groups
300 - 399	POS TG User data groups
400 - 499	POS LV User data groups
500 - 599	POS LS User data groups
600 - 699	POS SV User data groups
700 - 799	POS MC User data groups
800 - 9999	Reserved

- 10000 - 10099 POS Core Raw data groups
- 10100 - 10199 POS MV Raw data groups
- 10200 - 10299 POS AV Raw data groups
- 10300 - 10399 POS TG Raw data groups
- 10400 - 10499 POS LV Raw data groups
- 10500 - 10599 POS LS Raw data groups
- 10600 - 10699 POS SV Raw data groups
- 10700 - 10799 POS MC Raw data groups
- 10800 - 19999 Reserved
- 20000 POS Core User diagnostic group
- 20001 - 20099 POS Core Proprietary diagnostic groups
- 20100 POS MV User diagnostic group

Core User data groups and **MV User data groups** comprise groups that contain real-time operational data. During normal operation, these are the only groups that a user would require for observing or recording relevant POS MV data.

Core Raw data groups and **POS MV Raw data groups** comprise the unaltered data streams from the navigation sensors received by the PCS. POS MV packages the sensor data into the specified group formats and outputs the groups. These groups are typically used for post-mission processing and analysis.

Table 1: Output Group Data Rates

Group	Contents	Display Port Output Rate (Hz)		Real-Time Data Port Output Rate (Hz)		Logging Data Port Output Rate (Hz)	
		Standby	Navigate	Standby	Navigate	Standby	Navigate
<i>POS Data Groups</i>							
1*	Vessel position, velocity, attitude & dynamics	-	1 ¹	-	1-200	-	1-200
2	Vessel navigation performance metrics	-	1 ¹	-	1	-	1
3	Primary GPS status	1 ¹	1 ¹	1	1	1	1
4	Time-tagged IMU data	1	1	200	200	200	200
5	Event 1 data ²	1	1	1-500	1-500	1-500	1-500
6	Event 2 data ²	1	1	1-500	1-500	1-500	1-500
7	PPS data ²	1	1	1	1	1	1
8	Reserved	-	-	-	-	-	-

Group	Contents	Display Port Output Rate (Hz)		Real-Time Data Port Output Rate (Hz)		Logging Data Port Output Rate (Hz)	
		Standby	Navigate	Standby	Navigate	Standby	Navigate
9	GAMS solution status	-	1	-	1	-	1
10	General and FDIR status	1 ¹	1 ¹	1	1	1	1
11	Secondary GPS status	1	1	1	1	1	1
12	Auxiliary 1 GPS status	1	1	1	1	1	1
13	Auxiliary 2 GPS status	1	1	1	1	1	1
14	Calibrated installation parameters	-	1	-	1	-	1
15	Reserved	-	-	-	-	-	-
16	Reserved	-	-	-	-	-	-
17	User time status	1	1	1	1	1	1
20	IIN solution status	-	1	-	1	-	1
21	Base 1 GPS modem status	1	1	1	1	1	1
22	Base 2 GPS modem status	1	1	1	1	1	1
23	Auxiliary 1 GPS display data ²	1	1	1	1	1	1
24	Auxiliary 2 GPS display data ²	1	1	1	1	1	1
25	Reserved	-	-	-	-	-	-
26	Reserved	-	-	-	-	-	-
99	Versions and statistics	1	1	1	1	1	1
102	Sensor 1 position, velocity, attitude, heave & dynamics	-	1	-	1-200	-	1-200
103	Sensor 2 position, velocity, attitude, heave & dynamics	-	1	-	1-200	-	1-200
104	Sensor 1 position, velocity & attitude performance metrics	-	1	-	1	-	1
105	Sensor 2 position, velocity & attitude performance metrics	-	1	-	1	-	1
110	MV general status & FDIR	1	1	1	1	1	1
111	Heave & True Heave	-	1	-	25	-	25
112	NMEA strings	-	1	-	1-50	-	1-50
113	Heave performance metrics	-	1	-	25	-	25
114	TrueZ and TrueTide altitude	-	1	-	25	-	25
<i>Raw Data Groups</i>							
10001	Primary GPS data stream	-	-	1-10	1-10	1-10	1-10

Group	Contents	Display Port Output Rate (Hz)		Real-Time Data Port Output Rate (Hz)		Logging Data Port Output Rate (Hz)	
		Standby	Navigate	Standby	Navigate	Standby	Navigate
10002	IMU data stream	-	-	200	200	200	200
10003	PPS data	-	-	1	1	1	1
10004	Event 1 data	-	-	1-500	1-500	1-500	1-500
10005	Event 2 data	-	-	1-500	1-500	1-500	1-500
10006	Reserved	-	-	-	-	-	-
10007	Auxiliary 1 GPS data stream			1-10	1-10	1-10	1-10
10008	Auxiliary 2 GPS data stream			1-10	1-10	1-10	1-10
10009	Secondary GPS data stream	-	-	1-10	1-10	1-10	1-10
10010	Reserved	-	-	-	-	-	-
10011	Base 1 GPS data stream	-	-	0-1	0-1	0-1	0-1
10012	Base 2 GPS data stream	-	-	0-1	0-1	0-1	0-1

Note: When POS is in Navigation mode but not aligned then the output rate is implementation dependent.

* Data is in the vessel frame for POS MV.

¹ These groups are the minimum output of the Display Port for driving the POS View display and cannot be deselected.

² Groups are only posted when data were available.

3.2.3 Group Format

The structure of each output group is defined in this section. The group structure is the same for all groups and consists of a *header*, *data* and *footer*. Table 2 presents the complete groups format, showing the header and footer separated by the data. The next section specifies the data for each group.

Table 2: Group format

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	Group number	N/A
Byte count	2	ushort	Group dependent	bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
<i>Data</i>	<i>Group dependent size and format</i>			
Pad	0 to 3	byte	0	N/A

Item	Bytes	Format	Value	Units
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Table 3: Time and distance fields

Item	Bytes	Format	Value	Units
Time 1	8	double	N/A	seconds
Time 2	8	double	N/A	seconds
Distance tag	8	double	N/A	meters
Time types	1	byte	<u>Time 1 Select</u>	<u>Value in bits 0-3</u>
			Time 1: POS time	0
			Time 1: GPS time	1 (default)
			Time 1: UTC time	2
			<u>Time 2 Select</u>	<u>Value in bits 4-7</u>
			Time 2: POS time	0 (default)
			Time 2: GPS time	1
			Time 2: UTC time	2
Distance type	1	byte	<u>Distance Select</u>	<u>Value</u>
			N/A	0
			POS distance	1 (default)
			DMI distance	2

The *header* consists of the following components:

- ASCII group start (\$GRP)
- group identification (Group ID) number
- byte count
- time/distance fields

The *group identification* or *Group ID* is a short unsigned integer equal to the group number having the group numbering convention described in Section 3.2.2.

The *byte count* is a short unsigned integer that includes all fields in the group except the \$GRP delimiter, the Group ID and the byte count. Therefore, the byte count is always 8 bytes less than the length of the group.

The *time/distance fields* are shown in Table 3. These occupy 26 bytes and have the same format across all groups. They comprise the following:

- Time 1
- Time 2
- Distance tag and time and distance type flags.

Time 1 is the POS MV system time of validity of the data in the group, given in one of the following time bases:

- POS time (time in seconds since power-on)
- GPS seconds of the week
- UTC seconds of the week

The user can select any of these times for Time 1. Time 1 is set to POS time on power-up and changes to the user selected time base once the primary GPS receiver has locked on to a sufficient number of satellites to compute a time solution.

Time 2 is the POS MV system time of validity of the data in the group, given in one of the following time bases:

- POS time (time in seconds since power-on)
- GPS seconds of the week
- UTC seconds of the week
- User time

User time is specified by the user, with the procedure to set user time described in the POS MV V4 User Guide. It allows the groups to be time tagged with an external computer's time clock. The Time 2 field is always set to POS time for the raw (10000) series of data groups.

Distance tag is the distance of validity of the data in the group as determined by one of the following distance measurement sources:

- distance traveled derived from the POS MV blended navigation solution
- DMI (distance measurement index) distance tag

The group *data* follows the header. Its format is dependent on the particular group. Some group data lengths are fixed, whereas others may vary. For variable length groups the *byte count* is always updated to reflect the actual length of the group.

The group is terminated by the *footer*, which consists of the following components:

- a pad (if required)
- checksum
- ASCII group end delimiter (\$#).

The *pad* is used to make the total lengths of all groups a multiple of four bytes. The *checksum* is calculated so that the sum of byte pairs cast as short (16 bit) integers over the complete group results in a net sum of zero.

The byte, short, ushort, long, ulong, float and double formats are defined in Appendix A: Data Format Description.

The ranges of valid values for group fields that contain numbers are specified using the following notation.

$[a, b]$ implies the range a to b including the range lower and upper boundaries. A value x that falls in this range will respect the inequality $a \leq x \leq b$.

(a, b) implies the range a to b excluding the range lower and upper boundaries. A value x that falls in this range will respect the inequality $a < x < b$.

$(a, b]$ implies the range a to b excluding the lower boundary and including the upper boundary. A value x that falls in this range will respect the inequality $a < x \leq b$.

$[a, b)$ implies the range a to b excluding the range lower and upper boundaries. A value x that falls in this range will respect the inequality $a \leq x < b$.

If a value a or b is not given, then there is no corresponding lower or upper boundary.

The following are special cases:

- (0,) represents all positive numbers (excludes 0)
- [0,) represents all non-negative numbers (includes 0)
- (, 0) represents all negative numbers (excludes 0)
- (, 0] represents all non-positive numbers (includes 0)
- (,) represents all numbers in the range of valid numbers.

Group fields that contain numerical values may contain invalid numbers. Invalid byte, short, ushort, long, ulong, float and double values are defined in Table 82 in Appendix A: Data Format Description. POS MV outputs invalid values in fields containing numerical values for which POS MV has no valid data. This does not apply to fields containing bit settings.

3.2.4 Compatibility with Previous POS Products

The compatibility of POS MV V4 groups with POS MV V3 products is given as follows:

The POS MV V4 group format is the same as that of the POS MV V3 products.

The contents of Groups 1-8 and Group 99 are the same as those of the POS MV V3 products. However, Groups 7 and 8 have been expanded with new fields that occur before the Pad field. This is compatible with the POS MV V3 group design. Groups 9-98 are not defined in POS MV V3 products. Hence, no compatibility requirement exists for these groups.

Several groups in the range of Groups 9-98 are the same as or similar to some POS MV V3 product-specific groups. For example, Group 10 is similar to POS MV V3 Group 101.

The contents of Groups 10001-10005 are the same as those of all POS MV V3 products.

3.3 Output Group Tables

3.3.1 POS Data Groups

Group 1: Vessel Position, Velocity, Attitude & Dynamics

The POS MV group 1 contains data valid for the position defined by the user-entered reference to vessel lever arms (see Message 121: Vessel Installation Parameter Set-up). POS MV assumes the vessel and reference frames are co-aligned, therefore the reference to vessel mounting angles (see Message 20: General Installation and Processing Parameters) should be zero.

Table 4: Group 1: Vessel position, velocity, attitude & dynamics

Item	Bytes	Format	Value	Units
Group start	4	Char	\$GRP	N/A
Group ID	2	Ushort	1	N/A
Byte count	2	Ushort	132	bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Latitude	8	double	(-90, 90]	degrees
Longitude	8	double	(-180, 180]	degrees
Altitude	8	double	(,)	meters
North velocity	4	float	(,)	meters/second
East velocity	4	float	(,)	meters/second
Down velocity	4	float	(,)	meters/second
Vessel roll	8	double	(-180, 180]	degrees
Vessel pitch	8	double	(-90, 90]	degrees
Vessel heading	8	double	[0, 360)	degrees
Vessel wander angle	8	double	(-180, 180]	degrees

Item	Bytes	Format	Value	Units
Vessel track angle	4	float	[0, 360)	degrees
Vessel speed	4	float	[0,)	meters/second
Vessel angular rate about longitudinal axis	4	float	(,)	degrees/second
Vessel angular rate about transverse axis	4	float	(,)	degrees/second
Vessel angular rate about down axis	4	float	(,)	degrees/second
Vessel longitudinal acceleration	4	float	(,)	meters/second ²
Vessel transverse acceleration	4	float	(,)	meters/second ²
Vessel down acceleration	4	float	(,)	meters/second ²
Alignment status	1	byte	See Table 5	N/A
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Table 5: Group 1 alignment status

Group 1 Status	Description
0	Full navigation (User accuracies are met)
1	Fine alignment is active (RMS heading error is less than 15 degrees)
2	GC CHI 2 (alignment with GPS, RMS heading error is greater than 15 degrees)
3	PC CHI 2 (alignment without GPS, RMS heading error is greater than 15 degrees)
4	GC CHI 1 (alignment with GPS, RMS heading error is greater than 45 degrees)
5	PC CHI 1 (alignment without GPS, RMS heading error is greater than 45 degrees)
6	Coarse leveling is active

Group 1 Status	Description
7	Initial solution assigned
8	No valid solution

Group 2: Vessel Navigation Performance Metrics

This group contains vessel position, velocity and attitude performance metrics. The data in this group is *valid for the position defined by the user-entered reference vessel lever arms.*

All data items in this group are given in RMS values.

Table 6: Group 2: Vessel navigation performance metrics

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	2	N/A
Byte count	2	ushort	80	bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
North position RMS error	4	float	[0,)	meters
East position RMS error	4	float	[0,)	meters
Down position RMS error	4	float	[0,)	meters
North velocity RMS error	4	float	[0,)	meters/second
East velocity RMS error	4	float	[0,)	meters/second
Down velocity RMS error	4	float	[0,)	meters/second
Roll RMS error	4	float	[0,)	degrees
Pitch RMS error	4	float	[0,)	degrees
Heading RMS error	4	float	[0,)	degrees
Error ellipsoid semi-major	4	float	[0,)	meters
Error ellipsoid semi-minor	4	float	[0,)	meters
Error ellipsoid orientation	4	float	(0, 360]	degrees
Pad	2	byte	0	N/A

Item	Bytes	Format	Value	Units
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 3: Primary GPS Status

This group contains status data from the primary GPS receiver. The group length is variable, depending on the number of primary GPS receiver channels that report data. This group assumes that the primary GPS receiver contains up to 12 channels and therefore provides up to 12 channel status fields. Each channel status field has the format given in Table 8. The GPS receiver type field identifies the primary GPS receiver in POS MV from among the GPS receiver types listed in Table 11 that POS MV supports. The GPS status field comprises a 4-byte array of status bits whose format depends on the GPS receiver type.

Table 7: Group 3: Primary GPS status

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	3	N/A
Byte count	2	ushort	76 + 20 x (number of channels)	bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Navigation solution status	1	byte	See Table 9	N/A
Number of SV tracked	1	byte	[0, 12]	N/A
Channel status byte count	2	ushort	[0, 240]	bytes
<i>Channel status</i>	variable	<i>See Table 8</i>		
HDOP	4	float	(,)	N/A
VDOP	4	float	(,)	N/A
DGPS correction latency	4	float	[0, 999.9]	seconds
DGPS reference ID	2	ushort	[0, 1023]	N/A
GPS/UTC week number	4	ulong	[0, 1023] 0 if not available	week
GPS/UTC time offset (GPS time - UTC time)	8	double	(,)	seconds

Item	Bytes	Format	Value	Units
GPS navigation message latency	4	float	Number of seconds from the PPS pulse to the start of the GPS navigation data output	seconds
Geoidal separation	4	float	(,)	meters
GPS receiver type	2	ushort	<i>See Table 11</i>	N/A
GPS status	4	ulong	GPS summary status fields which depend on GPS receiver type.	
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Table 8: GPS receiver channel status data

Item	Bytes	Format	Value	Units
SV PRN	2	ushort	[1, 40]	N/A
Channel tracking status	2	ushort	See Table 10	N/A
SV azimuth	4	float	[0, 360)	degrees
SV elevation	4	float	[0, 90]	degrees
SV L1 SNR	4	float	[0,)	dB
SV L2 SNR	4	float	[0,)	dB

Table 9: GPS navigation solution status

Status Value	Description	Expected Accuracy
-1	Unknown	N/A
0	No data from Receiver	N/A
1	Horizontal C/A mode (unconstrained vertical position)	75 meters
2	3-dimension C/A mode	75 meters
3	Horizontal DGPS mode (unconstrained vertical position)	1 meter
4	3-dimension DGPS mode	1 meter

Status Value	Description	Expected Accuracy
5	Float RTK mode	0.25 meters
6	Integer wide lane RTK mode	0.2 meters
7	Integer narrow lane RTK mode	0.02 meters
8	P-Code mode	10 meters

Table 10: GPS channel status

Channel Status	Description
0	L1 Idle
1	Reserved
2	L1 acquisition
3	L1 Code lock
4	Reserved
5	L1 Phase lock (full performance tracking for L1-only receiver)
6	L2 Idle
7	Reserved
8	L2 acquisition
9	L2 Code lock
10	Reserved
11	L2 phase lock (full performance for L1/L2 receiver)

Table 11: GPS receiver type

GPS type	Description
0	No receiver
1 to 10	Reserved
11	Trimble Force 5 GRAM-S
12	Reserved
13	Trimble BD950

GPS type	Description
14 and up	Reserved

Table 12: Trimble BD950 GPS receiver status

Item	Bytes	Format	Failure	
Status of Receiver (Report Packet 0x9, bytes 19-22)	4	chars	<u>Description</u>	<u>Value</u>
			SETT	Setting time
			GETD	Updating Health
			CAL1	Calibrating
			MEAS	Static Survey
			KINE	Kinematic Survey

Group 4: Time-tagged IMU Data

This group consists of the time-tagged IMU data that is suitable for import by POSPAC, Applanix’ post-processing software package. U.S. and Canadian export control laws prohibit publication of the IMU data format.

Table 13: Group 4: Time-tagged IMU data

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	4	N/A
Byte count	2	ushort	60	bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
<i>IMU Data</i>	29			
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 5: Event 1

The time and distance fields in this group indicate the time and distance of Event 1 discrete signals that the POS MV receives. A client can use this message to attach GPS/UTC time to external events.

Group 6: Event 2

The time and distance fields in this group indicate the time and distance of Event 2 discrete signals that the POS MV receives. A client can use this message to attach GPS/UTC time to external events.

Table 14: Group 5/6: Event 1/2

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	5 or 6	N/A
Byte count	2	ushort	36	bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Event pulse number	4	ulong	[0,)	N/A
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 7: PPS Time Recovery and Status

The time and distance fields in this group indicate the time and distance of the PPS from the primary GPS receiver. The PPS count is the number of PPS messages since power-up and initialization of the GPS receivers. The time synchronization status field indicates the status of POS MV synchronization to the PPS time provided by the primary GPS receiver as follows:

No synchronization indicates that the POS MV has not synchronized to GPS time. This is the case if the GPS receiver has not initialized and provided time recovery data to the POS MV.

Synchronizing indicates that the POS MV is in the process of synchronizing to GPS time. This lasts on the order of 10-20 seconds as the POS MV establishes its internal clock offset and drift parameters.

Fully synchronized indicates that the POS MV has established synchronization to GPS time with less than 10 microseconds error and is maintaining the synchronization once per second.

Using old offset indicates that the POS MV is using the last good clock offset to compute GPS times. The POS MV has either not received a PPS or time recovery message or has rejected erroneous GPS time synchronization data.

This data provides for PPS time recovery of any of the time bases supported by the POS MV. It allows an external device to acquire GPS or UTC time, or to relate GPS time to POS MV time.

Table 15: Group 7: PPS Time Recovery and Status

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	7	N/A
Byte count	2	ushort	36	bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
PPS count	4	ulong	[0,)	N/A
Time synchronization status	1	byte	0 Not synchronized 1 Synchronizing 2 Fully synchronized 3 Using old offset	
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group End	2	char	\$#	N/A

Group 8: Reserved

Group 9: GAMS Solution

This group contains the GAMS solution and solution status. The following are descriptions of some of the group elements.

The *number of satellites* field gives the number of satellites in the GAMS solution. The *PDOP* is the PDOP of the satellite constellation selected by GAMS. The *computed antenna separation* is the length of the baseline vector that GAMS computes. The *solution status* describes the status of the current GAMS solution. The *PRN assignment* fields give the satellite PRN assigned to each observables processing channel. The *cycle slip flag* identifies processing channels in which the ambiguity search algorithm has detected cycle slips.

The *GAMS heading* is the heading of the antenna baseline vector. The *heading RMS error* is estimated by GAMS based on the RMS uncertainties of the primary and secondary carrier phase measurements reported by the primary and secondary GPS receivers.

Table 16: Group 9: GAMS Solution Status

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	9	N/A
Byte count	2	ushort	72	bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Number of satellites	1	ubyte	N/A	N/A
A priori PDOP	4	float	[0, 999]	N/A
Computed antenna separation	4	float	[0,)	meters
Solution Status	1	byte	0 fixed integer 1 fixed integer test install data 2 degraded fixed integer 3 floated ambiguity 4 degraded floated ambiguity 5 solution without install data 6 solution from navigator attitude and install data 7 no solution	
PRN assignment	12	12 bytes	Each byte contains 0-32 where 0 = unassigned PRN 1-40 = PRN assigned to channel	
Cycle slip flag	2	ushort	<u>Bits 0-11:</u> ($k-1$) th bit set to 1 implies cycle slip in channel k . Example: Bit 3 set to 1 implies cycle slip in channel 4. <u>Bits 12-15:</u> not used.	

Item	Bytes	Format	Value	Units
GAMS heading	8	double	[0,360)	Degrees
GAMS heading RMS error	8	double	(0,)	Degrees
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 10: General Status and FDIR

This group is used to output general and Fault Detection, Isolation and Reconfiguration (FDIR) status information. The POS Controller decodes and displays the sensor hardware status output in this group. The following is a brief description of group contents.

General Status A contains bit-encoded status information from the following processes: integrated navigation, data logging and generic hardware.

General Status B contains bit-encoded status information from the following processes: primary GPS data input, secondary GPS data input, auxiliary GPS data input, GAMS.

General Status C contains bit-encoded information from the following processes: integrated navigation, gimbal data input, DMI data input, base GPS messages (RTCM, CMR, RTCA) input.

FDIR Level 1, similar to a built-in test, reports problems in communications between the sensors and the PCS.

FDIR Level 2, the direct reasonableness test, compares the sensor data against reasonable magnitude limits for the POS-instrumented Vessel.

FDIR Level 3, the direct comparison test, compares IMU data against aiding sensor data and identifies unreasonable differences when they occur.

FDIR Level 4, the residual test, monitors the measurement residuals from the Kalman filter and rejects measurements that fall outside a specified 95% confidence level. Consistent measurement rejection indicates a potential IMU or aiding sensor failure.

FDIR Level 5, the indirect reasonableness test, monitors Kalman filter estimates of inertial sensor errors and installation errors. Soft sensor failures appear as slow increases in these errors. If a threshold is exceeded, a sensor failure is flagged.

Table 17: Group 10: General and FDIR status

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	10	N/A
Byte count	2	ushort	56	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
General Status A	4	ulong	Coarse levelling active	bit 0: set
			Coarse levelling failed	bit 1: set
			Quadrant resolved	bit 2: set
			Fine align active	bit 3: set
			Inertial navigator initialised	bit 4: set
			Inertial navigator alignment active	bit 5: set
			Degraded navigation solution	bit 6: set
			Full navigation solution	bit 7: set
			Initial position valid	bit 8: set
			Reference to Primary GPS Lever arms = 0	bit 9: set
			Reference to Sensor 1 Lever arms = 0	bit 10: set
			Reference to Sensor 2 Lever arms = 0	bit 11: set
			Logging Port file write error	bit 12: set
			Logging Port file open	bit 13: set
			Logging Port logging enabled	bit 14: set
			Logging Port device full	bit 15: set
			RAM configuration differs from NVM	bit 16: set
			NVM write successful	bit 17: set
NVM write fail	bit 18: set			
NVM read fail	bit 19: set			
CPU loading exceeds 55% threshold	bit 20: set			
CPU loading exceeds 85% threshold	bit 21: set			
Spare	bits: 22-31			

Item	Bytes	Format	Value	Units
General Status B	4	ulong	User attitude RMS performance	bit 0: set
			User heading RMS performance	bit 1: set
			User position RMS performance	bit 2: set
			User velocity RMS performance	bit 3: set
			GAMS calibration in progress	bit 4: set
			GAMS calibration complete	bit 5: set
			GAMS calibration failed	bit 6: set
			GAMS calibration requested	bit 7: set
			GAMS installation parameters valid	bit 8: set
			GAMS solution in use	bit 9: set
			GAMS solution OK	bit 10: set
			GAMS calibration suspended	bit 11: set
			GAMS calibration forced	bit 12: set
			Primary GPS navigation solution in use	bit 13: set
			Primary GPS initialisation failed	bit 14: set
			Primary GPS reset command sent	bit 15: set
			Primary GPS configuration file sent	bit 16: set
			Primary GPS not configured	bit 17: set
			Primary GPS in C/A mode	bit 18: set
			Primary GPS in Differential mode	bit 19: set
			Primary GPS in float RTK mode	bit 20: set
			Primary GPS in wide lane RTK mode	bit 21: set
			Primary GPS in narrow lane RTK mode	bit 22: set
			Primary GPS observables in use	bit 23: set
			Secondary GPS observables in use	bit 24: set
			Auxiliary GPS navigation solution in use	bit 25: set
			Auxiliary GPS in P-code mode	bit 26: set
			Auxiliary GPS in Differential mode	bit 27: set

Item	Bytes	Format	Value	Units
			Auxiliary GPS in float RTK mode	bit 28: set
			Auxiliary GPS in wide lane RTK mode	bit 29: set
			Auxiliary GPS in narrow lane RTK mode	bit 30: set
			Primary GPS in P-code mode	bit 31: set
General Status C	4	ulong	Gimbal input ON	bit 0: set
			Gimbal data in use	bit 1: set
			DMI data in use	bit 2: set
			ZUPD processing enabled	bit 3: set
			ZUPD in use	bit 4: set
			Position fix in use	bit 5: set
			RTCM differential corrections in use	bit 6: set
			RTCM RTK messages in use	bit 7: set
			RTCA RTK messages in use	bit 8: set
			CMR RTK messages in use	bit 9: set
			IIN in DR mode	bit 10: set
			IIN GPS aiding is loosely coupled	bit 11: set
			IIN in C/A GPS aided mode	bit 12: set
			IIN in RTCM DGPS aided mode	bit 13: set
			IIN in code DGPS aided mode	bit 14: set
			IIN in float RTK aided mode	bit 15 set
			IIN in wide lane RTK aided mode	bit 16: set
			IIN in narrow lane RTK aided mode	bit 17: set
			Received RTCM Type 1 message	bit 18: set
			Received RTCM Type 3 message	bit 19: set
			Received RTCM Type 9 message	bit 20: set
			Received RTCM Type 18 messages	bit 21: set
			Received RTCM Type 19 messages	bit 22: set
			Received CMR Type 0 message	bit 23: set

Item	Bytes	Format	Value	Units
			Received CMR Type 1 message	bit 24: set
			Received CMR Type 2 message	bit 25: set
			Received CMR Type 94 message	bit 26 set
			Received RTCA SCAT-1 message	bit 27: set
			Spare	bit: 28-31
FDIR Level 1 status	4	ulong	IMU-POS checksum error	bit 0: set
			IMU status bit set by IMU	bit 1: set
			Successive IMU failures	bit 2: set
			IIN configuration mismatch failure	bit 3: set
			Primary GPS not in Navigation mode	bit 5: set
			Primary GPS not available for alignment	bit 6: set
			Primary data gap	bit 7: set
			Primary GPS PPS time gap	bit 8: set
			Primary GPS time recovery data not received	bit 9: set
			Primary GPS observable data gap	bit 10: set
			Primary ephemeris data gap	bit 11: set
			Primary GPS excessive lock-time resets	bit 12: set
			Primary GPS missing ephemeris	bit 13: set
			Primary GPS SNR failure	bit 16: set
			Base GPS data gap	bit 17: set
			Base GPS parity error	bit 18: set
			Base GPS message rejected	bit 19: set
			Secondary GPS data gap	bit 20: set
			Secondary GPS observable data gap	bit 21: set
			Secondary GPS SNR failure	bit 22: set
			Secondary GPS excessive lock-time resets	bit 23: set
			Auxiliary GPS data gap	bit 25: set
			GAMS ambiguity resolution failed	bit 26: set

Item	Bytes	Format	Value	Units
			Gimbal data gap DMI failed or is offline IIN WL ambiguity error IIN NL ambiguity error Spare	bit 27: set bit 28: set bit 30: set bit 31: set bits: 4, 14, 15, 24, 29
FDIR Level 1 IMU failures	2	ushort	Shows number of FDIR Level 1 Status IMU failures (bits 0 or 1) = Bad IMU Frames	
FDIR Level 2 status	2	ushort	Inertial speed exceeds max Primary GPS velocity exceeds max Primary GPS position error exceeds max Auxiliary GPS position error exceeds max DMI speed exceeds max Spare	bit 0: set bit 1: set bit 2: set bit 3: set bit 4: set bits: 5-15
FDIR Level 3 status	2	ushort	Spare	bits: 0-15
FDIR Level 4 status	2	ushort	Primary GPS position rejected Primary GPS velocity rejected GAMS heading rejected Auxiliary GPS data rejected DMI data rejected Primary GPS observables rejected Spare	bit 0: set bit 1: set bit 2: set bit 3: set bit 4: set bit 5: set bits: 6-15
FDIR Level 5 status	2	ushort	X accelerometer failure Y accelerometer failure Z accelerometer failure X gyro failure Y gyro failure Z gyro failure Excessive GAMS heading offset	bit 0: set bit 1: set bit 2: set bit 3: set bit 4: set bit 5: set bit 6: set

Item	Bytes	Format	Value	Units
			Excessive primary GPS lever arm error	bit 7: set
			Excessive auxiliary 1 GPS lever arm error	bit 8: set
			Excessive auxiliary 2 GPS lever arm error	bit 9: set
			Excessive POS position error RMS	bit10:set
			Excessive primary GPS clock drift	bit11:set
			Spare	bits: 12-15
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$\$	N/A

max = maximum

Group 11: Secondary GPS Status

This group contains status data from the secondary GPS receiver. The group length is variable, depending on the number of secondary GPS receiver channels that report data. This group assumes that the secondary GPS receiver contains up to 12 channels and therefore provides 12 channel status fields. Each channel status field has the format given in Table 8. The *GPS navigation message latency* field contains the time between the PPS pulse and the start of the GPS navigation data output

Table 18: Group 11: Secondary GPS status

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	11	N/A
Byte count	2	ushort	76 + 20 x (number of channels)	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Navigation solution status	1	byte	See Table 9	N/A
Number of SV tracked	1	byte	[0, 12]	N/A
Channel status byte count	2	ushort	[0, 240]	Bytes
<i>Channel status</i>	variable	<i>See Table 8</i>		

Item	Bytes	Format	Value	Units
HDOP	4	float	(0,)	N/A
VDOP	4	float	(0,)	N/A
DGPS correction latency	4	float	[0, 99.9]	Seconds
DGPS reference ID	2	ushort	[0, 1023]	N/A
GPS/UTC week number	4	ulong	[0, 1023] 0 if not available	Week
GPS/UTC time offset (GPS time - UTC time)	8	double	(, 0]	Seconds
GPS navigation message latency	4	float	[0,)	Seconds
Geoidal separation	4	float	(,)	Meters
GPS receiver type	2	ushort	See Table 11	N/A
GPS status	4	ulong	GPS summary status fields which depend on GPS receiver type.	
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 12: Auxiliary 1 GPS Status

This group contains data from an optional auxiliary 1 external GPS receiver. The group is variable in length because it is dependent upon the number of satellites that the auxiliary 1 GPS receiver is tracking. This group assumes that the auxiliary 1 GPS receiver contains up to 12 channels and therefore provides 12 channel status fields. The centre section of this group grows with increasing number of satellites tracked.

Group 13: Auxiliary 2 GPS Status

This group contains data from an optional auxiliary 2 external GPS receiver. The group has the same format as Group 12. Table 19 specifies the format for both Groups 12 and 13

Table 19: Group 12/13: Auxiliary 1/2 GPS status

Item	Bytes	Format	Value	Units												
Group start	4	char	\$GRP	N/A												
Group ID	2	ushort	12 or 13	N/A												
Byte count	2	ushort	72 + 20 x (number of channels)	Bytes												
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>														
Navigation solution status	1	byte	See Table 9	N/A												
Number of SV Tracked	1	byte	[0, 40]	N/A												
Channel status byte count	2	ushort	[0,)	Bytes												
<i>Channel status</i>	variable	<i>See Table 8</i>														
HDOP	4	float	(0,)	N/A												
VDOP	4	float	(0,)	N/A												
DGPS correction latency	4	float	(0,)	Seconds												
DGPS reference ID	2	ushort	[0, 1023]	N/A												
GPS/UTC week number	4	ulong	[0, 1023] 0 if not available	Week												
GPS time offset (GPS time - UTC time)	8	double	(, 0]	Seconds												
GPS navigation message latency	4	float	[0,)	Seconds												
Geoidal separation	4	float	N/A	Meters												
NMEA messages Received	2	ushort	<table border="0"> <tr> <td><u>Bit (set)</u></td> <td><u>NMEA Message</u></td> </tr> <tr> <td>0</td> <td>GGA (GPS position)</td> </tr> <tr> <td>1</td> <td>GST (noise statistics)</td> </tr> <tr> <td>2</td> <td>GSV (satellites in view)</td> </tr> <tr> <td>3</td> <td>GSA (DOP & active SVs)</td> </tr> <tr> <td>4-15</td> <td>Reserved</td> </tr> </table>	<u>Bit (set)</u>	<u>NMEA Message</u>	0	GGA (GPS position)	1	GST (noise statistics)	2	GSV (satellites in view)	3	GSA (DOP & active SVs)	4-15	Reserved	
<u>Bit (set)</u>	<u>NMEA Message</u>															
0	GGA (GPS position)															
1	GST (noise statistics)															
2	GSV (satellites in view)															
3	GSA (DOP & active SVs)															
4-15	Reserved															

Item	Bytes	Format	Value	Units	
Aux 1/2 in Use ¹	1	byte	0 1	Not in use In use	N/A
Pad	1	byte	0		N/A
Checksum	2	ushort	N/A		N/A
Group end	2	char	\$#		N/A

1 Group 12/13 Aux in Use fields will not be set *in use* simultaneously.

Group 14: Calibrated Installation Parameters

This group lists the calibrated installation parameters that the POS MV computes during Navigate mode when the Calibrate function is active. The group includes a Figure of Merit (FOM) for each set of parameters that the user can choose to calibrate. The FOM ranges from 0 to 100 and describes the percentage of a complete calibration that a calibration has achieved. A FOM equal to 0 indicates one of two possibilities:

- A parameter is not being calibrated because the user did not flag the parameter for calibration in Message 57: Installation calibration control (see Section 0).
- A parameter is not calibrated during a calibration of the parameter because the Vessel has not executed the required dynamics to effect the calibration.

Table 20: Group 14: Calibrated installation parameters

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	14	N/A
Byte count	2	ushort	116	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Calibration status	2	See Table 21		
Reference to Primary GPS X lever arm	4	float	(,)	Meters
Reference to Primary GPS Y lever arm	4	float	(,)	Meters
Reference to Primary GPS Z lever arm	4	float	(,)	Meters
Reference to Primary GPS lever arm calibration FOM	2	ushort	[0, 100]	N/A
Reference to Auxiliary 1 GPS X lever arm	4	float	(,)	Meters

Item	Bytes	Format	Value	Units
Reference to Auxiliary 1 GPS Y lever arm	4	float	(,)	Meters
Reference to Auxiliary 1 GPS Z lever arm	4	float	(,)	Meters
Reference to Auxiliary 1 GPS lever arm calibration FOM	2	ushort	[0, 100]	N/A
Reference to Auxiliary 2 GPS X lever arm	4	float	(,)	Meters
Reference to Auxiliary 2 GPS Y lever arm	4	float	(,)	Meters
Reference to Auxiliary 2 GPS Z lever arm	4	float	(,)	Meters
Reference to Auxiliary 2 GPS lever arm calibration FOM	2	ushort	[0, 100]	N/A
Reference to DMI X lever arm	4	float	(,)	Meters
Reference to DMI Y lever arm	4	float	(,)	Meters
Reference to DMI Z lever arm	4	float	(,)	Meters
Reference to DMI lever arm calibration FOM	2	ushort	[0, 100]	N/A
DMI scale factor	4	float	(,)	%
DMI scale factor calibration FOM	2	ushort	[0, 100]	N/A
Reference to DVS X lever arm	4	float	(,)	Meters
Reference to DVS Y lever arm	4	float	(,)	Meters
Reference to DVS Z lever arm	4	float	(,)	meters
Reference to DVS lever arm calibration FOM	2	ushort	[0, 100]	N/A
DVS scale factor	4	float	(,)	%
DVS scale factor calibration FOM	2	ushort	[0, 100]	N/A
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Table 21: IIN Calibration Status

Bit Set	Status Description
0	Reference to Primary GPS lever arm calibration is in progress
1	Reference to Auxiliary 1 GPS lever arm calibration is in progress
2	Reference to Auxiliary 2 GPS lever arm calibration is in progress
3	Reference to DMI lever arm calibration is in progress
4	DMI scale factor calibration is in progress
5	Reference to DVS lever arm calibration is in progress
6	Reference to Position Fix lever arm calibration is in progress
7	Reserved
8	Reference to Primary GPS lever arm calibration is completed
9	Reference to Auxiliary 1 GPS lever arm calibration is completed
10	Reference to Auxiliary 2 GPS lever arm calibration is completed
11	Reference to DMI lever arm calibration is completed
12	DMI scale factor calibration is completed
13	Reference to DVS lever arm calibration is completed
14	Reference to Position Fix lever arm calibration is completed
15	Reserved

Group 15: Reserved

Group 16: Reserved

Group 17: User Time Status

This group contains status information about user time synchronization.

Table 22: Group 17: User Time Status

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	17	N/A

Item	Bytes	Format	Value	Units
Byte count	2	ushort	40	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Number of Time Synch message rejections	4	ulong	[0,)	N/A
Number of User Time resynchronizations	4	ulong	[0,)	N/A
User time valid	1	byte	1 or 0	N/A
Time Synch message received	1	byte	1 or 0	N/A
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 20: IIN Solution Status

This group contains the IIN observables processing status and relevant data. The following are descriptions of some of the fields.

The *number of satellites* field gives the number of satellites in the IIN solution. The *a priori PDOP* is the PDOP of the satellite constellation selected by IIN before processing. The *baseline length* is the computed distance between the primary GPS antenna and the reference GPS antenna. The *IIN processing status* describes the status of the current IIN solution. The 12 *PRN assignment* fields give the satellite PRN used in each observables processing channel in the IIN solution. The *L1 cycle slip flag* field contains a bit array whose bits when set, indicate an L1 cycle slips in the observables processing channels. The *L2 cycle slip flag* field contains a bit array whose bits when set, indicate L2 cycle slips in observables processing channels. In each bit array, bit $(k-1)$ indicates the cycle slip status of processing channel k .

Table 23: Group 20: IIN solution status

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	20	N/A
Byte count	2	ushort	60	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Number of satellites	2	ushort	[0, 12]	N/A
A priori PDOP	4	float	[0, 999]	N/A

Item	Bytes	Format	Value	Units
Baseline length	4	float	[0,)	Meters
IIN processing status	2	ushort	1 Fixed Narrow Lane RTK 2 Fixed Wide Lane RTK 3 Float RTK 4 Code DGPS 5 RTCM DGPS 6 Autonomous (C/A) 7 GPS navigation solution 8 No solution	
PRN assignment	12	12 byte	Each byte contains 0-40 where 0 = unassigned PRN 1-40 = PRN assigned to channel	
L1 cycle slip flag	2	ushort	<u>Bits 0-11:</u> $(k-1)^{th}$ bit set to 1 implies L1 cycle slip in channel k PRN. Example: Bit 3 set to 1 implies an L1 cycle slip in channel 4. <u>Bits 12-15:</u> not used.	
L2 cycle slip flag	2	ushort	<u>Bits 0-11:</u> $(k-1)^{th}$ bit set to 1 implies L2 cycle slip in channel k PRN. Example: Bit 3 set to 1 implies an L2 cycle slip in channel 4. <u>Bits 12-15:</u> not used.	
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 21: Base GPS 1 Modem Status

The base GPS process may receive differential corrections from a base station via a modem connected to one of the POS MV serial ports. This group contains status information about the modem connected to the serial port associated with the Base GPS 1 input.

Group 22: Base GPS 2 Modem Status

This group contains status information about the modem connected to the serial port associated with the Base GPS 2 input.

Table 24: Group 21/22: Base GPS 1/2 Modem Status

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	21 or 22	N/A
Byte count	2	ushort	116	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Modem response	16	char	N/A	N/A
Connection status	48	char	N/A	N/A
Number of redials per disconnect	4	ulong	[0,)	N/A
Maximum number of redials per disconnect	4	ulong	[0,)	N/A
Number of disconnects	4	ulong	[0,)	N/A
Data gap length	4	ulong	[0,)	N/A
Maximum data gap length	4	ulong	[0,)	N/A
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 23: Auxiliary 1 GPS Display Data

This group contains the auxiliary 1 GPS receiver data stream, containing the NMEA strings requested by the PCS from the receiver plus any other bytes that the receiver inserts into the stream. The length of this group is variable. It is identical to group 10007 except for the time2 restriction and the fact it is intended for display only.

Group 24: Auxiliary 2 GPS Display Data

This group contains the auxiliary 2 GPS receiver data stream, containing the NMEA strings requested by the PCS from the receiver plus any other bytes that the receiver inserts into the stream. The length of this group is variable. It is identical to group 10008 except for the time2 restriction and the fact it is intended for display only.

Table 25: Group 23/24: Auxiliary 1/2 GPS raw display data

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	10007 or 10008	N/A
Byte count	2	ushort	variable	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Reserved	6	byte	N/A	N/A
Variable message byte count	2	ushort	[0,)	Bytes
<i>Auxiliary GPS raw data</i>	<i>variable</i>	<i>char</i>	<i>N/A</i>	<i>N/A</i>
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 25: Reserved

Group 26: Reserved

Group 99: Versions and Statistics

This group provides feedback of the current statistics and software and hardware version numbers of the POS MV. This group contains operational statistics such as total hours of operation, number of runs, average run length and longest run.

Table 26: Group 99: Versions and statistics

Item	Bytes	Format	Value	Units
Group Start	4	Char	\$GRP	N/A
Group ID	2	Ushort	99	N/A
Byte Count	2	Ushort	332	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
System version	120	Char	Product - Model, Version, Serial Number, Hardware version,	

Item	Bytes	Format	Value	Units
			Software release version - Date, ICD release version, Operating system version, IMU type, Primary GPS type (Table 11), Secondary GPS type (Table 11), DMI type, Gimbal type [,Option mnemonic-expiry time] [,Option mnemonic-expiry time] Example: MV-320,VER4,S/N123,HW1.80-7, SW03.20-Aug3/05,ICD01.00, OS425B,IMU2,PGPS13,SGPS13, DMI0,GIM0,RTK-75 N/A	
Primary GPS version	80	char	Available information is displayed, eg: <ul style="list-style-type: none"> • Model number • Serial number • Hardware configuration version • Software release version • Release date 	
Secondary GPS version	80	Char	Available information is displayed, eg: <ul style="list-style-type: none"> • Model number • Serial number • Hardware configuration version • Software release version 	

Item	Bytes	Format	Value	Units
			• Release date	
Total hours	4	float	[0,) 0.1 hour resolution	Hours
Number of runs	4	ulong	[0,)	N/A
Average length of run	4	float	[0,) 0.1 hour resolution	Hours
Longest run	4	float	[0,) 0.1 hour resolution	Hours
Current run	4	float	[0,) 0.1 hour resolution	Hours
Pad	2	short	0	N/A
Checksum	2	ushort	N/A	N/A
Group End	2	char	\$#	N/A

Group 102: Sensor 1 Position, Velocity, Attitude, Heave & Dynamics

This group contains position, velocity, attitude, track, speed and dynamics data for the sensor 1 position.

Group 103: Sensor 2 Position, Velocity, Attitude, Heave & Dynamics

This group contains position, velocity, attitude, track, speed and dynamics data for the sensor 2 position.

Table 27: Group 102/103: Sensor 1/2 Position, Velocity, Attitude, Heave & Dynamics

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	102 or 103	N/A
Byte count	2	ushort	128	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Latitude	8	double	(-90, 90]	Deg
Longitude	8	double	(-180, 180]	Deg
Altitude	8	double	(,)	M
Along track velocity	4	float	(,)	m/s
Across track velocity	4	float	(,)	m/s

Item	Bytes	Format	Value	Units
Down velocity	4	float	(,)	m/s
Roll	8	double	(-180, 180]	Deg
Pitch	8	double	(-90, 90]	Deg
Heading	8	double	[0, 360)	Deg
Wander angle	8	double	(-180, 180]	Deg
Heave ¹	4	float	(,)	M
Angular rate about longitudinal axis	4	float	(,)	deg/s
Angular rate about transverse axis	4	float	(,)	deg/s
Angular rate about down axis	4	float	(,)	deg/s
Longitudinal acceleration	4	float	(,)	m/s ²
Transverse acceleration	4	float	(,)	m/s ²
Down acceleration	4	float	(,)	m/s ²
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

1 Heave is output in the gravity direction from a local level frame located at the sensor 1 or 2 position. The Heave sign is positive down.

Group 104: Sensor 1 Position, Velocity, and Attitude Performance Metrics

This group contains sensor 1 position, velocity and attitude performance metrics. All data in this group are RMS values.

Group 105: Sensor 2 Position, Velocity, and Attitude Performance Metrics

This group contains sensor 2 position, velocity and attitude performance metrics. All data in this group are RMS values.

Table 28: Group 104/105: Sensor 1/2 Position, Velocity, and Attitude Performance Metrics

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	104 or 105	N/A
Byte count	2	ushort	68	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
N position RMS	4	float	[0,)	M
E position RMS	4	float	[0,)	M
D position RMS	4	float	[0,)	M
Along track velocity RMS error	4	float	[0,)	m/s
Across track velocity RMS error	4	float	[0,)	m/s
Down velocity RMS error	4	float	[0,)	m/s
Roll RMS error	4	float	[0,)	Deg
Pitch RMS error	4	float	[0,)	Deg
Heading RMS error	4	float	[0,)	Deg
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 110: MV General Status & FDIR

This group contains MV specific status bits. It is an extension of the Core group 10 information.

Table 29: Group 110: MV General Status & FDIR

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	110	N/A
Byte count	2	ushort	32	Bytes

Item	Bytes	Format	Value	Units
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
General Status	2	ulong	User logged in <i>reserved</i> TrueZ Active TrueZ Ready TrueZ In Use <i>Reserved</i>	bit 0: set <i>bit 1 to 9</i> bit 10: set bit 11: set bit 12: set <i>bit 13 to 31</i>
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 111: Heave & True Heave Data

This group contains data from the True Heave calculations (delayed in time), along with time-matched Heave (Real-time) data. Both the Real-Time and True Heave values are in the gravity direction from a local level frame located at the Sensor 1 position. The Heave sign is positive down.

Table 30: Group 111: Heave & True Heave Data

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	111	N/A
Byte count	2	ushort	76	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
True Heave	4	float	(,)	M
True Heave RMS	4	float	[0,)	M
Status	4	ulong	True Heave Valid Real-time Heave Valid <i>reserved</i>	bit 0: set bit 1: set <i>bit 2 to 31</i>
Heave	4	float	(,)	M
Heave RMS	4	float	[0,)	M

Item	Bytes	Format	Value	Units
Heave Time 1	8	double	N/A	Sec
Heave Time 2	8	double	N/A	Sec
Rejected IMU Data Count	4	ulong	[0,)	N/A
Out of Range IMU Data Count	4	ulong	[0,)	N/A
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 112: NMEA Strings

This group contains a copy of the NMEA strings output from the user selected COM port. This group will be available for output at the same rate selected for NMEA output on the COM port. Note that the user must select this group for output on the desired Data in order to receive the data.

Table 31: Group 112: NMEA Strings

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	112	N/A
Byte count	2	ushort	<i>variable</i>	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Variable group byte count	2	float	[0,)	N/A
<i>NMEA strings</i>	<i>variable</i>	<i>char</i>	<i>N/A</i>	<i>N/A</i>
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 113: Heave & True Heave Performance Metrics

This group contains quality data from the True Heave calculations.

Table 32: Group 113: Heave & True Heave Performance Metrics

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	113	N/A
Byte count	2	ushort	68	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Heave Time 1	8	double	N/A	Sec
Quality Control 1	8	double	N/A	N/A
Quality Control 2	8	double	N/A	N/A
Quality Control 3	8	double	N/A	N/A
Status	4	ulong	Quality Control 1 Valid Quality Control 2 Valid Quality Control 3 Valid <i>Reserved</i>	bit 0: set bit 1: set bit 2: set <i>bit 3 to 31</i>
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 114: TrueZ & TrueTide Data

This group contains altitude data from the delayed TrueZ and delayed TrueTide calculations along with the time-matched real-time data. The real-time TrueZ, delayed TrueZ and delayed TrueTide values are in the gravity direction from a local level frame located at the Sensor 1 position. The real-time TrueTide values are in the gravity direction from a local level frame located at the Vessel position.

Table 33: Group 114: TrueZ & TrueTide Data

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	114	N/A
Byte count	2	ushort	76	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Delayed TrueZ	4	float	(,)	M
Delayed TrueZ RMS	4	float	[0,)	M
Delayed TrueTide	4	float	(,)	M
Status	4	ulong	Delayed TrueZ Valid Real-time TrueZ Valid <i>Reserved</i>	bit 0: set bit 1: set <i>bit 2 to 31</i>
TrueZ	4	float	(,)	M
TrueZ RMS	4	float	[0,)	M
TrueTide	4	float	(,)	M
TrueZ Time 1	8	double	N/A	Sec
TrueZ Time 2	8	double	N/A	Sec
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

3.3.2 Raw Data Groups

Group 10001: Primary GPS Data Stream

This group contains the primary GPS receiver data as output by the receiver. The length of this group is variable. The GPS data stream is packaged into the group as it is received, irrespective of GPS message boundaries. The messages contained in this group depends on the primary GPS receiver that the POS MV uses. If a data extraction process concatenates the data components from these groups into a single file, then the resulting file will be the same as a file of data recorded directly from the primary GPS receiver.

Table 34: Group 10001: Primary GPS data stream

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	10001	N/A
Byte count	2	ushort	variable	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
GPS receiver type	2	ushort	See Table 11	N/A
Reserved	4	long	N/A	N/A
Variable message byte count	2	ushort	[0,)	Bytes
<i>GPS Receiver raw data</i>	<i>variable</i>	<i>char</i>	<i>N/A</i>	<i>N/A</i>
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 10002: Raw IMU Data

This group contains the IMU data as output by the IMU directly. The length of this group is variable.

The IMU header field contains 6 characters of which the first 4 are “\$IMU” and the last two are the IMU type number in ASCII format (example: “\$IMU01” identifies IMU type 1). The Data checksum is a 16-bit sum of the IMU data. The POS MV provides this checksum in addition to the possible IMU-generated checksums in the IMU data field. U.S. and Canadian export control laws prevent the publication of the IMU data field formats for the different IMU’s that the POS MV supports.

Table 35: Group 10002: Raw IMU data

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	10002	N/A
Byte count	2	ushort	Variable	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
IMU header	6	char	<i>\$IMU</i> <i>nn</i> where <i>nn</i> identifies the IMU type.	

Item	Bytes	Format	Value	Units
Variable message byte count	2	ushort	[0,)	Bytes
<i>IMU raw data</i>	<i>variable</i>	<i>byte</i>	<i>N/A</i>	<i>N/A</i>
Data Checksum	2	short	N/A	N/A
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 10003: Raw PPS

This group contains the raw PPS data that the POS MV generates. The time of the PPS is given in the Time/Distance fields.

Table 36: Group 10003: Raw PPS

Item	Bytes	Format	Value	Units
Group start	4	Char	\$GRP	N/A
Group ID	2	Ushort	10003	N/A
Byte count	2	Ushort	36	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
PPS pulse count	4	Ulong	[0,)	N/A
Pad	2	Byte	0	N/A
Checksum	2	Ushort	N/A	N/A
Group end	2	Char	\$#	N/A

Group 10004: Raw Event 1

This group contains the raw Event 1 data that the POS MV generates. The time of the event pulse count is given in the Time/Distance fields.

Group 10005: Raw Event 2

This group contains the raw Event 2 data that the POS MV generates. The time of the event pulse count is given in the Time/Distance fields.

Table 37: Group 10004/10005: Raw Event 1/2

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	10004 or 10005	N/A
Byte count	2	ushort	36	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
Event 1 pulse count	4	ulong	[0,)	N/A
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

Group 10006: Reserved

Group 10007: Auxiliary 1 GPS Data Stream

This group contains the auxiliary 1 GPS receiver data stream, containing the NMEA strings requested by the PCS from the receiver plus any other bytes that the receiver inserts into the stream. The length of this group is variable. If a data extraction process concatenates the data components from these groups into a single file, then the resulting file will be the same as an ASCII file of NMEA strings recorded directly from the auxiliary 1 GPS receiver.

Group 10008: Auxiliary 2 GPS Data Stream

This group contains the auxiliary 2 GPS receiver data stream, containing the NMEA strings requested by the PCS from the receiver plus any other bytes that the receiver inserts into the stream. The length of this group is variable. If a data extraction process concatenates the data components from these groups into a single file, then the resulting file will be the same as an ASCII file of NMEA strings recorded directly from the auxiliary 2 GPS receiver.

Table 38: Group 10007/10008: Auxiliary 1/2 GPS data streams

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	10007 or 10008	N/A
Byte count	2	ushort	variable	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
reserved	2	byte	N/A	N/A

Item	Bytes	Format	Value	Units
reserved	4	long	N/A	N/A
Variable message byte count	2	ushort	[0,)	Bytes
<i>Auxiliary GPS raw data</i>	<i>variable</i>	<i>char</i>	<i>N/A</i>	<i>N/A</i>
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$\$	N/A

Group 10009: Secondary GPS Data Stream

This group contains the secondary GPS receiver data as output by the receiver. The length of this group is variable. The GPS data stream is packaged into the group as it is received, irrespective of GPS message boundaries. The messages contained in this group depends on the secondary GPS receiver that the POS MV uses. If a data extraction process concatenates the data components from these groups into a single file, then the resulting file will be the same as a file of data recorded directly from the secondary GPS receiver.

Table 39: Group 10009: Secondary GPS data stream

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	10009	N/A
Byte count	2	ushort	Variable	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
GPS receiver type	2	ushort	See Table 11	N/A
Reserved	4	byte	N/A	N/A
Variable message byte count	2	ushort	[0,)	Bytes
<i>GPS Receiver Message</i>	<i>variable</i>	<i>char</i>	<i>N/A</i>	<i>N/A</i>
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$\$	N/A

Group 10010: Reserved

Group 10011: Base GPS 1 Data Stream

This group contains the message data stream the POS MV receives as differential corrections. The length of this group is variable and dependent on the messages received by the PCS. If a data extraction process concatenates the data components from this group into a single file, then the resulting file will be the same as a file of data captured from the serial data stream connected to a differential corrections port.

Group 10012: Base GPS 2 Data Stream

This group contains the message data stream the POS MV receives as differential corrections. The length of this group is variable and dependent on the messages received by the PCS. If a data extraction process concatenates the data components from this group into a single file, then the resulting file will be the same as a file of data captured from the serial data stream connected to a differential corrections port.

Table 40: Group 10011/10012: Base GPS 1/2 data stream

Item	Bytes	Format	Value	Units
Group start	4	char	\$GRP	N/A
Group ID	2	ushort	10011 or 10012	N/A
Byte count	2	ushort	variable	Bytes
<i>Time/Distance Fields</i>	26	<i>See Table 3</i>		
reserved	6	byte	N/A	N/A
Variable message byte count	2	ushort	[0,)	Bytes
<i>Base GPS raw data</i>	<i>variable</i>	<i>byte</i>	<i>N/A</i>	<i>N/A</i>
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	\$#	N/A

4 Message Input and Output

4.1 Introduction

The POS MV uses the Control Port to receive control messages from the *POS Controller*, (a user's custom software application or MV POSView), and to acknowledge successful receipt of the messages. The Control Port is bi-directional and uses the TCP/IP protocol to communicate with the control and display software.

Each message sent to POS MV causes an action to be initiated. When POS MV receives and validates a message, it replies to the *POS Controller* by sending an 'Acknowledge' message, Message ID 0, on the Control Port over which it received the message. The Acknowledge message protocol is defined below. The purpose of the Acknowledge message is to inform the *POS Controller* that the POS MV has received a message and has either accepted or rejected it. In addition, POS MV also outputs a message echo on each of the Display and Data ports to indicate the current system state, regardless of whether the action was successful or not.

4.2 Message Output Data Rates

The POS MV periodically generates copies (echos) of received control message or internally generated messages at maximum frequencies described in Table 41. This output allows a *POS Controller* to monitor the current state of the configuration of the POS MV. The content of the output messages reflects the current state of the POS MV. Thus, if the state of the system changes, as part of the normal operations, it is reflected in the next set of echo messages from the POS MV.

4.2.1 Message Numbering Convention

All POS products use the following message numbering convention. POS MV outputs the message categories shown. Reserved message numbers are assigned to other products or previous versions of POS products. In particular, POS MV V3 core messages occupy the namespace range 1-19.

0	Core - Acknowledge message
1 - 19	Core - Reserved
20 - 49	Core - Installation parameter set-up messages
50 - 79	Core - Processing control messages
80 - 89	Core - Reserved
90 - 99	Core - Program control override messages
100 - 199	POS MV specific messages
200 - 19999	Reserved

- 20000 - 20099 Core - Diagnostic messages
- 20100 - 20199 POS MV specific diagnostic messages
- 20200 - 29999 Reserved

The **Acknowledge message** is the message that POS MV sends as a reply to a message from the POS Controller. It is described in detail in Section 0 of this document.

Installation parameter set-up messages comprise all messages that the user sends via the POS Controller to implement a particular installation of the POS MV. The POS Controller would not normally send these messages once the installation is completed. Messages 20-29 are signal processing parameter set-up messages. These specify sensor installation parameters and user accuracies. Messages 30-49 are hardware control messages. These specify communication control parameters and real-time message selections.

Processing control messages comprise all messages that the user requires to control and monitor POS MV during a navigation session. These include navigation mode control, data acquisition control and possibly initialization of navigation quantities if no GPS signal is available.

Program control override messages permits the user to directly control functions that POS MV normally performs automatically. The user would send a program control override message only under special circumstances. For example, the user may believe that the primary or secondary GPS receiver has lost its configuration and chooses to manually command the POS MV to re-configure the receiver. This message category also includes control messages that alter the normal operation or output of POS MV for diagnosis purposes. The actions induced by these messages are not part of the normal POS MV operation and should be interpreted only by qualified Applanix service personnel.

Table 41: Control messages output data rates

Message	Contents	Display Port (Hz)		Real-Time Data Port (Hz)		Logging Data Port (Hz)	
		Stby	Nav	Stby	Nav	Stby	Nav
0	Acknowledge	-	-	-	-	-	-
<i>Installation Parameter Set-up Messages</i>							
20	General installation parameters ¹	1.0	1.0	0.1	0.1	0.1	0.1
21	GAMS installation parameters ¹	1.0	1.0	0.1	0.1	0.1	0.1
22	Reserved						
23	Reserved						
24	User accuracy specifications ¹	1.0	1.0	0.1	0.1	0.1	0.1
25	Reserved						
30	Primary GPS set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1

Message	Contents	Display Port (Hz)		Real-Time Data Port (Hz)		Logging Data Port (Hz)	
		Stby	Nav	Stby	Nav	Stby	Nav
31	Secondary GPS set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
32	Set POS IP address	1.0	1.0	0.1	0.1	0.1	0.1
33	Event discrettes set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
34	COM port set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
35	See message 135						
36	See message 136						
37	Base GPS 1 Set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
38	Base GPS 2 Set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
40	Reserved	-	-	-	-	-	-
41	Reserved	-	-	-	-	-	-
<i>Processing Control Messages</i>							
50	Navigation mode control	1.0	1.0	1.0	0.1	0.1	0.1
51	Display Port control ¹	1.0	1.0	1.0	0.1	0.1	0.1
52	Real-Time Data Port control ¹	1.0	1.0	1.0	0.1	0.1	0.1
53	Reserved	-	-	-	-	-	-
54	Save/restore parameters command	-	-	-	-	-	-
55	Time synchronization control	1.0	1.0	1.0	0.1	0.1	0.1
56	General data	1.0	1.0	1.0	0.1	0.1	0.1
57	Installation calibration control	-	-	-	-	-	-
58	GAMS calibration control	-	-	-	-	-	-
60	Reserved	-	-	-	-	-	-
61	Logging Data Port control ¹	1.0	1.0	1.0	0.1	0.1	0.1
<i>Program Control Override Messages</i>							
90	Program control	-	-	-	-	-	-
91	GPS control	-	-	-	-	-	-
92	Reserved	-	-	-	-	-	-
93	Reserved	-	-	-	-	-	-
<i>POS MV Specific Messages</i>							
105	Analog port set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
106	Heave filter set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
111	Password control	-	-	-	-	-	-

Message	Contents	Display Port (Hz)		Real-Time Data Port (Hz)		Logging Data Port (Hz)	
		Stby	Nav	Stby	Nav	Stby	Nav
120	Sensor parameter set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
121	Vessel Installation parameters ¹	1.0	1.0	0.1	0.1	0.1	0.1
135	NMEA output set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
136	Binary output set-up ¹	1.0	1.0	0.1	0.1	0.1	0.1
<i>POS MV Specific Diagnostic Control Messages</i>							
20102	Binary output diagnostics set-up	1.0	1.0	0.1	0.1	0.1	0.1
20103	Analog port diagnostics set-up	1.0	1.0	0.1	0.1	0.1	0.1

¹ Message is saved in NVM

4.2.2 Compatibility with Previous POS Products

The compatibility of POS MV V4 messages with POS MV V3 products is given as follows:

- The POS MV V4 message format is the same as that of POS MV V3 products.
- The POS MV V4 Message 0 is the same as that of POS MV V3 products.
- The POS MV V4 message namespace occupies 20-98, which does not intersect the core message namespace for POS MV V3 products. Several POS MV V4 messages either are the same or command similar actions or functions as POS MV V3 core messages in the namespace 1-19. This separation of the message namespace allows for the unrestricted re-organization of the POS MV V4 messages and re-design of their content without creating compatibility problems.

4.3 Message Format

4.3.1 Introduction

All control messages have the format described in Table 42. The messages consist of a *header*, message *body* and *footer*. The next section describes the specific message formats.

Table 42: Message format

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	Message dependent	N/A
Byte count	2	ushort	Message dependent	N/A

Item	Bytes	Format	Value	Units
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Message body	<i>Message dependent format and content.</i>			
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

The *header* consists of the following components:

- an ASCII string (\$MSG)
- unique message identifier
- byte count
- transaction number

The *byte count* is a short unsigned integer that includes the number of bytes in all fields in the message except the Message start ASCII delimiter, the Message ID and the byte count. Therefore, the byte count is always 8 bytes less than the length of the complete message.

The *transaction number* is a number that is attached to the input message by the client. POS MV returns this number to the user in the *Acknowledge* message (ID 0). This mechanism permits the client to know which message the POS MV is responding to; the number must be between 0 and 65532 when sent to POS. The transaction numbers 65533 to 65535 are used by POS when outputting the echo copy of the messages.

The message body falls between the header and footer. While many messages have a message body, it is not a requirement of the protocol. Message without bodies may in themselves act as events, or messages may use the body to command a particular state.

Messages end with a *footer* that contains a pad, a checksum and an ASCII delimiter (\$#).

The *pad* is used to make each message length a multiple of four bytes. The *checksum* is calculated so that short (16 bit) integer addition of sequential groups of two bytes results in a net sum of zero.

Parameters flagged as default are the factory settings.

The byte, short, ushort, long, ulong, float and double formats are defined in Appendix A: Data Format Description.

The ranges of valid values for message fields that contain numbers are specified in the same way as for numerical group fields.

Message fields that contain numerical values may contain invalid numbers. Invalid byte, short, ushort, long, ulong, float and double values are defined in Table 82 (Appendix A: Data Format Description). POS MV ignores invalid values that it receives in fields containing numerical values. This does not apply to fields containing bit settings.

4.4 Messages Tables

4.4.1 General Messages

The following tables list the format that POS MV expects for each message input and provides for each message output.

Message 0: Acknowledge

POS MV responds to a user control message with the Acknowledge message in three possible ways described below:

1. The control message from the POS Controller triggers a change of state within the POS MV. Some changes of state such as navigation mode transitions may require several seconds to complete. POS MV sends Message 0: Acknowledge indicating that the transition is in progress but not necessarily complete. For example, POS MV replies to a message commanding the POS MV to transition to Navigate mode as soon as the mode transition begins.
2. The control message from the POS Controller contains new POS MV installation or set-up parameters that replace the parameters currently used by the POS MV. The Acknowledge message then indicates whether the POS MV has received and begun to use the new parameters. POS MV responds with Message 0: Acknowledge only when it has begun to use the new parameters.
3. The control message from the POS Controller starts the transmission of one or more groups of data. The Acknowledge message indicates the successful completion of the requested action. The POS MV subsequently transmits the requested groups on the Display and/or Data ports. If the data for one or more of the requested groups are not current at the time of request, the P POS MV outputs the group(s) with stale fields set to invalid values as described in Table 82. Message 0: Acknowledge indicates if the data for a requested group is available (not yet implemented).

The *New Parameters Status* field indicates if the message being acknowledged has changed the parameters. This allows a *POS Controller* to prompt the user to direct the POS MV to save the parameters to non-volatile memory if the user has not already done so before commanding a Standby mode transition or system shutdown.

POS MV sets the *Parameter Name* to the name of a parameter that it has rejected or to a null string if it did not reject any parameters.

Table 43: Message 0: Acknowledge

Item	Bytes	Format	Value	Units								
Message start	4	char	\$MSG	N/A								
Message ID	2	ushort	0	N/A								
Byte count	2	ushort	44	N/A								
Transaction number	2	ushort	Transaction number sent by client.	N/A								
ID of received message	2	ushort	Any valid message number.	N/A								
Response code	2	ushort	See Table 44	N/A								
New parameters status	1	byte	<table border="0"> <tr> <td>Value</td> <td>Message</td> </tr> <tr> <td>0</td> <td>No change in parameters</td> </tr> <tr> <td>1</td> <td>Some parameters changed</td> </tr> <tr> <td>2-255</td> <td>Reserved</td> </tr> </table>	Value	Message	0	No change in parameters	1	Some parameters changed	2-255	Reserved	N/A
Value	Message											
0	No change in parameters											
1	Some parameters changed											
2-255	Reserved											
Parameter name	32	char	Name of rejected parameter on parameter error only	N/A								
Pad	1	bytes	0	N/A								
Checksum	2	ushort	N/A	N/A								
Message end	2	char	\$#	N/A								

Table 44: Message response codes

Field Value	Field Name	Description
0	Not applicable	The message is not applicable to the POS MV.
1	Message accepted	POS MV has properly accepted the message from the <i>POS Controller</i> .
2	Message accepted - too long	POS MV has accepted the messaged from the <i>POS Controller</i> . This is a warning that the POS MV expected a shorter message than the one received. This could be caused if the POS MV and the <i>POS Controller</i> have different ICD versions.

Field Value	Field Name	Description
3	Message accepted - too short	POS MV has accepted the message from the <i>POS Controller</i> . This is a warning that the POS MV expected a longer message than the one received. This could be caused if the POS MV and the <i>POS Controller</i> have different ICD versions.
4	Message parameter error	The message contains one or more parameter errors.
5	Not applicable in current state	POS MV cannot process the message or cannot output data requested in its current state.
6	Data not available	The requested data is not available from POS MV.
7	Message start error	The message does not have the proper header "\$MSG".
8	Message end error	The message does not have the proper footer "\$#".
9	Byte count error	The byte count of the message is too large for POS MV's internal buffer.
10	Checksum error	The message checksum validation failed.
11	User not logged in	Password protection feature is in effect, and user must enter password before sending the command. This should only occur if an incompatible Controller or Controller version is being used.
12	Password incorrect	User was prompted for password and entered incorrect password.
13-65535	Reserved	Reserved

4.4.2 Installation Parameter Set-up Messages

Message 20: General Installation and Processing Parameters

This message contains general installation parameters that POS MV requires to correctly process sensor data and output the computed navigation data. The POS MV accepts this message at any time. The parameters contained in this message become part of the processing parameters (referred to as "settings") that POS MV saves to NVM.

The following are brief descriptions of the parameters that this message contains.

Time Tag Selection

The *Time Tag Type* field selects the time tag types used for Time 1, Time 2 and Distance fields in the Time/Distance fields in each group (see Table 3). The user can select POS, GPS or UTC time for Time 1 and POS, GPS, UTC or User time for Time 2.

Selection of **GPS time** directs POS MV to set the selected Time 1 or Time 2 field in all groups to the GPS seconds of the current week. The GPS week number can be obtained from Group 3: Primary GPS status.

Selection of **UTC time** directs POS MV to set the selected Time 1 or Time 2 field in all groups to the UTC seconds of the current week. UTC seconds of the week will lag GPS seconds of the week by the accumulated leap seconds since the startup of GPS at which time the two times were synchronized.

AutoStart Selection

The *Select/Deselect Autostart* field directs POS MV to enable or disable the AutoStart function. When AutoStart is enabled POS MV enters Navigate mode immediately on power-up using the parameters stored in its NVM. When Autostart is disabled, POS MV enters Standby mode on power-up. The user must explicitly command a transition to Navigate mode.

Lever Arms and Mounting Angles

This message contains a series of fields that contain lever arm components and mounting angles. These define the positions and orientations of the IMU and aiding sensors (GPS antennas) with respect to user-defined reference and Vessel coordinate frames. These coordinate frames and the installation data contained in this message are defined for an IMU that is rigidly mounted to the Vessel.

The *Vessel frame* is a right-handed coordinate frame that is fixed to the Vessel whose navigation solution the POS MV computes. The X-Y-Z axes are directed along the forward, right and down directions of the Vessel. These are the forward along beam, starboard and vertical directions.

The *reference frame* is a user-defined coordinate frame that is co-aligned with the Vessel frame, but which may be at a location that allows easier measurement of lever arms. It is also the coordinate frame in which the relative positions and orientations of the IMU and aiding sensors are measured. Its origin does not necessarily coincide with the Vessel frame origin, however it is aligned with the Vessel frame.

The *IMU frame* is a right-handed coordinate frame whose X-Y-Z axes coincide with the inertial sensor input axes. The IMU delivers inertial data resolved in the IMU frame to the PCS. The position and orientation of the IMU frame is fixed with respect to the Vessel frame when the user mounts the IMU. Practical considerations may limit the choices in IMU location, in which case the actual position and orientation of the IMU frame may differ from a desired position and orientation.

The interpretations of the lever arm and orientation fields are as follows:

Reference to IMU lever arm components

These are the X-Y-Z distances from the user-defined reference frame origin to the IMU inertial sensor assembly origin, resolved in the *reference frame*.

Note: When MV POSView is used to send this message to the POS MV, the lever arm measurement entered in MV POSView should be to the target painted on the top of the IMU enclosure. MV POSView automatically adds the correct IMU enclosure to the IMU sensing centre offsets (including mounting angles) when constructing the message. The echo message output by POS MV on the Display and Data ports contain the lever arm to the sensing centre parameters. Prior to displaying the lever arm value, MV POSView applies the inverse offset to the Reference to IMU lever arm. If a user wishes to write a POS Controller application, the appropriate offsets can be supplied upon request.

Reference to Primary GPS lever arm components

These are the X-Y-Z distances measured from the user-defined reference frame origin to the phase centre of the primary GPS antenna, resolved in the *reference frame*.

Reference to Auxiliary 1 GPS lever arm components

These are the X-Y-Z distances measured from the user-defined reference frame origin to the phase centre of the auxiliary 1 GPS antenna, resolved in the *reference frame*. POS MV uses these lever arm components whenever it processes data from an optional auxiliary 1 GPS receiver. If POS MV does not receive the auxiliary 1 GPS data, then it does not use these parameters.

Reference to Auxiliary 2 GPS lever arm components

These are the X-Y-Z distances measured from the user-defined reference frame origin to the phase centre of the auxiliary 2 GPS antenna, resolved in the *reference frame*. POS MV uses these lever arm components whenever it processes data from an optional auxiliary 2 GPS receiver. If POS MV does not receive the auxiliary 2 GPS data, then it does not use these parameters.

IMU with respect to Reference frame mounting angles

These are the angular offsets (θ_x , θ_y , θ_z) of the IMU frame with respect to the reference frame when the IMU is rigidly mounted to the **Vessel**. The angles define the Euler sequence of rotations that bring the reference frame into alignment with the IMU frame. The angles follow the Tate-Bryant sequence of rotation, given as follows:

right-hand screw rotation of θ_z about the z axis

right-hand screw rotation of θ_y about the once rotated y axis

right-hand screw rotation of θ_x about the twice rotated x axis

The angles θ_x , θ_y and θ_z may be thought of as the roll, pitch and yaw of the IMU body frame with respect to the user IMU frame.

Reference Frame with respect to Vessel Frame mounting angles

Although these X-Y-Z fields are part of Core message 20 they are not used in the POS MV product. POS MV assumes the reference frame and the Vessel frame are co-aligned. MV POSView does not provide data entry fields for these values.

Multipath Setting

The Multipath Environment field directs POS MV to set its processing parameters for one of three multipath levels impinging on primary, secondary and auxiliary GPS antennas. These are LOW, MEDIUM and HIGH multipath. This field allows the user to select the multipath environment which best describes the present multipath conditions. POS uses this information to scale the RMS errors on the position and velocity outputs reported to the user to ensure that the reported errors are reasonable. If the user selects *LOW*, POS MV assumes virtually no multipath error in the primary, secondary and auxiliary GPS data. If the user selects *MEDIUM* or *HIGH*, POS MV assumes, respectively, moderate or severe multipath errors and accounts for these in its GPS processing algorithms.

Table 45: Message 20: General Installation and Processing Parameters

Item	Bytes	Format	Value	Units																				
Message start	4	char	\$MSG	N/A																				
Message ID	2	ushort	20	N/A																				
Byte count	2	ushort	84	N/A																				
Transaction Number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A																				
Time types	1	byte	<table border="0"> <tr> <td><u>Value (bits 0-3)</u></td> <td><u>Time type 1</u></td> </tr> <tr> <td>0</td> <td>POS time</td> </tr> <tr> <td>1</td> <td>GPS time (default)</td> </tr> <tr> <td>2</td> <td>UTC time</td> </tr> <tr> <td>3-16</td> <td>Reserved</td> </tr> <tr> <td><u>Value (bits 4-7)</u></td> <td><u>Time type 2</u></td> </tr> <tr> <td>0</td> <td>POS time (default)</td> </tr> <tr> <td>1</td> <td>GPS time</td> </tr> <tr> <td>2</td> <td>UTC time</td> </tr> <tr> <td>3</td> <td>User time</td> </tr> </table>	<u>Value (bits 0-3)</u>	<u>Time type 1</u>	0	POS time	1	GPS time (default)	2	UTC time	3-16	Reserved	<u>Value (bits 4-7)</u>	<u>Time type 2</u>	0	POS time (default)	1	GPS time	2	UTC time	3	User time	
<u>Value (bits 0-3)</u>	<u>Time type 1</u>																							
0	POS time																							
1	GPS time (default)																							
2	UTC time																							
3-16	Reserved																							
<u>Value (bits 4-7)</u>	<u>Time type 2</u>																							
0	POS time (default)																							
1	GPS time																							
2	UTC time																							
3	User time																							

Item	Bytes	Format	Value	Units										
			4-16 Reserved											
Distance type	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>State</u></td> </tr> <tr> <td>0</td> <td>N/A</td> </tr> <tr> <td>1</td> <td>POS distance (default)</td> </tr> <tr> <td>2</td> <td>DMI distance</td> </tr> <tr> <td>3-255</td> <td>Reserved</td> </tr> </table>	<u>Value</u>	<u>State</u>	0	N/A	1	POS distance (default)	2	DMI distance	3-255	Reserved	
<u>Value</u>	<u>State</u>													
0	N/A													
1	POS distance (default)													
2	DMI distance													
3-255	Reserved													
Select/deselect AutoStart	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>State</u></td> </tr> <tr> <td>0</td> <td>AutoStart disabled (default)</td> </tr> <tr> <td>1</td> <td>AutoStart enabled</td> </tr> <tr> <td>2-255</td> <td>Reserved</td> </tr> </table>	<u>Value</u>	<u>State</u>	0	AutoStart disabled (default)	1	AutoStart enabled	2-255	Reserved			
<u>Value</u>	<u>State</u>													
0	AutoStart disabled (default)													
1	AutoStart enabled													
2-255	Reserved													
Reference to IMU X lever arm	4	float	(,) default = 0	meters										
Reference to IMU Y lever arm	4	float	(,) default = 0	meters										
Reference to IMU Z lever arm	4	float	(,) default = 0	meters										
Reference to Primary GPS X lever arm	4	float	(,) default = 0	meters										
Reference to Primary GPS Y lever arm	4	float	(,) default = 0	meters										
Reference to Primary GPS Z lever arm	4	float	(,) default = 0	meters										
Reference to Auxiliary 1 GPS X lever arm	4	float	(,) default = 0	meters										
Reference to Auxiliary 1 GPS Y lever arm	4	float	(,) default = 0	meters										
Reference to Auxiliary 1 GPS Z lever arm	4	float	(,) default = 0	meters										
Reference to Auxiliary 2 GPS X lever arm	4	float	(,) default = 0	meters										
Reference to Auxiliary 2	4	float	(,) default = 0	meters										

Item	Bytes	Format	Value	Units										
GPS Y lever arm														
Reference to Auxiliary 2 GPS Z lever arm	4	float	(,) default = 0	meters										
X IMU wrt Reference frame mounting angle	4	float	[-180, +180] default = 0	degrees										
Y IMU wrt Reference frame mounting angle	4	float	[-180, +180] default = 0	degrees										
Z IMU wrt Reference frame mounting angle	4	float	[-180, +180] default = 0	degrees										
X Reference frame wrt Vessel frame mounting angle	4	float	[-180, +180] default = 0	degrees										
Y Reference frame wrt Vessel frame mounting angle	4	float	[-180, +180] default = 0	degrees										
Z Reference frame wrt Vessel frame mounting angle	4	float	[-180, +180] default = 0	degrees										
Multipath environment	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Multipath</u></td> </tr> <tr> <td>0</td> <td>Low</td> </tr> <tr> <td>1</td> <td>Medium</td> </tr> <tr> <td>2</td> <td>High (default)</td> </tr> <tr> <td>3-255</td> <td>Reserved</td> </tr> </table>	<u>Value</u>	<u>Multipath</u>	0	Low	1	Medium	2	High (default)	3-255	Reserved	
<u>Value</u>	<u>Multipath</u>													
0	Low													
1	Medium													
2	High (default)													
3-255	Reserved													
Pad	2	byte	0	N/A										
Checksum	2	ushort	N/A	N/A										
Message end	2	char	\$\$	N/A										

Message 21: GAMS Installation Parameters

This message contains the GAMS installation parameters. POS MV accepts this message at any time. The parameters contained in this message become part of the processing parameters (referred to as “settings”) that POS MV saves to NVM.

The following are brief descriptions of the parameters that this message contains.

The *Primary-Secondary Antenna Separation* field contains the separation between the primary and secondary antenna centres as measured by the user. This value must have an accuracy of one centimetre or better in order for it to be useful to the algorithm. POS MV flags any value smaller than 10 centimetres as invalid. The default value is zero.

The *Baseline Vector X-Y-Z Component* fields contain the components of the primary-secondary antenna baseline vector resolved in the IMU frame. The user is usually not able to measure these and hence may insert the components that the POS MV computed in a previous GAMS calibration. POS MV computes the vector length and flags any length smaller than 10 centimetres as invalid. It replaces a user-entered primary-secondary antenna separation with a valid length. The default is a zero vector. Only an experienced user should use this message, as a wrong value will disable the GAMS algorithm and a re-calibration will be necessary.

The *Maximum Heading Error RMS For Calibration* field contains the maximum navigation solution heading error RMS that the POS MV uses for executing a GAMS baseline calibration. If the current heading error RMS exceeds the specified maximum when the user commands a GAMS calibration, then POS MV defers the calibration until the heading error RMS drops to below the specified maximum.

The *Heading Correction* field contains a user-entered azimuth error in the primary-secondary antenna baseline vector. POS MV computes a new baseline vector that has been rotated so that the POS MV computed heading changes by the specified heading correction when GAMS is on-line.

Note: POS MV echos this message with the updated Baseline Vector and the Heading Correction field cleared. The user should not enter another Heading Correction without also restoring the original calibrated Baseline Vector.

Table 46: Message 21: GAMS installation parameters

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	21	N/A
Byte count	2	ushort	32	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Primary-secondary antenna separation	4	float	[0,) default = 0	Meters
Baseline vector X component	4	float	(,) default = 0	Meters
Baseline vector Y component	4	float	(,) default = 0	meters

Item	Bytes	Format	Value	Units
Baseline vector Z component	4	float	(,) default = 0	meters
Maximum heading error RMS for calibration	4	float	[0,) default = 3	degrees
Heading correction	4	float	(,) default = 0	degrees
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 22: Reserved

Message 23: Reserved

Message 24: User Accuracy Specifications

This message sets the user accuracy specifications for full navigation status. POS MV declares Full Navigation status on the front panel LED's and through the *POS Controller* when the position, velocity, attitude and heading error RMS have all dropped to or below these accuracy specifications.

POS MV accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as "settings") that POS MV saves to NVM.

Table 47: Message 24: User accuracy specifications

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	24	N/A
Byte count	2	ushort	24	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> 65533 to 65535	N/A
User attitude accuracy	4	float	(0,) default = 0.05	degrees
User heading accuracy	4	float	(0,) default = 0.05	degrees
User position accuracy	4	float	(0,) default = 2	meters
User velocity accuracy	4	float	(0,) default = 0.5	meters/second

Item	Bytes	Format	Value	Units
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 25: Reserved

Message 30: Primary GPS Setup

This message contains the setup parameters for the primary GPS receiver. POS MV accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as “settings”) that POS MV saves to NVM.

The *Select/Deselect GPS AutoConfig* field directs POS MV to reconfigure the primary GPS receiver if the POS MV detects that the primary GPS configuration is incorrect. If the user chooses to disable auto-configuration, then the user must configure the primary GPS receiver manually.

The *Primary GPS COM1 Output Message Rate* field specifies the rate at which the primary GPS receiver outputs its raw observables messages over its COM1 port to the POS MV. POS MV only process 1 Hz observables, however, selecting a higher output rate will allow more data to be logged which may be useful for a post processed solution.

The *Primary GPS COM2 Port Control* directs the primary GPS receiver to accept RTCM differential corrections, RTCA Type 18/19 corrections, CMR corrections or commands over its COM2 port. This message assumes that the user can access the GPS receiver COM2 port directly and connect either a source of RTCM differential corrections or a PC-compatible computer running control software that is compatible with the primary GPS receiver. The POS MV V4 hardware connects the *GPS 1* port on the PCS back panel directly to the Primary GPS COM2 port. The Primary GPS COM2 port must not be confused with the COM2 port on the PCS. POS MV V4 processes raw GPS observables and corrections so there is no need to feed corrections directly to the Primary GPS receiver. The GPS 1 port on the PCS read panel is primarily to allow GPS receiver firmware upgrades.

Note: GPS Autoconfig will be turned off upon receipt of an Accept Command message and will be turned on again when either an Accept RTCM or a GPS reconfigure message is issued.

The *Primary GPS COM2 Communication Protocol* fields are elaborated in Table 49. They specify the COM2 RS-232 communication protocol settings.

Table 48: Message 30: Primary GPS Setup

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	30	N/A
Byte count	2	ushort	16	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Select/deselect GPS AutoConfig	1	byte	<u>Value</u> <u>State</u> 0 AutoConfig disabled 1 AutoConfig enabled (default) 2-255 Reserved	
Primary GPS COM1 port message output rate (not supported)	1	byte	<u>Value</u> <u>Rate (Hz)</u> 1 1 (default) 2 2 3 3 4 4 5 5 10 10 11-255 Reserved	
Primary GPS COM2 port control	1	byte	<u>Value</u> <u>Operation</u> 0 Accept RTCM (default) 1 Accept commands 2 Accept RTCA 3-255 Reserved	
Primary GPS COM2 communication protocol	4	See Table 49 Default: 9600 baud, no parity, 8 data bits, 1 stop bit, none		

Item	Bytes	Format	Value		Units
Antenna frequency (only applicable for Trimble Force5 GPS receivers)	1	byte	<u>Value</u>	<u>Operation</u>	
			0	Accept L1 only	
			1	Accept L1/L2	
			2	Accept L2 only	
Pad	2	byte	0		N/A
Checksum	2	ushort	N/A		N/A
Message end	2	char	\$#		N/A

Table 49: RS-232/422 communication protocol settings

Item	Bytes	Format	Value	
RS-232/422 port baud rate	1	byte	<u>Value</u>	<u>Rate</u>
			0	2400
			1	4800
			2	9600
			3	19200
			4	38400
			5	57600
			6	76800
			7	115200
	8-255	Reserved		
Parity	1	byte	<u>Value</u>	<u>Parity</u>
			0	no parity
			1	even parity
			2	odd parity
			3-255	Reserved

Item	Bytes	Format	Value	
Data/Stop Bits	1	byte	<u>Value</u>	<u>Data/Stop Bits</u>
			0	7 data, 1 stop
			1	7 data, 2 stop
			2	8 data, 1 stop
			3	8 data, 2 stop
			4-255	Reserved
Flow Control	1	byte	<u>Value</u>	<u>Flow Control</u>
			0	none
			1	hardware
			2	XON/XOFF
			3-255	Reserved

Message 31: Secondary GPS Setup

This message contains the set-up parameters for the secondary GPS receiver. POS MV accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as “settings”) that POS MV saves to NVM.

The *Select/Deselect GPS AutoConfig* field directs POS MV to reconfigure the secondary GPS receiver if the POS MV detects that the secondary GPS configuration is incorrect. If the user chooses to disable auto-configuration, then the user must configure the secondary GPS receiver manually.

The *Secondary GPS COM1 Output Message Rate* field specifies the rate at which the secondary GPS receiver outputs messages over its COM1 port to POS MV.

The *Secondary GPS COM2 Port Control* directs the secondary GPS receiver to accept RTCM differential corrections, RTCA Type 18 corrections or commands over its COM2 port. This message assumes that the user can access the GPS receiver COM2 port directly and connect either a source of RTCM differential corrections or a PC-compatible computer running control software that is compatible with the secondary GPS receiver. The current POS MV hardware connects the *GPS 2* port on the PCS back panel directly to the Secondary GPS COM2 port. The Secondary GPS COM2 port must not be confused with the COM2 port on the PCS. POS MV V4 processes raw GPS observables and corrections so there is no need to feed corrections directly to the Secondary GPS receiver. The GPS 1 port on the PCS read panel is primarily to allow GPS receiver firmware upgrades.

The *Secondary GPS COM2 Communication Protocol* fields are elaborated in Table 49. They specify the COM2 RS-232 communication protocol settings.

Table 50: Message 31: Secondary GPS Setup

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	31	N/A
Byte count	2	ushort	16	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Select/deselect GPS AutoConfig	1	byte	<u>Value</u> <u>State</u> 0 AutoConfig disabled 1 AutoConfig enabled (default) 2-255 Reserved	
Secondary GPS COM1 port message output rate (Not Supported)	1	byte	<u>Value</u> <u>Rate (Hz)</u> 1 1 (default) 2 2 3 3 4 4 5 5 10 10 11-255 Reserved	
Secondary GPS COM2 port control	1	byte	<u>Value</u> <u>Operation</u> 0 Accept RTCM (default) 1 Accept commands 2 Accept RTCA 3-255 Reserved	
Secondary GPS COM2 communication protocol	4	See Table 49 Default: 9600 baud, no parity, 8 data bits, 1 stop bit, none		

Item	Bytes	Format	Value	Units								
Antenna frequency (only applicable for Trimble Force5 GPS receivers)	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Operation</u></td> </tr> <tr> <td>0</td> <td>Accept L1 only</td> </tr> <tr> <td>1</td> <td>Accept L1/L2</td> </tr> <tr> <td>2</td> <td>Accept L2 only</td> </tr> </table>	<u>Value</u>	<u>Operation</u>	0	Accept L1 only	1	Accept L1/L2	2	Accept L2 only	
<u>Value</u>	<u>Operation</u>											
0	Accept L1 only											
1	Accept L1/L2											
2	Accept L2 only											
Pad	2	byte	0	N/A								
Checksum	2	ushort	N/A	N/A								
Message end	2	char	\$#	N/A								

Message 32: Set POS IP Address

This message installs a new IP address and subnet mask in POS MV. POS MV accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as “settings”), POS MV does not save it to NVM but changes OS setup file.

When POS MV is installed the new IP address, it will disconnect from any connected controller and begin using the new IP address. The changes take effect immediately upon receipt of the message.

Table 51: Message 32: Set POS IP Address

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	32	N/A
Byte count	2	ushort	16	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
IP address: Network part 1	1	byte	[128, 191] Class B, subnet mask 255.255.0.0 [192, 232] Class C, subnet mask 255.255.255.0 default = 129	N/A

Item	Bytes	Format	Value	Units
IP address: Network part 2	1	byte	[0, 255] default = 100	N/A
IP address: Host part 1	1	byte	[0, 255] default = 0	N/A
IP address: Host part 2	1	byte	[1, 253] default = 219	N/A
Subnet mask: Network part 1	1	byte	[255] default = 255	
Subnet mask: Network part 2	1	byte	[255] default = 255	
Subnet mask: Host part 1	1	byte	[0, 255] default = 255 * see conditions below	
Subnet mask: Host part 2	1	byte	[0, 254] default = 0 * see conditions below	
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

* Not only must the host parts of the subnet mask be within the ranges specified, but if the 2 host fields are considered as one 16 bit word, then any bit that is set may not have a cleared bit to its left. This results in the following valid subnet masks:

- | | | |
|-----------------|-----------------|-----------------|
| 255.255.0.0 | 255.255.128.0 | 255.255.192.0 |
| 255.255.224.0 | 255.255.240.0 | 255.255.248.0 |
| 255.255.252.0 | 255.255.254.0 | 255.255.255.0 |
| 255.255.255.128 | 255.255.255.192 | 255.255.255.224 |
| 255.255.255.224 | 255.255.255.240 | 255.255.255.248 |
| 255.255.255.252 | 255.255.255.254 | |

Message 33: Event Discrete Setup

This message directs POS MV to set the senses of the signals for the Event 1 and 2 discrete triggers. The user can select either positive or negative edge trigger for each event. POS MV accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as “settings”) that POS MV saves to NVM.

Table 52: Message 33: Event Discrete Setup

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	33	N/A
Byte count	2	ushort	8	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Event 1 trigger	1	byte	<u>Value</u> <u>Command</u> 0 Positive edge (default) 1 Negative edge 2-255 Reserved	
Event 2 trigger	1	byte	<u>Value</u> <u>Command</u> 0 Positive edge (default) 1 Negative edge 2-255 Reserved	
Pad	0	short	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 34: COM Port Setup

This message sets up the communication protocol and selects the input and output content for all available COM ports. It is a variable length message to accommodate POS hardware with varying numbers of COM ports.

When this message is sent to POS it may contain parameters for 1 to 10 COM ports. Any COM port can be assigned. If an assigned COM port is not present it will be ignored. Any COM port or ports can be specified as long as they are listed in ascending order and the Port Mask field has bits set corresponding to each COM port entry. All input selections and the Base GPS output

selections must be uniquely assigned to a COM port. NMEA and Real-time Binary outputs may be assigned to any number of COM ports.

When this message is output from POS it always contains parameters for all *n* COM ports available for that particular system, with the current protocol and input/output selections.

Table 53: Message 34: COM Port Setup

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	34	N/A
Byte count	2	ushort	$12 + 8 \times nPorts$	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Number of COM ports	2	ushort	[1,10] Number (<i>nPorts</i>) of COM ports assigned by this message.	N/A
COM Port Parameters	$8 \times nPorts$	See Table 54 One set of parameters for each of <i>nPorts</i> COM port.		
Port mask	2	ushort	Input: Bit positions indicate which port parameters are in message (port parameters must appear in order of increasing port number). Bit 0 ignored Bit <i>n</i> set COM <i>n</i> parameter in message Bit <i>n</i> clear COM <i>n</i> parameter not in message Output: Bit positions indicate which port numbers are available on the PCS for I/O configuration.	
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Table 54: COM port parameters

Item	Bytes	Format	Value	Units
Communication protocol	4		See Table 49 Default: 9600 baud, no parity, 8 data bits, 1 stop bit, none	
Input select	2	ushort	<u>Value</u>	<u>Input</u>
			0	No input
			1	Auxiliary 1 GPS
			2	Auxiliary 2 GPS
			3	Reserved
			4	Base GPS 1
			5	Base GPS 2
6-255	No input			
Output select	2	ushort	<u>Value</u>	<u>Output</u>
			0	No output
			1	NMEA messages
			2	Real-time binary
			3	Base GPS 1
			4	Base GPS 2
5-255	No output			

Message 35: See Message 135

Message 36: See Message 136

Message 37: Base GPS 1 Setup

This message selects the message types assigned to the Base GPS 1 port identified in Message 34. If POS MV is connected to a Hayes compatible telephone modem, then this message directs POS MV’s configuration of the modem.

Message 38: Base GPS 2 Setup

This message selects the message types assigned to the Base GPS 2 port identified in Message 34. If POS MV is connected to a Hayes compatible telephone modem, then this message directs POS MV’s configuration of the modem.

The *connection control* field will always be set to NO_ACTION when sent by POS MV except when the message sent by the client had *modem control* set to AUTOMATIC and the *connection control* set to CONNECT. The reason for this is to prevent manual or command actions from getting saved in NVM and being inadvertently activated when POS MV is started. The AUTOMATIC-CONNECT combination is the only one that a user may want to save to NVM.

Table 55: Message 37/38: Base GPS 1/2 Setup

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	37/38	N/A
Byte count	2	ushort	240	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Select Base GPS input type	2	ushort	<u>Value</u> <u>Operation</u> 0 Do not accept base GPS messages 1 Accept RTCM 1/9 (default) 2 Accept RTCM 3, 18/19 3 Accept CMR/CMR+ 4 Accept RTCA 5-65535 Reserved	
Line control	1	byte	<u>Value</u> <u>Operation</u> 0 Line used for Serial (default) 1 Line used for Modem 2-255 Reserved	

Item	Bytes	Format	Value	Units												
Modem control	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Operation</u></td> </tr> <tr> <td>0</td> <td>Automatic control (default)</td> </tr> <tr> <td>1</td> <td>Manual control</td> </tr> <tr> <td>2</td> <td>Command control</td> </tr> <tr> <td>3-255</td> <td>Reserved</td> </tr> </table>	<u>Value</u>	<u>Operation</u>	0	Automatic control (default)	1	Manual control	2	Command control	3-255	Reserved			
<u>Value</u>	<u>Operation</u>															
0	Automatic control (default)															
1	Manual control															
2	Command control															
3-255	Reserved															
Connection control	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Operation</u></td> </tr> <tr> <td>0</td> <td>No action (default)</td> </tr> <tr> <td>1</td> <td>Connect</td> </tr> <tr> <td>2</td> <td>Disconnect/Hang-up</td> </tr> <tr> <td>3</td> <td>Send AT Command</td> </tr> <tr> <td>4-255</td> <td>No action</td> </tr> </table>	<u>Value</u>	<u>Operation</u>	0	No action (default)	1	Connect	2	Disconnect/Hang-up	3	Send AT Command	4-255	No action	
<u>Value</u>	<u>Operation</u>															
0	No action (default)															
1	Connect															
2	Disconnect/Hang-up															
3	Send AT Command															
4-255	No action															
Phone number	32	char	N/A	N/A												
Number of redials	1	byte	[0,) default = 0	N/A												
Modem command string	64	char	N/A	N/A												
Modem initialization string	128	char	N/A	N/A												
Data timeout length	2	ushort	[0, 255] default = 0	seconds												
Pad	2	byte	0	N/A												
Checksum	2	ushort	N/A	N/A												
Message end	2	char	\$\$	N/A												

Message 40: Reserved

Message 41: Reserved

4.4.3 Processing Control Messages

Message 50: Navigation Mode Control

This message directs POS MV to transition to a specified navigation mode. The two basic navigation modes are Standby and Navigate.

Table 56: Message 50: Navigation mode control

Item	Bytes	Format	Value	Units										
Message start	4	char	\$MSG	N/A										
Message ID	2	ushort	50	N/A										
Byte count	2	ushort	8	N/A										
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A										
Navigation mode	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Mode</u></td> </tr> <tr> <td>0</td> <td>No operation (default)</td> </tr> <tr> <td>1</td> <td>Standby</td> </tr> <tr> <td>2</td> <td>Navigate</td> </tr> <tr> <td>3-255</td> <td>Reserved</td> </tr> </table>	<u>Value</u>	<u>Mode</u>	0	No operation (default)	1	Standby	2	Navigate	3-255	Reserved	
<u>Value</u>	<u>Mode</u>													
0	No operation (default)													
1	Standby													
2	Navigate													
3-255	Reserved													
Pad	1	byte	0	N/A										
Checksum	2	ushort	N/A	N/A										
Message end	2	char	\$#	N/A										

Message 51: Display Port Control

This message directs POS MV to output specified groups on the Display Port primarily for the purpose of display of data on the *POS Controller*.

The *Number of Groups* field contains the number *n* of groups that this message selects. Thereafter follow *n Display Port Output Group Identification* fields, each of which identifies one selected group to be output on the Display Port.

The POS MV always outputs Groups 1, 2, 3, 10 and 110 on the Display Port to provide a minimal set of data for the *POS Controller*. These cannot be de-selected by omission from this message.

POS MV accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as “settings”) that POS MV saves to NVM.

When MV POSView is connected to a POS MV Control port, it immediately sends message 51 requesting the groups it requires to populate all its currently open windows. Whenever the user opens a new display window, MV POSView automatically sends message 51 requesting the additional group(s) that are required. Hence there is no user setup window for the Display port in MV POSView.

Table 57: Message 51: Display Port Control

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	51	N/A
Byte count	2	ushort	10 + 2 x number of groups (+2 if pad bytes are required)	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Number of groups selected for Display Port	2	ushort	[4, 70] default = 4 <i>(Groups 1,2,3,10 are always output on Display Port)</i>	N/A
Display Port output group identification	2	ushort	Group ID to output [1, 65534]	N/A
...	...	ushort	...	N/A
Display Port output group identification	2	ushort	Group ID to output [1, 65534]	N/A
Reserved	2	ushort	0	N/A
Pad	0 or 2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 52: Real-Time Data Port Control

This message directs POS MV to output specified groups on the Real-Time Data Port at a specified rate.

The *Number of Groups* field contains the number *n* of groups that this message selects. Thereafter follow *n Data Port Output Group Identification* fields, each of which identifies one selected group to be output on the Data Port.

The *Data Port Output Rate* field selects the output rates of all specified groups from one of several available discrete output rates. POS MV outputs a selected group at the lesser of the user-specified rate or the internal update rate; this depends on the selected group. If the user selects a group to be output at maximum available rate when the internal update rate of the group data is 1

Hz, then POS MV outputs the selected group at 1 Hz. An exception is Group 4: Time-tagged IMU, which the POS MV outputs at the IMU data rate regardless of the user-specified data rate.

POS MV accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as “settings”) that POS MV saves to NVM.

Table 58: Message 52/61: Real-Time/Logging Data Port Control

Item	Bytes	Format	Value	Units																				
Message start	4	char	\$MSG	N/A																				
Message ID	2	ushort	52 or 61	N/A																				
Byte count	2	ushort	10 + 2 x number of groups (+2 if pad bytes are required)	N/A																				
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A																				
Number of groups selected for Data Port	2	ushort	[0, 70] default = 0	N/A																				
Data Port output group identification	2	ushort	Group ID to output [1, 65534]	N/A																				
...	...	ushort	...	N/A																				
Data Port output group identification	2	ushort	Group ID to output [1, 65534]	N/A																				
Data Port output rate	2	ushort	<table border="0"> <thead> <tr> <th><u>Value</u></th> <th><u>Rate (Hz)</u></th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1 (default)</td> </tr> <tr> <td>2</td> <td>2</td> </tr> <tr> <td>10</td> <td>10</td> </tr> <tr> <td>20</td> <td>20</td> </tr> <tr> <td>25</td> <td>25</td> </tr> <tr> <td>50</td> <td>50</td> </tr> <tr> <td>100</td> <td>100</td> </tr> <tr> <td>200</td> <td>200</td> </tr> <tr> <td>other values</td> <td>Reserved</td> </tr> </tbody> </table>	<u>Value</u>	<u>Rate (Hz)</u>	1	1 (default)	2	2	10	10	20	20	25	25	50	50	100	100	200	200	other values	Reserved	
<u>Value</u>	<u>Rate (Hz)</u>																							
1	1 (default)																							
2	2																							
10	10																							
20	20																							
25	25																							
50	50																							
100	100																							
200	200																							
other values	Reserved																							
Pad	0 or 2	byte	0	N/A																				

Item	Bytes	Format	Value	Units
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 53: Reserved

Message 54: Save/Restore Parameters Control

This message directs POS MV to save the current configuration to non-volatile memory (NVM) or to retrieve the currently saved parameters from NVM. POS MV accepts this message at anytime.

If the *Control* field is set to any value other than 1-3, this message has no effect. If the *Control* field is set to 1, POS MV saves the current parameters to NVM, thereby overwriting the previously saved parameters. If the *Control* field is set to 2, POS MV retrieves the currently saved parameters into the active parameters for the current navigation session. If the *Control* field is set to 3, POS MV resets the active parameters to the factory default settings. The previously active parameters are overwritten.

Table 59: Message 54: Save/restore parameters control

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	54	N/A
Byte count	2	ushort	8	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Control	1	byte	<u>Value</u> <u>Operation</u> 0 No operation 1 Save parameters in NVM 2 Restore user settings from NVM 3 Restore factory default settings 4-255 No operation	
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 55: User Time Recovery

This message specifies the time of the last PPS in user time to POS MV. It directs POS MV to synchronize its User Time with the time specified in the *User PPS Time* field. POS MV accepts this message at anytime at a maximum rate of once per second.

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

Table 60: Message 55: User time recovery

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	55	N/A
Byte count	2	ushort	24	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
User PPS time	8	double	[0,) default = 0.0	seconds
User time conversion factor	8	double	[0,) default = 1.0	•/seconds
Pad	2	short	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 56: General Data

This message provides POS MV with an initial time, position, distance and attitude fix when either the primary GPS receiver is unable to provide this information within a maximum initialization time. The data in this message allows a stationary POS MV to complete the coarse leveling algorithm and begin operating in Navigate mode. POS MV can also be commanded to start (or continue) in an alignment status beyond coarse leveling should the accuracy of prescribed initial conditions warrant. The *initial horizontal position CEP* describes the circular error probability of the initial position. The *initial altitude standard deviation* describes the uncertainty in the initial altitude. These can be used to re-align POS MV at a last known position following an integration failure when GPS is unavailable.

POS MV accepts this message at any time. It will only use the data in this message if GPS data remains unavailable for longer than 120 seconds after receipt of this message. It will supersede

this general data with GPS position data as soon as the GPS data becomes available. POS MV does not save this message to NVM, hence the user must provide this message during every POS MV start-up where the general data are required.

Table 61: Message 56: General data

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	56	N/A
Byte count	2	ushort	80	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Time of day: Hours	1	byte	[0, 23] default = 0	hours
Time of day: Minutes	1	byte	[0, 59] default = 0	minutes
Time of day: Seconds	1	byte	[0, 59] default = 0	seconds
Date: Month	1	byte	[1, 12] default = 1	month
Date: Day	1	byte	[1, 31] default = 1	day
Date: Year	2	ushort	[0, 65534] default = 0	year
Initial alignment status	1	byte	See Table 5	N/A
Initial latitude	8	double	[-90, +90] default = 0	degrees
Initial longitude	8	double	[-180, +180] default = 0	degrees
Initial altitude	8	double	[-1000, +10000] default = 0	meters
Initial horizontal position CEP	4	float	[0,) default = 0	meters
Initial altitude RMS uncertainty	4	float	[0,) default = 0	meters
Initial distance	8	double	[0,) default = 0	meters
Initial roll	8	double	[-180, +180] default = 0	degrees
Initial pitch	8	double	[-180, +180] default = 0	degrees
Initial heading	8	double	[0, 360) default = 0	degrees
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A

Item	Bytes	Format	Value	Units
Message end	2	char	\$#	N/A

Message 57: Installation Calibration Control

This message controls the POS MV function of self-calibration of primary installation parameters. POS MV accepts this message at any time. The primary installation parameters exclude the GAMS installation parameters, which are handled by a separate calibration function and controlled separately by Message 58: GAMS Calibration Control.

The calibration is done assuming that the IMU Frame is the Reference Frame. If it is desirable to have the IMU and Reference Frames non-coincident, then the user must apply additional offsets consistently to all sensor frames to define a non-coincident Reference Frame.

The *calibration action* byte specifies a calibration action. The *calibration select* byte identifies installation parameter sets on which the calibration action is applied. POS MV executes the specified calibration action as soon as it receives this message. The following are calibration actions available to the user:

- start an auto-calibration or a manual calibration of selected installation parameters
- stop an ongoing calibration
- perform normal transfer of selected calibrated parameters following manual calibration
- perform forced transfer of selected calibrated parameters following manual calibration

The user selects one or more installation parameter sets for calibration by setting the bits in the calibration select byte corresponding to the parameter sets to be calibrated to 1. The user starts a calibration of the selected installation parameters by setting the calibration action byte to 2 for a manual calibration or 3 for an auto-calibration. POS MV restarts the Navigate mode with the calibration option set. It then computes corrected versions of the selected installation parameters and reports these with corresponding calibration figures of merit (FOM) in Group 14: Calibrated installation parameters. A calibration of a selected set of installation parameters is completed when the corresponding FOM reaches 100.

The user stops all calibrations by setting the calibration action byte to 1. POS MV restarts the Navigate mode without the calibration option and abandons any previous calibration actions.

In an auto-calibration, POS MV replaces the existing set of installation parameters and issues a corresponding Message 20: General Installation and Processing Parameters or Message 22: Aiding Sensor Installation Parameters when the calibration is completed. POS MV resets its Kalman filter and restarts the normal Navigate mode with the updated installation parameters when all selected calibrations are completed.

In a manual calibration, POS MV continues the calibration and displays the final values in Group 14: Calibrated installation parameters until it receives a user command to stop the calibration or transfer the calibrated parameters.

In a normal transfer of calibrated parameters, POS MV replaces the existing set of installation parameters selected by the calibration select byte with the corrected parameters displayed in Group 14: Calibrated installation parameters and having a FOM of 100. POS MV resets its Kalman filter and restarts the normal Navigate mode with the possibly updated installation parameters.

In a forced transfer of calibrated parameters, POS MV replaces the existing set of installation parameters selected by the calibration select byte with the corrected parameters displayed in Group 14: Calibrated installation parameters and having a FOM greater than 0. POS MV resets its Kalman filter and restarts the normal Navigate mode with the updated installation parameters.

Table 62: Message 57: Installation calibration control

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	57	N/A
Byte count	2	ushort	8	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Calibration action	1	byte	<u>Value</u> <u>Command</u> 0 No action (default) 1 Stop all calibrations 2 Manual calibration 3 Auto-calibration 4 Normal calibrated parameter transfer 5 Forced calibrated parameter transfer 6-255 No action	
Calibration select	1	byte	<u>Bit (set)</u> <u>Command</u> 0 Calibrate primary GPS lever arm 1 Calibrate auxiliary 1 GPS lever arm 2 Calibrate auxiliary 2 GPS lever arm 3 - 7 reserved	

Item	Bytes	Format	Value	Units
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 58: GAMS Calibration Control

This message controls the operation of the GAMS calibration function. POS MV accepts this message at any time.

The GAMS Calibration Control field directs POS MV to do the following:

- stop a current nalibration in progress
- begin a new calibration or resume a suspended calibration
- suspend a current calibration in progress or
- force a calibration to start without regard to the current navigation solution attitude accuracy

POS MV returns Message 21: GAMS Installation Parameters containing the new GAMS installation parameters when the calibration is completed.

Table 63: Message 58: GAMS Calibration Control

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	58	N/A
Byte count	2	ushort	8	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
GAMS calibration control	1	byte	<u>Value</u> <u>Command</u> 0 Stop calibration (default) 1 Begin or resume calibration 2 Suspend calibration 3 Force calibration 4-255 No action	
Pad	1	byte	0	N/A

Item	Bytes	Format	Value	Units
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 60: Reserved

Message 61: Logging Data Port Control

This message directs the POS MV to output specified groups on the Logging Data Port at a specified rate. The format and content of the message is the same as that of Message 52 and is given by Table 58.

POS MV accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as “settings”) that POS MV saves to NVM.

4.4.4 Program Control Override Messages

Message 90: Program Control

This message controls the operational status of POS MV. POS MV accepts this message at any time.

POS MV interprets the values in the message as follows.

- 000 The connected POS Controller is alive and the TCP/IP connection is good.
- 001 Terminate the TCP/IP connection. This allows the POS Controller to disconnect as controller and re-connect later.
- 100 Reset the GAMS algorithm to clear any pending problems.
- 101 Reset POS to clear pending problems. All parameters will be loaded from NVM after a reset.
- 102 Shutdown POS in preparation for power-off. This function allows POS to synchronize its files before the user disconnects the power. The user should ensure that POS settings are saved before beginning the shutdown procedure.

POS MV continuously monitors the TCP/IP connection between itself and the *POS Controller*. POS MV expects to receive at least one message from the *POS Controller* every 30 seconds or it will automatically terminate the TCP/IP connection. The purpose of this function is for the POS MV to determine if the *POS Controller* has failed, in which case it can reset the TCP/IP port. This message can be used with a value of 0 as a no operation (NOP) message when no other messages need to be sent to POS MV.

Table 64: Message 90: Program Control

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	90	N/A
Byte count	2	ushort	8	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Control	2	ushort	<u>Value</u> <u>Command</u> 000 Controller alive 001 Terminate TCP/IP connection 100 Reset GAMS 101 Reset POS 102 Shutdown POS all other values are reserved	
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 91: GPS Control

This message directs POS MV to configure or reset its internal GPS receivers. POS MV accepts this message at any time.

The *Control Command* field when set to *Send GPS configuration* (0) directs POS MV to reconfigure the GPS receivers. POS MV then sends the configuration script messages to the receivers in the same way as it does during initialization following power-up. The user would use this command if he suspected that an internal GPS receiver had not initialized correctly or had lost its configuration.

The *Control Command* field when set to *Send reset command* (1) directs POS MV to send “cold reset” commands to the GPS receivers. This directs an internal GPS receiver to revert to the factory default configurations. The user would use this command to establish a starting point for troubleshooting problems with a GPS receiver.

Table 65: Message 91: GPS control

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	91	N/A
Byte count	2	ushort	8	N/A
Transaction number	2	ushort	<u>Input:</u> Transaction number <u>Output:</u> [65533, 65535]	N/A
Control command	1	byte	<u>Value</u> <u>Command</u> 0 Send primary GPS configuration 1 Send primary GPS reset command 2 Send secondary GPS configuration 3 Send secondary GPS reset command 4-255 No action	
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 92: Reserved

Message 93: Reserved

4.4.5 POS MV Specific Messages

Message 105: Analog Port Set-up

This message allows the user to configure the analog port to communicate with other equipment. For the analog port, the user is able to configure the output message format, the scale factor and the parameter sense required.

Table 66: Message 105: Analog Port Set-up

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	105	N/A

Item	Bytes	Format	Value	Units
Byte count	2	ushort	24	N/A
Transaction #	2	ushort	Input: Transaction number set by client Output: [65533, 65535]	N/A
Roll Scale Factor	4	float	$\alpha = (0,)$ (default = 1.0)	N/A
Pitch Scale Factor	4	float	$\beta = (0,)$ (default = 1.0)	N/A
Heave Scale Factor	4	float	$\gamma = (0,)$ (default = 1.0)	N/A
Roll Sense	1	byte	<u>Value</u> <u>Analog +ve</u> 0 port up (default) 1 starboard up	N/A
Pitch Sense	1	byte	<u>Value</u> <u>Analog +ve</u> 0 bow up (default) 1 stern up	N/A
Heave Sense	1	byte	<u>Value</u> <u>Analog +ve</u> 0 up (default) 1 down	N/A
Analog Formula Select	1	byte	<u>Value</u> <u>Formula</u> 0 (Tate-Bryant Trig) roll = $\alpha \times 10 \sin \phi$ pitch = $\beta \times 10 \sin \theta$ heave = $\gamma \times \text{heave}$ 1 (Tate-Bryant Linear) roll = $\alpha \times \phi$ pitch = $\beta \times \theta$ heave = $\gamma \times \text{heave}$ 2 (default) (TSS Trig) roll = $\alpha \times 10 (\sin \phi \cos \theta)$ pitch = $\beta \times 10 \sin \theta$ heave = $\gamma \times \text{heave}$ 3 (TSS Linear) roll = $\alpha \times \sin^{-1}(\sin \phi \cos \theta)$ pitch = $\beta \times \theta$	volts

Item	Bytes	Format	Value	Units
			4 heave = $\gamma \times \text{heave}$ (RPH) roll = $\alpha \times \phi$ pitch = $\beta \times \theta$ heading = $\gamma \times \psi$	
Analog Output	1	byte	<u>Value</u> <u>Condition</u> 0 analog off 1 analog on (default)	N/A
Frame of Reference	1	byte	<u>Value</u> <u>Condition</u> 0 sensor 1 (default) 1 sensor 2	N/A
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 106: Heave Filter Set-up

This message allows the user to set the cut-off frequency and damping ratio of the heave filter. Also, the message is accepted at anytime and may be saved.

Table 67: Message 106: Heave Filter Set-up

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	106	N/A
Byte count	2	ushort	16	N/A
Transaction #	2	ushort	Input: Transaction number set by client Output: [65533, 65535]	N/A
Heave Corner Period	4	float	(10.0,)(default = 200.0)	seconds
Heave Damping Ratio	4	float	(0, 1.0)(default = 0.707)	N/A
Pad	2	byte	0	N/A

Item	Bytes	Format	Value	Units
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$\$	N/A

Message 111: Password Protection Control

This command “Logs in” the user, or changes the password used for user login.

The message is accepted anytime, but is redundant if “Login” (Password Control) is sent when “user logged in” condition exists (see Table 29: Group 110: MV General Status & FDIR). This is the case when the user has logged in within the last 10 minutes, and has not disconnected or terminated the connection to the PCS, since the login.

The message is not saved to NVM, when sent (and accepted) with Password Control equal to “Change Password”. The new password is, however, immediately saved in the operating system’s configuration file. The message is not echoed nor output to any of Display or Data Ports.

Table 68: Message 111: Password Protection Control

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	111	N/A
Byte count	2	ushort	48	N/A
Transaction #	2	ushort	Input: Transaction number set by client Output: [65533, 65535]	N/A
Password Control	1	byte	<u>Value</u> <u>Command</u> 0 Login 1 Change Password	N/A
Password	20	char	String value of current Password, terminated by “null” if less than 20 characters, or 20 (non-null) characters. Default: <i>pcsPasswd</i>	N/A

Item	Bytes	Format	Value	Units
New Password	20	char	If Password Control = 0: N/A If Password Control = 1: String value of new (user-selected) Password, terminated by “null” if less than 20 characters, or 20 (non-null) characters.	N/A
Pad	1	short	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 120: Sensor Parameter Set-up

This message contains data that is sent to POS to define the installation parameters of sensors 1 and 2 and the heave lever arm.

The interpretation of the items in this message is as follows:

Sensor(s) wrt Reference frame mounting angle:

Physical angular offsets of the sensor(s) body frame with respect to the user defined reference frame. The reference frame is defined as the right-handed orthogonal co-ordinate system with its origin defined at any point the user wishes. The axes are fixed to the reference frame, with the x axis in the forward going direction, the y axis perpendicular to the x axis and pointing to the right (starboard side), and the z axis pointing down. The sensor(s) body frame is defined as the right-handed orthogonal co-ordinate system with its origin at the sensing centre of the sensor. These axes are fixed to the sensor.

The angles define the Euler sequence of rotations that bring the reference frame into alignment with the sensor body frame. The angles follow the Tate-Bryant sequence of rotation given as follows: right-hand screw rotation of θ_z about the z axis followed by a rotation of θ_y about the once rotated y axis followed by a rotation of θ_x about the twice rotated x axis. The angles θ_x , θ_y , and θ_z may be thought of as the roll, pitch, and yaw of the sensor body frame with respect to the reference frame.

Reference to Sensor(s) Lever arms:

Distances measured from the reference frame origin to the sensing centre of the sensors resolved in the reference frame. Since the reference frame is always aligned to the vessel frame (by design), then from the reference frame origin, x is positive towards the bow, y is positive towards the starboard side of the vessel, and z is positive down (Right-Hand Rule).

Reference to Centre of Rotation Lever arms:

This set of lever arms allows the user to enter the lever arms between the reference frame origin and the point on the vessel that experiences vertical motion due only to heave, without roll and/or pitch induced vertical motion. The lever arms are defined as the distances measured from the reference frame origin to the centre of rotation (*CoR*) resolved in the reference frame. Since the reference frame is always aligned to the vessel frame (by design), then from the reference frame origin, x is positive towards the bow, y is positive towards the starboard side of the vessel, and z is positive down (Right-Hand Rule).

Vertical acceleration data from the IMU is transformed to the centre of vessel rotation (specified by the lever arms), double integrated and passed through the high-pass heave filter and then transformed back to the sensor positions. If this parameter is not entered, heave is calculated at the IMU location and then transformed to the sensor positions.

Table 69: Message 120: Sensor Parameter Set-up

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	120	N/A
Byte count	2	ushort	68	N/A
Transaction #	2	ushort	Input: Transaction number set by client Output: [65533, 65535]	N/A
X Sensor 1 wrt reference frame mounting angle	4	float	[-180, +180] default = 0	deg
Y Sensor 1 wrt reference frame mounting angle	4	float	[-180, +180] default = 0	deg
Z Sensor 1 wrt reference frame mounting angle	4	float	[-180, +180] default = 0	deg
X Sensor 2 wrt reference frame mounting angle	4	float	[-180, +180] default = 0	deg
Y Sensor 2 wrt reference frame mounting angle	4	float	[-180, +180] default = 0	deg

Item	Bytes	Format	Value	Units
Z Sensor 2 wrt reference frame mounting angle	4	float	[-180, +180] default = 0	deg
Reference to Sensor 1 X lever arm	4	float	(,) default = 0	m
Reference to Sensor 1 Y lever arm	4	float	(,) default = 0	m
Reference to Sensor 1 Z lever arm	4	float	(,) default = 0	m
Reference to Sensor 2 X lever arm	4	float	(,) default = 0	m
Reference to Sensor 2 Y lever arm	4	float	(,) default = 0	m
Reference to Sensor 2 Z lever arm	4	float	(,) default = 0	m
Reference to CoR X lever arm	4	float	(,) default = 0	m
Reference to CoR Y lever arm	4	float	(,) default = 0	m
Reference to CoR Z lever arm	4	float	(,) default = 0	m
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

wrt = with respect to

Message 121: Vessel Installation Parameter Set-up

This message contains data that is sent to POS to define the installation parameters of the vessel.

The interpretation of the items in this message is as follows:

Reference to Vessel Lever Arms:

This set of lever arms allows the user to define a different point at which the position and velocity data is valid for the vessel than the point to which all lever arms are measured. Thus, it is possible to have position valid at the vessel bridge, but measure all sensor lever arms to some conveniently accessible reference point.

The lever arm distances are measured from the user defined reference frame origin to vessel position of interest resolved in the *reference frame*.

Table 70: Message 121: Vessel Installation Parameter Set-up

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	121	N/A
Byte count	2	ushort	20	N/A
Transaction #	2	ushort	Input: Transaction number set by client Output: [65533, 65535]	N/A
Reference to Vessel X lever arm	4	float	(,) default = 0	m
Reference to Vessel Y lever arm	4	float	(,) default = 0	m
Reference to Vessel Z lever arm	4	float	(,) default = 0	m
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Message 135: NMEA Output Set-up

This message allows the user to configure Nmea output on one or more COM ports. The COM ports on which the Nmea output appears is controlled by message 34.

Note that this is a MV specific version of the Core message 35.

The ZDA, UTC and PPS output strings are fixed at 1 Hz (if selected) and synchronized to the GPS PPS. They may be combined with other outputs at higher rates.

Table 71: Message 135: NMEA Output Set-up

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	135	N/A
Byte count	2	ushort	For even #ports (16 + #ports x 10) For odd #ports (18 + #ports x 10)	N/A
Transaction #	2	ushort	Input: Transaction number set by client Output: [65533, 65535]	N/A
Reserved	9	byte	N/A	N/A
Number of Ports	1	byte	[0, 10]	N/A
NMEA Port Definitions	#ports x 10	<i>See Table 72: NMEA Port Definition</i>		
Pad	0 or 2 ¹	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Pad size is 0 bytes if number of ports is even, size is 2 bytes if number of ports is odd.

Table 72: NMEA Port Definition

Port Number	1	byte	[1, 10]	N/A												
Nmea Formula Select	4	ulong	<table border="0"> <tr> <td><u>Bit (set)</u></td> <td><u>Format</u></td> <td><u>Formula</u></td> </tr> <tr> <td>0</td> <td>\$xxGST</td> <td>NMEA (pseudorange measurement noise stats)</td> </tr> <tr> <td>1 (default)</td> <td>\$xxGGA</td> <td>NMEA (Global Position System Fix)</td> </tr> <tr> <td>2</td> <td>\$xxHDT</td> <td>NMEA (heading)</td> </tr> </table>	<u>Bit (set)</u>	<u>Format</u>	<u>Formula</u>	0	\$xxGST	NMEA (pseudorange measurement noise stats)	1 (default)	\$xxGGA	NMEA (Global Position System Fix)	2	\$xxHDT	NMEA (heading)	N/A
<u>Bit (set)</u>	<u>Format</u>	<u>Formula</u>														
0	\$xxGST	NMEA (pseudorange measurement noise stats)														
1 (default)	\$xxGGA	NMEA (Global Position System Fix)														
2	\$xxHDT	NMEA (heading)														

			3 \$xxZDA NMEA (date & time) 4,5 reserved 6 \$xxVTG NMEA (track and speed) 7 \$PASHR NMEA (attitude (Tate-Bryant)) 8 \$PASHR NMEA (attitude (TSS)) 9 \$PRDID NMEA (attitude (Tate-Bryant)) 10 \$PRDID NMEA (attitude (TSS)) 11 \$xxGGK NMEA (Global Position System Fix) 12 \$UTC UTC date and time 13 reserved 14 \$xxPPS UTC time of PPS pulse xx - is substituted by the Talker ID																			
Nmea output rate	1	ushort	<table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>Rate (Hz)</u></th> </tr> </thead> <tbody> <tr><td>0</td><td>N/A</td></tr> <tr><td>1</td><td>1 (default)</td></tr> <tr><td>2</td><td>2</td></tr> <tr><td>5</td><td>5</td></tr> <tr><td>10</td><td>10</td></tr> <tr><td>20</td><td>20</td></tr> <tr><td>25</td><td>25</td></tr> <tr><td>50</td><td>50</td></tr> </tbody> </table>	<u>Value</u>	<u>Rate (Hz)</u>	0	N/A	1	1 (default)	2	2	5	5	10	10	20	20	25	25	50	50	Hz
<u>Value</u>	<u>Rate (Hz)</u>																					
0	N/A																					
1	1 (default)																					
2	2																					
5	5																					
10	10																					
20	20																					
25	25																					
50	50																					
Talker ID	1	byte	<table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>ID</u></th> </tr> </thead> <tbody> <tr><td>0</td><td>IN (default)</td></tr> <tr><td>1</td><td>GP</td></tr> </tbody> </table>	<u>Value</u>	<u>ID</u>	0	IN (default)	1	GP	N/A												
<u>Value</u>	<u>ID</u>																					
0	IN (default)																					
1	GP																					
Roll Sense	1	byte	<table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>Digital +ve</u></th> </tr> </thead> <tbody> <tr><td>0</td><td>port up (default)</td></tr> <tr><td>1</td><td>starboard up</td></tr> </tbody> </table>	<u>Value</u>	<u>Digital +ve</u>	0	port up (default)	1	starboard up	N/A												
<u>Value</u>	<u>Digital +ve</u>																					
0	port up (default)																					
1	starboard up																					
Pitch Sense	1	byte	<table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>Digital +ve</u></th> </tr> </thead> <tbody> <tr><td>0</td><td>bow up (default)</td></tr> <tr><td>1</td><td>stern up</td></tr> </tbody> </table>	<u>Value</u>	<u>Digital +ve</u>	0	bow up (default)	1	stern up	N/A												
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Heave Sense	1	byte	<table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>Digital +ve</u></th> </tr> </thead> <tbody> <tr><td>0</td><td>up (default)</td></tr> <tr><td>1</td><td>down</td></tr> </tbody> </table>	<u>Value</u>	<u>Digital +ve</u>	0	up (default)	1	down	N/A												
<u>Value</u>	<u>Digital +ve</u>																					
0	up (default)																					
1	down																					

Message 136: Binary Output Set-up

This message allows the user to configure the real-time binary output on one or more COM ports. The COM ports on which the binary output appears is controlled by message 34.

Note that this is a MV specific version of the Core message 36.

Table 73: Message 136: Binary Output Set-up

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	136	N/A
Byte count	2	ushort	For even #ports (16 + #ports x 10) For odd #ports (14 + #ports x 10)	N/A
Transaction #	2	ushort	Input: Transaction number set by client Output: [65533, 65535]	N/A
Reserved	7	byte	N/A	N/A
Number of Ports	1	byte	[0, 10]	N/A
Binary Port Definitions	#ports x 10	<i>See Table 74: Binary Port Definition</i>		
Pad	0, 2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	\$#	N/A

Pad size is 2 bytes if number of ports is even, size is 0 bytes if number of ports is odd.

Table 74: Binary Port Definition

Port Number	1	byte	[1, 10]	N/A												
Formula Select	4	ushort	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Format</u></td> <td><u>Formula</u></td> </tr> <tr> <td>0 - 2</td> <td>reserved</td> <td></td> </tr> <tr> <td>3</td> <td>Simrad1000 (Tate-Bryant)</td> <td>header roll = ϕ pitch = θ heave = heave heading = ψ</td> </tr> <tr> <td>4</td> <td>Simrad1000</td> <td>header</td> </tr> </table>	<u>Value</u>	<u>Format</u>	<u>Formula</u>	0 - 2	reserved		3	Simrad1000 (Tate-Bryant)	header roll = ϕ pitch = θ heave = heave heading = ψ	4	Simrad1000	header	N/A
<u>Value</u>	<u>Format</u>	<u>Formula</u>														
0 - 2	reserved															
3	Simrad1000 (Tate-Bryant)	header roll = ϕ pitch = θ heave = heave heading = ψ														
4	Simrad1000	header														

			<p>(TSS) roll = $\sin^{-1}(\sin\phi\cos\theta)$ pitch = θ heave = heave heading = ψ</p>
5	Simrad3000 header		<p>(Tate-Bryant) roll = ϕ pitch = θ heave = heave heading = ψ</p>
6	Simrad3000 header		<p>(TSS) roll = $\sin^{-1}(\sin\phi\cos\theta)$ pitch = θ heave = heave heading = ψ</p>
7	TSS (Format 1) header (default)		<p>horizontal acceleration vertical acceleration heave = heave status roll = $\sin^{-1}(\sin\phi\cos\theta)$ pitch = θ <CR><LF></p>
8	TSM 5265 header (Tate-Bryant)		<p>time tag roll = ϕ pitch = θ heave = heave heading = ψ vel (long, trans, down)</p>
9	TSM 5265 (TSS)		<p>time tag roll = $\sin^{-1}(\sin\phi\cos\theta)$ pitch = θ heave = heave heading = ψ vel (long, trans, down)</p>
10	Atlas (TSS)		<p>header roll = $\sin^{-1}(\sin\phi\cos\theta)$</p>

			pitch = θ heave = heave status footer 11 - 15 reserved 16 PPS header GPS seconds of week week number UTC offset PPS count checksum 17 TM1B header checksum byte count week number GPS seconds of week clock offset clock offset std. dev. UTC offset clock model status																							
Message Update Rate	1	ushort	<table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>Rate (Hz)</u></th> </tr> </thead> <tbody> <tr><td>0</td><td>N/A</td></tr> <tr><td>1</td><td>1</td></tr> <tr><td>2</td><td>2</td></tr> <tr><td>5</td><td>5</td></tr> <tr><td>10</td><td>10</td></tr> <tr><td>20</td><td>20</td></tr> <tr><td>25</td><td>25 (default)</td></tr> <tr><td>50</td><td>50</td></tr> <tr><td>100</td><td>100</td></tr> <tr><td>200</td><td>200</td></tr> </tbody> </table>	<u>Value</u>	<u>Rate (Hz)</u>	0	N/A	1	1	2	2	5	5	10	10	20	20	25	25 (default)	50	50	100	100	200	200	Hz
<u>Value</u>	<u>Rate (Hz)</u>																									
0	N/A																									
1	1																									
2	2																									
5	5																									
10	10																									
20	20																									
25	25 (default)																									
50	50																									
100	100																									
200	200																									
Roll Sense	1	byte	<table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>Digital +ve</u></th> </tr> </thead> <tbody> <tr><td>0</td><td>port up (default)</td></tr> <tr><td>1</td><td>starboard up</td></tr> </tbody> </table>	<u>Value</u>	<u>Digital +ve</u>	0	port up (default)	1	starboard up	N/A																
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Pitch Sense	1	byte	<table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>Digital +ve</u></th> </tr> </thead> <tbody> <tr><td>0</td><td>bow up (default)</td></tr> <tr><td>1</td><td>stern up</td></tr> </tbody> </table>	<u>Value</u>	<u>Digital +ve</u>	0	bow up (default)	1	stern up	N/A																
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Heave Sense	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Digital +ve</u></td> </tr> <tr> <td>0</td> <td>up (default)</td> </tr> <tr> <td>1</td> <td>down</td> </tr> </table>	<u>Value</u>	<u>Digital +ve</u>	0	up (default)	1	down	N/A
<u>Value</u>	<u>Digital +ve</u>									
0	up (default)									
1	down									
Sensor Frame Output	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Frame of Reference</u></td> </tr> <tr> <td>0</td> <td>sensor 1 frame (default)</td> </tr> <tr> <td>1</td> <td>sensor 2 frame</td> </tr> </table>	<u>Value</u>	<u>Frame of Reference</u>	0	sensor 1 frame (default)	1	sensor 2 frame	N/A
<u>Value</u>	<u>Frame of Reference</u>									
0	sensor 1 frame (default)									
1	sensor 2 frame									

4.4.6 POS MV Specific Diagnostic Control Messages

Message 20102: Binary Output Diagnostics

This message is used to set selected output values for the real-time binary output port. This is used to allow POS to generate user selectable constant outputs to test the communications interface between POS and the sensor.

Note that this message must be sent again to disable the fixed output.

Table 75: Message 20102: Binary Output Diagnostics

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	20102	N/A
Byte count	2	ushort	24	N/A
Transaction #	2	ushort	Input: Transaction number set by client Output: [65533, 65535]	N/A
Operator roll input	4	float	(-180, 180] default = 0	deg
Operator pitch input	4	float	(-180, 180] default = 0	deg
Operator heading input	4	float	[0, 360) default = 0	deg
Operator heave input	4	float	[-100 to 100] default = 0	m

Item	Bytes	Format	Value	Units						
Output Enable	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Command</u></td> </tr> <tr> <td>0</td> <td>Disabled (default) Output navigation solution data</td> </tr> <tr> <td>1</td> <td>Enabled Output operator specified fixed values</td> </tr> </table>	<u>Value</u>	<u>Command</u>	0	Disabled (default) Output navigation solution data	1	Enabled Output operator specified fixed values	
<u>Value</u>	<u>Command</u>									
0	Disabled (default) Output navigation solution data									
1	Enabled Output operator specified fixed values									
Pad	1	byte	0	N/A						
Checksum	2	ushort	N/A	N/A						
Message end	2	char	\$#	N/A						

Message 20103: Analog Port Diagnostics

This message is used to set the output values for the analog port. This is used to allow POS to generate user selectable constant sensor attitude inputs to test the communications interface between POS and the sensor.

Note that this message must be sent again to disable the fixed output.

Table 76: Message 20103: Analog Port Diagnostics

Item	Bytes	Format	Value	Units
Message start	4	char	\$MSG	N/A
Message ID	2	ushort	20103	N/A
Byte count	2	ushort	20	N/A
Transaction #	2	ushort	Input: Transaction number set by client Output: [65533, 65535]	N/A
Operator roll input	4	float	(-180, 180] default = 0	deg
Operator pitch input	4	float	(-180, 180] default = 0	deg
Operator heave input	4	float	[-100, 100] default = 0	m

Item	Bytes	Format	Value	Units						
Output Enable	1	byte	<table border="0"> <tr> <td><u>Value</u></td> <td><u>Command</u></td> </tr> <tr> <td>0</td> <td>Disabled (default) Output navigation solution data</td> </tr> <tr> <td>1</td> <td>Enabled Output operator specified fixed values</td> </tr> </table>	<u>Value</u>	<u>Command</u>	0	Disabled (default) Output navigation solution data	1	Enabled Output operator specified fixed values	
<u>Value</u>	<u>Command</u>									
0	Disabled (default) Output navigation solution data									
1	Enabled Output operator specified fixed values									
Pad	1	byte	0	N/A						
Checksum	2	ushort	N/A	N/A						
Message end	2	char	\$\$	N/A						

5 Appendix A: Data Format Description

5.1 Data Format

The data format for byte, short, long, float and double as used in POS are defined as follows:

Byte or Character

Table 77: Byte Format

MSBit							LSBit
7	6	5	4	3	2	1	0

Short Integer

The short integer format of the POS data is the INTEL style byte order as follows:

Table 78: Short Integer Format

MSB			LSB
15	8	7	0
Byte #:	1		0

Long Integer

The long integer format of the POS data is the INTEL style byte order as follows:

Table 79: Long Integer Format

MSB			LSB
31 24	23 16	15 8	7 0
Byte #:	3	2	1
			0

Float and Double

The floating point format of the POS data is the INTEL byte order from the IEEE-754 floating point representation standard as follows:

Table 80: Single-Precision Real Format

Single-Precision Data format				
31	30	23	22	0
s	e	f		

Single-Precision Data format	
Field Size in Bits	
Sign (s)	1
Biased Exponents (e)	8
Fraction (f)	23
Total	32
Interpretation of Sign	
Positive Fraction	s=0
Negative Fraction	s=1
Normalised Numbers	
Bias of Biased Exponent	+127 (\$7F)
Range of Biased Exponent	[0, 255] (\$FF)
Range of Fraction	zero or nonzero
Fraction	1.f (where $f = \text{bit}_{22}^{-1} + \text{bit}_{21}^{-2} + \dots + \text{bit}_0^{-23}$)
Relation to Representation of Real Numbers	$(-1)^s \times 2^{e-127} \times 1.f$
Approximate Ranges	
Maximum Positive Normalised	3.4×10^{38}
Minimum Positive Normalised	1.2×10^{-38}

Table 81: Double-Precision Real Format

Double-Precision Data format	
<div style="display: flex; justify-content: space-between; width: 100%;"> 63 62 52 51 0 </div> <div style="display: flex; justify-content: space-between; width: 100%; border: 1px solid black; margin-top: 5px;"> <div style="width: 10%; text-align: center;">s</div> <div style="width: 40%; text-align: center;">e</div> <div style="width: 50%; text-align: center;">f</div> </div>	
Field Size in Bits	
Sign (s)	1
Biased Exponents (e)	11
Fraction (f)	52
Total	64

Double-Precision Data format	
Interpretation of Sign	
Positive Fraction	s=0
Negative Fraction	s=1
Normalised Numbers	
Bias of Biased Exponent	+1023 (\$3FF)
Range of Biased Exponent	[0, 2047] (\$7FF)
Range of Fraction	zero or nonzero
Fraction	1.f (where $f = \text{bit}_{51}^{-1} + \text{bit}_{50}^{-2} \dots + \text{bit}_0^{-52}$)
Relation to Representation of Real Numbers	$(-1)^s \times 2^{e-1023} \times 1.f$
Approximate Ranges	
Maximum Positive Normalized	1.8×10^{308}
Minimum Positive Normalized	2.2×10^{-308}

5.2 Invalid Data Values

Since there are several fields in each group or message, it is possible that one or more numerical fields will be invalid when the group or message is output. The following numerical values should be interpreted as invalid if they are output in any group or message. This does not apply to single or multiple byte fields that are comprised of bit sub-fields.

The hexadecimal value describes the contents of the bytes that represent the invalid decimal value for the type. The invalid values for all integer types are the maximum positive values that the integer types can take.

The invalid value for the floating-point types is any value in the range of NaN (Not a Number) or INF (Infinity) defined by IEEE-754. The value NaN is by definition any float or double having a mantissa set to any nonzero value and an exponent whose bits are all set to 1. POS MV assigns an invalid float or double in any group by setting all bits representing the float or double set to 1. POS MV rejects any message that contains any of the invalid integer values in Table 82 or any value in the range of NaN or INF.

Table 82: Invalid data values

Data Type	Hexadecimal Value	Decimal Value
Byte	FF	255 ($=2^8 - 1$)
Short	7F FF	32767 ($=2^{15} - 1$)
Unsigned short (ushort)	FF FF	65535 ($=2^{16} - 1$)
Long	7F FF FF FF	2147483647 ($=2^{31} - 1$)
Unsigned long (ulong)	FF FF FF FF	4294967295 ($=2^{32} - 1$)
Float	FF FF FF FF	NaN
Double	FF FF FF FF FF FF FF FF	NaN

6 Appendix B: Glossary of Acronyms

AGC	automatic gain control
AutoConfig	auto configure
Aux	auxiliary
C/A	course acquisition
char	character
COM(1)	communications port 1
COM(2)	communications port 2
COM(3)	communications port 3
D	down
D/A	Digital-to-Analog
dB	decibels
DCM	direction cosine matrix
deg	degrees
deg/s	degrees/second
DGPS	differential global positioning system
DMI	distance measurement indicator
double	double precision floating point
DSP	digital signal processor
E	East
FDIR	Fault Detection, Isolation and Reconfiguration
float	floating-point precision
GAMS	GPS Azimuth Measurement Subsystem
GPS	Global Positioning System
H/W	hardware
HDOP	Horizontal Dilution of Precision
Hz	Hertz
I/O	input and output
ICD	interface control document
IMU	Inertial Measurement Unit
IP	Internet Protocol
KF	Kalman filter
lat	latitude
long	longitude
LSB	least significant bit
m	metres
m/s	metres/second
m/s ²	metres/second/second
ms	millisecond
MSB	most significant bit
N	North
N/A	not applicable
NOP	No Operation
NVM	non-volatile Memory

PCS	POS Computer System
POS	Position and Orientation System
POSPAC	Applanix POSPAC post-processing software package
PPS	Pulse per Second
PRN	Pseudo Random Noise
RAM	random access memory
RF	radio frequency
RMS	root-mean-square
RTK	real-time kinematic
RX	receive data
S/D	Strapdown
SCSI	Small Computer Systems Interface
sec	second
SV	space vehicle (GPS satellites)
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
ulong	unsigned long
ushort	unsigned short
UTC	Universal Coordinated Time
VDOP	Vertical Dilution of Precision
wrt	with respect to