APPLANIX
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POS TNG3 Core User Control, Display, Data and Logging Port Interface Control Document

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1 Scope

This document presents the functional specification of the Control, Display, Data and Logging Ports and data structures used by the POS Computer System (PCS) to communicate with the user over its Control, Display, Data and Logging Ports. The document is separated into specifications of output data groups and input and output control messages that are relevant to the user. A companion document with restricted circulation describes diagnostic groups and messages that are relevant only to factory and authorized service personnel.

This document applies to both TNG2 and TNG3. However, for clarity, only TNG3 is referenced.

2 References

[1] POS TNG3 Core Applanix Proprietary Control, Display, Data and Logging Port Interface Control Document, PUBS-ICD-000028

3 Ethernet and Data Acquisition Interfaces

The POS TNG3 provides a mechanism for control and data exchange in the form of control messages and data groups. Control messages direct the POS TNG3 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 TNG3 for the purpose of display on a control computer, recording to a mass storage device, or for real-time processing by another subsystem. The POS TNG3 exchanges all control messages with a user via the POS's Control Port. It outputs all data groups on the Display, Data and Logging Ports.

Applanix provides a program called the *POS Controller* with the POS TNG3 to run on the user's PC-compatible computer running Microsoft Windows 95/98/NT/2000. 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.

The POS TNG3 provides one physical Ethernet interface that has three logical communications ports called the *Display Port*, the *Control Port*, the *Primary Data Port and the Secondary Data Port*.

The POS TNG3 provides one PC-Card interface for logging POS data to a PC-Card device called the *Logging Port*.

The POS TNG3 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, Data and Logging. 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. The POS TNG3 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 Primary and Secondary **Data Ports** are *high rate* TCP/IP output ports that are designed to output multiple data groups at high data rates. To receive data from the Data Port, a computer must connect to it using the TCP/IP socket protocol. Only one computer may be connected to the Data Port at any one time. The POS Controller can log this data to the client computer's hard drive.

The port address for the Primary Data Port is 5602, and 5603 for Secondary Data Port. The IP subnet mask is 255.255.255.255.

The **Logging Port** is a high-rate data port that routes data to its own PC-Card storage medium. The purpose of the Logging Port is to record data for post-mission processing and data analysis.

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. The user is able to change the output options of the Display, Data and Logging ports at any time.

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.

4 Output Groups

4.1 Introduction

The POS TNG3 organizes the data coming from the Display, Data and Logging ports into output groups. Each group contains a block of related data at a specified group rate. The user directs the POS TNG3 via the POS Controller or Control Port messages to include a group or groups containing data items of interest in the Display, Data and Logging port data streams. 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 Controllerdisplay; hence a higher data output rate is not required. The output data rate on the Data and Logging Ports is group dependent, and has a range 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 and Logging ports.

4.2 Output Group Specification

4.2.1 Group Data Rates

There are several output groups defined for the Display, Data and Logging ports. The user can select any of these groups and *may select different groups* for the Display, Data and Logging port. The Standby and Navigate modes shown in Table 1 are defined in the POS TNG3 Installation and Operations Manual.

4.2.2 Group Classification and Numbering Convention

All POS products use the following group numbering convention. The POS TNG3 outputs the group categories shown. Reserved group numbers are assigned to other products.

0 - 99	Core User POS data groups
100 - 199	POS MV data groups
200 – 299	POS AV data groups
300 – 399	POS TG data groups
400 – 499	POS LV data groups
500 – 599	POS LS data groups
600 – 699	POS SV data groups
700 – 799	POS MC data groups
800 – 9999	Reserved
10000 - 10099	Core Raw POS data groups
10100 - 10199	Raw POS MV data groups
10200 – 10299	Raw POS AV data groups

10300 – 10399	Raw POS TG data groups
10400 – 10499	Raw POS LV data groups
10500 – 10599	Raw POS LS data groups
10600 – 10699	Raw POS SV data groups
10700 – 10799	Raw POS MC data groups
10800 – 19999	Reserved

Core 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 TNG3 data.

Core raw data groups comprise the unaltered data streams from the navigation sensors received by the PCS. The POS TNG3 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)		Data Port Output Rate (Hz)		Logging Port Output Rate (Hz)	
		Standby	Navigate	Standby	Navigate	Standby	Navigate
POS Data Groups							
1	Vehicle navigation solution	-	1[1]	-	1-200	-	1-200
2	VehicleVehicle 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	Logging status	1	1	1	1	1	1
9	GAMS solution status[7]	-	1	-	1	-	1
10	General and FDIR status	1[1]	1[1]	1	1	1	1
11	Secondary GPS status[3]	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	Time-tagged DMI data[4]	1	1	200	200	200	200
16	Time-tagged gimbal data[2]	1	1	0-50	0-50	0-50	0-50
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	Integrated DGPS Status[5]	1	1	1	1	1	1
26	DGPS Station Database[5]	0.1	0.1	0.1	0.1	0.1	0.1
99	Versions and statistics	1	1	1	1	1	1
Raw Data Groups							
10001	Primary GPS data stream	-	-	1-10	1-10	1-10	1-10
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	DMI data stream[4]	-	-	200[6]	200[6]	200[6]	200[6]
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[3]	-	-	1-10	1-10	1-10	1-10
10010	Gimbal data stream[2]	-	-	0-50	0-50	0-50	0-50
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 the POS is in Navigation mode but not aligned than the output rate is implementation dependent.*

[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] *When the Secondary GPS receiver is not installed this group does not get posted.*
[4] *This group only gets posted when DMI is connected and enabled.*

[5] *These groups are only posted when GPS type 12 receiver is installed as the Primary GPS receiver*
[6] *The DMI data rate and maximum Vehicle Navigation Solution data rate are releated to the IMU data rate and hence to the IMU type. The typical IMU data rate is 200 Hz.*
[7] *This group is output if GAMS feature available*

4.2.3 Group Form at

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
Time/Distance Fields	26	*See Table 3*		
Data	*Group dependent size and format*			
Pad	0 to 3	byte	0	N/A
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	Time 1 Select — Value in bits 0-3 Time 1: POS time 0 Time 1: GPS time 1 (default) Time 1: UTC time 2 Time 2 Select — Value in bits 4-7 Time 2: POS time 0 (default) Time 2: GPS time 1 Time 2: UTC time 2 Time 2: User time 3	

Item	Bytes	Format	Value			Units
Distance type	1	byte	Distance Select	Value		
			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 4.2.2.

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 will always be 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 TNG3 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 TNG3 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 TNG3 Installation and Operation Manual. 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 TNG3 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* will always be 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 90 in Appendix A: Data Format Description. The POS TNG3 will output invalid values in fields containing numerical values for which the POS TNG3 has no valid data. This does not apply to fields containing bit settings.

4.2.4 Compatibility With Previous POS Products

The compatibility of POS TNG3 groups with POS TNG0 products is given as follows:

The POS TNG3 group format is the same as that of all POS TNG0 products.

The contents of Groups 1-8 and Group 99 are the same as those of all POS TNG0 products. However, Groups 7 and 8 have been expanded with new fields that occur before the Pad field. This is compatible with the POS TNG0 group design. Groups 9-98 are not defined in POS TNG0 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 TNG0 product-specific groups. For example, Group 10 is similar to POS/MV TNG0 Group 101. It is expected that a POS/MV product derived from the POS TNG3 will define its Group 101 to be the same as Group 10, with the exception of definitions of reserved bits.

The contents of Groups 10001-10005 are the same as those of all POS TNG0 products.

4.3 Output Group Tables

4.3.1 POS Data Groups

4.3.1.1 Group 1: Vehicle Navigation Solution

This group contains a complete Vehicle navigation solution comprising position, velocity, attitude, track, speed and dynamics data for the Vehicle. The data in this group is *valid for the position defined by the user-entered reference to Vehicle lever arms.*

Table 4: Group 1: Vehicle navigation solution

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
Time/Distance Fields	26	*See Table 3*		
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
Vehicle roll	8	double	(-180, 180]	degrees
Vehicle pitch	8	double	(-90, 90]	degrees
Vehicle heading	8	double	[0, 360)	degrees
Vehicle wander angle	8	double	(-180, 180]	degrees
Vehicle track angle	4	float	[0, 360)	degrees
Vehicle speed	4	float	[0,)	meters/second
Vehicle angular rate about longitudinal axis	4	float	(,)	degrees/second
Vehicle angular rate about transverse axis	4	float	(,)	degrees/second
Vehicle angular rate about down axis	4	float	(,)	degrees/second
Vehicle longitudinal acceleration	4	float	(,)	meters/second^2
Vehicle transverse acceleration	4	float	(,)	meters/second^2
Vehicle down acceleration	4	float	(,)	meters/second^2
Alignment status	1	byte	See Table 5	N/A

Item	Bytes	Format	Value	Units
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
7	Initial solution assigned
8	No valid solution

4.3.1.2 Group 2: Vehicle Navigation Performance Metrics

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

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

Table 6: Group 2: Vehicle 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
Time/Distance Fields	26	*See Table 3*		
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
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.1.3 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 the POS TNG3 from among the GPS receiver types listed in Table 11 that POS TNG3 supports. The GPS status field comprises a 4-byte array of status bits whose format depends on the GPS receiver type. The formats for GPS receivers supported by the POS TNG3 are given in Table 12 to Table 16.

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
Time/Distance Fields	26	*See Table 3*		
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
Channel status	variable	*See Table 8*		
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
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	*See Table 11*	N/A
GPS status	4	ulong	GPS summary status fields which depend on GPS receiver type. See one of Table 12 to Table 16 for format.	
Pad	2	byte	0	N/A

Item	Bytes	Format	Value	Units
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
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

Channel Status	Description
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	NovAtel OEM2-3151 or -3151R GPSCard L1 receiver
2	NovAtel OEM3-Millennium L1/L2 receiver
3 to 7	Reserved
8	Trimble BD112
9	Trimble BD750
10	NovAtel OEM4/Euro4 (all models)
11	Reserved
12	Trimble BD132
13	Trimble BD950
14 and up	Reserved

Table 12: NovAtel OEM2-3151R GPS receiver status

Item	Bytes	Format	Failure	
Status Summary	4	ulong	GPS antenna good	bit 0: set
			L1 RF good	bit 1: set
			RAM good	bit 2: set
			ROM good	bit 3: set
			DSP good	bit 4: set
			L1 AGC good	bit 5: set
			COM1 good	bit 6: set
			COM2 good	bit 7: set
			L1 GPS frequency jammed	bit 11: set
			Buffer COM1 overload	bit 12: set
			Buffer COM2 overload	bit 13: set
			CPU overload	bit 15: set
			Not used Reserved	bits: 8-10, 14, bits: 16-31

Table 13: NovAtel OEM3-MiLLenium GPS receiver status

Item	Bytes	Format	Failure	
Status Summary	4	ulong	GPS antenna good	bit 0: set
			L1 RF good	bit 1: set
			RAM good	bit 2: set
			ROM good	bit 3: set
			DSP good	bit 4: set
			L1 AGC good	bit 5: set
			COM1 good	bit 6: set
			COM2 good	bit 7: set
			L1 GPS frequency jammed	bit 11: set
			Buffer COM1 overload	bit 12: set
			Buffer COM2 overload	bit 13: set
			CPU overload	bit 15: set
			Almanac Saved in NVM	bit 16: set
			L2 AGC good	bit 17: set
			L2 GPS frequency jammed	bit 18: set
			L2 RF good	bit 19: set
			OCXOPLL good	bit 20: set
			Saved Almanac needs update	bit 21: set
			Almanac is invalid	bit 22: set
			Position solution is invalid	bit 23: set
			Position Fixed	bit 24: set
			Clock Model invalid	bit 25: set
			Clock Steering disabled	bit 26: set
			Not used Reserved	bits: 8-10, 14, bits: 27-31

Table 14: NovAtel OEM4/Euro4 GPS receiver status

Item	Bytes	Format	Failure	
Status Summary	4	ulong	Error occurred	bit 0: set
			Temperature out of specified range	bit 1: set
			Voltage supply out of specified range	bit 2: set
			Antenna not powered	bit 3: set
			LNA status failed	bit 4: set
			Antenna open	bit 5: set
			Antenna shorted	bit 6: set
			CPU overload	bit 7: set
			COM1 buffer overrun	bit 8: set
			COM2 buffer overrun	bit 9: set
			COM3 buffer overrun	bit 10: set
			RF1 jammed	bit 14: set
			RF1 AGC bad	bit 15: set
			RF2 jammed	bit 16: set
			RF2 AGC bad	bit 17: set
			Almanac invalid	bit 18: set
			Position solution invalid	bit 19: set
			Fixed position	bit 20: set
			Clock steering disabled	bit 21: set
			Clock model invalid	bit 22: set
			Euro4 external oscillator PPL locked	bit 23: set
			AUX2 status event	bit 30: set
			AUX1 status event	bit 31: set
			Reserved	bits: 11-13, 24-29

Table 15: Trimble BD112 GPS receiver status

Item	Bytes	Format	Failure	
Status Code (Report Packet 0x46, byte 0)	1	byte	Description	Value
			Doing position fixes	0
			Do not have GPS time yet	1
			PDOP is too high	3
			No usable satellites	8
			Only 1 usable satellite	
			Only 2 usable satellites	10
			Only 3 usable satellites	11
			The chosen satellite is unusable	12
Error Flag (Report Packet 0x46, byte 1)	1	byte	Battery-backed memory failed	bit 0: set
			Antenna feed line fault	bit 4: set
			Excessive reference frequency errors	bit 5: set
			Reserved	bits: 1-3
				bits: 6-7
Status Flags 1 (Report Packet 0x4B, byte 1	1	byte	Battery powered time clock fault	bit 1: set
			A-to-D converter fault	bit 2: set
			Almanac invalid (not complete/current)	bit 3: set
			Receiver reset status acknowledged	bit 4: set
			Reserved	bits: 0, 5-7
Status Flags 2 (Report Packet 0x4B, byte 2)	1	byte	Output of TSIP superpackets supported	bit 0: set
			Reserved	bits: 1-7

Table 16: Trimble BD750 GPS receiver status

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

Table 17: Trimble BD132 GPS receiver status

Item	Bytes	Format	Failure	
Status Code (Report Packet 0x46, byte 0)	1	byte	Description	Value
			Doing position fixes	0
			Do not have GPS time yet	1
			PDOP is too high	3
			No usable satellites	8
			Only 1 usable satellite	
			Only 2 usable satellites	10
			Only 3 usable satellites	11
			The chosen satellite is unusable	12
Error Flag (Report Packet 0x46, byte 1)	1	byte	Battery-backed memory failed	bit 0: set
			Antenna feed line fault	bit 4: set
			Excessive reference frequency errors	bit 5: set
			Reserved	bits: 1-3
				bits: 6-7
Status Flags 1 (Report Packet 0x4B, byte 1	1	byte	Battery powered time clock fault	bit 1: set
			A-to-D converter fault	bit 2: set
			Almanac invalid (not complete/current)	bit 3: set
			Receiver reset status acknowledged	bit 4: set
			Reserved	bits: 0, 5-7
Status Flags 2 (Report Packet 0x4B, byte 2)	1	byte	Output of TSIP superpackets supported	bit 0: set
			Reserved	bits: 1-7

Table 18: Trimble BD950 GPS receiver status

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

4.3.1.4 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. The IMU type is Applanix's type designation, and is used by POSPAC to post-process the IMU data correctly. The IMU status word contains status bits as generated by the IMU. U.S. and Canadian export control laws prohibit publication of the IMU status word format.

Table 19: 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
Time/Distance Fields	26	*See Table 3*		
X incremental velocity	4	long	(,)	bits
Y incremental velocity	4	long	(,)	bits
Z incremental velocity	4	long	(,)	bits
X incremental angle	4	long	(,)	bits
Y incremental angle	4	long	(,)	bits
Z incremental angle	4	long	(,)	bits
Data status	1	byte	Bit (set) Status 0 1 bad raw IMU frame 1 2 bad raw IMU frames 2 3 bad raw IMU frames	
IMU type	1	byte	0-255	
POS IMU data rate *(future use)*	1	byte	Value Data Rate (Hz) 0 50 1 100 2 200 3 400 4 125 5 500	
IMU status	2	ushort	IMU summary status word	
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.1.5 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 TNG3 receives. A client can use this message to attach GPS/UTC time to external events.

Table 20: Group 5: Event 1

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	5	N/A
Byte count	2	ushort	36	bytes
Time/Distance Fields	26	*See Table 3*		
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

4.3.1.6 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 TNG3 receives. A client can use this message to attach GPS/UTC time to external events.

Table 21: Group 6: Event 2

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	6	N/A
Byte count	2	ushort	36	bytes
Time/Distance Fields	26	*See Table 3*		
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

4.3.1.7 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 TNG3 synchronization to the PPS time provided by the primary GPS receiver as follows:

No synchronization indicates that the POS TNG3 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 TNG3.

Synchronizing indicates that the POS TNG3 is in the process of synchronizing to GPS time. This lasts on the order of 10-20 seconds as the POS TNG3 establishes its internal clock offset and drift parameters.

Fully synchronized indicates that the POS TNG3 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 TNG3 is using the last good clock offset to compute GPS times. The POS TNG3 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 TNG3. It allows an external device to acquire GPS or UTC time, or to relate GPS time to POS TNG3 time.

Table 22: 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
Time/Distance Fields	26	*See Table 3*		
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

4.3.1.8 Group 8: Logging Parameters and Status

This group describes the status of data logging through the logging port. This information allows the user to determine the amount of disk space and time used and remaining.

Table 23: Group 8: Logging Information

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	8	N/A
Byte count	2	ushort	4848	N/A
Time/Distance Fields	26	*See Table 3*		
Disk Kbytes remaining	4	ulong	[0,)	Kbytes
Disk Kbytes logged	4	ulong	[0,)	Kbytes
Disk logging time remaining	4	float	[0,)	Seconds
Disk Kbytes total	4	ulong	[0,)	Kbytes
Logging State	1	byte	0 Standby 1 Logging 2 Buffering 255 Invalid	
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group End	2	char	$#	N/A

4.3.1.9 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 24: 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
Time/Distance Fields	26	*See Table 3*		
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	

Item	Bytes	Format	Value	Units
Cycle slip flag	2	ushort	Bits 0-11: $(k\text{-}1)^{th}$ bit set to 1 implies cycle slip in channel *k*. Example: Bit 3 set to 1 implies cycle slip in channel 4. Bits 12-15 are not used.	
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

4.3.1.10 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 Vehicle.

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 25: 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
Time/Distance Fields	26	*See Table 3*		

Item	Bytes	Format	Value	Units
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
			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

Item	Bytes	Format	Value	Units
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
			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

Item	Bytes	Format	Value	Units
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
			Gimbal data gap	bit 27: set
			DMI failed or is offline	bit 28: set
			IIN WL ambiguity error	bit 30: set
			IIN NL ambiguity error	bit 31: set
			Spare	bits: 4, 13-15, 24, 28, 29
FDIR Level 1 IMU failures	2	ushort	Shows number of FDIR Level 1 Status IMU failures (bits 0 or 1) = Bad IMU Frames	

Item	Bytes	Format	Value	Units
FDIR Level 2 status	2	ushort	Inertial speed exceeds maximum Primary GPS velocity exceeds maximum Primary GPS position error exceeds maximum Auxiliary GPS position error exceeds maximum DMI speed exceeds maximum 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: 5-15
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 Excessive primary GPS lever arm error Excessive auxiliary 1 GPS lever arm error Excessive auxiliary 2 GPS lever arm error Excessive POS position error RMS Excessive primary GPS clock drift Spare	bit 0: set bit 1: set bit 2: set bit 3: set bit 4: set bit 5: set bit 6: set bit 7: set bit 8: set bit 9: set bit10:set bit11:set bits: 11-15
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.1.11 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 26: 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
Time/Distance Fields	26	*See Table 3*		
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
Channel status	variable	*See Table 8*		
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. See one of Table 12 to Table 16 for format.	
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.1.12 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.

4.3.1.13 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 27 specifies the format for both Groups 12 and 13

Table 27: 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
Time/Distance Fields	26	*See Table 3*		
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
Channel status	variable	*See Table 8*		
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

Item	Bytes	Format	Value		Units
NMEA messages Received	2	ushort	Bit (set) 0 1 2 3 4-15	NMEA Message GGA (GPS position) GST (noise statistics) GSV (satellites in view) GSA (DOP & active SVs) Reserved	
Aux 1/2 in Use	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

4.3.1.14 Group 14: Calibrated Installation Parameters

This group lists the calibrated installation parameters that the POS TNG3 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 5.4.3.8).
- A parameter is not calibrated during a calibration of the parameter because the Vehicle has not executed the required dynamics to effect the calibration.

Table 28: 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
Time/Distance Fields	26	*See Table 3*		
Calibration status	2	See Table 29		
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
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

Item	Bytes	Format	Value	Units
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 29: 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

4.3.1.15 Group 15: Time-tagged DMI Data

This group contains DMI data as processed and used by the POS TNG3. The signed distance traveled is the distance traveled in meters where the direction sense is dependent on the DMI sensor and on which side of the vehicle the DMI sensor is mounted. The unsigned distance traveled is the absolute value of distance traveled in both forward and backward directions. The distance traveled measurements use the POS TNG3 real-time DMI scale factor. The scale factor may change at any time during real-time navigation. For this reason, the group includes the current DMI scale factor and a DMI data status value that indicates a new scale factor.

Table 30: Group 15: Time-tagged DMI data

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	15	N/A
Byte count	2	ushort	52	bytes
Time/Distance Fields	26	*See Table 3*		
Signed distance traveled	8	double	(,)	meters
Unsigned distance traveled	8	double	[0,)	meters
DMI scale factor	2	ushort	[0, 65534]	meters/pulse
Data status	1	byte	0 Invalid 1 Valid 2 Scale factor change	
DMI type	1	byte	0 None 1 Pulse and Direction 2 Quadrature	
DMI data rate (Data rate of this group may be different from the internal DMI data rate) *(future use)*	1	byte	Value Data Rate (Hz) 0 50 1 100 2 200 3 400 4 125	
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.1.16 Group 16: Time-tagged Gimbal Data

This group contains time-tagged gimbal data as received and used by the POS TNG3.

Table 31: Group 16: Time-tagged gimbal data

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	16	N/A
Byte count	2	ushort	56	bytes
Time/Distance Fields	26	*See Table 3*		
Roll encoder value	8	double	(,)	degrees
Tilt encoder value	8	double	(,)	degrees
Pan encoder value	8	double	(,)	degrees
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.1.17 Group 17: User Time Status

This group contains status information about user time synchronization.

Table: Group 17: User Time Status

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	17	N/A
Byte count	2	ushort	40	bytes
Time/Distance Fields	26	*See Table 3*		
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

4.3.1.18 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 32: 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
Time/Distance Fields	26	*See Table 3*		
Number of satellites	2	ushort	[0, 12]	N/A
A priori PDOP	4	float	[0, 999]	N/A
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	Bits 0-11: $(k\text{-}1)^{th}$ 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. Bits 12-15 are not used.	

Item	Bytes	Format	Value	Units
L2 cycle slip flag	2	ushort	Bits 0-11: $(k\text{-}1)^{th}$ 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. Bits 12-15 are not used.	
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.1.19 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 TNG3 serial ports. This group contains status information about the modem connected to the serial port associated with the Base GPS 1 input.

4.3.1.20 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 33: Group 21/22: Base GPS 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
Time/Distance Fields	26	*See Table 3*		
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

4.3.1.21 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.

4.3.1.22 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 34: Group 23/24: Auxiliary 1 and 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
Time/Distance Fields	26	*See Table 3*		
reserved	6	byte	N/A	N/A
Variable message byte count	2	ushort	[0,)	bytes
Auxiliary GPS raw data	*variable*	*char*	*N/A*	*N/A*
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.1.23 Group 25: Primary GPS Receiver Integrated DGPS Status

This group contains the Primary GPS Receiver *Integrated DGPS* status of Beacon or Satellite services. This Group is output at a frequency of 1 Hz. This Group is only output when GPS Type 12 is installed as the Primary GPS receiver. The information in this Group should be used with Group 26, on page 47 and Message 41 on page 101.

The *Frequency* field corresponds to either Beacon station frequency or OmniSTAR or LandStar satellite frequency.

The *SNR* field is the channel (0 or 1) signal to noise ratio ranging from 0-25.5 dB, in 0.1 dB units.

The *User Access* field corresponds to the availability of Satellite services Availability and Activation.

Table 35: Group 25: Primary GPS Receiver Integrated DGPS Status

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	25	N/A
Byte count	2	ushort	74	bytes
Time/Distance Fields	26	*See Table* 3		
Mobile Differential Mode	1	byte	0 Manual GPS 1 Manual DGPS 2 Differential Auto DGPS or GPS 3 Unknown 4-255 Reserved	N/A
Begin Beacon Channel 0 or Satellite Channel Data Block				
Frequency	8	double	(0,)	Hz
Acquisition Mode	1	byte	Channel 0 Acquisition Mode 0 Manual Mode 1 Auto Distance Mode 2 Auto Power Mode 4 Disable 5 Satellite Mode 6-255 Reserved	N/A

Item	Bytes	Format	Value	Units
Channel Status	1	byte	Channel 0 status 0 Idle – channel is powered down 1 Wideband FFT search 2 Searching for signal 3 Channel acquired signal 4 Channel is locked on signal 5 Channel is disabled 6-255 Reserved	N/A
RCTM Used flag	1	byte	Channel 0 RTCM flag settings 0 Channel 0 is not the source of RTCM differential corrections 1 Channel 0 is the source of RTCM differential corrections 2-255 Reserved	N/A
SNR	1	byte	[0x00-0xFF]	dB
Data Rate Index	1	byte	Channel 0 data transfer rate 0 25 bps 1 50 bps 2 100 bps 3 200 bps 4 600 bps 5 1200 bps 6 2400 bps 7 4800 bps 8-255 Reserved	bit/sec
Lock Indicator	1	byte	[0x00-0xFF]	N/A
DGPS Source Auto Switching	1	byte	Channel 0 DGPS source auto-switching state: 0 Disabled 1 Enabled 2-255 Reserved	N/A
Service Provider	1	byte	Service Provider 0 Unknown 1 Beacon 2 OmniSTAR 3 LandStar 4-255 Reserved	N/A
Begin Beacon Channel 1 data block (invalid data for Satellite)				
Frequency	8	double	(0,)	Hz

Item	Bytes	Format	Value	Units
Acquisition Mode	1	byte	Channel 1 Acquisition Mode 0 Manual Mode 1 Auto Distance Mode 2 Auto Power Mode 4 Disable 5 Satellite Mode 6-255 Reserved	N/A
Channel Status	1	byte	Channel 1 status 0 Idle – channel is powered down 1 Wideband FFT search 2 Searching for signal 3 Channel acquired signal 4 Channel is locked on signal 5 Channel is disabled 6-255 Reserved	N/A
RCTM Used flag	1	byte	Channel 1 RTCM flag settings 0 Channel 1 is not the source of RTCM differential corrections 1 Channel 1 is the source of RTCM differential corrections 2-255 Reserved	N/A
SNR	1	byte	[0x00-0xFF]	dB
Data Rate Index	1	byte	Channel 1 data transfer rate 0 25 bps 1 50 bps 2 100 bps 3 200 bps 4 600 bps 5 1200 bps 6 2400 bps 7 4800 bps 8-255 Reserved	bit/sec
Lock Indicator	1	byte	[0x00-0xFF]	N/A
DGPS Source Auto Switching	1	byte	Channel 1 DGPS source auto-switching state: 0 Disabled 1 Enabled 2-255 Reserved	N/A

Item	Bytes	Format	Value	Units
Service Provider	1	byte	Service Provider 0 Unknown 1 Beacon 2 OmniSTAR 3 LandStar 4-255 Reserved	N/A
Satellite Service Provider Information (OmniSTAR or LandStar)				
User ID Code	8	long		N/A
User Access	1	byte	Reports current state of User Access information: 0 Access information unavailable 1 User Omnistar disabled 2 User Omnistar enabled 3 User Landstar disabled 4 User Landstar enabled 5-255 Reserved	N/A
Decoder State	1	byte	Current state of decoder 0-4 Initialization in progress 5 Initialization complete 6 User access confirmed 7 RTCM data received 8 Decoder reset detected 9 Decoder unavailable 10 No new RTCM data 11 Need data update from master station 12 No offshore operation permitted 13 Invalid region of operation 14 Invalid satellite link 15-255 Reserved	N/A
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.1.24 Group 26: Primary GPS Receiver DGPS Station Database

This Group contains the station information database for the Integrated Beacon DGPS Service. It is sent out at a frequency of 0.1 Hz. This group is only output when GPS Type 12 is installed as the Primary GPS receiver. The information in this Group should be used with Group 25, on page 43 and Message 41 on page 101.

In Table 37, the *Seconds* field is the number of seconds since database record was updated.

Table 36: Group 26: Primary GPS Receiver DGPS Station Database

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	26	N/A
Byte count	2	ushort	30 + (24 × number of records)	bytes
Time/Distance Fields	26	*See Table* 3		
Station Records	variable	*See Table 37* *0 to 10 Station Record elements*		
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

Table 37: Definition of Integrated DGPS Station Record element

Item	Bytes	Format	Value	Units
Record Index and Flags	1	byte	*See Table 38*	N/A
Station ID	2	ushort	[0,1023]	N/A
Station Frequency	2	ushort	[2835,3250]	10 * kHz
Station Health	1	byte	Health of station: 0 Normal Health 1 Not monitored 2 No information available 3 Do not use 4-255 Reserved	N/A
Distance	4	float	[0,)	m
Range	4	float	[0,)	m
USCG Index	1	byte	(1,10) or 128	N/A
Seconds	8	long	[0,)	sec

Item	Bytes	Format	Value	Units
Modulation Rate	1	byte	Modulation rate: 0 25 bps 1 50 bps 2 100 bps 3 200 bps 4 600 bps 5 1200 bps 6 2400 bps 7 4800 bps 8-255 Reserved	N/A

Table 38: Definition of Integrated DGPS Record Index and Flags bit encoding

Item	Bit #	Format	Value	Units
Index number of database	7-4	bits	[0,9]	N/A
Satellite DGPS Database	3	bit	If Satellite Info 0 database of Racal LandStar stations 1 database of Omnistar stations	N/A
Station used as RTCM source	2	bit	if set	N/A
Station providing network corrections	1	bit	if set	N/A
Database type	0	bit	0 Beacon DGPS Database 1 Satellite DGPS Database	N/A

4.3.1.25 Group 99: Versions and Statistics

This group provides feedback of the current statistics and software and hardware version numbers of the POS TNG3. This group contains operational statistics such as total hours of operation, number of runs, average run length, and longest run.

Table 39: 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
Time/Distance Fields	26	*See Table 3*		
System version	120	Char	Product – Model, Version, Serial Number, Hardware version, 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: AV-310,VER3,S/N123,HW01.50, SW01.12-Aug3/00,ICD01.00, OS425B,IMU2,PGPS2,SGPS1, DMI1,GIM0,RTK-75,YDC-0 N/A	
Primary GPS version	80	char	Available information is displayed, eg: • Model number • Serial number • Hardware configuration version • Software release version • Release date	

Item	Bytes	Format	Value	Units
Secondary GPS version	80	Char	Available information is displayed, eg: • Model number • Serial number • Hardware configuration version • Software release version • 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

4.3.2 Raw Data Groups

4.3.2.1 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 will depend on the primary GPS receiver that the POS TNG3 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 40: 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
Time/Distance Fields	26	*See Table 3*		
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
GPS Receiver raw data	*variable*	*char*	*N/A*	*N/A*
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.2.2 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 TNG3 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 TNG3 supports.

Table 41: Group 10002: Raw IMU data

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	10002	N/A
Byte count	2	ushort	variable	bytes
Time/Distance Fields	26	*See Table 3*		
IMU header	6	char	*$IMUnn* where *nn* identifies the IMU type.	
Variable message byte count	2	ushort	[0,)	bytes
IMU raw data	*variable*	*byte*	*N/A*	*N/A*
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

4.3.2.3 Group 10003: Raw PPS

This group contains the raw PPS data that the POS TNG3 generates. The time of the PPS is given in the Time/Distance fields.

Table 42: 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
Time/Distance Fields	26	*See Table 3*		
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

4.3.2.4 Group 10004: Raw Event 1

This group contains the raw Event 1 data that the POS TNG3 generates. The time of the event pulse count is given in the Time/Distance fields.

4.3.2.5 Group 10005: Raw Event 2

This group contains the raw Event 2 data that the POS TNG3 generates. The time of the event pulse count is given in the Time/Distance fields.

Table 43: 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
Time/Distance Fields	26	*See Table 3*		
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

4.3.2.6 Group 10006: Raw DMI Data Stream

This group contains the raw DMI sensor data in the following format. The up/down pulse count comprises the signed sum of DMI pulses where the direction sense is dependent on the DMI sensor and on which side of the vehicle the DMI sensor is mounted. The rectified pulse count comprises the unsigned sum of DMI pulses, and indicates the total distance travelled either forward or backwards.

Table 44: Group 10006: Raw DMI data stream

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	10006	N/A
Byte count	2	ushort	48	bytes
Time/Distance Fields	26	*See Table 3*		
Up/down pulse count	4	long	$[-2^{23}, 2^{23}-1]$	N/A
Rectified pulse count	4	ulong	$[0, 2^{24}-1]$	N/A
Event count	4	long	$[-2^{23}, 2^{23}-1]$	N/A
Reserved count	4	ulong	$[0, 2^{24}-1]$	N/A
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.2.7 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.

4.3.2.8 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 45: Group 10007/10008: Auxiliary 1 and 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
Time/Distance Fields	26	*See Table 3*		
reserved	2	byte	N/A	N/A
reserved	4	long	N/A	N/A
Variable message byte count	2	ushort	[0,)	bytes
Auxiliary GPS raw data	*variable*	*char*	*N/A*	*N/A*
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.2.9 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 will depend on the secondary GPS receiver that the POS TNG3 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 46: 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
Time/Distance Fields	26	*See Table 3*		
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
GPS Receiver Message	*variable*	*char*	*N/A*	*N/A*
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.2.10 Group 10010: Raw Gimbal Data Stream

This group contains the raw gimbal data stream as received by the POS TNG3 through the user-selected gimbal input port. The group length is variable, dependent on the gimbal record format used. The Gimbal data stream is packaged into the group as it is received, irrespective of Gimbal message boundaries. The timestamp on this group is accurate to within 5 milliseconds.

Table 47: Group 10010: Raw Gimbal data stream

Item	Bytes	Format	Value	Units
Group start	4	char	$GRP	N/A
Group ID	2	ushort	10010	N/A
Byte count	2	ushort	variable	bytes
Time/Distance Fields	26	*See Table 3*		
Variable message byte count	2	ushort	[0,)	bytes
Message body	*variable*	*ushort*	*N/A*	*N/A*
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

4.3.2.11 Group 10011: Base GPS 1 Data Stream

This group contains the message data stream the POS TNG3 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.

4.3.2.12 Group 10012: Base GPS 2 Data Stream

This group contains the message data stream the POS TNG3 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 48: Group 10011/10012: Differential corrections 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
Time/Distance Fields	26	*See Table 3*		
reserved	6	byte	N/A	N/A
Variable message byte count	2	ushort	[0,)	bytes
Base GPS raw data	*variable*	*byte*	*N/A*	*N/A*
Pad	0-3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Group end	2	char	$#	N/A

5 Message Input and Output

5.1 Introduction

The POS TNG3 uses the Control Port to receive control messages from the POS Controller 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 the POS TNG3 causes the POS TNG3 to initiate an action. When the POS TNG3 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 TNG3 has received a message, and has either accepted or rejected it. In addition, POS TNG3 will also output a message echo on each of the Display, Data and Logging ports to indicate the current system state, regardless of whether the action was successful or not.

5.2 Message Output Data Rates

The POS TNG3 periodically generates copies (echos) of received control message or internally generated messages at maximum frequencies described in Table 49. This output allows a POS Controller to monitor the current state of the configuration of the POS TNG3. The content of the output messages reflects the current state of the POS TNG3. Thus, if the state of the system changes, as part of the normal operations, it will be reflected in the next set of echo messages from the POS TNG3.

5.2.1 Message Numbering Convention

All POS products use the following message numbering convention. The POS TNG3 outputs the message categories shown. Reserved message numbers are assigned to other products or previous versions of POS products. In particular, POS TNG0 core messages occupy the namespace range 1-19. All messages specific to POS products occupies the namespace range 100-19999.

0	Acknowledge message
1-19	Reserved
20-49	Installation parameter set-up messages
50-79	Processing control messages
80-89	Reserved
90-99	Program control override messages
100 and on	Reserved

The **Acknowledge message** is the message that the POS TNG3 sends as a reply to a message from the POS Controller. It is described in detail in Section 5.4.1.1 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 TNG3. 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 the POS TNG3 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 allow the user to directly control functions that the POS TNG3 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 TNG3 to re-configure the receiver. This message category also includes control messages that alter the normal operation or output of the POS TNG3 for diagnosis purposes. The actions induced by these messages are not part of the normal POS TNG3 operation and should be interpreted only by qualified Applanix service personnel.

5.2.2 Compatibility With Previous POS Products

The compatibility of POS TNG3 messages with POS TNG0 products is given as follows:

The POS TNG3 message format is the same as that of all POS TNG0 products.

The POS TNG3 Message 0 is the same as that of all POS TNG0 products.

The POS TNG3 message namespace occupies 20-98, which does not intersect the core message namespace for all POS TNG0 products. Several POS TNG3 messages either are the same or command similar actions or functions as POS TNG0 core messages in the namespace 1-19. This separation of the message namespace allows for the unrestricted re-organization of the POS TNG3 messages and re-design of their content without creating compatibility problems.

Table 49: Control messages output data rates

Message	Contents	Display Port		Data Port		Logging Port	
		Standby	Navigate	Standby	Navigate	Standby	Navigate
0	Acknowledge	-	-	-	-	-	-
Installation Parameter Set-up Messages							
20	General installation parameters[1]	1.0	1.0	0.1	0.1	0.1	0.1
21	GAMS installation parameters	1.0	1.0	0.1	0.1	0.1	0.1
22	Aiding sensor installation parameters	1.0	1.0	0.1	0.1	0.1	0.1
23	Gimballed platform installation parameters	1.0	1.0	0.1	0.1	0.1	0.1
24	User accuracy specifications	1.0	1.0	0.1	0.1	0.1	0.1
25	Zero-velocity update control	1.0	1.0	0.1	0.1	0.1	0.1
30	Primary GPS set-up	1.0	1.0	0.1	0.1	0.1	0.1
31	Secondary GPS set-up	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 discretes set-up	1.0	1.0	0.1	0.1	0.1	0.1
34	COM port set-up	1.0	1.0	0.1	0.1	0.1	0.1
35	NMEA message select	1.0	1.0	0.1	0.1	0.1	0.1
36	Binary message select	1.0	1.0	0.1	0.1	0.1	0.1
37	Base GPS 1 Set-up	1.0	1.0	0.1	0.1	0.1	0.1
38	Base GPS 2 Set-up	1.0	1.0	0.1	0.1	0.1	0.1
40	Gravity correction	1.0	1.0	0.1	0.1	0.1	0.1
41	Integrated DGPS Source Control	1.0	1.0	0.1	0.1	0.1	0.1
Processing Control Messages							
50	Navigation mode control	1.0	1.0	1.0	0.1	0.1	0.1
51	Display Port control	1.0	1.0	1.0	0.1	0.1	0.1
52	Data Port control	1.0	1.0	1.0	0.1	0.1	0.1
53	Logging Port control	1.0	1.0	1.0	0.1	0.1	0.1
54	Save/restore parameters command	-	-	-	-	-	-
55	Time synchronisation 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	Position fix control	1.0	1.0	0.1	0.1	0.1	0.1
61	Second Data Port control	1.0	1.0	1.0	0.1	0.1	0.1
Program Control Override Messages							
90	Program control	-	-	-	-	-	-
91	GPS control	-	-	-	-	-	-
92	Integration diagnostics control	1.0	1.0	1.0	0.1	0.1	0.1
93	Aiding sensor integration control	1.0	1.0	1.0	0.1	0.1	0.1

5.3 Message Format

5.3.1 Introduction

All control messages have the format described in Table 50. The messages consist of a *header*, the message *body* and a *footer*. The next section describes the specific message formats.

[1] *Message is saved in NVM*

Table 50: 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
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Message body	*Message dependent format and content.*			
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 will always be 8 bytes less than the length of the complete message.

The *transaction number* is a number, which is attached to the input message by the client. The POS TNG3 returns this number to the user in the *Acknowledge* message (ID 0). This mechanism shall allow the client to know which message the POS TNG3 is responding to. This number must be between 0 and 65535.

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 90 in Appendix A: Data Format Description. The POS TNG3 will ignore invalid values that it receives in fields containing numerical values. This does not apply to fields containing bit settings.

5.4 Messages Tables

5.4.1 General Messages

The following tables list the format that the POS TNG3 expects for each message input and provides for each message output.

5.4.1.1 Message 0: Acknowledge

The POS TNG3 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 TNG3. Some changes of state such as navigation mode transitions may require several seconds to complete. The POS TNG3 sends Message 0: Acknowledge indicating that the transition is in progress but not necessarily complete. For example, the POS TNG3 replies to a message commanding the POS TNG3 to transition to Navigate mode as soon as the mode transition begins.

2. The control message from the POS Controllercontains new POS TNG3 installation or set-up parameters that replace the parameters currently used by the POS TNG3. The Acknowledge message then indicates whether the POS TNG3 has received and begun to use the new parameters. The POS TNG3 will respond 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 TNG3 will subsequently transmit the requested groups on the Display, Data, and/or Logging ports. If the data for one or more of the requested groups are not current at the time of request, the POS TNG3 outputs the group(s) with stale fields set to invalid values as described in Table 90. Message 0: Acknowledge will indicate 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 POS TNG3 parameters. This allows a POS Controller to prompt the user to direct the POS TNG3 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.

The POS TNG3 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 51: 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 52	N/A
New parameters status	1	byte	**Value** **Message** 0 No change in parameters 1 Some parameters changed 2-255 Reserved	N/A
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 52: Message response codes

Field Value	Field Name	Description
0	Not applicable	The message is not applicable to the POS TNG3.
1	Message accepted	The POS TNG3 has properly accepted the message from the POS Controller.
2	Message accepted – too long	The POS TNG3 has accepted the messaged from the POS Controller. This is a warning that the POS TNG3 expected a shorter message than the one received. This could be caused if the POS TNG3 and the POS Controller have different ICD versions.
3	Message accepted – too short	The POS TNG3 has accepted the messaged from the POS Controller. This is a warning that the POS TNG3 expected a longer message than the one received. This could be caused if the POS TNG3 and the POS Controller have different ICD versions.
4	Message parameter error	The message contains one or more parameter errors.
5	Not applicable in current state	The POS TNG3 cannot process the message or cannot output data requested in its current state.

Field Value	Field Name	Description
6	Data not available	The requested data is not available from the POS TNG3.
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 the POS TNG3's internal buffer.
10	Checksum error	The message checksum validation failed.
11-65535	Reserved	Reserved

5.4.2 Installation Parameter Set-up Messages

5.4.2.1 Message 20: General Installation and Processing Parameters

This message contains general installation parameters that the POS TNG3 requires to correctly process sensor data and output the computed navigation data. The POS TNG3 accepts this message at any time. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 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 the POS TNG3 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 the POS TNG3 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 the POS TNG3 to enable or disable the AutoStart function. When AutoStart is enabled, the POS TNG3 enters Navigate mode immediately on power-up using the parameters stored in its NVM. When Autostart is disabled, the POS TNG3 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 and DMI) with respect to user-defined reference and Vehicle coordinate frames. These coordinate frames and the installation data contained in this message are defined for an IMU that is rigidly mounted to the Vehicle. If the IMU is mounted on a gimballed platform that can rotate with respect to the Vehicle, then the definitions of these coordinate frames are modified by Message 23: Gimballed Platform IMU Installation Parameters.

The *Vehicle frame* is a right-handed coordinate frame that is fixed to the Vehicle. The X-Y-Z axes are directed along the forward, right and down directions of the Vehicle. On a vessel, these

are the forward along beam, starboard and vertical directions. On an aircraft, these are the forward, right-wing and vertical directions.

The *reference frame* is a user-defined coordinate frame whose navigation solution the POS TNG3 computes. It can be thought of as defining the desired position and orientation of the IMU. It is also the coordinate frame in which the relative positions and orientations of the IMU and aiding sensors are measured. Its origin coincides with the Vehicle frame origin, however it is not necessarily aligned with the Vehicle 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 Vehicle 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*.

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*. The POS TNG3 uses these lever arm components whenever it processes data from an optional auxiliary 1 GPS receiver. If the POS TNG3 does not receive 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*. The POS TNG3 uses these lever arm components whenever it processes data from an optional auxiliary 2 GPS receiver. If the POS TNG3 does not receive 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 Vehicle. 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:

1. right-hand screw rotation of θ_z about the z axis
2. right-hand screw rotation of θ_y about the once rotated y axis
3. 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 Vehicle Frame mounting angles

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

4. right-hand screw rotation of θ_z about the z axis
5. right-hand screw rotation of θ_y about the once rotated y axis
6. 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 reference frame with respect to the Vehicle frame.

When the IMU is mounted on a gimballed platform, the Reference frame can rotate with respect to the Vehicle frame. In this case, (θ_x, θ_y, θ_z) are the angular offsets of the Reference frame in its “home” position, when the gimbal shaft angles are all zero.

Multipath Setting

The Multipath Environment field directs the POS TNG3 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*, the POS TNG3 assumes virtually no multipath error in the primary, secondary and auxiliary GPS data. If the user selects *MEDIUM* or *HIGH*, the POS TNG3 assumes respectively moderate or severe multipath errors, and accounts for these in its GPS processing algorithms.

Table 53: 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	Input: Transaction number Output: [65533, 65535]	N/A
Time types	1	byte	Value (bits 0-3) Time type 1 0 POS time 1 GPS time (default) 2 UTC time 3-16 Reserved Value (bits 4-7) Time type 2 0 POS time (default) 1 GPS time 2 UTC time 3 User time 4-16 Reserved	
Distance type	1	byte	Value State 0 N/A 1 POS distance (default) 2 DMI distance 3-255 Reserved	
Select/deselect AutoStart	1	byte	Value State 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

Item	Bytes	Format	Value	Units
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 GPS Y lever arm	4	float	(,) default = 0	meters
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 Vehicle frame mounting angle	4	float	[-180, +180] default = 0	degrees
Y Reference frame wrt Vehicle frame mounting angle	4	float	[-180, +180] default = 0	degrees
Z Reference frame wrt Vehicle frame mounting angle	4	float	[-180, +180] default = 0	degrees
Multipath environment	1	byte	Value: Multipath 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

5.4.2.2 Message 21: GAMS Installation Parameters

This message contains the GAMS installation parameters. The POS TNG3 accepts this message at any time. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 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. The POS TNG3 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 TNG3 computed in a previous GAMS calibration. The POS TNG3 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 TNG3 will use for executing a GAMS baseline calibration. If the current heading error RMS exceeds the specified maximum when the user commands a GAMS calibration, then the POS TNG3 will defer 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. The POS TNG3 computes a new baseline vector that has been rotated so that the POS TNG3 computed heading changes by the specified heading correction when GAMS is on-line.

Table 54: 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	Input: Transaction number Output: [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

5.4.2.3 Message 22: Aiding Sensor Installation Parameters

This message contains supplementary aiding sensor installation parameters that the POS TNG3 requires to correctly process sensor data and output the computed navigation data. Supplementary aiding sensors include a DMI and a DVS. Other supplementary aiding sensor may be added to the list that the POS TNG3 supports, in which case this message will be expanded to include the additional installation parameters.

The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

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

DMI Parameters

The Distance Measurement Indicator (DMI) or odometer parameters comprise the installation parameters for a single DMI. The POS TNG3 assumes that the DMI measures the along-track incremental position changes of the Vehicle and that the cross-track position changes average out to zero. Two types of DMI are compatible with the POS TNG3. One generates a series of pulses, each of which indicate an incremental change in the Vehicle's along-track position, plus a direction signal that indicates the direction of along-track motion. The other generates two series of pulses of the same frequency, where each pulse indicates an incremental change in the Vehicle's along-track position, and the phase relationship between the pulse streams indicates the direction of along-track motion. The interpretation of the DMI's direction sense is dependent on the type of DMI sensor used as well as the side of the Vehicle that the DMI sensor is mounted on.

The *DMI Scale Factor* field contains the integer number of pulses per meter that the DMI generates. For rotaryrotatary-type DMI sensors, this is usually the number of pulses per revolution divided by the wheel circumference. The sign of the DMI scale factor is made positive or negative, depending on the DMI direction signal with respect to the direction assumed by the POS TNG3, the type of DMI sensor and its mounting location on the Vehicle.

The *DMI frame* is a right-handed coordinate frame whose origin is called the DMI reference position. The DMI reference position is typically the average point of contact of the DMI-instrumented wheel with the road or rail. The X-Y-Z axes are assumed to be aligned with the Vehicle frame X-Y-Z axes. The *DMI lever arm components* contain the X-Y-Z components of the Reference-to-DMI lever arm. No Reference-to-DMI orientation angles are therefore available to describe the DMI-to-Reference orientation angles, as these are described by the Vehicle-to-Reference orientation angles.

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

Reference to DMI lever arm components

These are the X-Y-Z distances from the user-defined reference frame origin to the DMI reference position, resolved in the *reference frame*.

DVS Parameters

The POS TNG3 assumes that the Doppler Velocity Sensor (DVS) measures three orthogonal components of velocity with respect to a single-transducer phase centre. The transducer can be a radar antenna or a sonar transducer. The DVS transducer thus is assumed to define orthogonal X-Y-Z directions along which the DVS reports velocity components. An actual DVS may comprise individual single-axis transducers at different locations on the Vehicle. The POS TNG3 performs front-end processing of the DVS data from these transducers to generate an equivalent 3-axis velocity measurement referenced to a single "virtual" phase centre.

The *DVS frame* is a right-handed coordinate frame whose origin is the DVS transducer (radar antenna or sonar transducer) phase centre. This formulation assumes that a single real or virtual phase centre is the reference for DVS X-Y-Z velocity measurements. The DVS X-Y-Z axes are directed along the DVS transducer X-Y-Z directions, and are assumed orthogonal.

The *DVS Scale Factor Correction* field contains a correction to the DVS data to handle the case in which the DVS data are Doppler frequencies instead of velocities. The field defaults to 1.0 on the assumption that the DVS reports velocities in meters/second.

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

Reference to DVS lever arm components

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

DVS with respect to Reference frame mounting angles

These are the angular offsets (θ_x, θ_y, θ_z) of the DVS transducer frame with respect to the user-defined reference frame. The angles define the Euler sequence of rotations that bring the reference frame into alignment with the DVS transducer frame. The angles follow the Tate-Bryant sequence of rotation, given as follows:

1. right-hand screw rotation of θ_z about the z axis
2. right-hand screw rotation of θ_y about the once rotated y axis
3. 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 DVS transducer frame with respect to the reference frame.

Table 55: Message 22: Aiding Sensor Installation Parameters

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	22	N/A
Byte count	2	ushort	52	N/A
Transaction Number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
DMI scale factor	4	float	$[-10^6, 10^6]$ default = 1	Pulses per meter
Reference to DMI X lever arm	4	float	(,) default = 0	meters
Reference to DMI Y lever arm	4	float	(,) default = 0	meters
Reference to DMI Z lever arm	4	float	(,) default = 0	meters
DVS scale factor	4	float	$[-10^6, 10^6]$ default = 1	unitless
Reference to DVS X lever arm	4	float	(,) default = 0	meters
Reference to DVS Y lever arm	4	float	(,) default = 0	meters
Reference to DVS Z lever arm	4	float	(,) default = 0	meters
X DVS wrt Reference frame mounting angle	4	float	[-180, +180] default = 0	degrees
Y DVS wrt Reference frame mounting angle	4	float	[-180, +180] default = 0	degrees
Z DVS wrt Reference frame mounting angle	4	float	[-180, +180] default = 0	degrees
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.2.4 Message 23: Gimballed Platform Installation Parameters

This message supplements Message 20: General Installation and Processing Parameters when the IMU is mounted on a gimballed platform. In this case, the POS TNG3 is expected to import gimbal angles from the gimballed platform that describe the relative orientation of the platform with respect to a *home orientation*. The POS TNG3 accepts this message at any time. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

Dynamic Levers Arm Selection

The *Select/Deselect Dynamic Lever Arms* field directs the POS TNG3 to enable or disable dynamic lever arms computations. When dynamic lever arms are enabled, the POS TNG3 looks for gimbal angle data on the COM port configured for gimbal input, and from these computes lever arms between the IMU on a possibly rotating gimballed platform and the primary and auxiliary GPS antennas (and other aiding sensors) that are fixed to the Vehicle. When dynamic lever arms are disabled, the POS TNG3 ignores the gimbal angle data and computes static lever arms.

Lever Arms and Mounting Angles

The *gimbal frame* is a right-handed coordinate frame that is fixed to the gimballed platform with its origin located at the centre of platform rotation with respect to the platform case or housing. This frame is provided as a reference for measurement of the IMU installation.

The *gimbal home frame* is a right-handed coordinate frame that coincides with the gimbal frame when the platform is at its home orientation, i.e. when the gimbal angles are all zero. The platform gimbal angles imported by the POS TNG3 describe the orientation of the gimbal frame with respect to the gimbal home frame. The gimbal and gimbal home frames have coincident origins.

The reference to IMU lever arm components and IMU with respect to reference frame orientation angles given in Message 20: General Installation and Processing Parameters now have different interpretations. The Message 20 reference-to-IMU lever arm components become the components of the lever arm from the reference frame to the gimbal home frame origin. The Message 20 IMU with respect to reference frame orientation angles become the Euler angles of the gimbal home frame with respect to the reference frame.

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

Gimbal to IMU lever arm components

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

IMU with respect to Gimbal frame mounting angles

These are the angular offsets (θ_x, θ_y, θ_z) of the IMU frame with respect to the user-defined gimbal frame. The angles define the Euler sequence of rotations that bring the gimbal frame into alignment with the IMU frame. The angles follow the Tate-Bryant sequence of rotation, given as follows:

1. right-hand rotation of θ_z about the z axis
2. right-hand rotation of θ_y about the once rotated y axis
3. right-hand 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 frame with respect to the gimbal frame.

Table 56: Message 23: Gimballed Platform IMU Installation Parameters

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	23	N/A
Byte count	2	ushort	32	N/A
Transaction Number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Select/deselect dynamic lever arms	1	byte	Value State 0 Static lever arms (default) 1 Dynamic lever arms 2-255 Reserved	
Gimbal to IMU X lever arm	4	float	(,) default = 0	meters
Gimbal to IMU Y lever arm	4	float	(,) default = 0	meters
Gimbal to IMU Z lever arm	4	float	(,) default = 0	meters
X IMU wrt Gimbal frame mounting angle	4	float	[-180, +180] default = 0	degrees
Y IMU wrt Gimbal frame mounting angle	4	float	[-180, +180] default = 0	degrees
Z IMU wrt Gimbal frame mounting angle	4	float	[-180, +180] default = 0	degrees
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.2.5 Message 24: User Accuracy Specifications

This message sets the user accuracy specifications for full navigation status. The POS TNG3 will declare 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.

The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

Table 57: 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	Input: Transaction number Output: 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
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.2.6 Message 25: Zero-Velocity Update Control

This message sets the zero velocity update (ZUPD) control.

The *Control* word specifies the type of ZUPD that the POS TNG3 implements. A Manual ZUPD control directs the POS TNG3 to implement an unconditional ZUPD upon receipt of the message. The remaining fields are not used. The POS TNG3 ends the ZUPD upon receipt of a No ZUPD control.

The Auto-ZUPD controls direct the POS TNG3 to monitor the specified velocity (SNV, DMI or GPS) for a zero velocity condition, and then implement a ZUPD so long as the zero velocity condition holds. The *Detect zero velocity threshold* specifies the zero velocity detection threshold. *Reject zero velocity threshold* specifies the zero velocity rejection threshold. The *Zero velocity test period* field specifies the amount of time the specified velocities must remain below the zero velocity detection threshold before the POS TNG3 declares a zero velocity condition. The *ZUPD standard deviation* specifies the ZUPD standard deviation in each orthogonal direction (for example North, East, Down or X,Y,Z) to be used in the ZUPD measurement.
The POS TNG3 accepts this message at anytime. The Auto-ZUPD parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

Table 58: Message 25: Zero velocity update control

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	25	N/A
Byte count	2	ushort	24	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Control	2	ushort	Value Operation 0 no ZUPD (default) 1 manual ZUPD 2 SNV-detected Auto-ZUPD 3 DMI-detected Auto-ZUPD 4 GPS-detected Auto-ZUPD 5-65535 Reserved	
Detect zero velocity threshold	4	float	[0,) default = 0	meters/second
Reject zero velocity threshold	4	float	[0,) default = 0	meters/second
Zero velocity test period	4	float	[0,) default = 0	seconds
ZUPD standard deviation	4	float	[0,) default = 0	meters/second

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

5.4.2.7 Message 30: Primary GPS Setup

This message contains the setup parameters for the primary GPS receiver. The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

The *Select/Deselect GPS AutoConfig* field directs the POS TNG3 to reconfigure the primary GPS receiver if the POS TNG3 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 messages over its COM1 port to the POS TNG3.

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 current POS TNG3 hardware connects the DIFF 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.

Note that GPS Autoconfig will be turned off upon receipt of an Accept Commands 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 60. They specify the COM2 RS-232 communication protocol settings.

Table 59: 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	Input: Transaction number Output: [65533, 65535]	N/A
Select/deselect GPS AutoConfig	1	byte	Value State 0 AutoConfig disabled 1 AutoConfig enabled (default) 2-255 Reserved	

Item	Bytes	Format	Value		Units
Primary GPS COM1 port message output rate (not supported)	1	byte	Value 1 2 3 4 5 10 11-255	Rate (Hz) 1 (default) 2 3 4 5 10 Reserved	
Primary GPS COM2 port control	1	byte	Value 0 1 2 3-255	Operation Accept RTCM (default) Accept commands Accept RTCA Reserved	
Primary GPS COM2 communication protocol	4	See Table 60 Default: 9600 baud, no parity, 8 data bits, 1 stop bit, none			
Antenna frequency (only applicable for Trimble Force5 GPS receivers)	1	byte	Value 0 1 2	Operation Accept L1 only Accept L1/L2 Accept L2 only	
Pad	2	byte	0		N/A
Checksum	2	ushort	N/A		N/A
Message end	2	char	$#		N/A

Table 60: RS-232/422 communication protocol settings

Item	Bytes	Format	Value	
RS-232/422 port baud rate	1	byte	Value 0 1 2 3 4 5 6 7 8-255	Rate 2400 4800 9600 19200 38400 57600 76800 115200 Reserved

Item	Bytes	Format	Value	
Parity	1	byte	Value	Parity
			0	no parity
			1	even parity
			2	odd parity
			3-255	Reserved
Data/Stop Bits	1	byte	Value	Data/Stop Bits
			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	Value	Flow Control
			0	none
			1	hardware
			2	XON/XOFF
			3-255	Reserved

5.4.2.8 Message 31: Secondary GPS Setup

This message contains the set-up parameters for the secondary GPS receiver. The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

The *Select/Deselect GPS AutoConfig* field directs the POS TNG3 to reconfigure the secondary GPS receiver if the POS TNG3 detects that the secondary GPS configuration is incorrect. If the user chooses to disable auto-configuration, then the user must configure the primary 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 the POS TNG3.

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 TNG3 hardware connects the GPS 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.

The *Secondary GPS COM2 Communication Protocol* fields are elaborated in Table 60. They specify the COM2 RS-232 communication protocol settings.

Table 61: 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	Input: Transaction number Output: [65533, 65535]	N/A
Select/deselect GPS AutoConfig	1	byte	Value — State 0 — AutoConfig disabled 1 — AutoConfig enabled (default) 2-255 — Reserved	
Secondary GPS COM1 port message output rate (Not Supported)	1	byte	Value — Rate (Hz) 1 — 1 (default) 2 — 2 3 — 3 4 — 4 5 — 5 10 — 10 11-255 — Reserved	

Item	Bytes	Format	Value	Units
Secondary GPS COM2 port control	1	byte	Value Operation 0 Accept RTCM (default) 1 Accept commands 2 Accept RTCA 3-255 Reserved	
Secondary GPS COM2 communication protocol	4	See Table 60 Default: 9600 baud, no parity, 8 data bits, 1 stop bit, none		
Antenna frequency (only applicable for Trimble Force5 GPS receivers)	1	byte	Value Operation 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

5.4.2.9 Message 32: Set POS IP Address

This message installs a new IP address and subnet mask in the POS TNG3. The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as "settings"), the POS TNG3 does not save it to NVM but changes OS setup file.

When POS TNG3 has 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 62: 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	Input: Transaction number Output: [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
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

5.4.2.10 Message 33: Event Discrete Setup

This message directs the POS TNG3 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. The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

Table 63: 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	Input: Transaction number Output: [65533, 65535]	N/A
Event 1 trigger	1	byte	Value Command 0 Positive edge (default) 1 Negative edge 2-255 Reserved	
Event 2 trigger	1	byte	Value Command 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

5.4.2.11 Message 34: COM Port Setup

This message sets up the communication protocol and selects the input and output content for all available COM ports. Currently the POS TNG3 implements three ports labelled COM(1), COM(2) and COM(3). This message is structured to accommodate additional COM ports in future product releases.

This message sets up all available COM ports. The user must ensure that the parameters for each COM port are correct. The POS TNG3 will send this message to indicate the states of all COM ports. This message must specify **No input** or a unique input and **No output** or a unique output for each COM port. A message which assigns an input or output selection to more than one COM port contains an assignment conflict. The POS TNG3 will reject a message with assignment conflicts.
Currently COM(3) does not output data for Ampo P5x platform, hence the POS TNG3 ignores a message that specifies COM(3) output to be anything other than **No output** .

Table 64: 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 x *nPorts*	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Number of COM ports	2	ushort	[0,10] Number (*nPorts)* of COM ports assigned by this message.	N/A
COM Port Parameters	8 x *nPorts*	See Table 65 One set of parameters for each of *nPorts* 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 n set COMn parameter in message Bit n clear COMn 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 65: COM port parameters

Item	Bytes	Format	Value		Units
Communication protocol	4	See Table 60 Default: 9600 baud, no parity, 8 data bits, 1 stop bit, none			
Input select	2	ushort	Value	Input	
			0	No input	
			1	Auxiliary 1 GPS	
			2	Auxiliary 2 GPS	
			3	Gimbal	
			4	Base GPS 1	
			5	Base GPS 2	
			6-255	No input	
Output select	2	ushort	Value	Output	
			0	No output	
			1	NMEA messages	
			2	Real-time binary	
			3	Base GPS 1	
			4	Base GPS 2	
			5-255	No output	

5.4.2.12 Message 35: NMEA Message Select

This message selects the NMEA messages and the message rate to be output on the NMEA message port identified in Message 34.

The POS TNG3 implements generic NMEA selections that all derived POS products will output. This message may be superseded by a product-specific message in a derived POS product that outputs additional NMEA messages.

Table 66: Message 35: NMEA message select

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	35	N/A
Byte count	2	ushort	16	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Reserved	3	byte	N/A	

Item	Bytes	Format	Value			Units
Message update rate	2	ushort	Value	Rate (Hz)		
			0	N/A		
			1	1	(default)	
			2	2		
			5	5		
			10	10		
			20	20		
			25	25		
			50	50		
			other values	Reserved		
NMEA message select	4	ulong	Bit	Format	Formula	
			0	$INGST	Pseudorange noise statistics	
			1	$INGGA[1]	GPS fix	
			2	$INHDT	Heading	
			3	$INZDA	NMEA date, time	
			4	$EVT1	Event 1 time mark	
			5	$EVT2	Event 2 time mark	
			6	$INVTG	Track made good ground speed	
			7	$PASHR	Attitude, Tate-Bryant	
			8-12		*reserved*	
			13	$INGGA[2]	GPS fix	
Pad	1	short	0			N/A
Checksum	2	ushort	N/A			N/A
Message end	2	char	$#			N/A

[1] The geoidal separation is set to null to maintain the overall sentence length within the NMEA specification (82 characters) while providing sufficient decimal places for latitude and longitude.

[2] This message outputs geoidal separation but decreases decimal places for latitude and longitude to keep the overall sentence length within the NMEA specification.

5.4.2.13 Message 36: Binary Message Select

This message selects the binary messages and the message rate to be output on the binary message port identified in Message 34.

The POS TNG3 implements generic binary selections that all derived POS products will output. This message may be superseded by a product-specific message in a derived POS product that outputs additional binary messages.

Table 67: Message 36: Binary message select

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	36	N/A
Byte count	2	ushort	16	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Reserved	3	byte	N/A	
Message update rate	2	ushort	Value — Rate (Hz) 0 — N/A 1 — 1 (default) 2 — 2 5 — 5 10 — 10 20 — 20 25 — 25 50 — 50 100 — 100 200 — 200 other values — Reserved	
Binary message select	2	ushort	Value — Message 0 — Gimbal loop back (default) 1 — RDR1 2 — PAST2 3-255 — Reserved	
Pad	3	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

The following are messages selected by the *Binary message select* field:

The *Gimbal Loopback* diagnostic message contains roll, pitch and heading that are compatible with the POS TNG3 generic gimbal input data format. The user can connect an RS-232 cable

from the output port that issues the Gimbal Loopback message to the gimbal data input port and thereby conduct a full test of the gimbal processing function.

5.4.2.14 Message 37: Base GPS 1 Setup

This message selects the message types assigned to the Base GPS 1 port identified in Message 34. If the POS TNG3 is connected to a Hayes compatible telephone modem, then this message directs the POS TNG3's configuration of the modem.

5.4.2.15 Message 38: Base GPS 2 Setup

This message selects the message types assigned to the Base GPS 2 port identified in Message 34. If the POS TNG3 is connected to a Hayes compatible telephone modem, then this message directs the POS TNG3's configuration of the modem.

The *connection control* field will always be set to NO_ACTION when sent by POS TNG3 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 the POS TNG3 is started. The AUTOMATIC-CONNECT combination is the only one that a user may want to save to NVM.

Table 68: 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	Input: Transaction number Output: [65533, 65535]	N/A
Select Base GPS input type	2	ushort	Value — Operation 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	Value — Operation 0 — Line used for Serial (default) 1 — Line used for Modem 2-255 — Reserved	
Modem control	1	byte	Value — Operation 0 — Automatic control (default) 1 — Manual control 2 — Command control 3-255 — Reserved	

Item	Bytes	Format	Value	Units
Connection control	1	byte	Value Operation 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

5.4.2.16 Message 40: Precise Gravity Specification

This message contains a precise gravity specification in terms of the gravity magnitude (also called the scalar gravity), the North and East vertical deflection angles of the gravity vector from normal, and the geographic position at which the specified gravity vector is valid. The POS TNG3 computes a best estimate of the gravity vector using a gravity model that has a minimum wavelength of 300 km. The user may have a better estimate of the local gravity vector than what the gravity model can generate. This message directs the POS TNG3 to compute an additive correction to the model and apply it to all subsequent gravity computations.

Table 69: Message 40: Gravity

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	40	N/A
Byte count	2	ushort	56	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Gravity magnitude	8	double	[9.7, 9.9] default = 9.81	m/s^2
North deflection	8	double	[-30, +30] default = 0	arc-seconds
East deflection	8	double	[-30, +30] default = 0	arc-seconds
Latitude of validity	8	double	[-90, +90] default = 0	degrees
Longitude of validity	8	double	[-180, +180] default = 0	degrees
Altitude of validity	8	double	[-1000,) default = 0	meters
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.2.17 Message 41: Primary GPS Receiver Integrated DGPS Source Control

This message is used to specify settings related to the source or service provider of *Integrated DGPS* corrections. This message must be used with the information presented in Group 25 on page 43, which provides information on Primary GPS receiver integrated DGSP status and Group 26 on page 47, which provides information on the available DGPS station database. This message is only valid when GPS Type 12 is installed as the Primary GPS receiver. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

The *Beacon Channel 0 Frequency* field is the frequency of channel 0 for manual beacon mode and DGPS source auto-switching mode (units of 0.1 kHz). Value 0 corresponds to information unchanged.

The *Beacon Channel 1 Frequency* field is the frequency of channel 1 for manual beacon mode and DGPS source auto-switching mode (units of 0.1 kHz). Value 0 corresponds to information unchanged.

The *Satellite ID* field is the identification number from the list provided by the interface [1-20] and 0 when values are unchanged and 255 in the case that the user enters manually the frequency and bit rate values.

The *Satellite bit rate* field is the satellite bit rate (600, 1200 or 2400 baud).

The *Satellite frequency* field is the satellite frequency for manual satellite mode and DGPS source auto-switching mode (value 0 implies unchanged).

The *OmniSTAR Activation Code* field is the ASCII numeric user activation code provided by OmniSTAR upon subcription.

Table 70: Message 41: Primary GPS Receiver Integrated DGPS Source Control

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	41	N/A
Byte count	2	ushort	52	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A

Item	Bytes	Format	Value	Units
DGPS source mode	1	byte	Source mode for DGPS corrections: 0 Disabled 1 Beacon differential only 2 OmniSTAR differential only 3 LandStar differential only 4 Automatic switching between beacon and satellite DGPS sources 5-255 Reserved	N/A
Beacon Acquisition Mode	1	byte	Beacon mode used to acquire DGPS signals : 0 Channel disabled 1 Manual mode 2 Auto Distance mode 3 Auto Power mode 4–255 Reserved	N/A
Beacon Channel 0 Frequency	2	ushort	[2835-3250]	10 * kHz
Beacon Channel 1 Frequency	2	ushort	[2835-3250]	10 * kHz
Satellite ID	1	byte	[0,255]	N/A
Satellite bit rate	2	ushort	[600, 1200, 2400]	baud
Satellite frequency	8	double	[1500e6-1600e6]	Hz
Request Database Source	1	byte	0 Unknown 1 Beacon Stations 2 LandStar Stations 3-255 Reserved	N/A
Landstar Correction Source	1	byte	0 Unknown 1 LandStar Stations 2 LandStar Network 3-255 Reserved	N/A
OmniSTAR Activation Code	26	byte	0 Unknown (0,) Enter service Provider Activation Information	N/A
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.3 Processing Control Messages

5.4.3.1 Message 50: Navigation Mode Control

This message directs the POS TNG3 to transition to a specified navigation mode. The two basic navigation modes are Standby and Navigate.

Table 71: 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	Input: Transaction number Output: [65533, 65535]	N/A
Navigation mode	1	byte	Value — Mode 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

5.4.3.2 Message 51: Display Port Control

This message directs the POS TNG3 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 TNG3 always outputs Groups 1, 2, 3 and 10 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.

The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

Table 72: 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	Input: Transaction number Output: [65533, 65535]	N/A
Number of groups selected for Display Port	2	ushort	[4, 70] default = 4 *(Groups 1,2,3,10 are always output on Display Port)*	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

5.4.3.3 Message 52: First Data Port Control

This message directs the POS TNG3 to output specified groups on the first 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. The POS TNG3 will output a selected group at the lesser of the user-specified rate or the internal update rate. This will depend 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 the POS TNG3 will output the selected group at 1 Hz. An exception is Group 4: Time-tagged IMU, which the POS TNG3 will output at the IMU data rate regardless of the user-specified data rate.

The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

Table 73: Message 52/61: First/Second 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	Input: Transaction number Output: [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

Item	Bytes	Format	Value	Units
Data Port output rate	2	ushort	Value / Rate (Hz) 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
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.3.4 Message 53: Logging Port Control

This message controls a data logging device and directs the POS TNG3 to output specified groups on the Logging Port at a specified rate.

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

The *Logging Port Output Rate* field selects the output rates of all specified groups from one of several available discrete output rates. The POS TNG3 will output a selected group at the lesser of the user-specified rate or the internal update rate. This will depend on the selected group. If the user selects a group to be output at maximum available rate (200Hz) when the internal update rate of the group data is 1 Hz, then the POS TNG3 will output the selected group at 1 Hz. An exception is Group 4: Time-tagged IMU, which the POS TNG3 will output at the IMU data rate regardless of the user-specified data rate.

The *Select/Deselect AutoLog* field directs the POS TNG3 to enable or disable the AutoLog function; when the AutoLog function is enabled, the POS TNG3 begins to record data to the Logging Port using the automatically incrementing filename stored in NVM as soon as the POS TNG3 has powered up and self-initialized. This feature allows the user to operate the POS TNG3 and to record data without having to connect a client computer running POS Controller.

The *Disk Logging Control* field directs the POS TNG3 to begin and end logging to the logging device connected to the Logging Port. The *Filename Kernel* field sets the logging filename kernel. The POS TNG3 appends the filename kernel with extensions **.000** to **.999** to create filenames on the logging disk. Each file holds about 12MBytes of recorded data. The default filename kernel is **default**.

The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as “settings”) that the POS TNG3 saves to NVM.

Table 74: Message 53: Logging Port Control

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	53	N/A
Byte count	2	ushort	76 + 2 x number of groups (+2 if required for pad)	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Number of groups selected for Logging Port	2	ushort	[0, 70] default = 0	N/A

Item	Bytes	Format	Value	Units
Logging Port output group identification	2	ushort	Group ID to Output [1, 65534]	N/A
…	…	ushort	…	N/A
Logging Port output group identification	2	ushort	Group ID to Output [1, 65534]	N/A
Logging Port output rate	2	ushort	Value — Rate (Hz) 1 — 1 (default) 2 — 2 10 — 10 20 — 20 25 — 25 50 — 50 100 — 100 200 — 200 other values — reserved	
Select/deselect AutoLog	1	byte	Value — State 0 — AutoLog disabled (default) 1 — AutoLog enabled 2-255 — No action	
Disk logging control	1	byte	Value — Command 0 — Stop logging (default) 1 — Start logging 2-255 — No action	
Filename kernel	12	chars	Filename kernel (default = *default*)	N/A
Reserved	52	bytes	N/A	N/A
Pad	0 or 2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.3.5 Message 54: Save/Restore Parameters Control

This message directs the POS TNG3 to save the current configuration to non-volatile memory (NVM) or to retrieve the currently saved parameters from NVM. The POS TNG3 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, the POS TNG3 saves the current parameters to NVM, thereby overwriting the previously saved parameters. If the *Control* field is set to 2, the POS TNG3 retrieves the currently saved parameters into the active parameters for the current navigation session. If the *Control* field is set to 3, the POS TNG3 resets the active parameters to the factory default settings. The previously active parameters are overwritten.

Table 75: 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	Input: Transaction number Output: [65533, 65535]	N/A
Control	1	byte	Value Operation 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

5.4.3.6 Message 55: User Time Recovery

This message specifies the time of the last PPS in user time to the POS TNG3. It directs the POS TNG3 to synchronize its User Time with the time specified in the *User PPS Time* field. The POS TNG3 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 the POS TNG3 with this message after the PPS has occurred. The resolution of time synchronization is one microsecond.

Table 76: Message 55: User time recovery

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	55	N/A
Byte count	2	ushort	24	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
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

5.4.3.7 Message 56: General Data

This message provides the POS TNG3 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, or the POS TNG3 has been configured to initialize or re-align from a user-specified position (eg. POS/LS). The data in this message allows a stationary POS TNG3 to complete the coarse leveling algorithm and begin operating in Navigate mode. The POS TNG3 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 the POS TNG3 at a last known position following an integration failure when GPS is unavailable.

The POS TNG3 will accept 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. The POS TNG3 does not save this message to NVM, hence the user must provide this message during every POS TNG3 start-up where the general data are required.

Table 77: 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	Input: Transaction number Output: [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

Item	Bytes	Format	Value	Units
Initial heading	8	double	[0, 360) default = 0	degrees
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.3.8 Message 57: Installation Calibration Control

This message controls the POS TNG3 function of self-calibration of primary installation parameters. The POS TNG3 will accept 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 and/or non-aligned, 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. The POS TNG3 will execute 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. The POS TNG3 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. The POS TNG3 restarts the Navigate mode without the calibration option, and abandons any previous calibration actions.

In an auto-calibration, the POS TNG3 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. The POS TNG3 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, the POS TNG3 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, the POS TNG3 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. The POS TNG3 resets its Kalman filter and restarts the normal Navigate mode with the possibly updated installation parameters.

In a forced transfer of calibrated parameters, the POS TNG3 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. The POS TNG3 resets its Kalman filter and restarts the normal Navigate mode with the updated installation parameters.

Table 78: 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	Input: Transaction number Output: [65533, 65535]	N/A
Calibration action	1	byte	Value Command 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	Bit (set) Command 0 Calibrate primary GPS lever arm 1 Calibrate auxiliary 1 GPS lever arm 2 Calibrate auxiliary 2 GPS lever arm 3 Calibrate DMI lever arm 4 Calibrate DMI scale factor 5 Calibrate DVS lever arm 6 Calibrate DVS scale factor 7 Calibrate Position Fix lever arm	
Pad	0	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.3.9 Message 58: GAMS Calibration Control

This message controls the operation of the GAMS calibration function. The POS TNG3 will accept this message at any time.

The GAMS Calibration Control field directs the POS TNG3 to do the following:

- stop a current calibration 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.

The POS TNG3 will return Message 21: GAMS Installation Parameters containing the new GAMS installation parameters when the calibration is completed.

Table 79: 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	Input: Transaction number Output: [65533, 65535]	N/A
GAMS calibration control	1	byte	Value Command 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
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.3.10 Message 60: Position Fix Control

This message specifies position fixes and controls their use. The POS TNG3 will accept this message at any time.

The *Position fix control* field specifies the type of position fix. **No position fix** cancels any previous position fix control. **Dynamic position fix** specifies a single epoch position fix that is valid upon receipt of the message. **Static position fix at current ZUPD** specifies a position fix that is valid during the current ZUPD. If no ZUPD is in progress, then the POS TNG3 ignores the message. **Static position fix at next ZUPD** specifies a position fix that is valid during the next ZUPD.

The *Position format* field specifies the format of the position fix. The currently supported formats are **Geographic** (latitude, longitude, altitude) and **UTM** (Northing, Easting, Height).

The *Latitude/Northing*, *Longitude/Easting* and *Altitude/Height* position fix fields contain the three position fix coordinates in the specified format. The *X*, *Y* and *Z Lever Arm* fields contain the coordinates of a lever arm from the Reference frame origin to the specified position. The *North*, *East* and *Down Standard Deviation* fields contain respective standard deviations of the position fix.

Table 80: Message 60: Position Fix Control

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	60	N/A
Byte count	2	ushort	60	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Position fix control	2	ushort	Value Control 0 No position fix (default) 1 Dynamic position fix 2 Static position fix at current ZUPD 3 Static position fix at next ZUPD 4-255 No action	
Position format	2	ushort	Value Format 0 Geographic coordinates (default) 1 UTM coordinates 2-255 Reserved	
Latitude Northing	8	double	[-90, +90] default = 0 (,) default = 0	degrees meters
Longitude Easting	8	double	[-180, +180] default = 0 (,) default = 0	degrees meters
Altitude or Height	8	double	(,) default = 0	meters

Item	Bytes	Format	Value	Units
X lever arm	4	float	(,) default = 0	meters
Y lever arm	4	float	(,) default = 0	meters
Z lever arm	4	float	(,) default = 0	meters
North standard deviation	4	float	[0 ,) default = 0	meters
East standard deviation	4	float	[0 ,) default = 0	meters
Down standard deviation	4	float	[0 ,) default = 0	meters
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.3.11 Message 61: Second Data Port Control

This message directs the POS TNG3 to output specified groups on the second 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 73.

The POS TNG3 accepts this message at anytime. The parameters contained in this message become part of the processing parameters (referred to as “settings”) that the POS TNG3 saves to NVM.

5.4.4 Program Control Override Messages

5.4.4.1 Message 90: Program Control

This message controls the operational status of the POS TNG3. The POS TNG3 will accept this message at any time.

The POS TNG3 interprets the values in the message as follows.

0 The connected POS Controller is alive and the TCP/IP connection is good.
1 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.

The POS TNG3 continuously monitors the TCP/IP connection between itself and the POS Controller. The POS TNG3 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 TNG3 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 the POS TNG3.

Table 81: 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	Input: Transaction number Output: [65533, 65535]	N/A
Control	2	ushort	Value Command 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

5.4.4.2 Message 91: GPS Control

This message directs the POS TNG3 to configure or reset its internal GPS receivers. The POS TNG3 will accept this message at any time.

The *Control Command* field when set to *Send GPS configuration* (0) directs the POS TNG3 to reconfigure the GPS receivers. The POS TNG3 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 the POS TNG3 to send "cold reset" commands to the GPS receivers. This will direct an internal GPS receiver to revert to their factory default configurations. The user would use this command to establish a starting point for troubleshooting problems with a GPS receiver.

Table 82: 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	Input: Transaction number Output: [65533, 65535]	N/A
Control command	1	byte	Value Command 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

5.4.4.3 Message 92: Integration Diagnostics Control

This message directs the POS TNG3 to implement one or more of the following integration control functions:

- The user can select the Reference frame to be the user-defined Reference frame or the IMU frame. This diagnostic function allows the user to output the roll, pitch and heading of the IMU frame.

- The user can output fixed navigation parameters in place of the ones computed by the POS TNG3. This allows the user to debug his interface with the POS TNG3 using expected data output.

This message is provided for diagnostic purposes only. The POS TNG3 will accept this message at any time. This message is not saved to NVM.

Table 83: Message 92: Integration diagnostics control

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	92	N/A
Byte count	2	ushort	24	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Output data control	1	byte	Value Command 1 IMU Frame output 2 User parameter output 0, 3-255 No action	
User roll	4	float	[-180, +180] default = 0	degrees
User pitch	4	float	[-180, +180] default = 0	degrees
User heading	4	float	[0, 360) default = 0	degrees
Reserved	4	byte	N/A	N/A
Pad	1	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

5.4.4.4 Message 93: Aiding Sensor Integration Control

This message directs the POS TNG3 to override its internal aiding sensor data integration control. The POS TNG3 accepts this message at anytime. The parameters contained in this message are part of the processing parameters (referred to as "settings") that the POS TNG3 saves to NVM.

The user can force aiding sensor data to be valid or invalid regardless of the validity assigned by the POS TNG3 FDIR function. The user can use this function to enable or disable GAMS heading aiding or Y-Z zero velocity aiding. The POS TNG3 uses Y-Z zero velocity aiding to regulate lateral and vertical average velocities to zero. This is applicable on land vehicles, which are not subject to crab or drift angle.

Table 84: Message 93: Aiding sensor integration control

Item	Bytes	Format	Value	Units
Message start	4	char	$MSG	N/A
Message ID	2	ushort	93	N/A
Byte count	2	ushort	12	N/A
Transaction number	2	ushort	Input: Transaction number Output: [65533, 65535]	N/A
Override control	4	ulong	Bit — Action 0 — Force primary GPS data VALID. 1 — Force primary GPS data INVALID. 2 — Force auxiliary 1 or 2 GPS data VALID. 3 — Force auxiliary 1 or 2 GPS data INVALID. 4 — Disable GAMS heading aiding. 5 — Force DMI data VALID. 6 — Force DMI data INVALID. 7 — Disable zero Y-Z velocity aiding. 8 — Force DVS data VALID. 9 — Force DVS data INVALID. 10-31 — spare	
Pad	2	byte	0	N/A
Checksum	2	ushort	N/A	N/A
Message end	2	char	$#	N/A

6 Appendix A: Data Format Description

6.1 Data Format

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

Byte or Character

Table 85: 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 86: 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 87: 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 88: Single-Precision Real Format

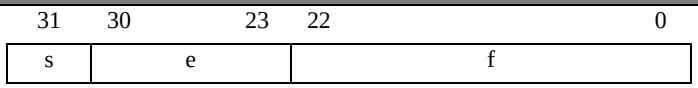
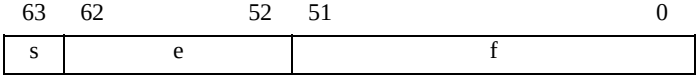
Data format	
	
Field Size in Bits	
Sign (s)	1
Biased Exponents (e)	8
Fraction (f)	23
Total	32
Interpretation of Sign	
Positive Fraction	s=0
Negative Fraction	s=1
Normalised Numbers	
Bias of Biased Exponent	+127 ($7F)
Range of Biased Exponent	[0, 255] ($FF)
Range of Fraction	zero or nonzero
Fraction	1.f (where $f=bit_{22}^{-1}+bit_{21}^{-2}\ldots+bit_{0}^{-23}$)
Relation to Representation of Real Numbers	$(-1)^{s}x2^{e-127}x1.f$
Approximate Ranges	
Maximum Positive Normalised	$3.4x10^{38}$
Minimum Positive Normalised	$1.2x10^{-38}$

Table 89: Double-Precision Real Format

Data format	
	
Field Size in Bits	
Sign (s)	1
Biased Exponents (e)	11
Fraction (f)	52
Total	64
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 $f=bit_{51}^{-1}+bit_{50}^{-2}\ldots+bit_{0}^{-52}$)
Relation to Representation of Real Numbers	$(-1)^{s}x2^{e-1023}x1.f$
Approximate Ranges	
Maximum Positive Normalized	$1.8x10^{308}$
Minimum Positive Normalized	$2.2x10^{-308}$

6.2 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. The POS TNG3 assigns an invalid float or double in any group by setting all bits representing the float or double set to 1. The POS TNG3 rejects any message that contains any of the invalid integer values in Table 90 or any value in the range of NaN or INF.

Table 90: 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

7 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