TRIMBLE NAVIGATION

HIP Protocol Object (HIPPO) Specification

Part Number 45171-XX-SP

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Table of Contents

TABLE OF FIGURES

1 Introduction

This document describes the format of HIPPO protocol and messages implemented in the HIP module.

HIPPO is one of three communication modes of the HIP module, and is the one present in normal usage. The serial port operates at 38400 baud, eight data bits, no parity, and one stop bit.

The other two modes are monitor mode, used for manufacture and low-level diagnosis and control, and flash-loading mode, used for updating the firmware. The receiver enters monitor mode through HIPPO command. The receiver will also enter monitor mode if the firmware ROM checksum fails. The only way to enter flash-loading mode is through the monitor mode. For detailed descriptions of these two modes, see the document "HIP Flash Loading Requirements", Trimble PN 45058-XX-SP, Rev 1.20.

2 HIPPO Protocol Rules

The HIPPO message structure is derived from the TSIP message structure. Both are binary protocols with pre-parsers that "unstuff" the bytes in the serial stream (S-bytes) to create packets of message bytes (M-bytes). Both are asynchronous protocols, allowing the host and module to send multiple commands without waiting for the completion of the previous command.

The HIPPO design offers easier and more reliable parsing. In contrast to TSIP, which requires a small state machine after the pre-parser to determine the start and end of the message packet, HIPPO uses unique S-bytes to identify the start and end before the pre-parser. The HIPPO message structure currently uses three control characters: 0x80 = HIPPO Control Character (HCC); 0x81 = Start of Message (SOM); and 0x82 = End of Message (EOM). HIPPO reserves five other bytes (0x83-0x87) for future use as control characters. This contrasts with TSIP, which has two (DLE and ETX). HIPPO has a higher control character overhead (3% versus 0.4% for TSIP), but parser design is much simpler.

Because the HIP module is designed to send messages at 10 Hz, the message length has been limited to 128 bytes to ensure that two messages can be transmitted per 100 ms cycle.

Number representations use IEEE formats, and are sent least significant byte first (Intel specification or "little endian").

The module acknowledges all commands with a reply message after parsing and processing are complete. "Completion" is the point at which all immediate actions are complete in the protocol layer. These actions include replying to queries, setting global variables, flags, or semaphores, and sending messages to other tasks. If the command is a successful query for a single report, the report response itself is the acknowledgment response; otherwise, the module sends an acknowledgment response packet 0x10 to the host.

There are two general types of messages: report messages and command messages.

2.1 General Message Structure Rules

The byte SOM only occurs as an S-byte (in the serial stream) at the start of a message. The byte EOM only occurs as an S-byte at the end of a message. From the SOM byte until the following EOM byte, the following structure rules apply:

The first two S-bytes are the Parser Code PCOD and Parser Subcode PSUB. These specify a unique parser for the data bytes. PCOD and PSUB never have values of 0x80 to 0x87, so they are never "stuffed".

Depending on PCOD and PSUB, the next byte may be an index byte INDEX. INDEX never has a value of 0x80 to 0x87, so it is never "stuffed". Examples of an index are a channel number and a satellite PRN. All indexed messages with the same parser code and subcode must have the same length, format, and data structure.

The byte HCC only occurs as an S-byte as a "stuffing" character, as defined in Section 2.3. It may appear before CS or any of the data bytes.

The value of the checksum M-byte CS is such that the 8-bit sum of the M-bytes from SOM to EOM inclusive is zero. If the checksum is between 0x80 and 0x87, it is HCC-stuffed.

The number of data bytes per message is limited to 128. Counting the bytes for the SOM, parser code, parser subcode, checksum, EOM, and index, the total number of M-bytes can as many as 134. Data is not valid until the message is complete and the checksum agrees.

HIPPO ignores S-bytes between messages (from EOM to the following SOM), unless the values are between 0x80 and 0x87. This feature allows ASCII messages such as NMEA or TAIP to be interspersed with HIPPO messages. TSIP messages and other binary protocols in general cannot be interspersed with HIPPO messages.

2.2 Report Message Structure (Module to Host)

Table 2.2.1shows the message structure for a simple data packet of N M-bytes. Each message has five framing bytes: SOM; two message ID bytes (PCOD and PSUB); a checksum byte; and EOM. The data type and data structure in the message (i.e., the parser) is specified by the Parser code PCOD and parser subcode PSUB.

Table 2.2.1 HIPPO Report Message Structure

M-byte	Meaning	Value
SOM	start of message	0x81
PCOD	Parser code	0x00 – 0x7F
PSUB	Parser subcode	0x00 – 0x7F, 0xFF
D[0]	First byte of data	0x00 – 0xFF
D[1]	Second byte of data	0x00 – 0xFF
…	…	…
D[N-1]	Last byte of data	0x00 – 0xFF
CS	Checksum	0x00 – 0xFF
EOM	End of message	0x82

Some parser code / subcodes have data indexed by channel or satellite, as shown in the following table. The index is the first byte after the parser subcode. The parser code/subcode specifies whether a message uses indexing.

Table 2.2.2 HIPPO Report Message Structure (Indexed Data)

M-byte	Meaning	Value
SOM	start of message	0x81
PCOD	Parser code	0x00 – 0x7F
PSUB	Parser subcode	0x00 – 0x7F
INDEX	Data indexed by channel, etc.	0x00-0x7F, 0xFF
D[0]	First byte of data	0x00 – 0xFF
D[1]	Second byte of data	0x00 – 0xFF
…	…	…
D[N-1]	Last byte of data	0x00 – 0xFF
CS	Checksum	0x00 – 0xFF
EOM	End of message	0x82

2.3 Command Message Structure (Host to Module)

Command messages sent from host to module are built upon the report message structure. Except for system commands such as system reset (see Section 3.3), every command either sets or queries a reportable data structure (See Sections 3.1 and 3.2). To do this, the HIPPO set or query command protocol simply “wraps around” the report message protocol. Table 2.3.1 shows the message structure for a command to set a typical data packet, and Table 2.3.2 shows the message structure for a query of indexed data.

Table 2.3.1 HIPPO Command Message Structure

M-byte	Meaning	Value
SOM	start of message	0x81
CCOD	Set Command code	0x01
PCOD	Parser code	0x00 – 7F
PSUB	Parser subcode	0x00 – 7F, 0xFF
D[0]	First byte of data	0x00 – FF
D[1]	Second byte of data	0x00 – FF
…	…	…
D[N-1]	Last byte of data	0x00 – FF
CS	Checksum	0x00 – FF
EOM	End of message	0x82

Table 2.3.2 HIPPO Query Message Structure for Indexed Data

M-byte	Meaning	Value
SOM	Start of message	0x81
CCOD	Query Command code	0x02
PCOD	Parser code	0x00 – 7F
PSUB	Parser subcode	0x00 – 7F
INDEX	Index	0x00 – 7F, 0xFF
CS	Checksum	0x00 – FF
EOM	End of message	0x82

2.4 Chained Messages

Chaining is not supported in the HIP module. If multiple messages are requested, they will be issued as time allows, between the high-priority automatic report messages. An acknowledgment message will appear at the end of the sequence of replies.

2.5 Post-Formatting: HCC Stuffing Before Transmission

Whenever an M-byte in the data fields or the checksum field is equal to one of the control characters 0x80-0x87, it generates two S-bytes as follows: the M-byte generates the S-byte pair [0x80, M-byte & 0x7F].

2.6 Pre-Parsing: HCC Unstuffing After Reception

Pre-parsing (assembly of the M-bytes) occurs as S-bytes are received. HIPPO pre-parsing begins with the appearance of the SOM S-byte and ends with the appearance of the EOM S-byte.

- Whenever the S-byte is SOM, a new message structure opens with room for 132 M-bytes. The first M-byte of a message is always SOM.
- Whenever the S-byte HCC appears, it does not generate a new M-byte. Rather, it generates a signal to OR the following S-byte with 0x80 to create the next M-byte. Otherwise, the M-byte is the same as the S-byte.
- If the S-byte is EOM, the message structure is closed. The last M-byte of a message is always EOM.
- The last M-byte before the EOM is the checksum. It is computed so that the sum of all M-bytes, including the SOM, the EOM, and the checksum, is zero.

After pre-parsing is complete, the message packet is ready to be parsed into structures according to the rules in Sections 3 and 4. The parser code and subcodes are the second and third M-bytes, directly after the SOM. The data will start on the fourth (non-indexed data) or fifth (indexed data) M-byte.

Possible pre-parser errors include:
1) Two SOMs appear without an EOM in between.
2) HCC occurs in the first two bytes (parser code and subcode).
3) The byte following HCC is not equal to the 7 LSB's of a HIPPO control character.
4) Control characters appear between message (after EOM but before the next SOM).
5) No EOM appears in the first 134 M-bytes.

3 Command Messages

HIPPO has three classes of command message packets: set parameters, query parameters, and system command.

The set command is simple: it "wraps around" the report message structure of the parameter(s) to be set.

The query command structure is even simpler: it calls out the report code and subcode (and index, if applicable) of the desired reports.

The module always acknowledges a command in one of two ways.
17- An explicit acknowledgment message (Section 4.2.1) is sent in reply to either:
1) a command;
2) an unsuccessful query;
3) a query that generates a series of report messages.
b) If the query successfully generates a single report message, that message is the implicit acknowledgment.

The acknowledgment contains a status indicating the completion of the operation.

3.1 Set Class

The set class packets set receiver, system, and any other defined parameters within the target system.

Two types of parameters can be set.

1) Configuration parameters such as DOP mask (see Section 4.3);
2) Initialization parameters such as position, velocity, time, and ephemeris (see Section 4.4.10).

The target system returns an acknowledgment packet (Section 4.2.1), but does not echo data values as in TSIP.

The parser code and subcode determine the length of the command packet. The packet has the following general format (indexed data has an extra byte after parser subcode):

Table 3.1.1 Set Class Message Structure

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x01	
	Parser Code	U8	0x00-7F	Report Code
	Parser Subcode	U8	0x00-7F	See report packet definition in Section 3.3.1.
0	Data Value			Data corresponding to the subcode.
…	…			…
N_{R-1}	Data Value			N_R is the size of data for the specified report.

For example, to set the operating dimension to "2-D Altitude Hold", the host issues the following command to the module:

Table 3.1.2 Example of GPS Configuration Message Parameter

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x01	
	Parser Code	U8	0x24	Report packet for GPS Configuration
	Parser Subcode	U8	0x01	Parameter Subcode for Operating Dim
0	Operating Dimension	U8	3	Alt-Hold (2D)

3.2 Query Class

The Query class packet allows user to retrieve configuration, report, and system data with the same packet. Like the Set class packet, it is indexed by the report code and subcode. This is possible because each parameter or set of parameters has a corresponding report message.

Four types of parameters can be queried.

1) System parameters (e.g., version numbers)
2) Configuration parameters (e.g. DOP mask)
3) Fix parameters (e.g., satellite strength, current position, velocity, time, ephemeris)
4) Initialization parameters (e.g., position, velocity, time, ephemeris)

The target system returns an acknowledgment packet. When a query for a single report is successful, the reply to that query is the acknowledgment. If the query fails, an explicit acknowledgment report message is sent as an acknowledgment. If the query generates a series of response messages, the last response is followed by an explicit acknowledgment report message that signals the end to the host's parser.

A query has two formats, depending on whether the information is indexed (e.g., by channel or satellite).

Table 3.2.1 Query Class Message Structure

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x02	
	Parser Code	U8	0x00-7F	
	Parser Subcode	U8	0x00-7F 0xFF	Single Subcode All subcodes

Table 3.2.2 Indexed Query Class Message Structure

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x02	
	Parser Code	U8	0x00-7F	Report Code (see Section 3.3.1.)
	Parser Subcode	U8	0x00-7F	See report packet definitions in Section 3.3.1.
	Index	U8	0x00-7F 0xFF	Single index (e. g., channel or satellite) All indices

Like the set class message, the query packet has two bytes body contains the parser code and subcode for a configuration packet or a report packet. For example, to query the operating dimension setting in the GPS configuration block:

Table 3.2.3 Example of Query for "Operating Dimension" parameter

Byte	Name	Type	Value	Meaning
	Command Code	U8	0x02	
	Parser Code	U8	0x24	Report packet for GPS Configuration
	Parser Subcode	U8	0x01	Parameter Subcode for Operating Dim

3.3 System Class

A system class packet is a set packet associated with the system operations. The following section describes each of packets.

3.3.1 Reset Receiver

This command resets the receiver software.

Table 3.3.1 0x03: Receiver Reset Command Messages

Byte	Name	Type	Value	Meaning
	Code	U8	0x03	
	Subcode	U8	0x01	Reset
			0x02	Clear RAM, reset
			0x03	Force to Monitor Mode
			0x04	Shut Down
			0x05	Clear ephemeris, reset
			0x06	Clear oscillator, reset
			0x07	Clear flash data and RAM, reset
			0x08	Clear position, reset
			0x09	Write BBRAM to flash, reset (graceful)
			0x0A	Io-DSP Pass-through mode

Force to Monitor Mode –Force the target system to exit from GPS function, and into the embedded monitor mode. The serial communication is reset to 38.4K baud, no parity. Once in the monitor mode, all HIPPO APIs are disabled. Refer to flash loading documents for more detail.

Shutdown: Once this packet is received, the target system shuts down the navigation system. The system can be restarted by hardware action (e.g., reset pin) only.

An acknowledgment packet in the current serial protocol is sent before the command is implemented, however transmission may not complete before the reset occurs.

4 Report Class

Report class packets are divided into four subclasses.

System data: contains system information, such as system status or an event log queue entry.
Configuration reports: have all the system configurable parameters.
Data reports: have navigation information generated by the Navigation Platform.
Initialization input reports: have start-up information and GPS system data (position, heading, almanac, etc.); also map-matching inputs for latitude, longitude, altitude, and heading.

Some report packets are indexed by channel number (tracking status, signal strength) or satellite number (almanac, ephemeris).

The parameters in the configuration and initialization reports can be set by 0x01 packet. (See Section 3.1)

The host can query all report packets using the 0x02 packet, except as noted. (See Section 3.2)

4.1 Report Message Code Assignment

This table lists all report data structures in HIPPO supported by the HIP module, and whether the data structure can be queried ('Q') or set ('S'). Data that can be neither queried no set is automatic output only.

Table 4.1.1 Message Codes

Code	Subcode	Indexed by	Message	Q	S
0x10	0x01		Acknowledge Set		
0x10	0x02		Acknowledge Query		
0x10	0x03		Acknowledge System Command		
0x11	0x01		Navigation Code ROM Version	Q	
0x11	0x02		Boot Code ROM Version	Q	
0x11	0x03		Io-DSP Code ROM Version	Q	
0x12	0x01		Start-up Message		
0x12	0x02		SW Mode	Q	
0x12	0x03		Product Information	Q	
0x12	0x04		Hardware ID	Q	
0x14	0x01	Event Log	Soft Event Log Entry	Q	
0x14	0x02	Event Log	Fatal Error Log Entry	Q	
0x15	various		Data Stored to Non-erasable Flash	Q	
0x16	0x01		Health Message	Q	
0x16	0x02		Repeat Start-Up Message	Q	
0x21	0x01		Hip Engine Rate	Q	S
0x23	0x01		Variable length RTCM data	Q	S
0x23			Reserved as a "wrapper" for non-HIPPO protocols		
0x24	0x01-08		GPS Configuration Parameters	Q	S
0x25			Kalman Filter Configuration Parameters	Q	S
0x26	0x01		Available Report Codes	Q	
0x26	0x02	Rpt code	Available report Subcodes	Q	
0x26	0x03		DPP model speed levels	Q	
0x26	0x04		DPP minimum speed for estimate	Q	
0x26	0x05		DPP maximum speed for estimate	Q	
0x27			DR Filter Parameters	Q	S
0x28	0x12	SV PRN	Compressed Almanac	Q	S
0x28	0x13		Compressed Almanac Health Page	Q	S
0x28	0x14		Compressed GPS Ionospheric / UTC Model Parameters	Q	S
0x28	0x16	SV PRN	Compressed Ephemeris	Q	S
0x29	0x01		Time Initialization	Q	S
0x29	0x02		Latitude / Longitude Initialization	Q	S
0x29	0x03		Altitude Initialization	Q	S
0x29	0x04		LO Frequency Initialization	Q	S
0x29	0x05		Heading Initialization	Q	S
0x29	0x07		Map-match Input	Q	S
0x29	0x08		Tacho Input	Q	S
0x2A	Rpt Code	Rpt Subcode	Automatic Output – Event	Q	S
0x2B	Rpt Code	Rpt Subcode	Automatic Output – Time Interval	Q	S
0x2C	Rpt Code	Rpt Subcode	Automatic Output – Distance Traveled	Q	S
0x2D	Rpt Code	Rpt Subcode	Automatic Output – Heading Change	Q	S
0x2E	0x01		Event Report Mask	Q	S
0x2F	0x02		Data Positioning Collection Test Interval Control		S
0x2F	0x04		Gyro Bench Test Interval Control		S
0x2F	0x06		Tacho/Reverse Production Test Interval Control		S

Table 4.1.2 Message Codes (continued)

0x30	0x02		Fast Fix with raw DR Data	Q	
0x30	0x03		Buffered DR data with Health and Start-up message	Q	
0x31	0x01		GPS Fix	Q	
0x32	0x01		UTC Time and Constellation Summary	Q	
0x32	0x02		Constellation Summary	Q	
0x32	0x03		UTC Time	Q	
0x33	0x01	Channel	GPS Channel Measurement Short Status	Q	
0x36	0x03		ZRO Calibration	Q	S
0x36	0x04		Gyro Sensitivity Calibration	Q	S
0x36	0x05		Direction Switch Calibration	Q	S
0x36	0x07		DPP Calibration	Q	S
0x36	0x08		ZRO Rate Calibration	Q	
0x3F	0x01		ADC and Gyro Self-Test Data	Q	
0x3F	0x02		Data Positioning Collection Test Data (ROM 14)		
0x3F	0x03		Data Positioning Collection Test Data (ROM 15+)		
0x3F	0x04		Gyro Bench Test Data		
0x3F	0x06		Tacho/Reverse Production Test Data		
0x66	various		Diagnostic tag		
0x70	0x01	Channel	GPS Raw Measurement Diagnostic		
0x70	0x02		GPS Raw Position / Velocity Diagnostic		
0x70	0x03		DR Data		
0x70	0x04		Reset Diagnostic		
0x70	0x05		DR BBRAM Diagnostic V1		
0x70	0x07		Map Match Data Echo Diagnostic		
0x70	0x08		DR BBRAM Diagnostic V2		
0x70	0x09		GPS No Fix		
0x70	0x0A		DR BBRAM Diagnostic V3		
0x70	0x7F		Toggle Diagnostic Output	Q	S

4.2 System Report Packets

4.2.1 0x10: Acknowledge / Error Response to Command Packets

This packet serves three different functions:

1. Acknowledge a command when the operation is carried out, such as set a flag to reset and change baud rate;
2. Indicate a result of an operation is successful, such as set commands; and
3. Indicate a parsing error.

Not all sets, queries, or auto-outputs generate a 0x10 response. Specifically, when a query or auto-output for a single report is successful, the reply to that query is the acknowledgment. When the query or auto-output fails, or when it generates a series of response messages, a 0x10 message follows the last response to explicitly end the host parser actions.

The last data byte of the message is a parser status code. If the status code is not zero, an error has occurred and the module has not implemented the command. The value of the status code indicates at the point in the procedure where the parser failed.

1. An M-byte stream of no more than 128 bytes could not be created (control character error);
2. The checksum did not compute properly;
3. The parser code and subcode were be recognized;
4. The message length as not correct for that parser code/subcode;
5. One or more of the data values was not reasonable and appropriate.
6. The data contradicts values of position, time, etc. that have been validated by the GPS. This data can be forced using the "host override" option if available.

There are three forms of the acknowledgment report:

1. for sets, queries, and auto-outputs of non-indexed reports,
2. for sets, queries, and auto-outputs of indexed reports, and
3. for system commands.

If the command includes a change in the serial port protocol, the module sends the acknowledgment in the old protocol.

The data length is three bytes if the report code (data byte 0) is for an non-indexed report.

Table 4.2.1 0x10: Non-indexed Set and Query Acknowledge

Byte	Name	Type	Value	Meaning
	Code	U8	0x10	
	Subcode	U8	0x01 0x02 0x04	Set acknowledge Query acknowledge Auto-output acknowledge
0	Command Code	U8	0x00-7F	Non-indexed report
1	Command Subcode	U8	0x00-7F 0xFF	Single subcode All subcodes
2	Status Code	U8	0 1 2 3 4 5 6 7 8	Acknowledged or a successful operation Pre-parser error Checksum error Unknown Code/Subcode Parser data length error Data value error (TBD) Contradicts current data Data table full (e.g., Output Interval Control) Data not available

For indexed sets and queries, the data length is four bytes. The parser will expect this data length if the report code (byte 0) is for an indexed report.

Table 4.2.2 0x10: Indexed Set and Query Acknowledge

Byte	Name	Type	Value	Meaning
	Code	U8	0x10	
	Subcode	U8	0x01 0x02	Set acknowledge Query acknowledge
0	Command Code	U8	0x00-7F	Indexed report
1	Command Subcode	U8	0x00-7F 0xFF	Single subcode All subcodes
2	Index	U8	0x00-7F	Channel or satellite index
3	Status Code	U8	0 1 2 3 4 5 6 7 8	Acknowledged or a successful operation Pre-parser error Checksum error Unknown Code/Subcode Parser data length error Data value error (TBD) Contradicts current data Data table full (e.g., Output Interval Control) Data not available

For system commands, the data length is two bytes.

Table 4.2.3 0x10-03: System Command Acknowledge

Byte	Name	Type	Value	Meaning
	Code	U8	0x10	
	Subcode	U8	0x03	System command acknowledge
0	System Cmd Code	U8		See Sec. 3.3
1	Status Code	U8	0 1 2 3 4 9	Acknowledged or a successful operation Pre-parser Error Checksum Error Unknown Subcode Parser data length error Failed to execute properly

A “query all” command may generate a series of responses, but only a single acknowledgment is sent to the host, with a “0xFF” byte in the report subcode or index field.

4.2.2 0x11: Version Report

This packet reports version numbers for the various firmware blocks within the module.

Table 4.2.4 0x11: Version Report Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x11	
	Subcode	U8	0x01 0x02 0x03	Navigation Code ROM Boot ROM Io-DSP ROM
0	Major Version	U8	0-100	Software major number
1	Minor Version	U8	0-100	software minor number
2	Release Code	U8	0 > 0	release beta version number
3	Release Day	U8	[1, 31]	software release day
4	Release Month	U8	[1, 12]	software release month
5-6	Release Year	U16	> 2000	software release year

4.2.3 0x12-01: Start-Up Report

The module issues this report only at startup. This report cannot be queried; to query the data content after start-up, use message 0x16-02. The first two bytes show the error code associated with the previous shutdown. The second two bytes indicate health of the RTC and RAM.

Table 4.2.5 0x12-01: Start-Up Report Message

Byte / Bit		Name	Type	Value	Meaning
		Code	U8	0x12	
		Subcode	U8	0x01	Parameter Subcode
0-1		Error Code	U16	0 other	Normal shutdown (SW or power) Abnormal shutdown (Table 5.2.1)
2		Reserved	U8		
3	0	RAM Signature	U1		1 = BBRAM signature valid
3	1	Gyro / ADC test	U1		1 = ADC or Gyro self-test error
3	2	RTC Valid	U1		1 = RTC valid at startup
3	3	Flash BBRAM	U1		1 = BBRAM loaded from Flash
3	4-7	Reserved			

4.2.4 0x12-02: Software Mode Report

This report indicates whether the module is currently in Monitor Mode or Normal mode. If the device is in monitor mode, it will recognize and reply (in HIPPO) to a HIPPO query for this report.

Table 4.2.6 0x12-02: Software Mode Report Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x12	
	Subcode	U8	0x02	Parameter Subcode
0	Mode	U8	1 2	Normal Mode Monitor Mode

4.2.5 0x12-03: Production Information Report

This report contains information stored in ROM; it cannot be set or changed through HIPPO command. It is available by query or auto-output. If the device is in Monitor mode, it will also recognize and reply (in HIPPO) to a HIPPO query for this report.

Table 4.2.7 0x12-03: Production Info Report Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x12	
	Subcode	U8	0x03	
0	Serial Number	U32		
4	Production Day	U8		
5	Production Month	U8		
6-7	Production Year	U16		
8-23	Product Name	16xCHAR		Descriptive string

4.2.6 0x12-04: Hardware ID Report

This report contains information stored in ROM; it cannot be set or changed through HIPPO command. It is available by query or auto-output.

Table 4.2.8 0x12-04: Hardware ID packet

Byte	Name	Type	Value	Meaning
	Code	U8	0x12	
	Subcode	U8	0x04	Parameter Sub code
0-15	Hardware ID	16xCHAR		Hardware ID

4.2.7 0x14-01: Soft Event Log Report

These reports are auto-output upon the event. The report can also be queried by index number. Because of the volume of information, these reports cannot be queried with the "0xFF" option. The host can clear the soft event log completely by using the "set all" (0xFF) command with no data.

For detailed information on soft events, see Section 5.3.

Table 4.2.9 0x14-01: Soft event log entry report

Byte	Name	Type	Value	Meaning
	Code	U8	0x14	
	Subcode	U8	0x01	Parameter subcode
	Index	U8	0 [1,127]	Most recent soft event Soft Event Log index number
0-1	Year	U16	0 >2000	No GPS/UTC; time is since power-up year
2	Month	U8	[1, 12]	
3	Day	U8	[1, 31]	
4	Hour	U8	[0, 23]	
5	Minute	U8	[0, 59]	
6	Second	U8	[0, 60]	
7	Identity Code	U8	0xFF 0-0x7F	No event See Section 5.3.
8	Condition Code	U8		See Section 5.3.

4.2.8 0x14-02: Fatal Error Log Report

For detailed information on fatal error logs, see Section 5.2.

On a fatal error, the receiver will reset. The report can be queried by index number after the reset. Because of the volume of information, these reports cannot be queried with the "0xFF" option. The fatal error log is reatined in flash and cannot be cleared by the host.

Table 4.2.10 0x14-02: Fatal error log entry report

Byte	Name	Type	Value	Meaning
	Code	U8	0x14	
	Subcode	U8	0x02	Parameter subcode
	Index	U8	0 [1, 31]	Most recent fatal error Fatal error Log index number
0	Year	U16	0 >2000	No GPS/UTC; time is since power-up year
2	Month	U8	[1, 12]	
3	Day	U8	[1, 31]	
4	Hour	U8	[0, 23]	
5	Minute	U8	[0, 59]	
6	Second	U8	[0, 60]	
7	Event Code	U16	0 >0	No entry. Event Code (See Section 5.2)
9 – 30	Info block			(See Section 5.2)

4.2.9 0x15: Data Stored in Non-erasable Flash Report

A section of non-erasable ROM is reserved for customer data blocks. There is no HIPPO command to set the data; data can only be set in Monitor mode. The data blocks are written serially into an area of ROM that cannot be erased or overwritten.

Each subcode corresponds to a different data block type. Unlike standard HIPPO, the parser is defined by the customer, so the message length and data content are not specified by the parser code and subcode. The maximum data block length is 128 bytes.

When queried with a subcode, the report scans the section of ROM and returns the last data block entry with that subcode. The customer can effectively "update" a data block by writing a new data block with the same subcode and updated data, provided that there is room left in the allocated ROM section (approximately 2K bytes).

If no data block is found with the queried subcode, the module returns an acknowledgment with "Data not available".

The "query all subcodes" mode 0xFF is not available.

Table 4.2.11 0x15: Data Stored in Non-erasable Flash Report

Byte	Name	Type	Value	Meaning
	Code	U8	0x15	
	Subcode	U8	0x01-7F	
0	User-defined	U8		
…	…			
N-1	User-defined	U8		0 < N <=128

4.2.10 0x16-01: Health Status Report

This report contains status of various real-time operations in the HIP module.

Table 4.2.12 0x16-01: Health status report

Byte		Name	Type	Value	Meaning
		Code	U8	0x16	
		Subcode	U8	0x01	
0	0	Direction Switch Status	U1	0 1	Normal Abnormal
0	1	Gyro status	U1	0 1	Normal Abnormal
0	2	Tacho status	U1	0 1	Normal Abnormal
0	3-7	Reserved			
1	0-1	Antenna status	U2	0 1 3	Normal Antenna open Antenna short
1	2	Oscillator status	U1	0 1	Normal Abnormal
1	3-7	Reserved			
2		Soft Event Index	U7	0 [1,127]	No soft event in log Most recent soft event index

4.2.11 0x16-02: Repeat Start-Up Report with System Time

This report is a copy of the start-up message. The first two bytes show the error code associated with the previous shutdown. The second two bytes indicate health of the RTC and RAM. The system time is the number of milliseconds since power-up.

Table 4.2.13 0x16-02: Repeat Start-Up Report with System Time Message

Byte / Bit		Name	Type	Value	Meaning
		Code	U8	0x16	
		Subcode	U8	0x02	Parameter Subcode
0-1		Error Code	U16	0 other	Normal shutdown (SW or power) Abnormal shutdown (Table 5.2.1)
2		Status	U8		Reserved
3	0	RAM Signature	U1		1 = BBRAM signature valid
3	1	Gyro / ADC test	U1		1 = ADC or Gyro self-test error
3	2	RTC Valid	U1		1 = RTC valid at startup
3	3	Flash BBRAM	U1		1 = BBRAM loaded from Flash
4		Soft Event Index	U7	0 [1,127]	No soft event in log at start-up Last soft event index in log at start-up
5-8		SysClock	U32	1 ms	System Time

4.3 Configuration Report packets

4.3.1 0x22-01: Output Interval Control Table

Table 4.3.1 0x24: Format of GPS Configuration Message Parameter

Byte	Name	Type	Value	Units	Meaning
	Code	U8	0x22		
	Subcode	U8	0x01		
0	Index	U8	0x00-0x0F, 0xFF		Table Slot Number
1	Code	U8	0x00-7F		Code in Slot
2	Subcode	U8	0x00-7F		Subcode in Slot
3-6	Automatic Output Event Trigger Mask	U32	0x00-0xFFFFFFFF		See Table x.x.x
7-10	Time Threshold	U32		1 ms	Minimum Time required
11-14	Time Trigger	U32	0 > 0	1 ms	Not used Trigger value
15-18	Distance Threshold	U32		1 cm	Minimum Distance required
19-22	Distance Trigger	U32	0 > 0	1 cm	Not used Distance Trigger value
23-26	Heading Threshold	U32		1 cdeg	Minimum Heading required
27-30	Heading Trigger	U32	0 > 0	1 cdeg	Not used Heading Trigger value

4.3.2 0x24: GPS Configuration

The Parser Code for GPS configuration parameters is 0x24. A typical parameter report is shown in Table 4.3.2

Table 4.3.2 0x24: Format of GPS Configuration Message Parameter

Byte	Name	type	Value	Meaning
	Code	U8	0x24	
	Subcode	U8	0x01-0x08	Parameter Subcode
0	Parameter Value	Refer to Table 4.3.3		

Table 4.3.3 shows the subcode, range, and default value for each of the GPS configuration parameters. DGPS does not apply to all products. Products to which DGPS does not apply have a default DGPS Mode of 1 (Ignore), and the value cannot be changed.

Table 4.3.3 List of GPS Configuration Message Parameters

Subcode	Name	Type	Units	Range	Default	Meaning
0x01	Operating Dimension	U8		0 3 4	0	Auto 2D/3D Alt-Hold (2D) Full Pos (3D)
0x02	DGPS Mode	U8		0 1 2	1	Require Ignore If Available
0x03	Dynamics Code	U8		17	17	Automobile
0x04	Elevation Mask	FLT	(degrees)	[0°, 90°]	5.0	Tracking limit
0x05	SNR Mask	U16	0.2 dBHz	[100, 240] = [20, 48] dBHz	145 = 29 dBHz	Fix limit
0x06	DOP Mask	FLT		[0.0, 99.0]	20.0	Fix limit
0x07	DOP Switch	FLT		[0.0, 99.0]	20.0	Fix limit
0x08	DGPS Age Limit	U16	1 s	0-240	30	Fix limit

4.3.3 0x25: Kalman Filter Configuration

The Parser Code for the Kalman Filter configuration parameters is 0x25. A typical parameter report is shown in Table 4.3.4

Table 4.3.4 0x25: Format of Kalman Filter Configuration Parameter

Byte	Name	Type	Value	Meaning
	Code	U8	0x25	
	Subcode	U8	0x01-17	Parameter Subcode
0	Parameter Value	Refer to Table 4.3.5		

Table 4.3.5 shows the subcode, range, and default value for each of the Kalman Filter configuration parameters.

Table 4.3.5 List of Kalman Filter Configuration parameters

Subcode	Name	Type	LSB	Range	Default	Meaning
0x01	MinGainIndex	U32	1 ms	< 40000	0	minimum settling time of code-carrier filter
0x02	MinSVs	U32		[3, # of channels]	3	Minimum number of SVs for fix
0x03	NoEditAMU5	U32	0.2 AMU	< 16.0 AMU	14.0 AMU	maximum AMU value at which editing is allowed
0x04	MinAMU5	U32	0.2 AMU	< 16.0 AMU	2.0 AMU	Minimum acceptable AMU value
0x05	MaxEdits	U32		$[0, 2^{32}-1]$	60	Maximum number of fix rejections before KF reset
0x06	MaxGPSPropTime	U32				Not currently used
0x07	MaxAcc	FLT	(m/s^2)	[0, 20]	10	vehicle acceleration limit
0x08	MaxVel	FLT	(m/s)	[0, 150]	150.0	vehicle velocity limit
0x09	SigmaHorizAcc	FLT	(m/s^2)	[0, 20]	0.5	typical horizontal acceleration
0x0A	SigmaFreqAcc	FLT	(m/s^2)	[0, 20]	1.0	typical frequency drift
0x0B	CarrSigSq	FLT	(m/s)	[0, 2]	$(0.07)^2$	Doppler error variance
0x0C	MaxAcceptSigmaSq	FLT	(σ^2)	$[0, 10^{12}]$	$(4.0)^2$	edit limit for residuals
0x0D	InitPosVar	FLT	(m^2)	$[0, 10^{12}]$	$(1000.)^2$	initial position error variance
0x0E	InitBiasVar	FLT	(m^2)	$[0, 10^{12}]$	$(1000.)^2$	initial clock bias error variance
0x0F	ClockModelError	FLT	(m^2)	$[0, 10^6]$	$(1.0)^2$	extra clock process noise (to de couple clock model)
0x10	RejectSSR	FLT	(σ^2)	$[0, 10^{12}]$	$(6.0)^2$	rejection limit for normalized a posteriori residual
0x11	SigSlope1Sq	FLT	$(slope^2)$	[0, 4]	$(0.1)^2$	typical velocity slope
0x12	SigSlope2Sq	FLT	$(slope^2)$	[0, 4]	$(0.05)^2$	typical change-in-position slope
0x13	MaxSlope3Sq	FLT	$(slope^2)$	[0, 4]	$(0.3)^2$	rejection limit for velocity slope
0x14	MinVVelSq	FLT	(m/s)	[0, 100]	100.0	minimum vertical velocity for slope rejection
0x15	Alt2Dvar	FLT	(m^2)	$[0, 10^8]$	$(1.0)^2$	Variance of 2D altitude-hold altitude measurement
0x16	fltMinPosVar	FLT	(m^2)	$[0, 10^8]$	$(1.0)^2$	Hard-limit minimum for east, north, up position variances
0x17	fltMaxHVar	FLT	(m^2)	$[0, 10^8]$	$(100.)^2$	Max sum-square of the east and north varainces for output

4.3.4 0x26-01: Available Report Codes

This message reports the report codes and subcodes that are available in the firmware. There is no set command for this report.

Table 4.3.6 0x26-01: Available Report Code Report Message

Byte		Name	Type	Value	Meaning
		Code	U8	0x26	
		Subcode	U8	0x01	
0	0	Parser Code 0x00	U1		1 = Available
0	1	Parser Code 0x01	U1		1 = Available
0	2	Parser Code 0x02	U1		1 = Available
…					
N	M	Parser Code (8 N + M)	U1		1 = Available
…					
15	6	Parser Code 0x7E	U1		1 = Available
15	7	Parser Code 0x7F	U1		1 = Available

4.3.5 0x26-02: Available Report Subcodes

This message reports the report subcodes in each report code that are available in the firmware. There is no set command for this report.

Table 4.3.7 0x26-02: Available Report Subcode Report Message

Byte		Name	Type	Value	Meaning
		Code	U8	0x26	
		Subcode	U8	0x02	
		Index	U8	0x00-7F	Parser Code
0	0	Parser Subcode 0x00	U1		1 = Available
0	1	Parser Subcode 0x01	U1		1 = Available
…					
N	M	Parser Subcode (8 N + M)	U1		1 = Available
…					
15	6	Parser Subcode 0x7E	U1		1 = Available
15	7	Parser Subcode 0x7F	U1		1 = Available

4.3.6 0x26-03, 0x26-04, 0x26-05: DPP Speed Model

The DPP model has multiple DPP values, each applicable over a limited speed range. The 0x26-03 message reports the maximum speed level of application for each DPP value. The 0x26-04 and 0x26-05 messages report the minimum and maximum speed levels used for calibrating each DPP. These values are compiled in the firmware, so there is no set procedure for these reports.

Table 4.3.8 0x26-03: DPP Model Message

Byte / Bit	Name	type	Units / LSB	Range / value	meaning
	Code	U8		0x26	
	Subcode	U8		0x03	
0	N = # of speed levels	U8			
1	Max Applicable Speed of DPP[0]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top speed Unlimited
…	…				
N	Max Applicable Speed of DPP[N-1]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top of range Unlimited

Table 4.3.9 0x26-04: DPP Minimum Calibration Speed Message

Byte / Bit	Name	type	Units / LSB	Range / value	meaning
	Code	U8		0x26	
	Subcode	U8		0x04	
0	N = # of speed levels	U8			
1	Min Calibration Speed of DPP[0]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top speed Unlimited
…	…				
N	Min Calibration Speed of DPP[N-1]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top of range Unlimited

Table 4.3.10 0x26-05: DPP Maximum Calibration Speed Message

Byte / Bit	Name	type	Units / LSB	Range / value	meaning
	Code	U8		0x26	
	Subcode	U8		0x05	
0	N = # of speed levels	U8			
1	Max Calibration Speed of DPP[0]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top speed Unlimited
…	…				
N	Max Calibration Speed of DPP[N-1]	U8	0.5 m/s	[0.5, 127.0] m/s =127.5 m/s	Top of range Unlimited

4.3.7 0x27: DR Filter Configuration

The Parser Code for the DR Filter configuration parameters is 0x27. A typical parameter report is shown in Table 4.3.11

Table 4.3.11 0x27: Format of DR Filter Configuration Parameter

Byte	Name	Type	Value	Meaning
	Code	U8	0x27	
	Subcode	U8	0x00-19 0x40-6F	Integer Parameter Subcode Float Parameter Subcode
0-3	Parameter Value	Refer to Table 4.3.12, Table 4.3.13		

Table 4.3.12 and Table 4.3.13 show the subcode, range, and default value for each of the DR Filter configuration parameters.

Table 4.3.12 List of DR Filter Configuration Integer Parameters

Subcode	Name	Type	LSB/ (Units)	Range	Default	Meaning
0x01	GPSVelEditHoldoff	S32	1 count	[0, 1000]	20	
0x02	MinSpdDirSwThresh	S32	1 m/s	[0, 126]	8	
0x03	DirSwWarning	S32	1 m/s	[0, 126]	14	
0x04	MaxDirSwSpd	S32	1 m/s	[0, 126]	20	
0x05	ZROGPSStatThldSpdHi	S32	1 cm/s	[0, 12600]	10	
0x06	ZROGPSStatThldSpdLo	S32	1 cm/s	[0, 12600]	10	
0x07	ZROMaxDistThld	S32	1 cm	[0, 1000]	5	
0x08	MinGPSInitNFix	S32	1 count	[0, 1000]	10	
0x09	GPSJumpHoldOff	S32	1 count	[0, 1000]	10	
0x0A	MaxHBMSecs	S32	1 ms	[0, 9000]	3000	
0x0B	MinHBMSecs	S32	1 ms	[0, 9000]	1000	
0x0C	ZROMaxEdit	S32	1 ADC sample	[0, 10^5]	1000	Gyro sampled at 100 Hz
0x0D	ZRRHoldOffSecs	S32	1 s	[0, 2^{31}-1]	0	
0x0E	ZROVarDecorTime	S32	1 s	[0, 100000]	1200	
0x0F	TachoDisconnectThrshld	S32	1 count	[0, 1000]	15	
0x10	GPSVDelayMSecs	S32	1 ms	[-2000, 2000]	300	
0x11	TachoDelayMSecs	S32	1 ms	[-2000, 2000]	0	
0x12	WinMaxTime	S32	1 ms	[0, 1000000]	300000	
0x13	WinMinPts	S32	1 count	[0, 1000]	10	
0x14	WinMin3D	S32	1 count	[0, 1000]	8	
0x15	WinENMinDist	S32	1 m	[0, 1000]	30	
0x16	MinPtsGrossErr	S32	1 count	[0, 1000]	3	
0x17	GSFCalcMinHdgChng	S32	2^{-15} sc	[0, 65536]	8192	45 degrees
0x18	GSFCalcMaxMsecs	S32	1 ms	[0, 100000]	100000	
0x19	MinTimeBetweenWinPos	S32	1 s	[0, 10000]	10	
0x1A	MaxHdgRateEndGSF	S32	2^{-15} sc/s	[208, 2086]	1564	54 degrees/s
0x1B	GSFCalcMinMsecs	S32	ms	[3000, 60000]	5000	

Table 4.3.13 List of DR Filter Configuration Float Parameters

Subcode	Name	Type	LSB / (Units)	Range	Default	Meaning
0x40	NoEditAddVelAccy	FLT	$(m/s)^2$	[0, 100]	1.0	
0x41	ZROMaxDeltaGyro	FLT	(GCnts)	[0, 49152]	4.9152	1.5 mV
0x42	BadTachoMinSpd	FLT	(m/s)	[0, 126]	8.0	
0x43	ZROCalcGyroNoiseVar	FLT	$(GCnts)^2$	[0, 107374.2]	67.1089	$(1.0\ mV)^2$
0x44	ZROCalcEditSigSq	FLT	$(unitless)^2$	[0, 10000]	100.0	
0x45	MaxGPSInitPosSig2	FLT	$(m)^2$	$[0, 10^{12}]$	100.0	
0x46	MinGPSInitDist	FLT	(m)	$[0, 10^6]$	60	
0x47	ZROVarValidThreshold	FLT	$(GCnts)^2$	[0, 67108900]	671089.	$(250\ mV)^2$
0x48	SnapThreshold2	FLT	$(m)^2$	$[0, 10^{12}]$	100	
0x49	MaxHBSpd	FLT	(m/s)	[0, 126]	0.05	
0x4A	MinWindowVelCfm	FLT	(m/s)	[0, 126]	12.0	
0x4B	HdgCalcMinSpd	FLT	(m/s)	[0, 126]	3.0	
0x4C	HdgCalcMinSpdNoTacho	FLT	(m/s)	[0, 126]	10.0	
0x4D	HdgCalcMinHdgSigSq	FLT	$(rad)^2$	[0, 12]	0.09	
0x4E	HdgMinSigSq	FLT	$(rad)^2$	[0, 12]	1.0	
0x4F	PosMinSigSq	FLT	$(m)^2$	$[0, 10^{12}]$	10000.	
0x50	DPPCalMinSigSq	FLT	$(m/pulse)^2$	[0, 1]	0.01	
0x51	SpdCalcMinSpdSigSq	FLT	$(m/s)^2$	[0, 900]	9.0	
0x52	SpdCalcMinSpeed	FLT	(m/s)	[0, 126]	8.0	
0x53	GPSVelEditSigSq	FLT	$(unitless)^2$	[0, 1000]	16.0	
0x54	GPSVelEditMaxHdSq	FLT	$(rad)^2$	[0, 12]	0.04	
0x55	MinGPSSpdMotNoTacho	FLT	(m/s)	[0, 126]	3.0	
0x56	GvarColdHdg	FLT	$(rad)^2$	[10, 100]	100.0	
0x57	GvarColdZRO	FLT	$(GCnts)^2$	[67.1089, 67108900]	671089.	$(250\ Mv)^2$
0x58	GvarColdZRR	FLT	$(GCnts/s)^2$	$[0, 10^6]$	0.662171	
0x59	GvarWarmHdg	FLT	$(rad)^2$	[0, 12]	0.01	
0x5A	GvarWarmZRO	FLT	$(GCnts)^2$	[67.1089, 67108900]	9663.68	$(30\ mV)^2$
0x5B	GvarWarmZRR	FLT	$(GCnts/s)^2$	$[0, 10^6]$	0.0025866	
0x5C	GPNVarHdg	FLT	$(rad)^2/s$	[0, 1]	10^{-8}	
0x5D	GPNVarZRO	FLT	$(GCnts)^2/s$	[0, 1]	0.000268435	$(5\ \mu V)^2\ /s$
0x5E	GPNVarZRR	FLT	$(GCnts)^2/s^3$	[0, 1]	5.17321e-6	
0x5F	GyroSnsSig2	FLT	$(unitless)^2$	[0, 1]	0.0004	As a proportion of nominal value
0x60	CarrSigMultFactor	FLT	$(unitless)^2$	[0, 10000]	9.0	
0x61	TinitVar	FLT	$(m/pulse)^2$	[.00001, 4]	1.0	
0x62	TPNVar	FLT	$(m/pulse)^2$ / s	[0, 1]	2.5e-11	
0x63	TmaxVar	FLT	$(m/pulse)^2$	[.00001, 4]	2.5e-5	
0x64	ZRRHoldOffZROAccy	FLT	$(GCnts)^2$	[.00107374, 107374.18]	10.7374	$(1.0\ mV)^2$
0x65	WinSnapThd	FLT	$(unitless)^2$	$[0, 10^6]$	36.0	
0x66	WinClusterVar	FLT	$(unitless)^2$	$[0, 10^6]$	9.0	
0x67	MaxInitGrossErrSq	FLT	$(m)^2$	$[0, 10^{12}]$	4.0e6	
0x68	MaxCorrectionSigSq	FLT	$(unitless)^2$	$[0, 10^6]$	4.0	
0x69	GSFCalcMinHdgRate	FLT	(rad/s)	[0, 3]	0.174533	
0x6A	GSFCalcMaxHdgRate	FLT	(rad/s)	[0, 3]	1.0472	
0x6B	GSFCalcMaxZROVar	FLT	$(unitless)^2$	$[0, 10^6]$	4.0	
0x6C	MaxGSFVar	FLT	$(GCnts/(rad/s))^2$	[0, 1]	4.53915e-10	$(2.5\ mV/(°/s))^2$
0x6D	MinGSFVar	FLT	$(GCnts/(rad/s))^2$	[0, 1]	4.53915 e-16	$(0.0025\ mV/(°/s))^2$
0x6E	MaxDelGSF	FLT	(GCnts/(rad/s))	[0, 1]	2.13053e-6	0.025 mV/(°/s)
0x6F	MinNormVelResidSq	FLT	$(unitless)^2$	[0, 100]	0.01	
0x70	GSFCalcMaxGPSVar	FLT	rad^2	[.000001, .16]	.0016	

(*) A GCnt is a 14-bit ADC count. Full scale (5 V) is 16384 GCnt, so 1 mV = 3.2768 GCnt.

4.3.8 0x2A, 0x2B, 0x2C; 0x2D: Output Interval Control

These reports contain the data structures describing the output interval for automatic messages. Automatic outputs are controlled by thresholds and triggers on three criteria: time, distance traveled, or heading change. A combination of criteria can be set for each message, and different report message codes can have different output controls. The number of message codes that can be chosen for auto-output is limited to 16.

The message codes chosen for auto-report are stored in a table that contains the values of time interval, distance traveled, and heading change since the last report. These values are kept separately for each message code. The table is scanned every time the gyro service routine is called (at 10 Hz or 5 Hz rate). For each message code, the current values of time interval, distance traveled, and heading change are differenced with the corresponding three table values. The three differences are compared against the three corresponding thresholds for that message code to determine whether an output is allowed. If so, the differences are then compared to against the three corresponding triggers (if any) to see if an output is required. If the message is output, the table values are updated to the current values.

The logic for report output is as follows:

$$\text{(Time interval} > T_{thresh}\text{) AND}$$
$$\text{(Distance traveled} > D_{thresh}\text{) AND}$$
$$\text{(Heading change} > H_{thresh}\text{) AND}$$
$$\text{(EVENT OR (Time interval} > T_{trigger}\text{) OR (distance traveled} > D_{trigger}\text{) OR (Heading change} > H_{trigger}\text{))}$$

Defaults are zero for all reports, except as specified in Table 4.3.18. No subcode is used in the query if the Subcode is 0xFF.

Table 4.3.14 0x2A: Automatic Output Event Trigger Report Message

Byte	Bit	Name	Type	Value	Meaning
		Code	U8	0x2A	Event Control
		Subcode	U8	0x00-7F 0xFF	Parser Code All Codes
		Index	U8	0x00-7F	Parser Subcode (Not used in query if Subcode is 0xFF)
0	1	Event 1	U1		Almanac Page Collected
0	2	Event 2	U1		Ephemeris Page Collected
0	3	Event 3	U1		Ionosphere-UTC Page Collected
0	6	Event 6	U1		Almanac Health page Collected
0	7	Event 7	U1		Tacho/Gyro Collected (10 Hz, HIP)
1	1	Event 9	U1		GPS Measurement Collected (1 Hz)
1	2	Event 10	U1		Least Squares (LS) Fix generated (1 Hz)
1	3	Event 11	U1		LS Fix not generated
1	4	Event 12	U1		Tracking SV List Updated
2	1	Event 17	U1		Self-test complete (HIP)
2	3	Event 19	U1		Receiver status changed
2	4	Event 20	U1		Power-on acknowledge
2	5	Event 21	U1		Start-up complete
2	6	Event 22	U1		Ready to shutdown
3	0	Event 24	U1		DPP Calibrated
3	1	Event 25	U1		Direction Switch Calibrated
3	2	Event 26	U1		Gyro Calibrated
3	4	Event 28	U1		Time status change (time set)
3	5	Event 29	U1		Hard Error

Table 4.3.15 0x2B: Automatic Output Time Interval Trigger Report Message

Byte	Name	Type	Value	Units	Meaning
	Code	U8	0x2B		Time Interval Control
	Subcode	U8	0x00-7F 0xFF		Parser Code All Codes
	Index	U8	0x00-7F		Parser Subcode (Not used in query if Subcode is 0xFF)
0-3	Threshold	U32		1 ms	Minimum required
4-7	Trigger	U32	0 > 0	1 ms	Not used Trigger value

Table 4.3.16 0x2C: Automatic Output Distance Traveled Trigger Report Message

Byte	Name	Type	Value	Units	Meaning
	Code	U8	0x2C		Distance Traveled Control
	Subcode	U8	0x00-7F 0xFF		Parser Code All Codes
	Index	U8	0x00-7F		Parser Subcode (Not used in query if Subcode is 0xFF)
0-3	Threshold	U32		1 cm	Minimum required
4-7	Trigger	U32	0 > 0	1 cm	Not used Trigger value

Table 4.3.17 0x2D: Automatic Output Heading Change Trigger Report Message

Byte	Name	Type	Range/Value	Units	Meaning
	Code	U8	0x2D		Heading Change Control
	Subcode	U8	0x00-7F 0xFF		Parser Code All Codes
	Index	U8	0x00-7F		Parser Subcode (Not used in query if Subcode is 0xFF)
0-3	Threshold	U32		1 cdeg	Minimum required
4-7	Trigger	U32	0 > 0	1 cdeg	Not used Trigger value

Table 4.3.18 List of Automatic Output Trigger Defaults

Code - Subcode	Event Trigger	Time Interval Threshold	Time Interval Trigger	Distance Traveled Threshold	Distance Traveled Trigger	Heading Change Threshold	Heading Change Trigger
12-01	21	*	0	0	0	0	0
30-02	-	*	200	0	0	0	0
31-01	10,11	*	0	0	0	0	0
32-01	10,11	*	0	0	0	0	0
33-01	10,11	*	0	0	0	0	0
36-03	26	*	0	0	0	0	0
36-04	26	*	0	0	0	0	0
36-05	25	*	0	0	0	0	0
36-07	24	*	0	0	0	0	0
36-08	26	*	0	0	0	0	0

* Since output thresholds and triggers are checked at the DR service rate, there is a minimum time interval corresponding to the DR engine rate (Section 4.3.13). The effective minimum time interval threshold is 200 ms for DR engine rate of 5 Hz and 100 ms for DR engine rate of 10 Hz.

4.3.9 0x2E-01: Soft Event Report Mask

The soft event report can be suppressed. The following data structure shows whether it is masked, and can be set or queried.

Table 4.3.19 0x2E-01: Event Report Mask Message

Byte		Name	Type	Value	Meaning
		Code	U8	0x2E	
		Subcode	U8	0x01	
		Index	U8	0-0x7F 0xFF	Soft Event Identity Code (See Section 5.3).) All
0	0-1	Mask	U2	0 1 3	Do not report Report on change (single) Report as detected (continuous)

4.3.10 0x2F-02: Data Positioning Collection Test Interval Control

This test is part of the factory testing. At the end of the test, the module outputs diagnostic data in packet 0x3F-02.

There are two modes possible: automatic and manual. Automatic-control mode sets the Time Interval between one and 3600 seconds. The test begins immediately upon receipt of the set command and lasts until the end of the time interval. Manual-control mode uses the set command with the Time Interval Data field set to a large number (e.g., 3600) and then issuing an "Stop Immediately" command when desired. This message cannot be queried. If a test is currently running, this command will return an acknowledgment "contradicts current data".

This test does not interfere with the normal functioning of the module. The test collects statistics for a report at the end of the test.

Table 4.3.20 0x2F-02: Data Positioning Collection Mode Control Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x2F	
	Subcode	U8	0x02	
0-1	Time Interval	U16	0 [1, 3600]	Stop Immediately Perform test for this interval (seconds)

4.3.11 0x2F-04: Gyro Bench Test Interval Control

The module can bench-test gyro performance. This test is similar to the gyro part of the power-up ADC/gyro test. The test starts immediately upon receipt of the set command for 2F-04. When the test is finished, it automatically reports message 3F-04. The unit must be stationary for this test to be meaningful. This message cannot be queried.

There are two modes possible: automatic and manual. Automatic-control mode sets the Time Interval between one and 60 seconds. The test begins immediately upon receipt of the set command and lasts until the end of the time interval. Manual-control mode uses the set command with the Time Interval Data field set to a large number (e.g., 60) and then issuing an "Stop Immediately" command when desired. If a test is currently running, this command will return an acknowledgment "contradicts current data".

Table 4.3.21 0x2F-04: Gyro Bench Test Interval Report Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x2F	
	Subcode	U8	0x04	
0-1	Time Interval	U16	0 [1, 60]	Stop Immediately Perform test for this interval (seconds)

4.3.12 0x2F-06: Tacho/Reverse Production Test Interval Control

The test starts immediately upon receipt of the set command for 2F-06. When the test is finished, it automatically reports message 3F-06. This message cannot be queried. If a test is currently running, this command will return an acknowledgment "contradicts current data".

There are two modes possible: automatic and manual. Automatic-control mode sets the Time Interval between one and 60 seconds. The test begins immediately upon receipt of the set command and lasts until the end of the time interval. Manual-control mode uses the set command with the Time Interval Data field set to a large number (e.g., 60) and then issuing an "Stop Immediately" command when desired.

Table 4.3.22 0x2F-06: Tacho/Reverse Production Test Control Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x2F	
	Subcode	U8	0x06	
0-1	Time Interval	U16	0 [1, 60]	Stop Immediately Perform test for this interval (seconds)

4.3.13 0x21-01: DR Engine Rate Control

The DR software engine can be adjusted to run at 5 Hz or 10 Hz sampling rate. The five Hz rate eases CPU load. The choice of rate affects the minimum report interval in report 0x2B. After the engine rate is changed, the system will be reset automatically.

Table 4.3.23 0x2F-06: Tacho/Reverse Production Test Control Message

Byte	Name	Type	Value	Meaning
	Code	U8	0x21	
	Subcode	U8	0x01	
0	DR Engine Rate	U8	5 10	5 Hz 10 Hz

4.4 Data Report Packets

Data report packets can be queried or output based on time interval, distance traveled, heading change. Data validity must be checked before the data field are translated or used.

4.4.1 0x30-02: Fast Fix with Raw DR Data Message

This message is prepared for output every fast cycle (5 Hz or 10 Hz) when in HIPPO mode, except for a short period at start-up. The Output Interval Control determines the actual rate of output. This message has higher priority than other messages, so a series of reports that lasts longer than 100 milliseconds may have one or more of these messages interspersed. This should cause no problem, since all series of reports are terminated by an acknowledgment.

Table 4.4.1 0x30-02: Fast Fix with Raw DR Data Message

Byte	Bit	Name	type	Units/LSB	Range / value	Meaning
		Code	U8	0x30		
		Subcode	U8	0x02		
0	0	Position Status	U1		0 1	Accuracy > 10000 Valid
0	1	Altitude Status	U1		0 1	Accuracy > 1000 Valid
0	2	Heading Status	U1			1 = Valid
0	3	Speed Status	U1			1 = Valid
0	4	Direction Switch Status	U1			1 = Valid
0	5	Delta-Distance Status	U1			1 = Valid
0	6	Delta-Heading Status	U1			1 = Valid
0	7	Motion Status	U1			1 = Valid
1	0	Motion Indicator	U1			1 = Motion
1	1	Direction	U1			1 = Backward
1	2	Gyro Calibration Status	U1			1 = Calibrated
1	3	Tacho Calibration Status	U1			1 = Calibrated
1	4-5	Time source	U2		0 1 2 3	System clock RTC GPS (< 10 ms) GPS (< 1 ms)
1	6	Snap to DR-GPS	U1		0 1	DR-Propagated Jump
2		GPS Data Age Index	U8	s	0-253 254 255	Age >253 s GPS N/A
3-6		GPS Time of Week	U32	1 ms	0-604800000	
7-10		Latitude	S32	2^{-31} sc	[-½, ½] sc.	
11-14		Longitude	S32	2^{-31} sc	[-1, 1) sc.	
15-16		Altitude	S16	1 m	[-400,10000] m	MSL
17-18		Heading	U16	2^{-15} sc	[0, 2) sc.	
19-20		Speed	U16	1 cm/s	[0, 655.34] m/s	Past 1 sec. avg.
21-22		Delta time	U16	1 ms	[0, 1100] ms	even
23-24		Delta Distance[1]	S16	1 cm	[-327.67, 327.67] m	
25-26		Delta Heading	S16	1 cdeg	[-327.67°, 327.67°]	
27-28		Position accuracy	U16	1 m	[0, 65534] m 65535	Accuracy Accuracy > 65534
29-30		Altitude Accuracy	U16	1 m	[0, 65534] m	
31-32		Heading Accuracy	U16	2^{-15} sc	[0, 2) sc.	
33-34		Speed Accuracy	U16	1 cm/s	[0, 655.34] m/s	
35-36		Delta distance accy	U16	1 cm	[0, 655.34] m	
37-38		Delta heading accy	U16	1 cdeg	[0°, 360°]	
39	0-6	# of Gyro Samples	U7		0-127	< 110 typ

39	7	Direction Switch Value	U1			1 = High
40-43		Gyro Counts	U32		0-450560	Sum ADC values
44-45		Tacho Counts	U16		0-65535	< 3300 typ

Notes:

[1] In ROM version 1.18 and in previous versions, Delta Distance is truncated (floored to the next lowest integer cm). In subsequent ROM versions, Delta Distance is rounded to the nearest integer cm.

The data source of the fast fix can be inferred from the current tacho status, the current gyro status, and the GPS age as follows:

Table 4.4.2 Fast Fix Data Sources

Tacho Status	Gyro Status	GPS Age	Lat / Lon Source	Altitude Source	Speed / Delta Distance Source	Heading / Delta Heading Source
1	1	< 255	GPS + DR	GPS	DR + GPS Cal	DR + GPS Cal
1	0	< 255	GPS + DR	GPS	DR + GPS Cal	GPS
0	1	< 255	GPS	GPS	GPS	DR + GPS Cal
0	0	< 255	GPS	GPS	GPS	GPS
1	1	255	BBRAM + DR	BBRAM	DR	DR
1	0	255	BBRAM	BBRAM	DR	None
0	1	255	BBRAM	BBRAM	None	DR
0	0	255	BBRAM	BBRAM	None	None

4.4.2 0x31-01: GPS Fix Message

Table 4.4.3 0x31-01: GPS Fix Message

Byte	Bit	Name	Type	Units / LSB	Range / value	Meaning
		Code	U8	0x31		
		Subcode	U8	0x01		
0-3		GPS Time of Week	U32	1 ms	<604800000	
4	0-5	Fix Source	U6		0 1 3 4 5 8 9 10 11 12 13 14 15 16 17	No Fix Input position, approximate Input position, accurate INTERNAL KF_HIVAR BBRAM / OLD POS_APPX AVSV FRIM XS_BIAS or TIME_SEQ 2-D fix, no reference altitude KF velocity RAIM failed KF edited too many SVs KF position RAIM failed Position Valid
4	6	Altitude Hold	U1		0 1	Full position (3-D) LS fix Altitude-Hold (2-D) LS fix
4	7	DGPS Status	U1			1 = DGPS-corrected
5	0	Position status	U1			1 = Valid
5	1	Altitude status	U1			1 = Valid
5	2	Heading status	U1			1 = Valid
5	3	Speed status	U1			1 = Valid
5	4-5	Time source	U2		0 1 2 3	System clock RTC GPS (< 10 ms) GPS (< 1 ms)
6-9		Latitude	S32	2^{-31} sc	[-½, ½] sc	
10-13		Longitude	S32	2^{-31} sc	[-1, 1) sc	
14-15		Altitude	S16	m	[-400,10000] m	MSL
16-17		Heading	U16	2^{-15} sc	[0, 2) sc	
18-19		Speed	U16	1 cm/s	[0, 655.34] m/s	
20-21		Position accuracy	U16	1 m	[0, 65535] m	
22-23		Altitude accuracy	U16	1 m	[0, 65535] m	
24-25		Heading Accuracy	U16	2^{-15} sc	[0, 2) sc	
26-27		Speed Accuracy	U16	1 cm/s	[0, 655.35] m/s	

Position, heading and speed values are from GPS measurements. Code-carrier filtering has been applied, but not velocity (PV) or DR filtering. These fixes will be quite noisy in urban environments.

4.4.3 0x32-01: UTC Time and Constellation Summary Message

Table 4.4.4 0x32-01: UTC Time and Constellation Summary Message

Byte		Name	Type	Units	Range / value	meaning
		Code	U8	0x32		
		Subcode	U8	0x01		
0-1		UTC year	U16		2000+	
2		UTC month	U8		[1, 12]	
3		UTC day	U8		[1, 31]	
4		UTC hour	U8		[0, 23]	
5		UTC minute	U8		[0, 59]	
6		UTC second	U8		[0, 60]	= 60 only for the leap second
7		UTC / GPS offset	U8			GPS = UTC + offset
8-9		PDOP	U16	2^{-8}		
10-11		HDOP	U16	2^{-8}		
12-13		VDOP	U16	2^{-8}	0 >0	2D position 3D position
14		Max DGPS age	U8	Sec	<255 255	Seconds Overage or invalid
15	0-3	GPS Status	U4		0 2 3 5 6 7 8	Doing position fixes Need time PDOP too high No usable SVs One usable SV Two usable SVs Three usable SVs
15	4-5	Time source	U2		0 1 2 3	System clock RTC GPS (< 10 ms) GPS (< 1 ms)
16	0-1	Search Mode	U2		0 1 2	None Blind Anywhere
16	7	Almanac Status	U1			1 = Complete
17	0-3	Number of SVs Visible	U4		[0,12]	

4.4.4 0x32-02: Constellation Summary Message

Table 4.4.5 0x32-02: Constellation Summary

Byte		Name	Type	Units	Range / value	meaning
		Code	U8	0x32		
		Subcode	U8	0x02		
0	0-3	GPS Status	U4		0 2 3 5 6 7 8	Doing position fixes Need time PDOP too high No usable SVs One usable SV Two usable SVs Three usable SVs
0	4-5	Time source	U2		0 1 2 3	System clock RTC GPS (< 10 ms) GPS (< 1 ms)
0	7	Almanac Status	U1			1 = Complete
1	0-3	Number of SVs Visible	U4		[0,12]	
1	4-5	Search Mode	U2		0 1 2	Not searching Blind Anywhere
2-5		GPS Time of Week	U32	1 ms	<604800000	Time of fix
6		Dimension	U8		2 3	Altitude-hold Full Position
7-8		PDOP	U16	2^{-8}		
9-10		HDOP	U16	2^{-8}		
11-12		VDOP	U16	2^{-8}		
13		Max DGPS age	U8	Sec	0-254 255	Age of oldest DGPS correction Overage or invalid

4.4.5 0x32-03: UTC Time Message

Table 4.4.6 0x32-03: UTC Time Message

Byte		Name	Type	Units	Range / value	meaning
		Code	U8	0x32		
		Subcode	U8	0x03		
0	4-5	Time source	U2		0 1 2 3	System clock RTC GPS (< 10 ms) GPS (< 1 ms)
1-4		GPS Time of Week	U32	1 ms	<604800000	
5-6		GPS Week Number	U16		>1024	
7		UTC / GPS offset	U8		0 >0	Not available GPS = UTC + offset
8-9		UTC year	U16		2000+	
10		UTC month	U8		[1, 12]	
11		UTC day	U8		[1, 31]	
12		UTC hour	U8		[0, 23]	
13		UTC minute	U8		[0, 59]	
14		UTC second	U8		[0, 60]	

4.4.6 0x33-01: GPS Channel Measurement Short Status

This report message type is indexed by channel number (0-7 for eight-channel receivers and 0-11 for twelve-channel receivers).

If the query is "query-all" (0xFF), only assigned channels will be reported. If channel status is queried for an unassigned channel, the data fields (including SV PRN) are zero-filled.

Table 4.4.7 0x33-01: GPS Channel Measurement Short Status Message

Byte	Bit	Name	type	Units	Range / value	meaning
		Code	U8	0x33		
		Subcode	U8	0x01		
		Index	U4		0-11	Channel
0		SV PRN	U5		0 1 – 32	Channel unassigned SV PRN
1	0	SV Visible	U1			1 = Elevation > Mask
1	1	reserved	U1			
1	2	SV Has Been Tracked	U1			1 = Already Tracked
1	3	reserved	U1			
1	4	SV Currently Tracking	U1			1 = Tracking
1	5	SV Meets SNR Mask	U1			1 = SNR Meets Mask
2		SNR	U8	0.2 dB-Hz	[0,48] dBHz	
3		Azimuth	U8	2°	[0°, 358°]	
4		Elevation	S8	1°	[-90°,90°]	
5	0-1	Almanac Status	U2		0 1 3	None Old Current
5	2-3	Ephemeris Status	U2		0 1 2 3	None Old Decoded Verified

4.4.7 0x36: DR Calibration Messages

The DR calibration messages contain the current settings for the gyro and tacho parameters. They are typically transmitted when the parameters are updated. ZRO, ZRO rate, and DPP are updated upon generation of a valid GPS velocity. ZRO and ZRO rate are also updated during periods of zero speed.

When the host uses the "set" procedure with these messages, the "source" field must be set to "Clear", "Host Input", or "Host Override". The "set" procedure is not supported for ZRO rate (0x36-08).

For "Clear", the rest of the fields are ignored.

For "Host Input", if the device has already calibrated the parameters, the set procedure is aborted. The acknowledgment message has status set to "Contradicts current data".

For "Host Override", the value and accuracy must be valid quantities.

The "Validity" and "Newness" fields are always ignored in the set procedure.

Table 4.4.8 0x36-03: ZRO Calibration Message

Byte / Bit		Name	type	Units / LSB	Range / value	Meaning
		Code	U8		0x36	
		Subcode	U8		0x03	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
1-4		Zero Rate Output (ZRO)	FLT	(mV)	(-2500.0, 2500.0)	
5-8		ZRO accuracy	FLT	(mV)	> 0	1 σ accuracy

Table 4.4.9 0x36-04: Gyro Linearity Calibration Message

Byte / Bit		Name	type	Units / LSB	Range / value	meaning
		Code	U8		0x36	
		Subcode	U8		0x04	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
1-4		Sensitivity (GyroSns)	FLT	(mV /(°/s))	[20.9, 31.2]	
5-8		Sensitivity Accuracy	FLT	(mV /(°/s))	> 0	1 σ accuracy

Table 4.4.10 0x36-05: Direction Switch Calibration Message

Byte / Bit		Name	type	Units / LSB	Range / value	meaning
		Code	U8		0x36	
		Subcode	U8		0x05	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
0	7	Direction Switch Sense	U1		0 1	0 = FWD, 1 = REV 0 = REV, 1 = FWD
1		Confidence Speed	U8	1 m/s	< DirSwWarning (see 0x27; default=14 m/s) < 256 if Source is Host Override	Last calibration speed

Table 4.4.11 0x36-07: DPP Calibration Message

Byte / Bit		Name	type	Units / LSB	Range / value	meaning
		Code	U8		0x36	
		Subcode	U8		0x07	
		Index	U8		[0, N_{DPP}-1]	Speed Level Index
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
1-4		DPP	FLT	(m / pulse)	[.005, 5.0]	< 5 m/pulse typ
5-8		DPP accuracy	FLT	(m / pulse)	[.001, 1.0]	1 σ accuracy

Table 4.4.12 0x36-08: ZRO Rate Calibration Message

Byte / Bit		Name	type	Units / LSB	Range / value	meaning
		Code	U8		0x36	
		Subcode	U8		0x08	
0	0-2	Source	U3		0 3	Invalid GPS Fix
0	3	Newness	U1		0 1	From BBRAM New (since start-up)
0	4	Validity	U1		1	1 = Valid
1-4		ZRO Rate of Change	FLT	(mV / sec)		
5-8		ZRO Rate accuracy	FLT	(mV / sec)		1 σ accuracy

4.4.8 0x3F-01: ADC and Gyro Self-test Data

The module performs a self-test on the ADC and gyro at start-up. (The module can also perform the gyro test after start-up; see Section 4.4.10.) If the tests are completely successful, the gyro/ADC self-test bit in the start-up message (0x12-01) is zero. If the bit is set to one, the host should examine the following message for diagnosis of the errors. The ADC at fixed voltage is from the test at start-up; the "at rest" data fields are from the most recent test. This information is not battery-backed, and is available by query only.

Table 4.4.13 0x3F-01: ADC and Gyro Self-Test Report Message

Byte / Bit	Name	Type	Units / LSB	Range / value	Meaning
	Code	U8	0x3F		
	Subcode	U8	0x01		
0	ADC validity	U8		0 1	No error ADC not functioning
1-4	ADC at fixed voltage	U32			
5-6	Samples at fixed voltage	U16			
7-10	ADC / gyro at rest	U32			
11-12	Samples at rest	U16			

4.4.9 0x3F-02: Data Positioning Collection Test Data (ROM 14 and before)

The Data Positioning Collection Mode Test starts immediately upon receipt of the set command 0x2F-02. When the test is finished, it automatically reports the data in this message. This information is not battery-backed. If no test has been performed, the Test Duration is 0.

Table 4.4.14 Built-In Diagnostic Test Report

Byte / Bit		Name	type	Units / LSB	Range / value	meaning
		Code	U8	0x3F		
		Subcode	U8	0x02		
0-3		Pulses counted	U32			
4-5		Maximum Speed	U16	1 cm/s		
6-9		Total Distance	U32	1 cm		
10	0	2-D GPS fix	U1			1 = 2-D fix failed
10	1	3-D GPS fix	U1			1 = 3-D fix failed
10	2	GPS calibrated DR	U1			1 = no GPS / DR cal
10	3	Almanac complete	U1			1 = incomplete
10	4	GPS error status	U1			1 = GPS error
11		Max SVs tracked	U8			
12		Max SNR	U8	0.2 dB-Hz		
13		DirSw transitions forward to reverse	U8			
14		DirSw transitions reverse to forward	U8			
15-16		Initial heading after ZRO cal	U16	2^{-15} sc	[0, 2) sc	
17-18		Final Heading	U16	2^{-15} sc	[0, 2) sc	
19-20		Test Duration	U16	1 s	0 [1,3600]	No test data

4.4.10 0x3F-03: Data Positioning Collection Test Data (ROM 15 and after)

This replaces report 0x3F-02 starting with ROM 15.

The Data Positioning Collection Mode Test starts immediately upon receipt of the set command 0x2F-02. When the test is finished, it automatically reports the data in this message. This information cannot be set or queried.

Table 4.4.15 0x3F-03: Built-In Diagnostic Test Report

Byte / Bit		Name	type	Units / LSB	Range / value	Meaning
		Code	U8	0x3F		
		Subcode	U8	0x03		
0	0	Heading Valid before motion	U1			1 = valid
0	2	ZRO valid before motion	U1			1 = valid
0	3	DPP valid before motion	U1			1 = valid
0	4	Final Heading Valid	U1			1 = valid
1-4		Pulses counted	U32			
5-6		Maximum Speed	U16	1 cm/s		
7-10		Total Distance	U32	1 cm		
11		DirSw transitions F→R	U8			
12		DirSw transitions R→F	U8			
13-14		Heading at ZRO cal	U16	2^{-15} sc	[0, 2) sc	
15-16		DeltaHeading	U16	2^{-15} sc	[0, 2) sc	
17-18		Final Heading	U16	2^{-15} sc	[0, 2) sc	
19-20		Test Duration	U16	1 s	[1,3600]	
21-22		Initial Heading after ZRO calibration	U16	2^{-15} sc	[0, 2) sc	
23	0	2-D GPS fix	U1			1 = 2-D fix failed
23	1	3-D GPS fix	U1			1 = 3-D fix failed
23	2	GPS didn't calibrate DR	U1			1 = no GPS / DR cal
23	3	Almanac incomplete	U1			1 = incomplete
23	4	GPS error status	U1			1 = GPS error
24		Max SVs tracked	U8			
25		Max SNR	U8	0.2 dB-Hz		

4.4.11 0x3F-04: Gyro Bench Test Data

The module can bench-test gyro performance. This test is similar to the gyro part of the power-up ADC/gyro test.

The Gyro Bench Test starts immediately upon receipt of the set command 0x2F-04. When the test is finished, it automatically reports the data in this message. This information cannot be set or queried.

Table 4.4.16 0x3F-04: Gyro Bench Test Report Message

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8	0x3F		
	Subcode	U8	0x04		
0-3	ADC / gyro at rest	U32		ADC counts	
4-5	Samples at rest	U16		1-6200 samples	
6-7	Test Duration	U16	1 s	[1,60]	

4.4.12 0x3F-06: Tacho/Reverse Production Test Data

The Tacho/Reverse Production Test starts immediately upon receipt of the set command 0x2F-06. When the test is finished, it automatically reports the data in this message. This information cannot be set or queried.

Table 4.4.17 0x3F-06: Tacho/Reverse Production Test Report Message

Byte / Bit	Name	Type	Units / LSB	Range / value	Meaning
	Code	U8	0x3F		
	Subcode	U8	0x06		
0	Tacho counts	U32		Tacho Counts	
4-5	Samples	U16		4-600 samples	
6-7	Changes in Direction Switch Value	U16			
8-9	Samples	U16		4-600 samples	
10-11	Test Duration	U16	1 s	[1,60]	

4.4.13 0x30-03: Buffered Cumulative DR message

This message provides the first 20 seconds (or more) of buffered DR information. If the host takes significant time to boot up, this provides the recent path for map-matching purposes. The host should also request start-up information (0x16-02) and health information (0x16-01) on late boot-up. Once the message is queried, the data is frozen, and subsequent queries return the same data.

Validity Bits:

- The “all data” flag bit is set if the data buffer contains all data since power-up.
- The “rolling start” bit will be set if a tacho pulse (other than a heartbeat) is detected in the first 200 ms.
- Delta-distance is “valid” if the tacho was calibrated at start-up.
- Delta-heading is “valid” if the gyro was calibrated before vehicle started moving.
- Time source and position, and heading validity bits are taken from the most recent 0x30-02 message. These can be used with the current timetag, position, and heading to formulate a HIPPO map-match message.

An array of up to 20 delta-distances and delta-headings are in the message. These values will have been corrected with the estimate of ZRO and DPP current at the time. Each will be over an interval lasting about one second, except for the first and last intervals. The intervals are reported in reverse order, from newest (most-recent) first, to oldest (first recorded). If the module has collected less than twenty intervals of data, the unrecorded array elements will be set to zero. These zero-distance elements will have no effect on map-matching algorithms.

The oldest (first-recorded) interval lasts from power-up until the first integer second at which motion is detected.

The most recent interval for delta-distance and delta-heading gives the data between the most recent integer second and the request, so it may not be a complete second. If no motion has been recorded since power-up, this is the only interval reported and it may be much longer than one second.

Distance accuracy is relative to the total distance traveled (the sum of all the intervals). The accuracy of each one-second segment should be scaled proportionately.

Delta Heading accuracy is over each one-second interval, and is roughly the same for each of the intervals except the most recent, which may be more accurate.

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Table 4.4.18 0x30-03: Buffered Cumulative DR Message

Byte / Bit		Name	Type	Units / LSB	Range / value	Meaning
		Code	U8		0x30	
		Subcode	U8		0x03	
0	0	Current Position Valid	U1			1 = Valid
0	1	Current Heading Valid	U1			1 = Valid
0	2	Delta Distance Valid	U1			1 = Valid
0	3	Delta Heading Valid	U1			1 = Valid
0	4	All data	U1			1 = contains all data since start
0	5	Rolling start	U1			1 = motion detected at start-up
0	6-7	Time Source	U2			Time Source for Map Match
1-2		Time Tag	U16	1 ms	[0, 65535] ms	Time Tag for Map Match
3-6		Current Latitude	S32	2^{-31} sc	[-½, ½] sc.	
7-10		Current Longitude	S32	2^{-31} sc	[-1, 1) sc.	
11-12		Current Heading	U16	2^{-15} sc	[0, 2) sc	
13-14		Delta Distance [0]	S16	1 cm	[-327.67, 327.67] m	(Now – 1 s) to (Now)
15-16		Delta Heading [0]	S16	1 cdeg	[-327.67°, 327.67°]	(Now – 1 s) to (Now)
17-18		Delta Distance [1]	S16	1 cm	[-327.67, 327.67] m	(Now – 2 s) to (Now – 1 s)
19-20		Delta Heading [1]	S16	1 cdeg	[-327.67°, 327.67°]	(Now – 2 s) to (Now – 1 s)
…						
…						
89-90		Delta Distance [19]	S16	1 cm	[-327.67, 327.67] m	(Now – 20 s) to (Now – 19 s)
91-92		Delta Heading [19]	S16	1 cdeg	[-327.67°, 327.67°]	(Now – 20 s) to (Now – 19 s)
93-94		Current Heading Acc'y	U16	2^{-15}sc	[0, 2) sc	
95-96		Current Position Acc'y	U16	1 m	[0, 65534] m	
97-98		Distance accy	U16	1 cm	[0, 655.36] m	
99-100		Delta heading accy	U16	1 cdeg	[0°, 360°]	

4.5 Initialization Information

The following reports contain the information that the module is currently storing in BBRAM for initialization in the next session. If any information is updated in real time through data decode or fixes the module reports the updated information.

When these reports are used with the "set" command, the host sends the message with the "Source" byte set to "Host Input". If the information is already in use in the system and validated by fixes or decode, the module may reject the host input. This will be indicated in the acknowledgment message. Validated data can be over-written using the "Host override" option.

If BBRAM is lost, byte 3 of the start-up message 12-01 will indicate the module is doing a cold-start. The host can upload the initialization information to the module using the set procedure to speed GPS satellite acquisition. This information includes:

1. almanac messages (28-12, 28-13, 28-14);
2. time message (29-01);
3. frequency message (29-04); and
4. latitude / longitude message (29-02).

Of the above list, the frequency message is optional but the others are required for "warm-start" performance. The order of data entry is important. The latitude / longitude message 29-02 must be provided after the time, almanac, and (optionally) frequency messages, because this message triggers an immediate satellite re-selection using the new data. The other initialization messages (altitude, DR calibration, ephemeris) will also speed the first fix, and can be sent either before or after the latitude / longitude message.

Many of the data structures in this section have "source" and "newness" fields. A set command can use values 0 (clear), 1 (host input), or 2 (host override) for the source field. If the source is currently 2 (host override) or 3 (derived from GPS) and a new set command has source value 1 (host input), the acknowledgment message returns error "value contradict" for set command. The newness field cannot be set; if newness is 0, a reset has occurred since the value was last updated.

4.5.1 0x28-12: Almanac Initialization

The elements of the almanac message match subframes 4 and 5 as downlinked by the satellite. TLM words, HOW words and parity bits are omitted. The data in this message may change after initialization through data decode. A 10-bit Week Number of Applicability is added as a time tag.

If the information is unknown, all data fields are zero. To erase almanac health information in the HIP module, set this data with source byte equal to zero (Invalid / Clear). All other data is ignored in this case. A Source of "Data Decode" is used only in the report and cannot be used when initializing data. The "Newness" field is always ignored when initializing data.

Table 4.5.1 0x28-12: Almanac Fixed Point Report Message

Byte / Bit		Name	type	Units/LSB	Range / value	Meaning
		Code	U8		0x28	
		Subcode	U8		0x12	Almanac
		Index	U8		1 – 32	SV PRN
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override Data Decode
0	3	Newness	U1		0 1	From BBRAM New
0	6-7	GPS Week Extension	U2			2 MSBs of WNoa
1		WN_{oa}	U8			IDC-200C
2-25		Compressed Almanac	24xU8			

4.5.2 0x28-13: Almanac Health Initialization

The elements of the almanac health message match subframe 4 and 5, page 25 as downlinked by the satellite. TLM words, HOW words and parity bits are omitted. The data in this message may change after initialization through data decode. An 8-bit Week Number of Applicability is included in the compressed data, and two extra bits are given in Byte 0 to extend this to a full GPS week number.

If the information is unknown, all data fields are zero. To erase almanac health information in the HIP module, set this data with source byte equal to zero (Invalid / Clear). All other data is ignored in this case. A Source of "Data Decode" is used only in the report and cannot be used when initializing data. The "Newness" field is always ignored when initializing data.

Table 4.5.2 0x28-13: Compressed Almanac Health Report Message

Byte / Bit		Name	Type	Units/LSB	Range / value	Meaning
		Code	U8		0x28	
		Subcode	U8		0x13	Almanac Health Page
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override Data Decode
0	3	Newness	U1		0 1	From BBRAM New
0	6-7	GPS Week Extension	U2			2 MSBs of WNoa
1		WN_{oa}	U8			IDC-200C
2-25		Compressed Health & A-S	24xU8			Subframe 4 Page 25
26-49		Compressed Health	24xU8			Subframe 5 Page 25

4.5.3 0x28-14: GPS Ionospheric Model and UTC Parameters Initialization

The elements of the ionosphere / UTC message match subframe 4, page 18 as downlinked by the satellite. TLM words, HOW words and parity bits are omitted. The data in this message may change after initialization through data decode. A 10-bit Week Number of Collection is added as a time tag.

If the information is unknown, all data fields are zero. To erase ionosphere and UTC model information in the HIP module, set this data with source byte equal to zero (Invalid / Clear). All other data is ignored in this case. A Source of "Data Decode" is used only in the report and cannot be used when initializing data. The "Newness" field is always ignored when initializing data.

Table 4.5.3 0x28-14: GPS Ionospheric Fixed Point Model Report Message

Byte / Bit		Name	type	Units/LSB	Range / value	Meaning
		Code	U8		0x28	
		Subcode	U8		0x14	Iono/UTC Model
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override Data Decode
0	3	Newness	U1		0 1	From BBRAM New
0	6-7	GPS Week Extension	U2			2 MSBs of Week
1		Week of collection	U8			8 LSBs of Week
2-25		Compressed Iono / UTC	24xU8			

4.5.4 0x28-16: Ephemeris Initialization

The elements of the ephemeris message match the three subframes that are downlinked by the satellite. TLM words, HOW words and parity bits are omitted. The data in this message may change after initialization through data decode. A 10-bit Week Number of Applicability is included in the compressed data.

If the information is unknown, all data fields are zero. To erase ephemeris information in the HIP module, set this data with source byte equal to zero (Invalid / Clear). All other data is ignored in this case. A Source of "Data Decode" is used only in the report and cannot be used when initializing data. The "Newness" field is always ignored when initializing data.

Table 4.5.4 0x28-16: GPS Ephemeris Fixed Point Model Report Message

Byte / Bit		Name	type	Units/LSB	Range / value	Meaning
		Code	U8		0x28	
		Subcode	U8		0x16	Ephemeris
		Index	U8	1-32		SV PRN
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override Data Decode
0	3	Newness	U1		0 1	From BBRAM New
1		Reserved				
2-25		Compressed Ephemeris	24xU8			Subframe 1
26-49		Compressed Ephemeris	24xU8			Subframe 2
50-73		Compressed Ephemeris	24xU8			Subframe 3

4.5.5 0x29-01: Time Initialization

The data in this message will change after initialization through fixes. The Invalid/Clear command and the Time Accuracy are currently not supported. A Source of "GPS Data Decode" is used only in the report and cannot be used when initializing data. The "Newness" field is always ignored when initializing data.

Table 4.5.5 0x29-01: Time Initialization Report Message

Byte / Bit		Name	Type	Units/LSB	Range / value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x01	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Data Decode
0	3	Newness	U1		0 1	From BBRAM New
0	4	Time Acc'y Status	U1		0 1	Acc'y Unknown Acc'y Valid
1-2		Week number	U16	1 wk	<1024	GPS week number
3-6		Time of week	U32	1 ms	<604800000 ms	GPS time of week
7-10		Time Accuracy	U32	1 ms	0-604800000 ms	1-sigma accuracy

4.5.6 0x29-02: Latitude / Longitude Initialization

The data in this message will change after initialization through fixes. To erase latitude / longitude initialization information, use the corresponding set command with source byte equal to zero (Invalid / Clear). To override current latitude and longitude estimates, use "host override". A Source of "GPS Fix" is used only in the report and cannot be used when initializing data. The "Newness" field is always ignored when initializing data.

Latitude and longitude initialization must be done before altitude initialization.

Table 4.5.6 0x29-02: Latitude / Longitude Initialization Report Message

Byte / Bit		Name	type	Units/LSB	Range / value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x02	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New
0	4	Lat/Lon Acc'y Status	U1		0 1	Acc'y Unknown Acc'y Valid
1-4		Latitude	S32	2^{-31} sc	[-½, ½] sc.	
5-8		Longitude	S32	2^{-31} sc	[-1, 1) sc.	
9-12		Latitude Accuracy	U32	2^{-31} sc	[0, 1) sc.	1-sigma accuracy
13-16		Longitude Accuracy	U32	2^{-31} sc	[0, 1) sc.	1-sigma accuracy
17-20		Lat/Lon Correlation	FLT	unitless	[-1.0,1.0]	

4.5.7 0x29-03: Altitude Initialization

The data in this message will change after initialization through fixes. To erase altitude initialization information, use the corresponding set command with source byte equal to zero (Invalid / Clear). To override current altitude estimate, use "host override". A Source of "GPS Fix" is used only in the report and cannot be used when initializing data. The "Newness" field is always ignored when initializing data.

Latitude and longitude initialization must be done before altitude initialization.

Table 4.5.7 0x29-03: Altitude Initialization Report Message

Byte	Bit	Name	type	Units/LSB	Range / value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x03	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New
0	4	Altitude Acc'y Status	U1		0 1	Acc'y Unknown Acc'y Valid
1-2		Altitude	S16	1 m	-400 – 10000 m	MSL
3-4		Altitude Accuracy	U16	1 m	0 – 10000 m	1-sigma accuracy

4.5.8 0x29-04: Local Oscillator (LO) Frequency Offset Initialization

The data in this message will change after initialization through fixes. To erase frequency initialization information, use the corresponding set command with source byte equal to zero (Invalid / Clear). A Source of "GPS Fix" is used only in the report and cannot be used when initializing data. The "Newness" field is always ignored when initializing data.

Table 4.5.8 0x29-04: Local Oscillator (LO) Frequency Offset Initialization Report Message

Byte	Bit	Name	type	Units/LSB	Range / value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x04	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New
0	4	Frequency Acc'y Status	U1		0 1	Acc'y Unknown Acc'y Valid
1-4		Frequency	S32	1 PPB	±50 PPM	
5-6		Frequency Accuracy	U16	1 PPB	0 – 8PPM	1-sigma accuracy

4.5.9 0x29-05: Heading Initialization

The data in this message will change after initialization through fixes. To erase heading initialization information, use the corresponding set command with source byte equal to zero (Invalid / Clear). To override current heading estimates, use "host override". A Source of "GPS Fix" is used only in the report and cannot be used when initializing data. The "Newness" field is always ignored when initializing data.

Table 4.5.9 0x29-05: Heading Initialization Report Message

Byte	Bit	Name	type	Units/LSB	Range / value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x05	
0	0-2	Source	U3		0 1 2 3	Invalid / Clear Host Input Host Override GPS Fix
0	3	Newness	U1		0 1	From BBRAM New
0	4	Heading Accuracy status	U1		0 1	Acc'y Unknown Acc'y Valid
1-2		Heading	U16	2^{-15} sc	[0, 2) sc.	
3-4		Heading Accuracy	U16	2^{-15} sc	[0, 1.1831] sc	1-sigma accuracy

4.6 Real-Time Input Data

The following reports are used primarily for the input of serial data for real-time aiding (e.g., DGPS corrections, map-match corrections) that are sent form the host to the HIP module.

4.6.1 0x29-07: Short Map-Match Data

This message contains the most recent map-match data. It can be set, queried, or auto-reported.

Table 4.6.1 0x29-07: Map-Match Report Message

Byte / Bit		Name	Type	Units/LSB	Range / value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x07	
0	0	Lat-Lon Valid	U1			1 = Valid
0	1	Altitude Valid	U1			1 = Valid
0	2	Heading Valid	U1			1 = Valid
0	3	Lat-Lon Accy Valid	U1			1 = Valid
0	4	Altitude Accy Valid	U1			1 = Valid
0	5	Heading Accy Valid	U1			1 = Valid
0	6	Time Source	U2			From Msg 30-02
1-2		Time Tag	U16	1 ms	[0, 65535] ms	16 LSBs from Msg 0x30-02
3-6		Latitude	S32	2^{-31} sc	[-½, ½] sc.	
7-10		Longitude	S32	2^{-31} sc	[-1, 1) sc.	
11-12		Altitude	S16	1 m	[-400, 10000] m	MSL
13-14		Heading	U16	2^{-15} sc	[0, 2) sc.	
15-16		East Accy	U16	1 m	(0, 1000] m	1-σ accuracy
17-18		North Accy	U16	1 m	(0, 1000] m	1-σ accuracy
19-20		East / North Covariance	S16	1 m	[-1000, 1000]	
21-22		Altitude Accy	U16	1 m	[1, 1000] m	1-σ accuracy
23-24		Heading Accy	U16	2^{-15} sc	(0, 1] sc.	1-σ accuracy

The Time of Week and Time Source data fields must exactly match the Time of Week (16 LSBs) and Time Source fields of a recent 0x30-02 message. The map-match information is assumed to be the position/heading estimate at the time of that 0x30-02 message.

The "East / North Covariance" data field is a signed quantity, derived from the off-diagonal element $Cov_{E,N}$ of the 2x2 East-North error covariance matrix as follows:

$$\text{SIGN}(Cov_{E,N})\ \text{SQRT}(\text{ABS}(Cov_{E,N}))$$

4.6.2 0x29-08: Tacho Data

This message contains Tacho data from the CAN bus. It is used if a tacho signal is not available. It can be set, queried, or auto-reported.

Table 4.6.2 0x29-08: Tacho Report Message

Byte / Bit		Name	Type	Units/LSB	Range / value	Meaning
		Code	U8		0x29	
		Subcode	U8		0x08	
0	0	Timetag Offset Valid	U1			1 = Valid
0	1	Tacho Valid	U1			1 = Valid
0	2	Direction SwitchValid	U1			1 = Valid
0	7	Reverse Switch Value	U1		0 1	Low High
1-2		Host System Clock Timetag	U16	ms	[0,65767]	(Host time) mod 2^{16}
3-4		Timetag offset	U16	ms	[0,65767]	(GPS – Host) mod 2^{16}
5-8		Tacho pulses	U32			Accumulated Tacho pulses

4.6.3 0x23-01: RTCM Data

This message contains raw RTCM data. The length of the message 0x23 message is specified in the first data byte. This message can be set, queried, or auto-reported.

RTCM bytes are sent in "six of eight" format. In this format, every byte starts with bits (0, 1) and the data bits are contained in the six LSBs (0x01yyyy). Bytes less than 0x40 or greater than 0x7F are non-RTCM bytes and must be removed by the host.

RTCM messages Type1, Type 2, and Type 9 are supported. The bytes do not have to be bit-aligned with the message frame.

Table 4.6.3 0x23-01: RCTM Report Message

Byte / Bit	Name	type	Units/LSB	Range / value	Meaning
	Code	U8		0x23	Protocol
	Subcode	U8		0x01	RTCM Data
0	Length	U8		0x00-0x7F	N = # bytes
1	First Byte	U8		0x40 – 0x7F	
…	…	…	…	…	…
N	Last Byte	U8		0x40 – 0x7F	

4.7 Diagnostic Report Packets

The following packets are used in the Bloodhound post-processing routine. The contents of these packages are designed so that the Bloodhound can replicate the performance of the real-time processing. The format of these messages are not fully documented because they change as the firmware is updated.

4.7.1 0x66: Diagnostic Index Message

This message outputs under firmware error conditions.

Table 4.7.1 0x66: Diagnostic Index Message

Byte / Bit	Name	Type	Units / LSB	Range / value	Meaning
	Code	U8	0x66		
	Subcode	U8	0x01 0x31 0x32		Variance underflow Task incomplete due to CPU load Task incomplete due to CPU load
0-3		U32			Error code

4.7.2 0x70-00: Diagnostic GPS Fixes Output in 0x31-01

Message 0x70-00 cannot be output. If the output for 0x70-00 is turned on, diagnostic positions which are non-least-squares and non-filtered can be output in message 0x31-01. If the output for 0x70-00 is turned off, such positions, when they occur, are suppressed.

4.7.3 0x70-01: GPS Raw Measurement Diagnostic Message

This message contains the satellite data used by the position filters.

Table 4.7.2 0x70-01: GPS Raw Measurement Diagnostic Message

Byte / Bit		Name	Type	Units / LSB	Range / value	meaning
		Code	U8	0x70		
		Subcode	U8	0x01		
		Index	U8		0-11	Channel
0		PRN	U8		1-32	
1		AMU5	U8	0.2 AMU		
2		Gain Index	U8			Code-carrier filter settling time
3		Measurement Age	U8	0.2 s		Time since last code fix
4-15		Line of sight	3 x FLT			Unit vector in ECEF frame
16-19		Pseudorange Error Variance	FLT	(m^2)		
20-23		Pseudorange Residual	FLT	(m)		Relative to PF Fix from 70-02
24-27		Delta-Range	FLT	(m/s)		Delta range
28-31		Delta-Range Residual	FLT	(m/s)		Delta range residual
32	0-5	SV	U6		0-31	Modulo 32
32		Sample Clock	U1		0 1	2.112 MHz 4.185 MHz
32		AFC / PLL	U1			
33		Byte17	U8			Meas integrity / bail-out condition

4.7.4 0x70-02: GPS Raw Position/Velocity Diagnostic Message

This message contains information about the Least-Squares (LS) fix. The Kalman filter currently uses some of the least-squares results directly (e.g., velocity). If the position, velocity, and DOP data fields are all zero, no fix was generated in that second. In some versions of firmware, a 0x70-09 is sent instead of 0x70-02 when a fix is not available; in some versions of firmware, no message is sent.

Table 4.7.3 0x70-02: GPS Raw Position/Velocity Diagnostic Message

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8	0x70		
	Subcode	U8	0x02		
0	Altitude Hold Mode	U8			
1-2	GPS Week Number	U16		[0,1023]	
3-10	GPS Time of Week	DBL	(s)	[0,604800)	
11-34	LS Position Fix	3 x DBL	(m)		ECEF
35-42	LS Clock Bias Fix	DBL	(m)		sign reversed from normal
43-54	LS Velocity Fix	3 x FLT	(m/s)		ECEF
55-58	LS Oscillator Bias Fix	FLT	(m/s)		sign reversed from normal
59-70	Vertical	3 x FLT			Unit vector in ECEF
71-74	DOP_{XX}	FLT			
75-78	DOP_{XY}	FLT			
79-82	DOP_{XZ}	FLT			
83-86	DOP_{XB}	FLT			
89-92	DOP_{YY}	FLT			
93-96	DOP_{YZ}	FLT			
97-100	DOP_{YB}	FLT			
101-104	DOP_{ZZ}	FLT			
105-108	DOP_{ZB}	FLT			
109-112	DOP_{BB}	FLT			

4.7.5 0x70-03: Diagnostics DR Data Message

Table 4.7.4 0x70-03: DR Data Diagnostic Message

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8	0x70		
	Subcode	U8	0x03		

4.7.6 0x70-04: Reset Diagnostic Message

Table 4.7.5 0x70-04: GPS Reset Diagnostic Message

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8	0x70		
	Subcode	U8	0x04		

4.7.7 0x70-05: BBRAM V1 Diagnostic Message

Table 4.7.6 0x70-05: BBRAM V1 Diagnostic Message

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8	0x70		
	Subcode	U8	0x05		

4.7.8 0x70-07: Map-Matching Data Echo Diagnostic Message

Table 4.7.7 0x70-07: Map-Matching Data Echo Diagnostic Message

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8	0x70		
	Subcode	U8	0x07		

4.7.9 0x70-08: BBRAM V2 Diagnostic Message

Table 4.7.8 0x70-08: BBRAM V2 Diagnostic Message

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8	0x70		
	Subcode	U8	0x08		

4.7.10 0x70-09: GPS No Fix Message

This message outputs if no GPS fix is available for the current second. Either this message or a 0x70-02 will be sent every second.

Table 4.7.9 0x70-09: GPS No Fix Message

Byte / Bit	Name	Type	Units / LSB	Range / value	Meaning
	Code	U8	0x70		
	Subcode	U8	0x09		

4.7.11 0x70-0A: BBRAM V3 Diagnostic Message

Table 4.7.10 0x70-0A: BBRAM V3 Diagnostic Message

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8	0x70		
	Subcode	U8	0x08		

4.7.12 0x70-0B: BBRAM V4 Diagnostic Message

Table 4.7.11 0x70-0B: BBRAM V4 Diagnostic Message

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8	0x70		
	Subcode	U8	0x0A		
0	N = # of speed levels	U8			
1	DirSw Sense	U8			
2	DirSw Speed	U8			
3	Tacho Present	S8			
4	Gyro Cal Week Number	S16			
6	Gyro Cal MSecs	S32	Ms		
10	Status Bits	U32			
14	Lat	DBL			
22	Lon	DBL			
30	Alt	FLT			
34	Hdg	FLT			
38	GZRO	FLT			
42	GSF	FLT			
46	Latitude Variance	FLT			
50	Longitude Variance	FLT			
54	Lat/Lon Covaraince	FLT			
58	Altiude Variance	FLT			
62	Heading Variance	FLT			
66	ZRO Variance	FLT			
70	GSF Variance	FLT			
74	DPP_0	FLT			
78	DPP_0 Variance	FLT			
82	DPP_1	FLT			
86	DPP_1 Variance	FLT			
90	DPP_2	FLT			
94	DPP_2 Variance	FLT			

4.7.13 0x70-20: Version Diagnostic Message

This message is output on startup if the corresponding diagnostic message output is turned on. This message can also be queried.

Byte / Bit	Name	Type	Units / LSB	Range / value	meaning
	Code	U8		0x70	
	Subcode	U8		0x20	
0	Index	U8		0x01	
1-4	Firmware Checksum	U32			Firmware Checksum
5	Nav Major Version	U8		0-100	Software major number

6	Nav Minor Version	U8		0-100	software minor number
7	Nav Release Code	U8		0 > 0	release beta version number
8	Nav Release Day	U8		[1, 31]	software release day
9	Nav Release Month	U8		[1, 12]	software release month
10-11	Nav Release Year	U16		> 2000	software release year
12	Boot Major Version	U8		0-100	Software major number
13	Boot Minor Version	U8		0-100	software minor number
14	Boot Release Code	U8		0 > 0	release beta version number
15	Boot Release Day	U8		[1, 31]	software release day
16	Boot Release Month	U8		[1, 12]	software release month
17-18	Boot Release Year	U16		> 2000	software release year
19	Io Major Version	U8		0-100	Software major number
20	Io Minor Version	U8		0-100	software minor number
21	Io Release Code	U8		0 > 0	release beta version number
22	Io Release Day	U8		[1, 31]	software release day
23	Io Release Month	U8		[1, 12]	software release month
24-25	Io Release Year	U16		> 2000	software release year

4.7.14 0x70-7F: Diagnostics Toggle Message

This message controls output of the 0x70 diagnostic messages. There are 128 flag bits corresponding to messages 0x70-00 to 0x70-7F. The bit flag for 0x70-YZ is in:

- bit (Z) of byte (2Y) for Z <8, and
- bit (Z-8) of byte (2Y+1) for Z > 7 .

Table 4.7.12 0x70-7F: Diagnostics Toggle Message

Byte / Bit	Name	Type	Units / LSB	Range / value	Meaning
	Code	U8	0x70		
	Subcode	U8	0x7F		
0-15	Flag bits	16 x (8 x U1)			1 = on 0 = off

5 Event Log Queue

5.1 Theory of Operation

There are two types of events, hard and soft. Each type has its separate log. The soft event log resides in RAM and the fatal error log resides in flash. Each event has an event ID (two-byte unsigned value), a time tag indicating the time when the event occurred, and a status word if applicable.

Flow of execution for error logging is shown in the following figure:

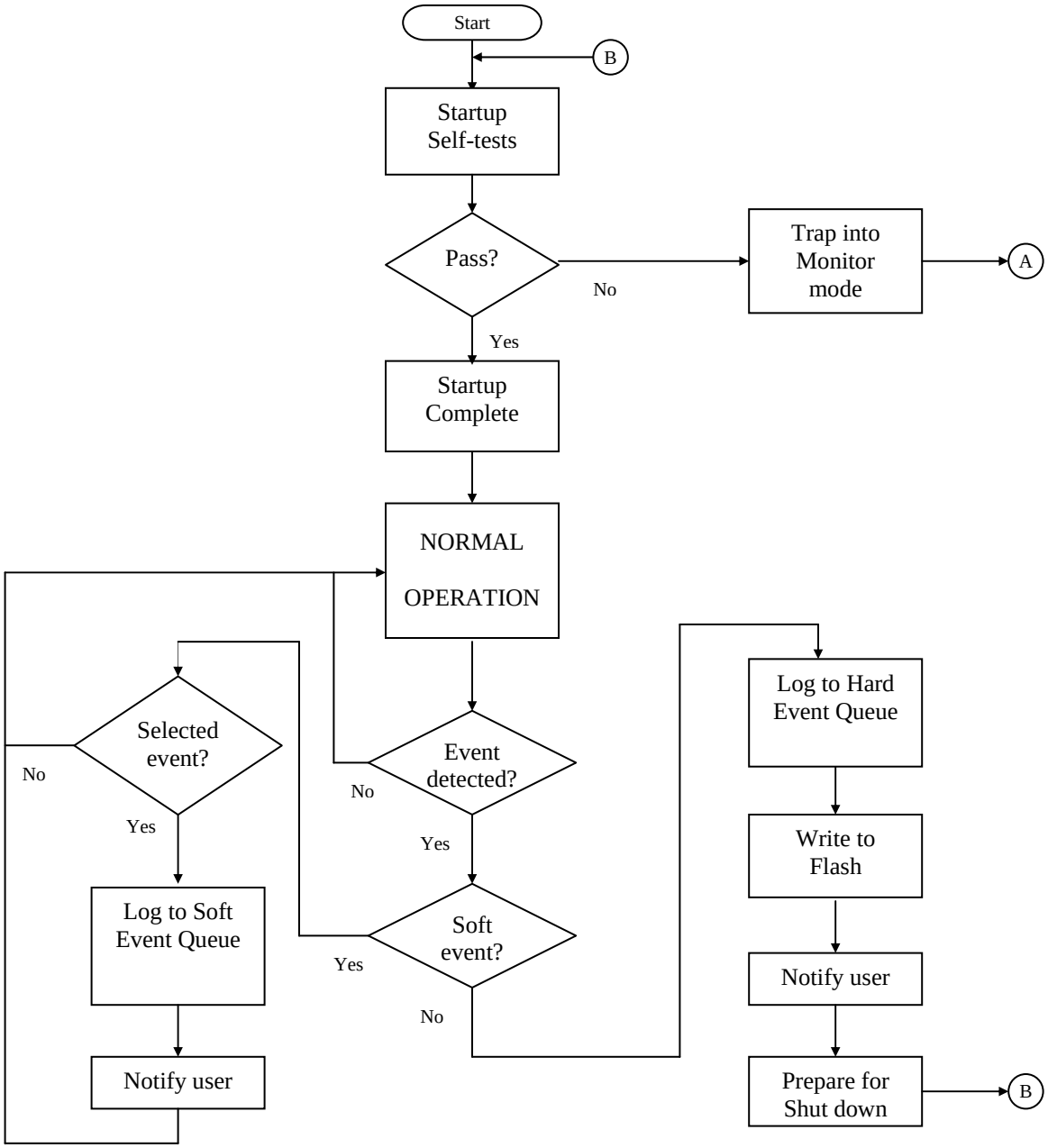

Figure 1. Flow of execution

5.2 Fatal Errors

Fatal errors indicate abnormal operation of the module. In general these errors (such as illegal address) are not recoverable. Under these conditions, the receiver writes to the log first, and then sends an event packet to notify user before it restarts (warm or cold reset). The fatal errors are divided based on the source of error:

1. Interrupt system errors have a high byte of 0x10. The low byte is the vector number at fault.
2. Hardware-related system error, e.g. RAM, ROM, or gyro, has a high byte of 0x12 or 0x13.
3. RTOS events (errors related to the Operating System related function calls) have a high byte of 0x20.
4. Navigation library events and run-time positioning diagnostics have a high byte of 0x40.

Hard Reset means “Clear RAM and Reset SW”. The column “Ver” indicates which ROM versions have this fatal error code feature.

Table 5.2.1 Fatal Error Code

Error/Event		Descriptions	Action	Ver
LOG_ILL_TRAP	0x10xx	Illegal hardware interrupts (xx = vector number)	Hard Reset	TBD
LOG_ERR_RAM_FAILED	0x1200	RAM failed on self-test.	Monitor Mode	TBD
LOG_ERR_ROM_FAILED	0x1201	ROM failed on checksum test.	Monitor Mode	TBD
LOG_GET_SEMAPHORE_ERR	0x2001	Failure on acquiring a semaphore.	Reset	TBD
LOG_RELEASE_SEMAPHORE_ERR	0x2002	Failure on releasing a semaphore.	Reset	TBD
LOG_SEND_MESSAGE_ERR	0x2003	Failure on sending a message.	Reset	TBD
LOG_RECEIVE_MESSAGE_ERR	0x2004	Failure on receiving a message.	Reset	TBD
LOG_DELETE_MESSAGEQ_ERR	0x2005	Failure on deleting a message queue.	Reset	TBD
LOG_DELETE_TASK_ERR	0x2006	Failure to remove task from system.	Reset	TBD
LOG_SUSPEND_TASK_ERR	0x2007	Failure on suspending a task.	Reset	TBD
LOG_RESUME_TASK_ERR	0x2008	Failure on resuming a task.	Reset	TBD
LOG_CREATE_SEMAPHORE_ERR	0x2009	Failure on creating a semaphore.	Reset	TBD
LOG_CONNECTION_ERR	0x200A	Failure to connect to Io-DSP cell.		TBD
LOG_CREATE_TASK_ERR	0x200B	Failure to creating a task.	Reset	TBD
LOG_ALLOCATE_BUF_ERR	0x200C	Failure on memory allocation.	Reset	TBD
LOG_MESSAGEQ_FULL	0x2120	A given message queue is full.	Reset	TBD
LOG_SIO_OPEN_ERR	0x2121	Failure to open serial port.	Monitor Mode	TBD
LOG_NAV_HARD_COCOM	0x4001	COCOM event, no recovery.	Hard Reset	TBD
LOG_NAV_HARD_ERR	0x4003	Other error in navigation library	Hard Reset	TBD

The fatal error log is located in the flash memory space at memory location 0x3000 - 0x4000. There are 31 reportable entries with 32 bytes per entry. The host cannot erase this log. A write-after-erase algorithm ensures the integrity of the log.

Table 5.2.2 Format of fatal error log entry

Field	Type	Descriptions
Msec	U32	Time tag in GPS milliseconds. (0xffffffff if not available)
Week	U16	Time tag in GPS week number. (0xffff if not available)
Code	U16	Event/error code. See Hard Reset means "Clear RAM and Reset SW". The column "Ver" indicates which ROM versions have this fatal error code feature. Table 5.2.1.
Status	U16	Status code associated with the event. 0 if not apply.
Info block	22 bytes	See Table 5.2.3, Table 5.2.4, and Table 5.2.5

The last field holds information associated with type of error. It can be a stack frame, a memory dump up to 22 bytes, or the program count for the address of error. The following tables describe the format for each fatal error types.

Table 5.2.3 Block Format for Status Code 10xx

Field	Type	Descriptions
Vector	U8	Illegal vector number
PC	U32	Program counter at fault
SP	U32	Supervisor stack address

Table 5.2.4 Block Format for Status Code 12xx

Field	Type	Descriptions
Soft value	U32	Soft checksum or memory content.
Actual value	U32	Data read from the target.
Address	U32	Status code 1201 only.

Table 5.2.5 Block Format for Status Code 2xxx

Field	Type	Descriptions
Src task	U8	Caller task ID
Dest task	U8	Receive task ID – 0 if not applicable.
Resource ID	U8	System resource such as semaphore, message queue,

5.3 Soft Events

Soft events, which include soft errors, periodic events, and user requested events, occur frequently. Only selected events will be logged into BBRAM. None of these events triggers a software reset. If the host desires to be notified of specific events with a HIPPO output message, it can specify the events to report with the event mask function (Sec 4.3.9).

Soft events have a 7-bit identity code and a two-bit condition status code.

The soft event identity code is between 1 and 127, as defined in Table 5.3.1. The last column in Table 5.3.1 indicates whether the event is a persistent condition such as a shorted antenna (C) or a single event like a RTC fault (S). The column "Ver" indicates which ROM versions have this soft event code feature.

Table 5.3.1 Soft Event Identity Code

Soft event/Event		Descriptions	S/C	Ver
LOG_NO_ERROR	0x00	No error recorded in this entry		14 +
LOG_SOFT_RESET	0x01	System performed a warm reset.	S	13 +
LOG_COLD_RESET	0x02	System performed a cold reset.	S	13 +
LOG_FACTORY_RESET	0x03	System cleared flash and RAM, reset.	S	14 +
LOG_SHUT_DOWN	0x04	System shut down by command.	S	13 +
LOG_BBRAM_INVALID	0x05	Invalid BBRAM detected on startup.	S	13 +
LOG_GRACEFUL_SHUTDOWN	0x06	System did graceful shutdown	S	14 +
LOG_TEST_PASSED	0x10	System passed all diagnostic tests.	S	13 +
LOG_TEST_START	0x11	Begin system test.	S	13 +
LOG_TEST_END	0x12	Indicates the end of a test event.	S	13 +
LOG_FORCE_TO_MONITOR	0x20	Force to monitor command executed.	S	13 +
LOG_NAV_FIRST_FIX	0x40	GPS receives the first fix on start up.	S	13 +
LOG_POSITION_SNAP	0x42	Output solution snapped to DR-GPS	S	11 - 12
LOG_POSITION_RECOVERY	0x43	Position recovery, snapped to GPS	S	14 +
LOG_HEADING_RECOVERY	0x44	Heading recovery, snapped to GPS	S	14 +
LOG_DPP_RECOVERY	0x45	DPP recovery, snapped to GPS	S	14 +
LOG_ZRO_RECOVERY	0x46	ZRO recovery	S	B+
LOG_NAV_USER_TIME	0x50	User entered time on startup.	S	14 +
LOG_NAV_USER_POS	0x51	User entered position on startup.	S	14 +
LOG_NAV_FIX_SANITY	0x61	GPS receiver fix unreasonable.	C	14 +
LOG_GYRO_ANOMALY	0x62	Gyro readings not within specification	C	14 +
LOG_NO_TACHO_WHILE_MOVING	0x63	No Tacho when GPS detects motion	C	13 +
LOG_EXCESSIVE_TACHO	0x64	Consistently excessive tacho data	C	TBD
LOG_REVERSE_GPS_DISAGREE	0x65	Reverse signal opposite to GPS	C	14 +
LOG_LARGE_JUMP	0x66	Large jump at power-up	S	14 +
LOG_OSCILLATOR_ANOMALY	0x67	Oscillator values out of specification.	C	B1+
LOG_ERR_ANT_OPEN	0x70	Antenna open detected.	C	13 +
LOG_ERR_ANT_SHORT	0x71	Antenna short detected.	C	13 +
LOG_CONNECTION_ERR	0x72	Failure to connect to GPS DSP.	S	14 +
LOG_RTC_ERROR	0x73	RTC disagreed with GPS time	S	B2+
LOG_ERR_GYRO	0x74	Gyro failed on startup.	C	13 +
LOG_ERR_A2D	0x75	A2D failed on self-test.	S	13 +
LOG_GYRO_SHORT_TO_3V	0x76	Gyro reads 3.3 V consistently.	C	13 +
LOG_BAD_HIP_ENGINE_RATE	0x77	Rate set to value other than 5 or 10 Hz.	S	16+
LOG_BBRAM_CHECKSUM_FAILED_MASTER	0x78	Master data checksum failed.	S	B1+
LOG_BBRAM_CHECKSUM_FAILED_BACKUP	0x79	Backup data checksum failed.	S	B1+
LOG_BBRAM_MB_DISCREPANCY	0x7A	Master data and backup data differ.	S	TBD
LOG_BBRAM_CHECK_FAILED_BBRAM	0x80	BBRAM checksum calculation failed.	S	B1+
LOG_BBRAM_CHECK_FAILED_FLASH	0x81	Flash checksum calculation failed.	S	B1+

LOG_BBRAM_RESTORING_DEFAULTS	0x82	BBRAM defaults loaded.	S	B1+
LOG_BBRAM_MEMSET_ZERO	0x83	No defaults, BBRAM data set to 0.	S	B1+
LOG_BBRAM_COPY_FAILED_MASTER	0x84	Copy to data master failed.	S	B1+
LOG_BBRAM_COPY_FAILED_BACKUP	0x85	Copy to data backup failed.	S	B1+
LOG_CREATE_SEMAPHORE	0x86	Unable to create semaphore.	S	TBD
LOG_GET_SEMAPHORE	0x87	Unable to acquire semaphore.	S	TBD
LOG_RELEASE_SEMAPHORE	0x88	Unable to release semaphore.	S	TBD

Some of these soft events are “informational”, and result from user action. Those soft events that are generated internally are explained in more detail starting in Section 5.3.1.

The condition code has four states. For a single event, the condition status code is zero. For a soft event condition, the condition code is defined in Table 5.3.2.

Table 5.3.2 Soft Event Condition Code

Numeric Value	Descriptions
0x00	Status unknown (backwards compatible to old software) or single event
0x10	Newly detected condition
0x20	Condition previously detected, still present
0x30	Condition newly cleared

As an example, when an antenna short condition is first detected, a soft event with identity and condition codes (0x71, 0x10) is generated. Every second, when the antenna fault detection is repeated, the soft event (0x17, 0x20) is generated. When the condition is cleared and no fault is found, the soft event (0x17, 0x30) is generated.

The soft event log resides at the beginning of the RAM area in a circular buffer with 127 entries. The log records all single-event soft events and all changes in soft event conditions, but does not record soft events with status code 0x2 (condition previously detected, still present). The log persists as long as there is a battery-backup power. The log is erasable by user via a HIPPO command or by the startup RAM test (cold start only). The host can retrieve logs at any time via HIPPO query. Table 5.3.3 shows the format of the log entry for soft events:

Table 5.3.3 Format of soft event log entry

Field	Type	Descriptions
Msec	U32	Time tag in GPS milliseconds.
Week	U16	Time tag in GPS week number.
Identity	U8	Soft event identity code. (See Table 5.3.1)
Condition	U8	Soft event condition code. (See Table 5.3.2)
Reserved	U16	

5.3.1 Invalid BBRAM detected on startup.

Condition cause: Hardware failure.

Effect before Action: If not cleared, very long time to first fix or worse.

Soft Event Detected: BBRAM checksum mismatch at power-up.

Action: Clear BBRAM.

5.3.2 Position recovery, solution snapped to GPS

Condition cause: Incorrect position at start-up, or substantial drift of DR-GPS position estimate.

Effect before Action: Large position offset between GPS and DR outputs for a number of seconds.

Soft Event Detected: Compute average of "window" of recent unfiltered GPS positions, propagated to current time using GPS velocities. Soft event occurs if this window average passes a series of criteria (see DR-GPS KF algorithm document 45172-XX-SP) and the offset relative to the DR position is large enough.

Action: The DR position is snapped to the window average.

5.3.3 Heading recovery, solution snapped to GPS

Condition cause: Incorrect heading at start-up, or substantial drift of DR-GPS heading estimate.

Effect before Action: Large heading offset between GPS and DR outputs for a number of seconds.

Soft Event Detected: Compute average of "window" of recent raw GPS headings, propagated to current time gyro measurements. Soft event occurs if this window average passes a series of criteria (see DR-GPS KF algorithm document 45172-XX-SP) and the offset relative to the DR heading is large enough.

Action: The DR heading is snapped to the window average.

5.3.4 DPP recovery, solution snapped to GPS

Condition cause: Incorrect DPP at start-up, or substantial drift of DR-GPS DPP estimate.

Effect before Action: Large speed offset between GPS and DR outputs for a number of seconds.

Soft Event Detected: Compute average of "window" of recent DPP estimates, derived directly from the raw GPS speed and number of pulses. Soft event occurs if this window average passes a series of criteria (see DR-GPS KF algorithm document 45172-XX-SP) and the offset relative to the DR DPP is large enough.

Action: The DPP estimate is snapped to the window average.

5.3.5 GPS receiver fixes not reasonable; try to recover.

Condition cause: pseudorange error or ephemeris error.

Effect before Action: GPS positions incorrect.

Soft Event Detected: Fix altitude is above 18000 m or below –1000 m and fix speed is above 515 m/s.

Soft Event Cleared: Cleared at reset.

Action (ROM15): Erase BBRAM and RTC, re-start unit.

5.3.6 Gyro readings do not stay within specification

Condition cause: Hardware failure.

Effect before Action: Position goes in circles.

Soft Event Detected: Average gyro reading over ten seconds at standstill is not between 2.0 V and 3.0 V.

Soft Event Cleared: Cleared at reset.

Action: Gyro labeled "bad". DR suspended. Speed measurement continues and tacho continues to be calibrated.

5.3.7 No Tacho data when GPS is detecting movement

Condition cause: Tacho is disconnected or malfunctioning.

Effect before Action: Position solution will be not change when moving.

Soft Event Detected: GPS speed > 8.0 m/s and no tacho pulses reported (except heartbeats) for 15 GPS fixes.

Soft Event Cleared: Tacho pulse is reported, or unit is reset.

Action: Tacho labeled as “absent”. DR is suspended. Heading measurement continues and gyro continues to be calibrated.

5.3.8 Excessive tacho data is received for a long period of time

Condition cause: Wheels spinning, other tacho malfunction.

Effect before Action: Position fixes move at higher speed than actual position.

Soft Event Detected: Not implemented in ROM 15. Function partly done by DPP recovery.

5.3.9 Reverse signal opposite to direction determined by GPS.

Condition cause: Disconnected reverse switch.

Effect before Action: Reverse driving is mistaken for forward driving, resulting in incorrect position.

Soft Event Detected: Driving in reverse at raw GPS speed > 14 m/s.

Soft Event Cleared: Driving forward at raw GPS speed > 14 m/s.

Action: Direction Switch sense changed.

5.3.10 Large jump at power-up

Condition cause: Position in BBRAM incorrect (e.g., travel by ferry).

Effect before Action: Positions are offset by many kilometers after power-up.

Soft Event Detected: Offset between first three GPS points and DR position > 2000 m.

Action: Reset position to average GPS position.

5.3.11 Oscillator values are not within specification.

Condition cause: Excessive temperature response or aging of crystal.

Effect before Action: Extended time-to-first fix.

Soft Event Detected: Not implemented in ROM 15.

5.3.12 Antenna open detected.

Condition cause: Hardware failure.

Effect before Action: No GPS positions.

Soft Event Detected: Hardware signal queried at one Hz.

Soft Event Cleared: Hardware signal queried at one Hz.

Action: DR functions without GPS positions.

5.3.13 Antenna short detected.

Condition cause: Hardware failure.

Effect before Action: No GPS positions.

Soft Event Detected: Hardware signal queried at one Hz.

Soft Event Cleared: Hardware signal queried at one Hz.

Action: DR functions without GPS positions.

5.3.14 Failure to connect to GPS DSP.

Condition cause: Hardware failure.

Effect before Action: No GPS positions.

Soft Event Detected: No response from DSP within 5 seconds.

Action: DR functions without GPS positions.

5.3.15 RTC disagreed with GPS time

Condition cause: Low battery voltage while powered down.

Effect before Action: Long time to first fix.

Soft Event Detected: Not implemented in ROM15.

5.3.16 Gyro Failure.

Condition cause: Hardware failure.

Effect before Action: Position goes in circles.

Soft Event Detected: Tested with ADC at startup. Also tested at standstill; average gyro values (one-second averages) are collected over ten seconds at standstill. If average is not between 0.75 V and 4.25 V, declare detection.

Soft Event Cleared: Cleared at reset.

Action: Gyro labeled “bad”. DR suspended. Speed measurement continues and tacho continues to be calibrated.

5.3.17 ADC Failure.

Condition cause: Hardware failure.

Effect before Action: Position goes in circles.

Soft Event Detected: At power-up.

Action: Gyro labeled “bad”. DR suspended. Speed measurement continues and tacho continues to be calibrated.

5.3.18 Gyro Shorted to 3.3 V.

Condition cause: Hardware failure.

Effect before Action: Position goes in circles.

Soft Event Detected: Average and range of gyro values (one-second averages) are collected over ten seconds at standstill. If average is between 3.05 V and 3.55 V, and range is less than six mV, declare detection.

Soft Event Cleared: Cleared at reset.

Action: Gyro labeled “bad”. DR suspended. Speed measurement continues and tacho continues to be calibrated.