Binary Protocol

Protocol Specification 4.1.1

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1 Overview

The Swift Navigation Binary Protocol (SBP) is a fast, simple, and minimal binary protocol for communicating with Carnegie Robotics Devices. It is the native binary protocol used by the Piksi GPS receiver to transmit solutions, observations, status, and debugging messages, as well as receive messages from the host operating system, such as differential corrections and the almanac. As such, it is an important interface with your Piksi receiver and the primary integration method with other systems.

2 MessageFramingStructure

SBP consists of two pieces:

an over-the-wire message framing format

structured payload definitions

As of Version 4.1.1, the frame consists of a 6-byte binary header section, a variable-sized payload field, and a 16-bit CRC value. All multibyte values are ordered in **little-endian** format. SBP uses the CCITT CRC16 (XMODEM implementation) for error detection1.

Offset (bytes)	Size (bytes)	Name	Description
0 1 3 5 6 N	1 2 2 1 N 2	Preamble MessageType Sender Length Payload CRC	Denotesthestartofframetransmission.Always0x55. Identifiesthepayloadcontents. Auniqueidentifierofthesender.2 Length(bytes)ofthePayloadfield. Binarymessagecontents. CyclicRedundancyCheckoftheframe'sbinarydatafromtheMessage
+ 6			Type up to the end of Payload (does not include the Preamble).
	N+ 8		TotalFrameLength

Table 2.0.1: Swift Binary Protocol message structure. N denotes a variable-length size.

3 NMEA-0183

Carnegie Robotics Devices, such as the Piksi, also have limited support for the standard NMEA-0183 protocol.
Note that NMEA-0183 doesn't define standardized message string equivalents for many important SBP messages such as observations, baselines and ephemerides. For this reason it is strongly recommended to use SBP for new development. NMEA-0183 output is provided primarily to support legacy devices.

CCI[1]TT 16-bit CRC Implementation uses parameters used by XMODEM, i.e. the polynomial: x16 + x12 + x5 + 1. For more details, please see the implementation at https://github.com/swift-nav/libsbp/blob/master/c/src/edc.c#L59. See also *A Painless Guide to CRC Error Detection Algorithms* at http://www.ross.net/crc/download/crc_v3.txt

By [2]default, clients of 'libsbp' use a sender id value of '0x42' which represents device controllers such as the Piksi Console. On the Piksi, the sender ID is set to the 2 least significant bytes of the device serial number. A stream of SBP messages may also include sender IDs for forwarded messages from other systems. For instance, when using Starling as a hosted software product, Sender 0x1000 (4096) indicates a message originated from the GNSS subsystem, while sender 0x315 (789) indicates a message originated from the sensor fusion subsystem. Sender 0 always indicates the message has been forwarded and contains some form of differential corrections.

4 Basic Formats and Payload Structure

The binary payload of an SBP message decodes into structured data based on the message type defined in the header. SBP uses several primitive numerical and collection types for defining payload contents.

Name	Size (bytes)	Description
s8	1	Signed 8-bit integer
s16	2	Signed 16-bit integer
s32	4	Signed 32-bit integer
s64	8	Signed 64-bit integer
u8	1	Unsigned 8-bit integer
u16	2	Unsigned 16-bit integer
u32	4	Unsigned 32-bit integer
u64	8	Unsigned 64-bit integer
float	4	Single-precision float (IEEE-754)
double	8	Double-precision float (IEEE-754)
array	—	Fixed or variable length array of any fill type
string	—	Fixed or variable length string (NULL padded/terminated)
bitfield	—	A primitive type, typically a u8, can encode boolean and enumerated status flags.

Table 4.0.1: SBP primitive types

Example Message

As an example, consider this framed series of bytes read from a serial port:

55 0b 02 cc 04 14 70 3d d0 18 cf ef ff ff ef e8 ff ff f0 18 00 00 00 00 05 00 15 dc

Thisbytearraydecodesintoa MSG_BASELINE_EC(sEeFepg.24),whichreportsthebaselinepositionsolutionoftherover receiver relative to the base station receiver in Earth Centered Earth Fixed (ECEF) coordinates. The segments of this byte array and its contents break down as follows:

Field Name	Type	Value	Bytestring Segment
Preamble	u8	0x55	55
Message Type	u16	MSG_BASELINE_ECEF	0b cc
Sender	u16	1228	14 70
Length	u8	20	f0
Payload	—		00
MSG_BASELINE_ECEF			05
.tow	u32	416300400ms	0e c1
.x	s32	−59055mm	15 8
.y	s32	63846mm	3
.z		0	
.accuracy	s32	5	d
.nsats	u16	0	ef
.flags	u8	0x9443	e
CRC	u8		dc
	u16		8
			1
			8
			0
			0
			d0 18 cf ef ff ff ef e8 ff ff
			00 00 0 0 0 0
			d0 18 0 0 5 0
			ff ff
			ff ff
			00 00

Table 4.0.2: SBP breakdown for MSG_BASELINE_ECEF

5 MessageTypes

Packages define a logical collection of SBP messages. The contents and layout of messages in packages marked **stable** are unlikely to change in the future. **Draft** messages *will change with future development* and are detailed purely for *informational purposes only*. Many draft messages are implementation-defined, and some collections, such as the acquisition package, are used for internal development.

Package	Msg ID	Name	Size (bytes)	Description
Stable				
Ext Events	257	MSG_EXT_EVENT	12 17	Reports timestamped external pin event Raw IMU data Auxiliary IMU data Plaintext logging messages with levels Wrapper for FWD a separate stream of informa- tion over SBP Raw magnetometer data GPS Time GPS Time UTC Time UTC Time Dilution of Precision Single-point position in ECEF Single-point position in ECEF Geodetic Position Geodetic Position Geodetic Position and Accuracy Baseline Position in ECEF Baseline in NED Velocity in ECEF Velocity in ECEF Velocity in NED Velocity in NED GNSS-only Position in ECEF GNSS-only Position in ECEF GNSS-only Geodetic Position GNSS-only Geodetic Position GNSS-only Velocity in ECEF GNSS-only Velocity in ECEF GNSS-only Velocity in NED GNSS-only Velocity in NED Velocity in User Frame Velocity expressed as course over ground Age of corrections GPS satellite observations Base station position Base station position in ECEF Satellite broadcast ephemeris for GPS Deprecated Satellite broadcast ephemeris for GPS Satellite broadcast ephemeris for QZSS Satellite broadcast ephemeris for BDS Deprecated Satellite broadcast ephemeris for Galileo Satellite broadcast ephemeris for SBAS Satellite broadcast ephemeris for GLO Deprecated Satellite broadcast ephemeris for SBAS Satellite broadcast ephemeris for GLO Satellite broadcast ephemeris for GLO
Imu	230	MSG_IMU_RAW	4	
Logging	4	MSG_IMU_AUX MSG_LOG	N+1	
	230	MSG_FWD	N+2	
	5	MSG_MAG_RAW		
	102	MSG_GPS_TIME		
Mag	5	MSG_GPS_TIME_GNSS	11 11 11	
Navigation	102	MSG_UTC_TIME	16 16 15	
	6	MSG_UTC_TIME_GNSS	32 54 34	
	230	MSG_DOPS	54 67 20	
	6	MSG_POS_ECEF	22 20 42	
	258	MSG_POS_ECEF_COV	22 42 32	
	260	MSG_POS_LLH	54 34 54	
	259	MSG_POS_LLH_COV	20 42 22	
	261	MSG_POS_LLH_ACC	42 42 29	
	520	MSG_BASELINE_ECEF	6 17N +	
	521	MSG_BASELINE_NED	11 24 24	
	532	MSG_VEL_ECEF	185 183	
	522	MSG_VEL_ECEF_COV	139 139	
	529	MSG_VEL_NED	147 152	
	536	MSG_VEL_NED_COV	153 112	
	523	MSG_POS_ECEF_GNSS	112 110	
	524	MSG_POS_ECEF_COV_G	74 110	
	525	NSS	119	
	533	MSG_POS_LLH_GNSS		
	526	MSG_POS_LLH_COV_GNS		
	530	S MSG_VEL_ECEF_GNSS		
	553	MSG_VEL_ECEF_COV_GN		
	564	SS MSG_VEL_NED_GNSS		
	554	MSG_VEL_NED_COV_GNS		
	561	S MSG_VEL_BODY		
	557	MSG_VEL_COG		
	565	MSG_AGE_CORRECTION		
	558	S MSG_OBS		
	562	MSG_BASE_POS_LLH		
Observation	531	MSG_BASE_POS_ECEF		
	540	MSG_EPHEMERIS_GPS_D		
	528	EP_E		
	74	MSG_EPHEMERIS_GPS_D		
	68	EP_F		
	72	MSG_EPHEMERIS_GPS		
	129	MSG_EPHEMERIS_QZSS		
	134	MSG_EPHEMERIS_BDS		
	138	MSG_EPHEMERIS_GAL_D		
	142	EP_A		
	137	MSG_EPHEMERIS_GAL		
	149	MSG_EPHEMERIS_SBAS_		
	141	DEP_A		
	130	MSG_EPHEMERIS_GLO_D		
	131	EP_A		
	132	MSG_EPHEMERIS_SBAS_		
	140	DEP_B		
	133	MSG_EPHEMERIS_SBAS		
	135	MSG_EPHEMERIS_GLO_D		
		EP_B		
		MSG_EPHEMERIS_GLO_D		
		EP		

	136	MSG_EPHEMERIS_GLO_DEP_D	120 92	Deprecated Satellite broadcast ephemeris for GLO Iono corrections L2C capability mask GNSS capabilities Group Delay Group Delay Group Delay Satellite broadcast ephemeris for GPS Satellite broadcast ephemeris for GLO GLONASS L1/L2 Code-Phase biases Satellite azimuths and elevations OSR corrections Save settings to flash Write device configuration settings
	139	MSG_EPHEMERIS_GLO	70 10	
	144	MSG_IONO	110 14	
	145	MSG_SV_CONFIGURATION_GPS_	17 15 94	
	150	DEP MSG_GNSS_CAPB	78 9 4N	
	146	MSG_GROUP_DELAY_DEP_A	19N + 11	
	147	MSG_GROUP_DELAY_DEP_B	0 N N+1	
	148	MSG_GROUP_DELAY		
	114	MSG_ALMANAC_GPS		
	115	MSG_ALMANAC_GLO		
	117	MSG_GLO_BIASES		
	151	MSG_SV_AZ_EL MSG_OSR		
	1600	MSG_SETTINGS_SAVE		
Settings	161	MSG_SETTINGS_WRITE		
	160	MSG_SETTINGS_WRITE_RESP		Acknowledgement with status of MSG_SETTINGS_WRITE Read device configuration settings Read device configuration settings Read setting by direct index Read setting by direct index Finished reading settings Solution Sensors Metadata System start-up message Status of received corrections System heartbeat message Status report message Inertial Navigation System status message Offset of the local time with respect to GNSS time Local time at detection of PPS pulse Solution Group Metadata
	175	MSG_SETTINGS_READ_REQ		
	164	MSG_SETTINGS_READ_RESP		
	165	MSG_SETTINGS_READ_BY_INDE	N N 2	
	162	X_REQ	N+2 0	
	167	MSG_SETTINGS_READ_BY_INDE	2N + 16	
	166	X_RESP	4 N+4 4	
	6529	MSG_SETTINGS_READ_BY_INDE	4N + 12	
	4	X_DONE	4 9	
Solution Meta System	6528	MSG_SOLN_META		
	0	MSG_STARTUP		
	6528	MSG_DGNSS_STATUS		
	2	MSG_HEARTBEAT		
	6553	MSG_STATUS_REPORT		
	5	MSG_INS_STATUS		
	6553	MSG_GNSS_TIME_OFFSET		
	4	MSG_PPS_TIME	9	
	6528	MSG_GROUP_META	2N+3	
	1			
	6528			
	7			
Draft				
Acquisition	47	MSG_ACQ_RESULT	14	Satellite acquisition result Acquisition perfomance measurement and de- bug Read file from the file system File read from the file system List files in a directory Files listed in a directory Delete a file from the file system Write to file File written to Request advice on the optimal configuration for FileIO Response with advice on the optimal configu- ration for FileIO. Heading relative to True North Quaternion 4 component vector Euler angles Vehicle Body Frame instantaneous angular rates Legacy message to load satellite almanac Send GPS time from host Reset the device Reset the device Legacy message for CW interference channel (Piksi => host) Legacy message for CW interference channel Reset IAR filters Deprecated
	6528			
	46	MSG_ACQ_SV_PROFILE	33N	
	8			
	168	MSG_FILEIO_READ_REQ		
File IO	6529	MSG_FILEIO_READ_RESP	N + 9	
	169	MSG_FILEIO_READ_DIR_	N + 4	
	170	REQ	N + 8	
	172	MSG_FILEIO_READ_DIR_	N + 4 N	
	173	RESP	N + 9 16 4	
	171	MSG_FILEIO_REMOVE	4	
	409	MSG_FILEIO_WRITE_REQ	10	
	7	MSG_FILEIO_WRITE_RES	37	
	409	P	29	
	8	MSG_FILEIO_CONFIG_RE	17	
		Q		
Orientation	527	MSG_FILEIO_CONFIG_RE		
	544	SP		
	545			
	546	MSG_BASELINE_HEADING		
Piksi	105	MSG_ORIENT_QUAT	0	
	104	MSG_ORIENT_EULER	0	
	182	MSG_ANGULAR_RATE	4	
	178	MSG_ALMANAC	0	
	192	MSG_SET_TIME	0	
	193	MSG_RESET	0	
	34	MSG_RESET_DEP	1	
	35	MSG_CW_RESULTS	0	
		MSG_CW_START		
		MSG_RESET_FILTERS		
		MSG_INIT_BASE_DEP		

	23 29	MSG_THREAD_STATE	26	State of an RTOS thread
	24 25	MSG_UART_STATE	74	State of the UART channels
	43	MSG_UART_STATE_DEPA	58	Deprecated
	181	MSG_IAR_STATE	4	State of the Integer Ambiguity Resolution (IAR) process
	184	MSG_MASK_SATELLITE	3	Mask a satellite from use in Piksi subsystems
	185	MSG_DEVICE_MONITOR	10	Device temperature and voltage levels
	188	MSG_COMMAND_REQ	N+4	Execute a command
	186	MSG_COMMAND_RESP	8	Exit code from executed command (device => host)
	187	MSG_COMMAND_OUTPUT	N + 4 0	Command output
	189	MSG_NETWORK_STATE_REQ	5 0	Request state of Piksi network interfaces
	190	MSG_NETWORK_STATE_RES	4 0 N	State of network interface
	81	P	N + 5	Bandwidth usage reporting message
	191	MSG_NETWORK_BANDWIDT	N + 2 8	Cell modem information update message
	3058	H_USAGE	1 6 3 4	Spectrum analyzer
	3	MSG_CELL_MODEM_STATUS	5 0 3 N	RF AGC status
	1501	MSG_SPECAN	+ 1 0	Raw SBAS data
	1505	MSG_FRONT_END_GAIN	8 N +	Precise orbit and clock correction
	1510	MSG_SBAS_RAW	1 5	Precise code biases correction
Sbas	1531	MSG_SSR_ORBIT_CLOCK	1 1 N +	Precise phase biases correction
Ssr	1532	MSG_SSR_CODE_BIASES	1 4 5 N	STEC correction polynomial coefficients
	1526	MSG_SSR_PHASE_BIASES	+ 2 3	
	1540	MSG_SSR_STEC_CORRECTI		Gridded troposphere and STEC correction SSR
	65 97	ON		atmospheric correction tile. Satellite antenna
	45 44	MSG_SSR_GRIDDED_CORRE		phase center corrections Signal tracking
	2048	CTION		channel states Measurement Engine signal
	2307	MSG_SSR_TILE_DEFINITION	24	tracking channel states Tracking channel
	2308	MSG_SSR_SATELLITE_APC	32	correlations Tracking channel correlations User
Tracking		MSG_TRACKING_STATE	N	data Vehicle forward (x-axis) velocity
		MSG_MEASUREMENT_STATE	4N	Accumulated wheeltick count message
		MSG_TRACKING_IQ	3N	
		MSG_TRACKING_IQ_DEP_B	4N+3	
		MSG_USER_DATA	8N+3	
User		MSG_ODOMETRY	N 9 14	
Vehicle		MSG_WHEELTICK		

Table 5.0.2: SBP message types

6 Stable Message Definitions

6.1 Ext Events

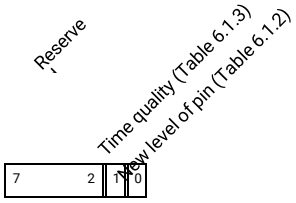
Messages reporting accurately-timestamped external events, e.g. camera shutter time.

MSG_EXT_EVENT — 0x0101 — 257

Reports detection of an external event, the GPS time it occurred, which pin it was and whether it was rising or falling.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16	weeks	wn	GPSweeknumber
2	4	u32	ms	tow	GPStimeofweekroundedtothenearestmillisecond
6	4	s32	ns	residual	Nanosecondresidualofmillisecond-rounded TOW (ranges from -500000 to 500000)
10	1	u8		flags	Flags
11	1	u8		pin	Pinnumber.0..9=DEBUG0..9.
	12				Total Payload Length

Table 6.1.1: MSG_EXT_EVENT 0x0101 message structure



Field 6.1.1: Flags (flags)

Value	Description
0	Low(fallingedge)
1	High(risingedge)

Table 6.1.2: New level of pin values (flags[0])

Value	Description
0	Unknown-don'thavenavsolution
1	Good(<1microsecond)

Table6.1.3:Timequalityvalues(flags[1])

6.2 Imu

Inertial Measurement Unit (IMU) messages.

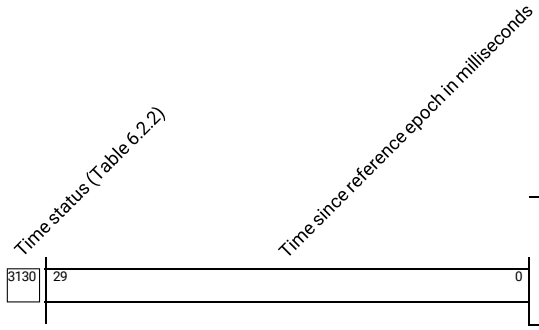
MSG_IMU_RAW — 0x0900 — 2304

Raw data from the Inertial Measurement Unit, containing accelerometer and gyroscope readings. The sense of the measurements are to be aligned with the indications on the device itself. Measurement units, which are specific to the device hardware and settings, are communicated via the MSG_IMU_AUX message. If using ”time since startup” time tags, the receiving end will expect a ‘MSG_GNSS_TIME_OFFSET‘ when a PVT fix becomes available to synchronise IMU measurements with GNSS. The timestamp must wrap around to zero when reaching one week (604800 seconds).

The time-tagging mode should not change throughout a run.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32		tow	Millisecondssincereferenceepochandtime status.
4	1	u8	ms/256	tow_f	Millisecondssincereferenceepoch,fractional part
5	2	s16		acc_x	AccelerationintheIMUframeXaxis
7	2	s16		acc_y	AccelerationintheIMUframeYaxis
9	2	s16		acc_z	AccelerationintheIMUframeZaxis
11	2	s16		gyr_x	AngularratearoundIMUframeXaxis
13	2	s16		gyr_y	AngularratearoundIMUframeYaxis
15	2	s16		gyr_z	AngularratearoundIMUframeZaxis
	17				Total Payload Length

Table 6.2.1: MSG_IMU_RAW 0x0900 message structure



Field 6.2.1: Milliseconds since reference epoch and time status. (tow)

Value	Description
0	ReferenceepochisstartofcurrentGPSweek
1	Referenceepochistimeofsystemstartup
2	Referenceepochisunknown
3	ReferenceepochislastPPS

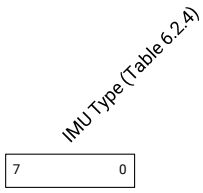
Table6.2.2:Timestatusvalues(tow[30:31])

MSG_IMU_AUX — 0x0901 — 2305

Auxiliary data specific to a particular IMU. The ‘imu_type‘ field will always be consistent but the rest of the payload is device specific and depends on the value of ‘imu_type‘.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 1 3	1 2 1 4	u8 s16 u8		imu_type temp imu_conf	IMUtype RawIMUtemperature IMUconfiguration
					Total Payload Length

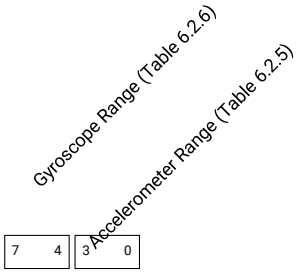
Table 6.2.3: MSG_IMU_AUX 0x0901 message structure



Field 6.2.2: IMU type (imu_type)

Value	Description
0	BoschBMI160
1	STMicroelectronicsASM330LLH

Table6.2.4:IMUTypevalues(imu_type[0:7])



Field 6.2.3: IMU configuration (imu_conf)

Value	Description
0	+/-2g
1	+/-4g
2	+/-8g
3	+/-16g

Table 6.2.5: Accelerometer Range values (imu_conf[0:3])

Value	Description
0	+/-2000deg/s
1	+/-1000deg/s
2	+/-500deg/s
3	+/-250deg/s
4	+/-125deg/s

Table 6.2.6: Gyroscope Range values (imu_conf[4:7])

6.3 Logging

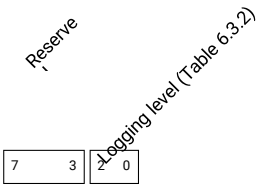
Logging and debugging messages from the device.

MSG_LOG — 0x0401 — 1025

This message contains a human-readable payload string from the device containing errors, warnings and informational messages at ERROR, WARNING, DEBUG, INFO logging levels.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		level	Logginglevel
1	N	string		text	Human-readablestring
	+ 1				Total Payload Length

Table 6.3.1: MSG_LOG 0x0401 message structure



Field 6.3.1: Logging level (level)

Value	Description
0	EMERG
1	ALERT
2	CRIT
3	ERROR
4	WARN
5	NOTICE
6	INFO
7	DEBUG

Table 6.3.2: Logging level values (level[0:2])

MSG_FWD — 0x0402 — 1026

This message provides the ability to forward messages over SBP. This may take the form of wrapping up SBP messages received by Piksi for logging purposes or wrapping another protocol with SBP.
The source identifier indicates from what interface a forwarded stream derived. The protocol identifier identifies what the expected protocol the forwarded msg contains. Protocol 0 represents SBP and the remaining values are implementation defined.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 1 2	6.3.3 1	u8		source	sourceidentifier
	N N	u8		protocol	protocolidentifier
		u8[N]		fwd_payload	variablelengthwrappedbinarymessage
	+ 2				Total Payload Length

Table 6.3.3: MSG_FWD 0x0402 message structure

6.4 Mag

Magnetometer (mag) messages.

MSG_MAG_RAW — 0x0902 — 2306

Raw data from the magnetometer.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	tow	Millisecondssincestartof GPSweek.Ifthe high bit is set, the time is unknown or invalid.
4	1	u8	ms/256	tow_f	Millisecondssincestartof GPSweek,fractional part
5	2	s16	microteslas	mag_x	MagneticfieldinthebodyframeXaxis
7	2	s16	microteslas	mag_y	MagneticfieldinthebodyframeYaxis
9	2	s16	microteslas	mag_z	MagneticfieldinthebodyframeZaxis
	11				Total Payload Length

Table 6.4.1: MSG_MAG_RAW 0x0902 message structure

6.5 Navigation

Geodetic navigation messages reporting GPS time, position, velocity, and baseline position solutions. For position solutions, these messages define several different position solutions: single-point (SPP), RTK, and pseudo-absolute position solutions.

The SPP is the standalone, absolute GPS position solution using only a single receiver. The RTK solution is the differential GPS solution, which can use either a fixed/integer or floating carrier phase ambiguity. The pseudo-absolute position solution uses a user-provided, well-surveyed base station position (if available) and the RTK solution in tandem.

When the inertial navigation mode indicates that the IMU is used, all messages are reported in the vehicle body frame as defined by device settings. By default, the vehicle body frame is configured to be coincident with the antenna phase center. When there is no inertial navigation, the solution will be reported at the phase center of the antenna. There is no inertial navigation capability on Piksi Multi or Duro.

The tow field, when valid, is most often the Time of Measurement. When this is the case, the 5th bit of flags is set to the default value of 0. When this is not the case, the tow may be a time of arrival or a local system timestamp, irrespective of the time reference (GPS Week or else), but not a Time of Measurement.

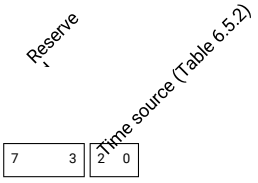
MSG_GPS_TIME — 0x0102 — 258

This message reports the GPS time, representing the time since the GPS epoch began on midnight January 6, 1980 UTC. GPS time counts the weeks and seconds of the week. The weeks begin at the Saturday/Sunday transition. GPS week 0 began at the beginning of the GPS time scale.

Within each week number, the GPS time of the week is between between 0 and 604800 seconds (=60*60*24*7). Note that GPS time does not accumulate leap seconds, and as of now, has a small offset from UTC. In a message stream, this message precedes a set of other navigation messages referenced to the same time (but lacking the ns field) and indicates a more precise time of these messages.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16	weeks	wn	GPSweeknumber
2	4	u32	ms	tow	GPStimeofweekroundedtothenearestmillisecond
6	4	s32	ns	residual	Nanosecondresidualofmillisecond-rounded TOW (ranges from -500000 to 500000)
10	1	u8		flags	Statusflags(reserved)
	11				Total Payload Length

Table 6.5.1: MSG_GPS_TIME 0x0102 message structure



Field 6.5.1: Status flags (reserved) (flags)

Value	Description
0	None(invalid)
1	GNSSSolution
2	Propagated

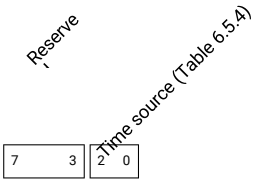
Table 6.5.2: Time source values (flags[0:2])

MSG_GPS_TIME_GNSS — 0x0104 — 260

This message reports the GPS time, representing the time since the GPS epoch began on midnight January 6, 1980 UTC. GPS time counts the weeks and seconds of the week. The weeks begin at the Saturday/Sunday transition. GPS week 0 began at the beginning of the GPS time scale.
Within each week number, the GPS time of the week is between between 0 and 604800 seconds (=60*60*24*7). Note that GPS time does not accumulate leap seconds, and as of now, has a small offset from UTC. In a message stream, this message precedes a set of other navigation messages referenced to the same time (but lacking the ns field) and indicates a more precise time of these messages.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16	weeks	wn	GPSweeknumber
2	4	u32	ms	tow	GPStimeofweekroundedtothenearestmil-lisecond
6	4	s32	ns	residual	Nanosecondresidualofmillisecond-rounded TOW (ranges from -500000 to 500000)
10	1	u8		flags	Statusflags(reserved)
	11				Total Payload Length

Table 6.5.3: MSG_GPS_TIME_GNSS 0x0104 message structure



Field 6.5.2: Status flags (reserved) (flags)

Value	Description
0	None(invalid)
1	GNSSSolution
2	Propagated

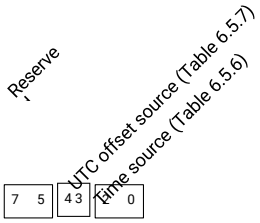
Table 6.5.4: Time source values (flags[0:2])

MSG_UTC_TIME — 0x0103 — 259

This message reports the Universal Coordinated Time (UTC). Note the flags which indicate the source of the UTC offset value and source of the time fix.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		flags	Indicatessourceandtimevalidity
1	4	u32	ymesar	tyoewar	GPStimeofweekroundedtothenearestmil-lisecond
5	2	u16	months	month	Year
7	1	u8	day	day	Month(range1..12)
8	1	u8	hours	hours	daysinthemonth(range1-31)
9	1	u8	minutes	minutes	hoursofday(range0-23)
10	1	u8	seconds	seconds	minutesofhour(range0-59)
11	1	u8			secondsofminute(range0-60)rounded down
12	4	u32	nanoseconds	ns	nanoseconds of second (range 0-999999999)
	16				Total Payload Length

Table 6.5.5: MSG_UTC_TIME 0x0103 message structure



Field 6.5.3: Indicates source and time validity (flags)

Value	Description
0	None(invalid)
1	GNSSSolution
2	Propagated

Table 6.5.6: Time source values (flags[0:2])

Value	Description
0	FactoryDefault
1	NonVolatileMemory
2	DecodedthisSession

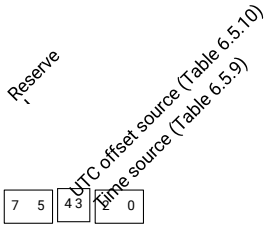
Table 6.5.7: UTC offset source values (flags[3:4])

MSG_UTC_TIME_GNSS — 0x0105 — 261

This message reports the Universal Coordinated Time (UTC). Note the flags which indicate the source of the UTC offset value and source of the time fix.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 1	1 4	u8		flags	Indicatessourceandtimevalidity
		u32	ymesar	tyoewar	GPStimeofweekroundedtothenearestmil-lisecond
		u16	months	month	
5	2	u8	day	day	Year
7	1	u8	hours	hours	Month(range1..12)
8	1	u8	minutes	minutes	daysinthemonth(range1-31)
9	1	u8	seconds	seconds	hoursofday(range0-23)
10	1	u8			minutesofhour(range0-59)
11	1	u32	nanoseconds	ns	secondsofminute(range0-60)rounded down
12	4				nanoseconds of second (range 0-999999999)
	16				Total Payload Length

Table 6.5.8: MSG_UTC_TIME_GNSS 0x0105 message structure



Field 6.5.4: Indicates source and time validity (flags)

Value	Description
0	None(invalid)
1	GNSSSolution
2	Propagated

Table 6.5.9: Time source values (flags[0:2])

Value	Description
0	FactoryDefault
1	NonVolatileMemory
2	DecodedthisSession

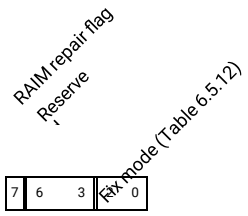
Table 6.5.10: UTC offset source values (flags[3:4])

MSG_DOPS — 0x0208 — 520

This dilution of precision (DOP) message describes the effect of navigation satellite geometry on positional measurement precision. The flags field indicated whether the DOP reported corresponds to differential or SPP solution.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 6 8 10 12 14	4 2 2 2 2 2 1	u32	ms	tow	GPSTimeofWeek
		u16	0.01	gdop	GeometricDilutionofPrecision
		u16	0.01	pdop	PositionDilutionofPrecision
		u16	0.01	tdop	TimeDilutionofPrecision
		u16	0.01	hdop	HorizontalDilutionofPrecision
		u16	0.01	vdop	VerticalDilutionofPrecision
		u8		flags	Indicatesthepositionsolutionwithwhichthe DOPS message corresponds
	15				Total Payload Length

Table 6.5.11: MSG_DOPS 0x0208 message structure



Field 6.5.5: Indicates the position solution with which the DOPS messagecorresponds(flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	Undefined
6	SBASPosition

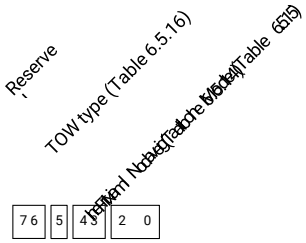
Table 6.5.12: Fix mode values (flags[0:2])

MSG_POS_ECEF — 0x0209 — 521

The position solution message reports absolute Earth Centered Earth Fixed (ECEF) coordinates and the status (single point vs pseudo-absolute RTK) of the position solution. If the rover receiver knows the surveyed position of the base station and has an RTK solution, this reports a pseudo-absolute position solution using the base station position and the rover's RTK baseline vector. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 12 20 28 30 31	4 8 8 8 2 1 1	u32	ms	tow	GPSTimeofWeek
		double	m	x	ECEFXcoordinate
		double	m	y	ECEFYcoordinate
		double	m	z	ECEFZcoordinate
		u16	mm	accuracy	Positionestimatedstandarddeviation
		u8		n_sats	Numberofsatellitesusedinsolution
		u8		flags	Statusflags
					Total Payload Length

Table 6.5.13: MSG_POS_ECEF 0x0209 message structure



Field 6.5.6: Status flags (flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	DeadReckoning
6	SBASPosition

Table 6.5.14: Fix mode values (flags[0:2])

Value	Description
0	None
1	INSused

Table 6.5.15: Inertial Navigation Mode values (flags[3:4])

Value	Description
0	TimeofMeasurement
1	Other

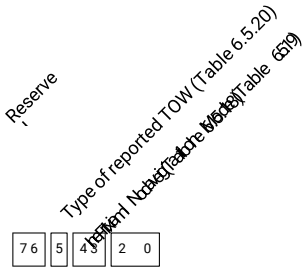
Table 6.5.16: TOW type values (flags[5:5])

MSG_POS_ECEF_COV — 0x0214 — 532

The position solution message reports absolute Earth Centered Earth Fixed (ECEF) coordinates and the status (single point vs pseudo-absolute RTK) of the position solution. The message also reports the upper triangular portion of the 3x3 covariance matrix. If the receiver knows the surveyed position of the base station and has an RTK solution, this reports a pseudo-absolute position solution using the base station position and the rover's RTK baseline vector. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 12 20 28 32 36 40 44 48 52 53	4 8 8 8 4 4 4 4 4 4 1 1	u32	ms	tow	GPSTimeofWeek
		double	m	x	ECEFXcoordinate
		double	m	y	ECEFYcoordinate
		double	m	z	ECEFZcoordinate
		float	m^2	cov_x_x	Estimatedvarianceofx
		float	m^2	cov_x_y	Estimatedcovarianceofxandy
		float	m^2	cov_x_z	Estimatedcovarianceofxandz
		float	m^2	cov_y_y	Estimatedvarianceofy
		float	m^2	cov_y_z	Estimatedcovarianceofyandz
		float	m^2	cov_z_z	Estimatedvarianceofz
		u8		n_sats	Numberofsatellitesusedinsolution
		u8		flags	Statusflags
					Total Payload Length

Table 6.5.17: MSG_POS_ECEF_COV 0x0214 message structure



Field 6.5.7: Status flags (flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	DeadReckoning
6	SBASPosition

Table 6.5.18: Fix mode values (flags[0:2])

Value	Description
0	None
1	INSused

Table 6.5.19: Inertial Navigation Mode values (flags[3:4])

Value	Description
0	TimeofMeasurement
1	Other

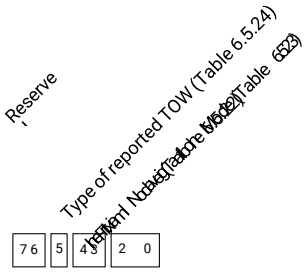
Table 6.5.20: Type of reported TOW values (flags[5:5])

MSG_POS_LLH — 0x020A — 522

This position solution message reports the absolute geodetic coordinates and the status (single point vs pseudo-absolute RTK) of the position solution. If the rover receiver knows the surveyed position of the base station and has an RTK solution, this reports a pseudo-absolute position solution using the base station position and the rover's RTK baseline vector. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 12 20 28	4 8 8 8 2	u32	ms	tow	GPSTimeofWeek
		double	deg	lat	Latitude
		double	deg	lon	Longitude
		double	m	height	HeightaboveWGS84ellipsoid
		u16	mm	h_accuracy	Horizontalpositionestimatedstandarddeviation
30	2	u16 u8	mm	v_accuracy	Verticalpositionestimatedstandarddeviation
		u8		n_sats	Numberofsatellitesusedinsolution.
32	1			flags	Statusflags
33	1				Total Payload Length
	34				

Table 6.5.21: MSG_POS_LLH 0x020A message structure



Field 6.5.8: Status flags (flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	DeadReckoning
6	SBASPosition

Table 6.5.22: Fix mode values (flags[0:2])

Value	Description
0	None
1	INSused

Table 6.5.23: Inertial Navigation Mode values (flags[3:4])

Value	Description
0	TimeofMeasurement
1	Other

Table 6.5.24: Type of reported TOW values (flags[5:5])

MSG_POS_LLH_COV — 0x0211 — 529

This position solution message reports the absolute geodetic coordinates and the status (single point vs pseudo-absolute RTK) of the position solution as well as the upper triangle of the 3x3 covariance matrix. The position information and Fix Mode flags follow the MSG_POS_LLH message. Since the covariance matrix is computed in the local-level North, East, Down frame, the covariance terms follow that convention. Thus, covariances are reported against the ”downward” measurement and care should be taken with the sign convention.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 12 20 28 32 36	4 8 8 8 4 4 4	u32	ms	tow	GPSTimeofWeek
		double	deg	lat	Latitude
		double	deg	lon	Longitude
		double	m	height	HeightaboveWGS84ellipsoid
		float	m^2	cov_n_n	Estimatedvarianceofnorthing
		float	m^2	cov_n_e	Covarianceofnorthingandeasting
		float	m^2	cov_n_d	Covarianceofnorthinganddownwardmeasurement
40	4	float	m^2	cov_e_e	Estimatedvarianceofeasting
44	4	float	m^2	cov_e_d	Covarianceofeastinganddownwardmeasurement
48	4	float	m^2	cov_d_d	Estimatedvarianceofdownwardmeasurement
52	1	u8		n_sats	Numberofsatellitesusedinsolution.
53	1	u8		flags	Statusflags
	54				Total Payload Length

Table 6.5.25: MSG_POS_LLH_COV 0x0211 message structure

Field 6.5.9: Status flags (flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	DeadReckoning
6	SBASPosition

Table 6.5.26: Fix mode values (flags[0:2])

Value	Description
0	None
1	INSused

Table 6.5.27: Inertial Navigation Mode values (flags[3:4])

Value	Description
0	TimeofMeasurement
1	Other

Table 6.5.28: Type of reported TOW values (flags[5:5])

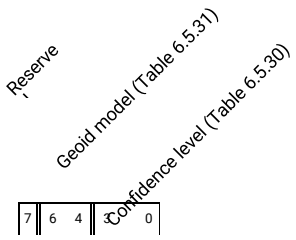
MSG_POS_LLH_ACC — 0x0218 — 536

This position solution message reports the absolute geodetic coordinates and the status (single point vs pseudo-absolute RTK) of the position solution as well as the estimated horizontal, vertical, cross-track and along-track errors. The position information and Fix Mode flags follow the MSG_POS_LLH message. Since the covariance matrix is computed in the local-level North, East, Down frame, the estimated error terms follow that convention.

The estimated errors are reported at a user-configurable confidence level. The user-configured percentile is encoded in the percentile field.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 12 20 28	4 8 8 8 8	u32	ms	tow	GPSTimeofWeek
		double	deg	lat	Latitude
		double	deg	lon	Longitude
		double	m	height	HeightaboveWGS84ellipsoid
		double	m	orthometric_height	Heightabooweth egeoid(ie. mean sea level). See confidence_and_geoid for geoid model used.
36	4	float	m	h_accuracy	Eusstiemr-ated horizontal error at the configured confidence level; zero implies invalid.
40	4	float	m	v_accuracy	Estimatedverticalerrorattheuser-configured confidence level; zero implies invalid.
44	4	float	m	ct_accuracy	Estimatedcross-trackerrorattheuser-configured confidence level; zero implies invalid.
48	4	float	m	at_accuracy	Estimatedalong-trackerrorattheuser-configured confidence level; zero implies invalid.
52	4	float	m	h_ellipse.semi_major	Thesemimajoraxisoftheestimatedhorizontal error ellipse at the user-configured confidence level; zero implies invalid.
56	4	float	m	h_ellipse.semi_minor	Thesemiminoraxisoftheestimatedhorizontal error ellipse at the user-configured confidence level; zero implies invalid.
60	4	float	deg	h_ellipse.orientation	Theorientationofthesemimajoraxisofthe estimated horizontal error ellipse with respect to North.
64	1	u8		confidence_and_geoid	Thelowerbitsdescribetheconfiguredconfidence level for the estimated position error. The middle bits describe the geoid model used to calculate the orthometric height.
65	1	u8		n_sats	Numberofsatellitesusedinsolution.
66	1	u8		flags	Statusflags
	67				Total Payload Length

Table 6.5.29: MSG_POS_LLH_ACC 0x0218 message structure



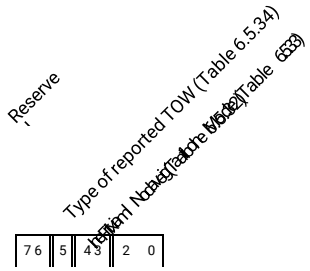
Field 6.5.10: The lower bits describe the configured confidence level for the estimated position error. The middle bits describe the geoid model used to calculate the orthometric height. (confidence_and_geoid)

Value	Description
0	reserved
1	39.35%
2	68.27%
3	95.45%

Table 6.5.30: Confidence level values (confidence_and_geoid[0:3])

Value	Description
0	No model
1	EGM96
2	EGM2008

Table 6.5.31: Geoid model values (confidence_and_geoid[4:6])



Field 6.5.11: Status flags (flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	DeadReckoning
6	SBASPosition

Table 6.5.32: Fix mode values (flags[0:2])

Value	Description
0	None
1	INSused

Table 6.5.33: Inertial Navigation Mode values (flags[3:4])

Value	Description
0	TimeofMeasurement
1	Other

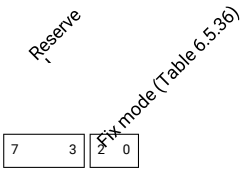
Table 6.5.34: Type of reported TOW values (flags[5:5])

MSG_BASELINE_ECEF — 0x020B — 523

This message reports the baseline solution in Earth Centered Earth Fixed (ECEF) coordinates. This baseline is the relative vector distance from the base station to the rover receiver. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 12 16 18 19	4 4 4 4 2 1 1 20	u32	ms	tow	GPSTimeofWeek
		s32	mm	x	BaselineECEFXcoordinate
		s32	mm	y	BaselineECEFYcoordinate
		s32	mm	z	BaselineECEFZcoordinate
		u16	mm	accuracy	Positionestimatedstandarddeviation
		u8		n_sats	Numberofsatellitesusedinsolution
		u8		flags	Statusflags
					Total Payload Length

Table 6.5.35: MSG_BASELINE_ECEF 0x020B message structure



Field 6.5.12: Status flags (flags)

Value	Description Invalid
0	Reserved
1	DifferentialGNSS(DGNSS)
2	FloatRTK
3	FixedRTK
4	Reserved
5	Reserved
6	

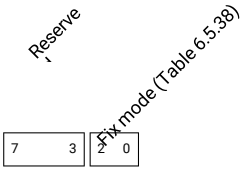
Table 6.5.36: Fix mode values (flags[0:2])

MSG_BASELINE_NED — 0x020C — 524

This message reports the baseline solution in North East Down (NED) coordinates. This baseline is the relative vector distance from the base station to the rover receiver, and NED coordinate system is defined at the local WGS84 tangent plane centered at the base station position. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 12 16	4 4 4 4 2	u32	ms	tow	GPSTimeofWeek
		s32	mm	n	BaselineNorthcoordinate
		s32	mm	e	BaselineEastcoordinate
		s32	mm	d	BaselineDowncoordinate
		u16	mm	h_accuracy	Horizontalpositionestimatedstandarddeviation
18	2	u16	mm	v_accuracy	Verticalpositionestimatedstandarddeviation
20	1	u8		n_sats	Numberofsatellitesusedinsolution
21	1	u8		flags	Statusflags
	22				Total Payload Length

Table 6.5.37: MSG_BASELINE_NED 0x020C message structure



Field 6.5.13: Status flags (flags)

Value	Description Invalid
0	Reserved
1	DifferentialGNSS(DGNSS)
2	FloatRTK
3	FixedRTK
4	Reserved
5	Reserved
6	

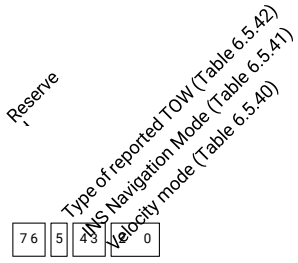
Table 6.5.38: Fix mode values (flags[0:2])

MSG_VEL_ECEF — 0x020D — 525

This message reports the velocity in Earth Centered Earth Fixed (ECEF) coordinates. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 12 16 18 19	4 4 4 4 2 1 1 20	u32	ms	tow	GPSTimeofWeek
		s32	mm/s	x	VelocityECEFXcoordinate
		s32	mm/s	y	VelocityECEFYcoordinate
		s32	mm/s	z	VelocityECEFZcoordinate
		u16	mm/s	accuracy	Velocityestimatedstandarddeviation
		u8		n_sats	Numberofsatellitesusedinsolution
		u8		flags	Statusflags
					Total Payload Length

Table 6.5.39: MSG_VEL_ECEF 0x020D message structure



Field 6.5.14: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	DeadReckoning

Table 6.5.40: Velocity mode values (flags[0:2])

Value	Description
0	None
1	INSused

Table 6.5.41: INS Navigation Mode values (flags[3:4])

Value	Description
0	TimeofMeasurement
1	Other

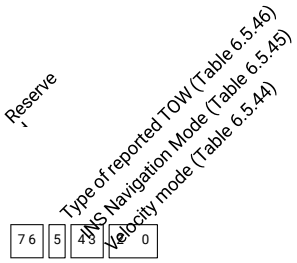
Table 6.5.42: Type of reported TOW values (flags[5:5])

MSG_VEL_ECEF_COV — 0x0215 — 533

This message reports the velocity in Earth Centered Earth Fixed (ECEF) coordinates. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	tow	GPSTimeofWeek
4	4	s32	mm/s	x	VelocityECEFXcoordinate
8	4	s32	mm/s	y	VelocityECEFYcoordinate
12	4	s32	mm/s	z	VelocityECEFZcoordinate
16	4	float	m^2/s^2	cov_x_x	Estimatedvarianceofx
20	4	float	m^2/s^2	cov_x_y	Estimatedcovarianceofxandy
24	4	float	m^2/s^2	cov_x_z	Estimatedcovarianceofxandz
28	4	float	m^2/s^2	cov_y_y	Estimatedvarianceofy
32	4	float	m^2/s^2	cov_y_z	Estimatedcovarianceofyandz
36	4	float	m^2/s^2	cov_z_z	Estimatedvarianceofz
40	1	u8		n_sats	Numberofsatellitesusedinsolution
41	1	u8		flags	Statusflags
	42				Total Payload Length

Table 6.5.43: MSG_VEL_ECEF_COV 0x0215 message structure



Field 6.5.15: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	DeadReckoning

Table 6.5.44: Velocity mode values (flags[0:2])

Value	Description
0	None
1	INSused

Table 6.5.45: INS Navigation Mode values (flags[3:4])

Value	Description
0	TimeofMeasurement
1	Other

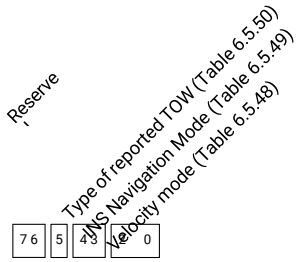
Table 6.5.46: Type of reported TOW values (flags[5:5])

MSG_VEL_NED — 0x020E — 526

This message reports the velocity in local North East Down (NED) coordinates. The NED coordinate system is de- fined as the local WGS84 tangent plane centered at the current position. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 12 16	4 4 4 4 2	u32	ms	tow	GPSTimeofWeek
		s32	mm/s	n	VelocityNorthcoordinate
		s32	mm/s	e	VelocityEastcoordinate
		s32	mm/s	d	VelocityDowncoordinate
		u16	mm/s	h_accuracy	Horizontalvelocityestimatedstandarddevia- tion
18	2	u16	mm/s	v_accuracy	Verticalvelocityestimatedstandarddeviation
20	1	u8		n_sats	Numberofsatellitesusedinsolution
21	1	u8		flags	Statusflags
	22				Total Payload Length

Table 6.5.47: MSG_VEL_NED 0x020E message structure



Field 6.5.16: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	DeadReckoning

Table 6.5.48: Velocity mode values (flags[0:2])

Value	Description
0	None
1	INSused

Table 6.5.49: INS Navigation Mode values (flags[3:4])

Value	Description
0	TimeofMeasurement
1	Other

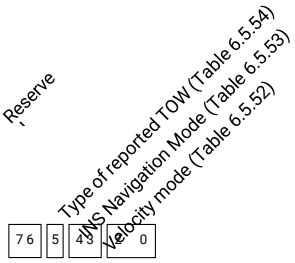
Table 6.5.50: Type of reported TOW values (flags[5:5])

MSG_VEL_NED_COV — 0x0212 — 530

This message reports the velocity in local North East Down (NED) coordinates. The NED coordinate system is de- fined as the local WGS84 tangent plane centered at the current position. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow). This message is similar to the MSG_VEL_NED, but it includes the upper triangular portion of the 3x3 covariance matrix.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	tow	GPSTimeofWeek
4	4	s32	mm/s	n	VelocityNorthcoordinate
8	4	s32	mm/s	e	VelocityEastcoordinate
12	4	s32	mm/s	d	VelocityDowncoordinate
16	4	float	mˆ2	cov_n_ n	Estimatedvarianceofnorthwardmeasure- ment
20	4	float	mˆ2	cov_n_ e	Covarianceofnorthwardandeastwardmea- surement
24	4	float	mˆ2	cov_n_ d	Covarianceofnorthwardanddownwardmea- surement
28	4	float	mˆ2	cov_e_ e	Estimatedvarianceofeastwardmeasure- ment
32	4	float	mˆ2	cov_e_ d	Covarianceofeastwardanddownwardmea- surement
36	4	float		cov_d_ d	Estimatedvarianceofdownwardmeasure- ment
40	1	u8		n_sats	Numberofsatellitesusedinsolution
41	1	u8		flags	Statusflags
	42				Total Payload Length

Table 6.5.51: MSG_VEL_NED_COV 0x0212 message structure



Field 6.5.17: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	DeadReckoning

Table 6.5.52: Velocity mode values (flags[0:2])

Value	Description
0	None
1	INSused

Table 6.5.53: INS Navigation Mode values (flags[3:4])

Value	Description
0	TimeofMeasurement
1	Other

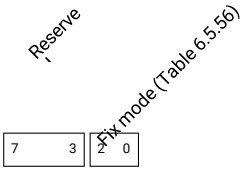
Table 6.5.54: Type of reported TOW values (flags[5:5])

MSG_POS_ECEF_GNSS — 0x0229 — 553

The position solution message reports absolute Earth Centered Earth Fixed (ECEF) coordinates and the status (single point vs pseudo-absolute RTK) of the position solution. If the rover receiver knows the surveyed position of the base station and has an RTK solution, this reports a pseudo-absolute position solution using the base station position and the rover's RTK baseline vector. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 12 20 28 30 31	4 8 8 8 2 1 1	u32	ms	tow	GPSTimeofWeek
		double	m	x	ECEFXcoordinate
		double	m	y	ECEFYcoordinate
		double	m	z	ECEFZcoordinate
		u16	mm	accuracy	Positionestimatedstandarddeviation
		u8		n_sats	Numberofsatellitesusedinsolution
		u8		flags	Statusflags
					Total Payload Length

Table 6.5.55: MSG_POS_ECEF_GNSS 0x0229 message structure



Field 6.5.18: Status flags (flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	Reserved
6	SBASPosition

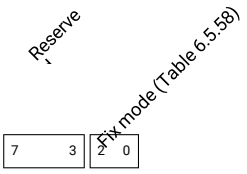
Table 6.5.56: Fix mode values (flags[0:2])

MSG_POS_ECEF_COV_GNSS — 0x0234 — 564

The position solution message reports absolute Earth Centered Earth Fixed (ECEF) coordinates and the status (single point vs pseudo-absolute RTK) of the position solution. The message also reports the upper triangular portion of the 3x3 covariance matrix. If the receiver knows the surveyed position of the base station and has an RTK solution, this reports a pseudo-absolute position solution using the base station position and the rover's RTK baseline vector. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 12 20 28 32 36 40 44 48 52 53	4 8 8 8 4 4 4 4 4 4 1 1	u32	ms	tow	GPSTimeofWeek
		double	m	x	ECEFXcoordinate
		double	m	y	ECEFYcoordinate
		double	m	z	ECEFZcoordinate
		float	m^2	cov_x_x	Estimatedvarianceofx
		float	m^2	cov_x_y	Estimatedcovarianceofxandy
		float	m^2	cov_x_z	Estimatedcovarianceofxandz
		float	m^2	cov_y_y	Estimatedvarianceofy
		float	m^2	cov_y_z	Estimatedcovarianceofyandz
		float	m^2	cov_z_z	Estimatedvarianceofz
		u8		n_sats	Numberofsatellitesusedinsolution
		u8		flags	Statusflags
					Total Payload Length

Table 6.5.57: MSG_POS_ECEF_COV_GNSS 0x0234 message structure



Field 6.5.19: Status flags (flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	Reserved
6	SBASPosition

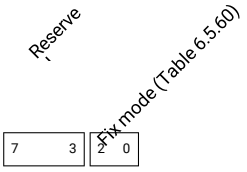
Table 6.5.58: Fix mode values (flags[0:2])

MSG_POS_LLH_GNSS — 0x022A — 554

This position solution message reports the absolute geodetic coordinates and the status (single point vs pseudo-absolute RTK) of the position solution. If the rover receiver knows the surveyed position of the base station and has an RTK solution, this reports a pseudo-absolute position solution using the base station position and the rover's RTK baseline vector. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	tow	GPSTimeofWeek
4	8	double	deg	lat	Latitude
12	8	double	deg	lon	Longitude
20	8	double	m	height	HeightaboveWGS84ellipsoid
28	2	u16	mm	h_accuracy	Horizontalpositionestimatedstandarddeviation
30	2	u16	mm	v_accuracy	Verticalpositionestimatedstandarddeviation
32	1	u8		n_sats	Numberofsatellitesusedinsolution.
33	1			flags	Statusflags
	34				Total Payload Length

Table 6.5.59: MSG_POS_LLH_GNSS 0x022A message structure



Field 6.5.20: Status flags (flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	Reserved
6	SBASPosition

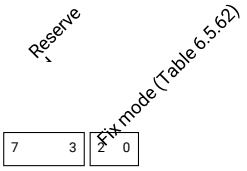
Table 6.5.60: Fix mode values (flags[0:2])

MSG_POS_LLH_COV_GNSS — 0x0231 — 561

This position solution message reports the absolute geodetic coordinates and the status (single point vs pseudo-absolute RTK) of the position solution as well as the upper triangle of the 3x3 covariance matrix. The position information and Fix Mode flags should follow the MSG_POS_LLH message. Since the covariance matrix is computed in the local-level North, East, Down frame, the covariance terms follow with that convention. Thus, covariances are reported against the ”downward” measurement and care should be taken with the sign convention.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 12 20 28 32 36	4 8 8 8 4 4 4	u32	ms	tow	GPSTimeofWeek
		double	deg	lat	Latitude
		double	deg	lon	Longitude
		double	m	height	HeightaboveWGS84ellipsoid
		float	m^2	cov_n_n	Estimatedvarianceofnorthing
		float	m^2	cov_n_e	Covarianceofnorthingandeasting
		float	m^2	cov_n_d	Covarianceofnorthinganddownwardmeasurement
40	4	float	m^2	cov_e_e	Estimatedvarianceofeasting
44	4	float	m^2	cov_e_d	Covarianceofeastinganddownwardmeasurement
48	4	float		cov_d_d	Estimatedvarianceofdownwardmeasurement
52	1	u8		n_sats	Numberofsatellitesusedinsolution.
53	1	u8		flags	Statusflags
	54				Total Payload Length

Table 6.5.61: MSG_POS_LLH_COV_GNSS 0x0231 message structure



Field 6.5.21: Status flags (flags)

Value	Description
0	Invalid
1	SinglePointPosition(SPP)
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK
5	DeadReckoning
6	SBASPosition

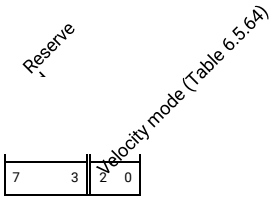
Table 6.5.62: Fix mode values (flags[0:2])

MSG_VEL_ECEF_GNSS — 0x022D — 557

This message reports the velocity in Earth Centered Earth Fixed (ECEF) coordinates. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 12 16 18 19	4 4 4 4 2 1 1 20	u32	ms	tow	GPSTimeofWeek
		s32	mm/s	x	VelocityECEFXcoordinate
		s32	mm/s	y	VelocityECEFYcoordinate
		s32	mm/s	z	VelocityECEFZcoordinate
		u16	mm/s	accuracy	Velocityestimatedstandarddeviation
		u8		n_sats	Numberofsatellitesusedinsolution
		u8		flags	Statusflags
					Total Payload Length

Table 6.5.63: MSG_VEL_ECEF_GNSS 0x022D message structure



Field 6.5.22: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	Reserved

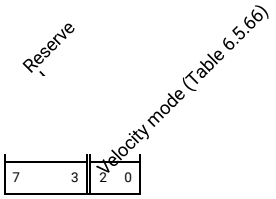
Table 6.5.64: Velocity mode values (flags[0:2])

MSG_VEL_ECEF_COV_GNSS — 0x0235 — 565

This message reports the velocity in Earth Centered Earth Fixed (ECEF) coordinates. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	tow	GPSTimeofWeek
4	4	s32	mm/s	x	VelocityECEFXcoordinate
8	4	s32	mm/s	y	VelocityECEFYcoordinate
12	4	s32	mm/s	z	VelocityECEFZcoordinate
16	4	float	m^2/s^2	cov_x_x	Estimatedvarianceofx
20	4	float	m^2/s^2	cov_x_y	Estimatedcovarianceofxandy
24	4	float	m^2/s^2	cov_x_z	Estimatedcovarianceofxandz
28	4	float	m^2/s^2	cov_y_y	Estimatedvarianceofy
32	4	float	m^2/s^2	cov_y_z	Estimatedcovarianceofyandz
36	4	float	m^2/s^2	cov_z_z	Estimatedvarianceofz
40	1	u8		n_sats	Numberofsatellitesusedinsolution
41	1	u8		flags	Statusflags
	42				Total Payload Length

Table 6.5.65: MSG_VEL_ECEF_COV_GNSS 0x0235 message structure



Field 6.5.23: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	Reserved

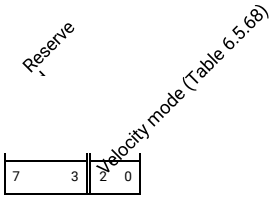
Table 6.5.66: Velocity mode values (flags[0:2])

MSG_VEL_NED_GNSS — 0x022E — 558

This message reports the velocity in local North East Down (NED) coordinates. The NED coordinate system is de- fined as the local WGS84 tangent plane centered at the current position. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 12 16	4 4 4 4 2	u32	ms	tow	GPSTimeofWeek
		s32	mm/s	n	VelocityNorthcoordinate
		s32	mm/s	e	VelocityEastcoordinate
		s32	mm/s	d	VelocityDowncoordinate
		u16	mm/s	h_accuracy	Horizontalvelocityestimatedstandarddeviation
18	2	u16	mm/s	v_accuracy	Verticalvelocityestimatedstandarddeviation
20	1	u8		n_sats	Numberofsatellitesusedinsolution
21	1	u8		flags	Statusflags
	22				Total Payload Length

Table 6.5.67: MSG_VEL_NED_GNSS 0x022E message structure



Field 6.5.24: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	Reserved

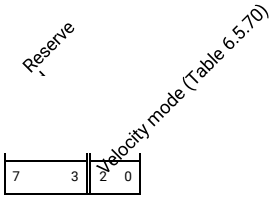
Table 6.5.68: Velocity mode values (flags[0:2])

MSG_VEL_NED_COV_GNSS — 0x0232 — 562

This message reports the velocity in local North East Down (NED) coordinates. The NED coordinate system is de- fined as the local WGS84 tangent plane centered at the current position. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow). This message is similar to the MSG_VEL_NED, but it includes the upper triangular portion of the 3x3 covariance matrix.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	tow	GPSTimeofWeek
4	4	s32	mm/s	n	VelocityNorthcoordinate
8	4	s32	mm/s	e	VelocityEastcoordinate
12	4	s32	mm/s	d	VelocityDowncoordinate
16	4	float	m^2	cov_n_ n	Estimatedvarianceofnorthwardmeasure- ment
20	4	float	m^2	cov_n_ e	Covarianceofnorthwardandeastwardmea- surement
24	4	float	m^2	cov_n_ d	Covarianceofnorthwardanddownwardmea- surement
28	4	float	m^2	cov_e_ e	Estimatedvarianceofeastwardmeasure- ment
32	4	float	m^2	cov_e_ d	Covarianceofeastwardanddownwardmea- surement
36	4	float		cov_d_ d	Estimatedvarianceofdownwardmeasure- ment
40	1	u8		n_sats	Numberofsatellitesusedinsolution
41	1	u8		flags	Statusflags
	42				Total Payload Length

Table 6.5.69: MSG_VEL_NED_COV_GNSS 0x0232 message structure



Field 6.5.25: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	Reserved

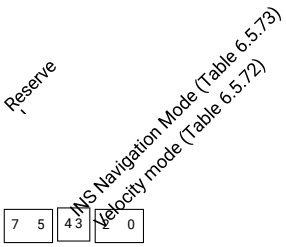
Table 6.5.70: Velocity mode values (flags[0:2])

MSG_VEL_BODY — 0x0213 — 531

This message reports the velocity in the Vehicle Body Frame. By convention, the x-axis should point out the nose of the vehicle and represent the forward direction, while as the y-axis should point out the right hand side of the vehicle. Since this is a right handed system, z should point out the bottom of the vehicle. The orientation and origin of the Vehicle Body Frame are specified via the device settings. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow). This message is only produced by inertial versions of Carnegie Robotics Products and is not available from Piksi Multi or Duro.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 12 16 20 24 28 32 36 40 41	4 4 4 4 4 4 4 4 4 4 1 1 42	u32	ms	tow	GPSTimeofWeek
		s32	mm/s	x	Velocityinxdirection
		s32	mm/s	y	Velocityinydirection
		s32	mm/s	z	Velocityinzdirection
		float	m^2	cov_x_x	Estimatedvarianceofx
		float	m^2	cov_x_y	Covarianceofxandy
		float	m^2	cov_x_z	Covarianceofxandz
		float	m^2	cov_y_y	Estimatedvarianceofy
		float	m^2	cov_y_z	Covarianceofyandz
		float	m^2	cov_z_z	Estimatedvarianceofz
		u8		n_sats	Numberofsatellitesusedinsolution
		u8		flags	Statusflags
					Total Payload Length

Table 6.5.71: MSG_VEL_BODY 0x0213 message structure



Field 6.5.26: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	DeadReckoning

Table 6.5.72: Velocity mode values (flags[0:2])

Value	Description
0	None
1	INSused

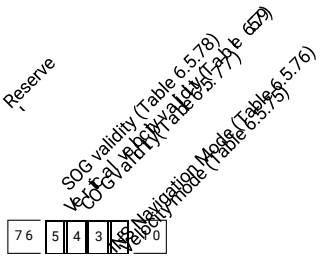
Table 6.5.73: INS Navigation Mode values (flags[3:4])

MSG_VEL_COG — 0x021C — 540

This message reports the receiver course over ground (COG) and speed over ground (SOG) based on the horizontal (N-E) components of the NED velocity vector. It also includes the vertical velocity in the form of the D-component of the NED velocity vector. The NED coordinate system is defined as the local WGS84 tangent plane centered at the current position. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow). Note: course over ground represents the receiver's direction of travel, but not necessarily the device heading.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 12 16	4 4 4 4 4	u32	ms	tow	GPSTimeofWeek
		u32	microdegrees	cog	Courseovergroundrelativetolocalnorth
		u32	mm/s	sog	Speedoverground
		s32	mm/s	vel_d	VelocityDowncoordinate
		u32	microdegrees	cog_accuracy	Courseovergroundestimatedstandarddevi-ation
20	4	u32	mm/s mm/s	sog_accuracy	Speedovergroundestimatedstandarddevia-tion
24	4	u32		vel_d_accuracy flags	Verticalvelocityestimatedstandarddeviation
28	1	u8			Statusflags
	29				Total Payload Length

Table 6.5.74: MSG_VEL_COG 0x021C message structure



Field 6.5.27: Status flags (flags)

Value	Description
0	Invalid
1	MeasuredDopplerderived
2	ComputedDopplerderived
3	DeadReckoning

Table 6.5.75: Velocity mode values (flags[0:1])

Value	Description
0	None
1	INSused

Table 6.5.76: INS Navigation Mode values (flags[2])

Value	Description
0	Invalid
1	COGvalid

Table 6.5.77: COG validity values (flags[3])

Value	Description
0	Invalid
1	SOGvalid

Table 6.5.78: SOG validity values (flags[4])

Value	Description
0	Invalid
1	Verticalvelocityvalid

Table 6.5.79: Vertical velocity validity values (flags[5])

MSG_AGE_CORRECTIONS — 0x0210 — 528

This message reports the Age of the corrections used for the current Differential solution.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	tow	GPSTimeofWeek
4	2	u16	deciseconds	age	Ageofthecorrections(0xFFFFindicatesinvalid)
	6				Total Payload Length

Table 6.5.80: MSG_AGE_CORRECTIONS 0x0210 message structure

6.6 Observation

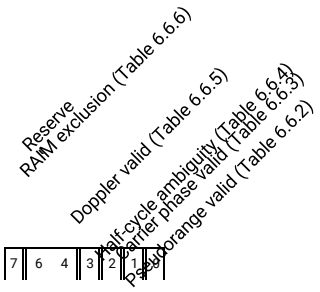
Satellite observation messages from the device. The SBP sender ID of 0 indicates remote observations from a GNSS base station, correction network, or Skylark, Swift's cloud GNSS correction product.

MSG_OBS — 0x004A — 74

The GPS observations message reports all the raw pseudorange and carrier phase observations for the satellites being tracked by the device. Carrier phase observation here is represented as a 40-bit fixed point number with Q32.8 layout (i.e. 32-bits of whole cycles and 8-bits of fractional cycles). The observations are be interoperable with 3rd party receivers and conform with typical RTCMv3 GNSS observations.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	header.t.tow	Millisecondssincestartof GPSweek
4	4	s32	ns	header.t.ns_residual	Nanosecondresidualofmillisecond-rounded TOW (ranges from -500000 to 500000)
8	2	u16	week	header.t.wn	GPSweeknumber
10	1	u8		header.n_obs	Totalnumberofobservations.Firstnibbleis the size of the sequence (n), second nibble is the zero-indexed counter (ith packet of n)
11	4	u32	2cm	obs[N].P	Pseudorangeobservation
15	4	s32	cycles	obs[N].L.i	Carrierphasewholecycles
19	1	u8	cycles / 256	obs[N].L.f	Carrierphasefractionalpart
20	2	s16	Hz	obs[N].D.i	DopplerwholeHz
22	1	u8	Hz / 256	obs[N].D.f	Dopplerfractionalpart
23	1	u8	dBHz/4	obs[N].cn0	Carrier-to-Noisedensity.Zeroimpliesinvalid cn0.
24	1	u8		obs[N].lock	Locktimer.Thisvaluegivesanindicationof the time for which a signal has maintained continuous phase lock. Whenever a signal has lost and regained lock, this value is reset to zero. It is encoded according to DF402 from the RTCM 10403.2 Amendment 2 specification. Valid values range from 0 to 15 and the most significant nibble is reserved for future use.
25	1	u8		obs[N].flags	Measurementstatusflags.Abitfieldofflags providing the status of this observation. If this field is 0 it means only the Cn0 estimate for the signal is valid.
26	1	u8		obs[N].sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
27	1	u8		obs[N].sid.code	Signalconstellation,bandandcode
	11				Total Payload Length

Table 6.6.1: MSG_OBS 0x004A message structure



Field 6.6.1: Measurement status flags. A bit field of flags providing the status of this observation. If this field is 0 it means only theCn0estimateforthesignalisvalid.(flags)

Value	Description
0	Invalidpseudorangemeasurement
1	ValidpseudorangemeasurementandcoarseTOWdecoded

Table6.6.2:Pseudorangevalidvalues(flags[0])

Value	Description
0	Invalidcarrierphasemeasurement
1	Validcarrierphasemeasurement

Table 6.6.3: Carrier phase valid values (flags[1])

Value	Description
0	Halfcyclephaseambiguityunresolved
1	Halfcyclephaseambiguityresolved

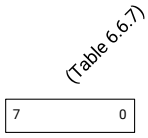
Table6.6.4:Half-cycleambiguityvalues(flags[2])

Value	Description
0	Invaliddopplermeasurement
1	Validdopplermeasurement

Table 6.6.5: Doppler valid values (flags[3])

Value	Description
0	Noexclusion
1	MeasurementwasexcludedbySPPRAIM,usewithcare

Table6.6.6:RAIMexclusionvalues(flags[7])



Field 6.6.2: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 6.6.7: values (sid.code[0:7])

MSG_BASE_POS_LLH — 0x0044 — 68

The base station position message is the position reported by the base station itself. It is used for pseudo-absolute RTK positioning, and is required to be a high-accuracy surveyed location of the base station. Any error here will result in an error in the pseudo-absolute position output.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 8 16	8 8 8	double double double	deg deg m	lat lon height	Latitude Longitude Height
	24				Total Payload Length

Table 6.6.8: MSG_BASE_POS_LLH 0x0044 message structure

MSG_BASE_POS_ECEF — 0x0048 — 72

The base station position message is the position reported by the base station itself in absolute Earth Centered Earth Fixed coordinates. It is used for pseudo-absolute RTK positioning, and is required to be a high-accuracy surveyed location of the base station. Any error here will result in an error in the pseudo-absolute position output.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 8 16	8 8 8 24	double	m	x	ECEFXcoordinate
		double	m	y	ECEFYcoordinate
		double	m	z	ECEFZcoordinate
					Total Payload Length

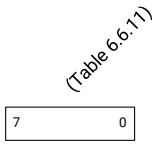
Table 6.6.9: MSG_BASE_POS_ECEF 0x0048 message structure

MSG_EPHEMERIS_GPS_DEP_E — 0x0081 — 129

The ephemeris message returns a set of satellite orbit parameters that is used to calculate GPS satellite position, velocity, and clock offset. Please see the Navstar GPS Space Segment/Navigation user interfaces (ICD-GPS-200, Table 20-III) for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16		common.sid.sat	Constellation-specificsatelliteidentifier. Note: unlike GnssSignal, GPS satellites are encoded as (PRN - 1). Other constellations do not have this offset.
2	1	u8 u8		common.sid.code	Signalconstellation,bandandcode
3	1	u32		common.sid.reserved	Reserved
4	4	u16	ms	common.toe.tow	MillisecondssincestartofGPSweek
8	2	double	week	common.toe.wn	GPSweeknumber
10	8	u32 u8	m	common.ura	UserRangeAccuracy
18	4	u8	s	common.fit_interval	Curvefitinterval
22	1			common.valid	Statusofephemeris,1=valid,0=invalid
23	1			common.health_bits	Satellitehealthstatus chapter 20.3.3.3.1.4 SBAS: 0 = valid, non-zero = invalid GLO: 0 = valid, non-zero = invalid
24	8	double	s	tgd	Groupdelaydifferentialbetween L1 and L2
32	8	double double	m rad	c_rs c_rc	Amplitudeofthesineharmoniccorrection term to the orbit radius
40	8	double double	rad/s rad	c_is c_ic	Amplitudeofthecosineharmoniccorrection term to the orbit radius
48	8	double double	m rad	m_0 ecc	Amplitudeofthecosineharmoniccorrection term to the argument of latitude
56	8	double double	m^(1/2) rad/s	sqrta omega_0	Amplitudeofthesineharmoniccorrection term to the argument of latitude
64	8	double double	rad rad	w inc	Amplitudeofthecosineharmoniccorrection term to the angle of inclination
72	8	double double	rad/s s	inc_dot af0	Amplitudeofthesineharmoniccorrection term to the angle of inclination
80	8	double double	rad/s^2 week	af1 af2 toc.tow toc.wn	Meanmotiondifference
88	8	double		iode iodc	Meananomalyatreferencetime
96	8	double			Eccentricityofsatelliteorbit
104	8	double			Squarerootofthesemi-majoraxisoforbit
112	8	double u32			Longitudeofascendingnodeoforbitplaneat weekly epoch
120	8	u16 u8			Rateofrightascension
128	8	u16			Argumentofperigee
136	8				Inclination
144	8				Inclinationfirstderivative
152	8				Polynomialclockcorrectioncoefficient(clock bias)
160	8				Polynomialclockcorrectioncoefficient(clock drift)
168	8				Polynomialclockcorrectioncoefficient(rate of clock drift)
176	4				MillisecondssincestartofGPSweek
180	2				GPSweeknumber
182	1				Issueofephemerisdata
183	2				Issueofclockdata
	185				Total Payload Length

Table 6.6.10: MSG_EPHEMERIS_GPS_DEP_E 0x0081 message structure



Field 6.6.3 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P

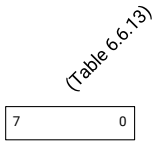
Table 6.6.11: values (common.sid.code[0:7])

MSG_EPHEMERIS_GPS_DEP_F — 0x0086 — 134

This observation message has been deprecated in favor of ephemeris message using floats for size reduction.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8 u32		common.sid.code	Signalconstellation,bandandcode
2	4	u16	s	common.toe.tow	SecondssincestartofGPSweek
6	2	double	week	common.toe.wn	GPSweeknumber
8	8	u32 u8	m	common.ura	UserRangeAccuracy
16	4	u8	s	common.fit_interval	Curvefitinterval
20	1			common.valid	Statusofephemeris,1=valid,0=invalid
21	1			common.health_bits	SatelliteHealthStatus, see IS-GPS-200H chapter 20.3.3.3.1.4 Others: 0 = valid, non-zero = invalid
22	8	double	s	tgd	GroupdelaydifferentialbetweenL1andL2
30	8	double double double	m rad rad/s	c_rs c_uc c_ic	Amplitudeofthesineharmoniccorrection term to the orbit radius
38	8	double double	rad	m0 ecc	Amplitudeofthecosineharmoniccorrection term to the orbit radius
46	8	double double double	m^(1/2)	sqrta omega0 dn	Amplitudeofthecosineharmoniccorrection term to the argument of latitude
54	8	double double double	rad rad rad/s	w inc inc_dot	Amplitudeofthesineharmoniccorrection term to the argument of latitude
62	8	double double	rad rad	inc_dot af0	Amplitudeofthecosineharmoniccorrection term to the angle of inclination
70	8	double double double	rad/s s s/s^2	af0 af1 af2	Amplitudeofthesineharmoniccorrection term to the angle of inclination
78	8	double double	week	toc.tow toc.wn	Meanmotiondifference
86	8	double		iode	Meananomalyatreferencetime
94	8	double		iodc	Eccentricityofsatelliteorbit
102	8	double			Squarerootofthesemi-majoraxisoforbit
110	8	double u32			Longitudeofascendingnodeoforbitplaneat weekly epoch
118	8	u16 u8			Rateofrightascension
126	8	u16			Argumentofperigee
134	8				Inclination
142	8				Inclinationfirstderivative
150	8				Polynomialclockcorrectioncoefficient(clock bias)
158	8				Polynomialclockcorrectioncoefficient(clock drift)
166	8				Polynomialclockcorrectioncoefficient(rate of clock drift)
174	4				SecondssincestartofGPSweek
178	2				GPSweeknumber
180	1				Issueofephemerisdata
181	2				Issueofclockdata
	183				Total Payload Length

Table 6.6.12: MSG_EPHEMERIS_GPS_DEP_F 0x0086 message structure



Field 6.6.4 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

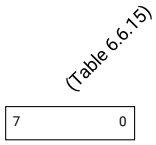
Table 6.6.13: values (common.sid.code[0:7])

MSG_EPHEMERIS_GPS — 0x008A — 138

The ephemeris message returns a set of satellite orbit parameters that is used to calculate GPS satellite position, velocity, and clock offset. Please see the Navstar GPS Space Segment/Navigation user interfaces (ICD-GPS-200, Table 20-III) for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8		common.sid.code	Signalconstellation,bandandcode
2	4	u32	s	common.toe.tow	SecondssincestartofGPSweek
6	2	u16	week	common.toe.wn	GPSweeknumber
8	4	float	m	common.ura	UserRangeAccuracy
12	4	u32	s	common.fit_interval	Curvefitinterval
16	1	u8		common.valid	Statusofephemeris,1=valid,0=invalid
17	1	u8		common.health_bits	SatelliteHealthstatus see GPS ICD chapter 20.3.3.3.1.4 SBAS: 0 = valid, non-zero = invalid GLO: 0 = valid, non-zero = invalid
18	4	float	s	tgd	GroupdelaydifferentialbetweenL1andL2
22	4	float float	m rad	c_rs c_rc	Amplitudeofthesineharmoniccorrection term to the orbit radius
26	4	float float	rad/s rad	c_uc c_us	Amplitudeofthecosineharmoniccorrection term to the orbit radius
30	4	float float	m^(1/2)	sqrta omega0	Amplitudeofthecosineharmoniccorrection term to the argument of latitude
34	4	double double	rad/s rad	w inc	Amplitudeofthesineharmoniccorrection term to the argument of latitude
38	4	double double	rad rad/s	inc_dot af0	Amplitudeofthecosineharmoniccorrection term to the angle of inclination
42	4	double double	s s/s^2	af1 toc.tow	Amplitudeofthesineharmoniccorrection term to the angle of inclination
46	8	double	week	toc.wn	Meanmotiondifference
54	8	double		iode	Meananomalyatreferencetime
62	8	float		iodc	Eccentricityofsatelliteorbit
70	8	float			Squarerootofthesemi-majoraxisoforbit
78	8	float			Longitudeofascendingnodeoforbitplaneat weekly epoch
86	8	u32			Rateofrightascension
94	8	u16 u8			Argumentofperigee
102	8	u16			Inclination
110	8				Inclinationfirstderivative
118	4				Polynomialclockcorrectioncoefficient(clock bias)
122	4				Polynomialclockcorrectioncoefficient(clock drift)
126	4				Polynomialclockcorrectioncoefficient(rate of clock drift)
130	4				SecondssincestartofGPSweek
134	2				GPSweeknumber
136	1				Issueofephemerisdata
137	2				Issueofclockdata
	139				Total Payload Length

Table 6.6.14: MSG_EPHEMERIS_GPS 0x008A message structure



Field 6.6.5 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 6.6.15: values (common.sid.code[0:7])

MSG_EPHEMERIS_QZSS — 0x008E — 142

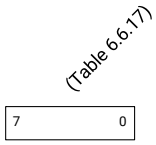
The ephemeris message returns a set of satellite orbit parameters that is used to calculate QZSS satellite position, velocity, and clock offset.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8		common.sid.code	Signalconstellation,bandandcode
2	4	u32	s	common.toe.tow	SecondssincestartofGPSweek
6	2	u16	week	common.toe.wn	GPSweeknumber
8	4	float	m	common.ura	UserRangeAccuracy
12	4	u32	s	common.fit_interval	Curvefitinterval
16	1	u8		common.valid	Statusofephemeris,1=valid,0=invalid
17	1				: 0 = valid, non-zero n-zero = invalid
18	4				eenL1andL2
22	4				iccorrection
26	4				oniccorrection
30	4				oniccorrection
34	4				titude iccorrection
38	4				titude oniccorrection
42	4				tion iccorrection
46	8				tion
54	8				me
62	8				
70	8				axisoforbit
78	8				oforbitplaneat
86	8				
94	8	u16			Argumentofperigee
102	8				Inclination
110	8				Inclinationfirstderivative
118	4				Polynomialclockcorrectioncoefficient(clock bias)
122	4				Polynomialclockcorrectioncoefficient(clock drift)
126	4				Polynomialclockcorrectioncoefficient(rate of clock drift)
130	4				SecondssincestartofGPSweek
134	2				GPSweeknumber
136	1				Issueofephemerisdata
137	2				Issueofclockdata
	139				Total Payload Length

t-highlight-text	text-fadeout	haOyaKf	text-fadeout 2	d-flex href	skeleton-bar hre	t-image
Volker Spieß	Finance & Contr	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Roland Frischko	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Marcus Küppers	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Frank Thiele	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Heiko Hanstein	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Katja Glybowska	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Roger Podstatny	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Olaf Pestl	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Dietmar Schicke	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Gabriele Siebert	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Christoph Schlüt	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Anne Lissner	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Manuela Schreit	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Martin Jost	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Ingo Schmidt	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Matthias Bürven	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Frank Dohna	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Michael Rothe	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w
Dietmar Schicke	Corporate Mana	+0	Top Managemer	https://app.dealfi	[object Object]	https://w

enders 1 1-6021

Table 6.6.16: MSG_EPHEMERIS_QZSS 0x008E message structure



Field 6.6.6 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

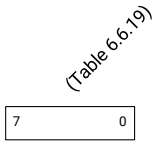
Table 6.6.17: values (common.sid.code[0:7])

MSG_EPHEMERIS_BDS — 0x0089 — 137

The ephemeris message returns a set of satellite orbit parameters that is used to calculate BDS satellite position, velocity, and clock offset. Please see the BeiDou Navigation Satellite System SIS-ICD Version 2.1, Table 5-9 for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8		common.sid.code	Signalconstellation,bandandcode
2	4	u32	s	common.toe.tow	SecondssincestartofGPSweek
6	2	u16	week	common.toe.wn	GPSweeknumber
8	4	float	m	common.ura	UserRangeAccuracy
12	4	u32	s	common.fit_interval	Curvefitinterval
16	1	u8		common.valid	Statusofephemeris,1=valid,0=invalid
17	1	u8		common.health_bits	SatelliteHealthstatus see BeiDou SIS-ICD-2.0.0 chapter 20.3.3.3.1.4 SBAS: 0 = valid, non-zero = invalid GLO: 0 = valid, non-zero = invalid
18	4	float	s	tgd1	GroupdelaydifferentialforB1
22	4	float	s	tgd2	GroupdelaydifferentialforB2
26	4	float float	m m	c_rs c_rc	Amplitudeofthesineharmoniccorrection term to the orbit radius
30	4	float float	rad rad	c_uc	Amplitudeofthecosineharmoniccorrection term to the orbit radius
34	4	float float	rad rad	c_us c_ic	Amplitudeofthecosineharmoniccorrection term to the argument of latitude
38	4	double double	rad/s $m^{a\hat{}d}(1/2)$	c_is dn m0	Amplitudeofthesineharmoniccorrection term to the argument of latitude
42	4	double double	rad rad/s	ecc sqrta	Amplitudeofthecosineharmoniccorrection term to the angle of inclination
46	4	double double	rad rad	omega0 omegado	Amplitudeofthesineharmoniccorrection term to the angle of inclination
50	8	double	rad/s	t	Meanmotiondifference
58	8	double	s	w	Meananomalyatreferencetime
66	8	double		inc	Eccentricityofsatelliteorbit
74	8	double	s/s	inc_dot	Squarerootofthesemi-majoraxisoforbit
82	8	float float	s/s^2	af0 af1	Longitudeofascendingnodeoforbitplaneat weekly epoch
90	8	u32	s	af2	Rateofrightascension
98	8	u16 u8	week	toc.tow	Argumentofperigee
106	8			toc.wn	Inclination
114	8			iode	Inclinationfirstderivative
122	8				Polynomialclockcorrectioncoefficient(clock bias)
130	4				Polynomialclockcorrectioncoefficient(clock drift)
134	4				Polynomialclockcorrectioncoefficient(rate of clock drift)
138	4				SecondssincestartofGPSweek
142	2				GPSweeknumber
144	1				IssueofephemerisdataCalculatedfrom the navigation data parameter t_oe per RTCM/CSNO recommendation: IODE = mod (t_oe / 720, 240)
145	2	u16		iodc	IssueofclockdataCalculatedfromthenavi-gation data parameter t_oe per RTCM/CSNO recommendation: IODE = mod (t_oc / 720, 240)
	147				Total Payload Length

Table 6.6.18: MSG_EPHEMERIS_BDS 0x0089 message structure



Field 6.6.7 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

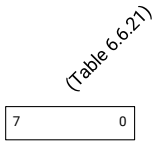
Table 6.6.19: values (common.sid.code[0:7])

MSG_EPHEMERIS_GAL_DEP_A — 0x0095 — 149

This observation message has been deprecated in favor of an ephemeris message with explicit source of NAV data.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8		common.sid.code	Signalconstellation,bandandcode
2	4	u32	s	common.toe.tow	SecondssincestartofGPSweek
6	2	u16	week	common.toe.wn	GPSweeknumber
8	4	float	m	common.ura	UserRangeAccuracy
12	4	u32	s	common.fit_interval	Curvefitinterval
16	1	u8		common.valid	Statusofephemeris,1=valid,0=invalid
17	1	u8		common.health_bits	Satellitehealthstatus GPS: ICD-GPS-200, chapter 20.3.3.3.1.4 SBAS: 0 = valid, non-zero = invalid GLO: 0 = valid, non-zero = invalid
18	4	float	s	bgd_e1e5a	E1-E5aBroadcastGroupDelay
22	4	float	s	bgd_e1e5b	E1-E5bBroadcastGroupDelay
26	4	float	m	c_rs	Amplitudeofthesineharmoniccorrection term to the orbit radius
30	4	float	m	c_rc	Amplitudeofthecosineharmoniccorrection term to the orbit radius
34	4	float	rad	c_uc	Amplitudeofthecosineharmoniccorrection term to the argument of latitude
38	4	float	rad	c_us	Amplitudeofthesineharmoniccorrection term to the argument of latitude
42	4	float	rad	c_ic	Amplitudeofthecosineharmoniccorrection term to the angle of inclination
46	4	float	rad	c_is	Amplitudeofthesineharmoniccorrection term to the angle of inclination
50	8	double	rad/s	dn	Meanmotiondifference
58	8	double	rad	m0	Meananomalyatreferencetime
66	8	double		ecc	Eccentricityofsatelliteorbit
74	8	double	m^(1/2)	sqrta	Squarerootofthesemi-majoraxisoforbit
82	8	double	rad	omega0	Longitudeofascendingnodeoforbitplaneat weekly epoch
90	8	double	rad/s	omegadot	Rateofrightascension
98	8	double	rad	w	Argumentofperigee
106	8	double	rad	inc	Inclination
114	8	double	rad/s	inc_dot	Inclinationfirstderivative
122	8	double	s	af0	Polynomialclockcorrectioncoefficient(clock bias)
130	8	double	s/s	af1	Polynomialclockcorrectioncoefficient(clock drift)
138	4	float	s/s^2	af2	Polynomialclockcorrectioncoefficient(rate of clock drift)
142	4	u32	s	toc.tow	SecondssincestartofGPSweek
146	2	u16	week	toc.wn	GPSweeknumber
148	2	u16		iode	Issueofdata(IODnav)
150	2	u16		iodc	Issueofdata(IODnav).Alwaysequaltoiode
	152				Total Payload Length

Table 6.6.20: MSG_EPHEMERIS_GAL_DEP_A 0x0095 message structure



Field 6.6.8 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

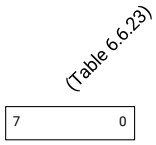
Table 6.6.21: values (common.sid.code[0:7])

MSG_EPHEMERIS_GAL — 0x008D — 141

The ephemeris message returns a set of satellite orbit parameters that is used to calculate Galileo satellite position, velocity, and clock offset. Please see the Signal In Space ICD OS SIS ICD, Issue 1.3, December 2016 for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8		common.sid.code	Signalconstellation,bandandcode
2	4	u32	s	common.toe.tow	SecondssincestartofGPSweek
6	2	u16	week	common.toe.wn	GPSweeknumber
8	4	float	m	common.ura	UserRangeAccuracy
12	4	u32	s	common.fit_interval	Curvefitinterval
16	1	u8		common.valid	Statusofephemeris,1=valid,0=invalid
17	1	u8		common.health_bits	SatelliteHealthstatus chapter 20.3.3.3.1.4 SBAS: 0 = valid, non-zero = invalid GLO: 0 = valid, non-zero = invalid
18	4	float	s	bgd_e1e5	E1-E5aBroadcastGroupDelay
22	4	float	s		E1-E5bBroadcastGroupDelay
26	4	float float	m m	a bgd_e1e5	Amplitudeofthesineharmoniccorrection term to the orbit radius
30	4	float float	rad rad	c_rs c_rc	Amplitudeofthecosineharmoniccorrection term to the orbit radius
34	4	float float	rad rad	c_uc c_us	Amplitudeofthecosineharmoniccorrection term to the argument of latitude
38	4	double double	rad (1/2)	c_ic c_is dn	Amplitudeofthesineharmoniccorrection term to the argument of latitude
42	4	double double	rad rad/s	m0 ecc	Amplitudeofthecosineharmoniccorrection term to the angle of inclination
46	4	double double	rad rad	sqrta omega0	Amplitudeofthesineharmoniccorrection term to the angle of inclination
50	8	double	rad/s	omegadot	Meanmotiondifference
58	8	double	s	w	Meananomalyatreferencetime
66	8	double	s/s	inc	Eccentricityofsatelliteorbit
74	8	double	s/s^2	inc_dot	Squarerootofthesemi-majoraxisoforbit
82	8	float u32	s	af0 af1 af2 toc.tow	Longitudeofascendingnodeoforbitplaneat weekly epoch
90	8	u16	week	toc.wn	Rateofrightascension
98	8	u16		iode	Argumentofperigee
106	8	u16 u8		iodc	Inclination
114	8			source	Inclinationfirstderivative
122	8				Polynomialclockcorrectioncoefficient(clock bias)
130	8				Polynomialclockcorrectioncoefficient(clock drift)
138	4				Polynomialclockcorrectioncoefficient(rate of clock drift)
142	4				SecondssincestartofGPSweek
146	2				GPSweeknumber
148	2				Issueofdata(IODnav)
150	2				Issueofdata(IODnav).Alwaysequaltoiode
152	1				0=I/NAV,1=F/NAV
	153				Total Payload Length

Table 6.6.22: MSG_EPHEMERIS_GAL 0x008D message structure



Field 6.6.9 : Signal constellation, band and code (common.sid.code)

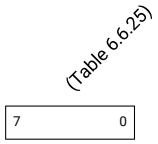
Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 6.6.23: values (common.sid.code[0:7])

MSG_EPHEMERIS_SBAS_DEP_A — 0x0082 — 130

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16		common.sid.sat	Constellation-specificsatelliteidentifier. Note: unlike GnssSignal, GPS satellites are encoded as (PRN - 1). Other constellations do not have this offset.
2	1	u8 u8		common.sid.code	Signalconstellation,bandandcode
3	1	u32		common.sid.reserved	Reserved
4	4	u16	ms	common.toe.tow	MillisecondssincestartofGPSweek
8	2	double	week	common.toe.wn	GPSweeknumber
10	8	u32 u8	m	common.ura	UserRangeAccuracy
18	4	u8	s	common.fit_interval	Curvefitinterval
22	1			common.valid	Statusofephemeris,1=valid,0=invalid
23	1			common.health_bits	SatelliteGPSL1C/A,L2C,L5 health status per IS-GPS-200, chapter 20.3.3.3.1.4 SBAS: 0 = valid, non-zero = invalid GLO: 0 = valid, non-zero = invalid
24	24	double[3]	m	pos	PositionoftheGEOattimetoe
48	24	double[3]	m/s	vel	VelocityoftheGEOattimetoe
72	24	double[3]	m/s^2	acc	AccelerationoftheGEOattimetoe
96	8	double double	$s_{s/s}$	a_{gf0}	TimeoffsetoftheGEOclockw.r.t.SBASNetwork Time
104	8				DriftoftheGEOclockw.r.t. SBASNetwork Time
	112				Total Payload Length

Table 6.6.24: MSG_EPHEMERIS_SBAS_DEP_A 0x0082 message structure



Field 6.6.10 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P

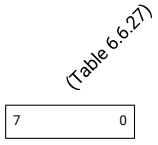
Table 6.6.25: values (common.sid.code[0:7])

MSG_EPHEMERIS_GLO_DEP_A — 0x0083 — 131

The ephemeris message returns a set of satellite orbit parameters that is used to calculate GLO satellite position, velocity, and clock offset. Please see the GLO ICD 5.1 ”Table 4.5 Characteristics of words of immediate information (ephemeris parameters)” for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16		common.sid.sat	Constellation-specificsatelliteidentifier. Note: unlike GnssSignal, GPS satellites are encoded as (PRN - 1). Other constellations do not have this offset.
2	1	u8 u8		common.sid.code	Signalconstellation,bandandcode
3	1	u32		common.sid.reserved	Reserved
4	4	u16	ms	common.toe.tow	MillisecondssincestartofGPSweek
8	2	double	week	common.toe.wn	GPSweeknumber
10	8	u32 u8	m	common.ura	UserRangeAccuracy
18	4	u8	s	common.fit_interval	Curvefitinterval
22	1			common.valid	Statusofephemeris,1=valid,0=invalid
23	1			common.health_bits	SatelliteHealthstatus, refer GPS IS-GPS-200, chapter 20.3.3.3.1.4 SBAS: 0 = valid, non-zero = invalid GLO: 0 = valid, non-zero = invalid
24	8	double		gam	Relativedeviationofpredictedcarrierfrequency from nominal
32	8	double[3]	s	ma	CorrectiontotheSVtime
40	24	double[3]	m	tau	PositionoftheSVattbinPZ-90.02coordinates system
64	24	double[3]	m / s	vel	VelocityvectoroftheSVattbinPZ-90.02coordinates system
88	24		m/s^2	acc	AccelerationvectoroftheSVattbinPZ-90.02 coordinates sys
	112				Total Payload Length

Table 6.6.26: MSG_EPHEMERIS_GLO_DEP_A 0x0083 message structure



Field 6.6.11 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P

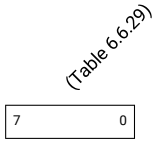
Table 6.6.27: values (common.sid.code[0:7])

MSG_EPHEMERIS_SBAS_DEP_B — 0x0084 — 132

This observation message has been deprecated in favor of ephemeris message using floats for size reduction.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8 u32		common.sid.code	Signalconstellation,bandandcode
2	4	u16	s	common.toe.tow	SecondssincestartofGPSweek
6	2	double	week	common.toe.wn	GPSweeknumber
8	8	u32 u8	m	common.ura	UserRangeAccuracy
16	4	u8	s	common.fit_interval	Curvefitinterval
20	1			common.valid	Statusofephemeris,1=valid,0=invalid
21	1			common.health_bits	SatelliteHealthstatus chapter 20.3.3.3.1.4 Others: 0 = valid, non-zero = invalid
22	24	double[3]	m	pos	PositionoftheGEOattimetoe
46	24	double[3]	m/s	vel	VelocityoftheGEOattimetoe
70	24	double[3]	m/s^2	acc	AccelerationoftheGEOattimetoe
94	8	double double	s s/s	a_gf0 a_gf1	TimeoffsetoftheGEOclockw.r.t.SBASNetwork Time
102	8				DriftoftheGEOclockw.r.t. SBASNetwork Time
	110				Total Payload Length

Table 6.6.28: MSG_EPHEMERIS_SBAS_DEP_B 0x0084 message structure



Field 6.6.12 : Signal constellation, band and code (common.sid.code)

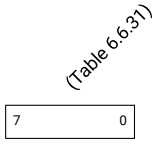
Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 6.6.29: values (common.sid.code[0:7])

MSG_EPHEMERIS_SBAS — 0x008C — 140

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8		common.sid.code	Signalconstellation,bandandcode
2	4	u32	s	common.toe.tow	SecondssincestartofGPSweek
6	2	u16	week	common.toe.wn	GPSweeknumber
8	4	float	m	common.ura	UserRangeAccuracy
12	4	u32	s	common.fit_interval	Curvefitinterval
16	1	u8		common.valid	Statusofephemeris,1=valid,0=invalid
17	1	u8		common.health_bits	SatelliteHealthstatus per ICD GPS IS-GPS-200 chapter 20.3.3.3.1.4 SBAS: 0 = valid, non-zero = invalid GLO: 0 = valid, non-zero = invalid
18	24	double[3]	m	pos	PositionoftheGEOattimetoe
42	12	float[3]	m/s	vel	VelocityoftheGEOattimetoe
54	12	float[3]	m/s^2	acc	AccelerationoftheGEOattimetoe
66	4	float	$s_{s/s}$	a_gf0	TimeoffsetoftheGEOclockw.r.t.SBASNetwork Time
70	4	float		a_gf1	DriftoftheGEOclockw.r.t. SBASNetwork Time
	74				Total Payload Length

Table 6.6.30: MSG_EPHEMERIS_SBAS 0x008C message structure



Field 6.6.13 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

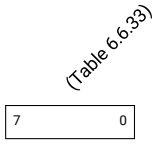
Table 6.6.31: values (common.sid.code[0:7])

MSG_EPHEMERIS_GLO_DEP_B — 0x0085 — 133

The ephemeris message returns a set of satellite orbit parameters that is used to calculate GLO satellite position, velocity, and clock offset. Please see the GLO ICD 5.1 ”Table 4.5 Characteristics of words of immediate information (ephemeris parameters)” for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8 u32		common.sid.code	Signalconstellation,bandandcode
2	4	u16	s	common.toe.tow	SecondssincestartofGPSweek
6	2	double	week	common.toe.wn	GPSweeknumber
8	8	u32 u8	m	common.ura	UserRangeAccuracy
16	4	u8	s	common.fit_interval	Curvefitinterval
20	1			common.valid	Statusofephemeris,1=valid,0=invalid
21	1			common.health_bits	Satellitehealthstatus chapter 20.3.3.3.1.4 Others: 0 = valid, non-zero = invalid
22	8	double		gam	Relativedeviationofpredictedcarrierfrequency from nominal
30	8	double[3]	s	ma	CorrectiontotheSVtime
38	24	double[3]	m	tau	PositionoftheSVattbinPZ-90.02coordinates system
62	24	double[3]	m/s	vel pos	VelocityvectoroftheSVattbinPZ-90.02coordinates system
86	24		m/s^2	acc	AccelerationvectoroftheSVattbinPZ-90.02 coordinates sys
	110				Total Payload Length

Table 6.6.32: MSG_EPHEMERIS_GLO_DEP_B 0x0085 message structure



Field 6.6.14 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

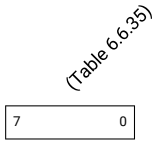
Table 6.6.33: values (common.sid.code[0:7])

MSG_EPHEMERIS_GLO_DEP_C — 0x0087 — 135

The ephemeris message returns a set of satellite orbit parameters that is used to calculate GLO satellite position, velocity, and clock offset. Please see the GLO ICD 5.1 ”Table 4.5 Characteristics of words of immediate information (ephemeris parameters)” for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8 u32		common.sid.code	Signalconstellation,bandandcode
2	4	u16	s	common.toe.tow	SecondssincestartofGPSweek
6	2	double	week	common.toe.wn	GPSweeknumber
8	8	u32 u8	m	common.ura	UserRangeAccuracy
16	4	u8	s	common.fit_interval	Curvefitinterval
20	1			common.valid	Statusofephemeris,1=valid,0=invalid
21	1			common.health_bits	Satellitehealthstatus chapter 20.3.3.3.1.4 Others: 0 = valid, non-zero = invalid
22	8	double		gam	Relativedeviationofpredictedcarrierfre-
30	8				inal time
38	8				tweenL1andL2
46	24				tbinPZ-90.02coordi-
70	24				eSVattbinPZ-90.02co-
94	24			acc	AccelerationvectoroftheSVattbinPZ-90.02 coordinates sys
118	1			fcn	Frequencyslot.FCN+8(thatis[1..14]).0or 0xFF for invalid
	119				Total Payload Length

Table 6.6.34: MSG_EPHEMERIS_GLO_DEP_C 0x0087 message structure



Field 6.6.15 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

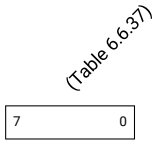
Table 6.6.35: values (common.sid.code[0:7])

MSG_EPHEMERIS_GLO_DEP_D — 0x0088 — 136

This observation message has been deprecated in favor of ephemeris message using floats for size reduction.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8 u32		common.sid.code	Signalconstellation,bandandcode
2	4	u16	s	common.toe.tow	SecondssincestartofGPSweek
6	2	double	week	common.toe.wn	GPSweeknumber
8	8	u32 u8	m	common.ura	UserRangeAccuracy
16	4	u8	s	common.fit_interval	Curvefitinterval
20	1			common.valid	Statusofephemeris,1=valid,0=invalid
21	1			common.health_bits	SatelliteHealthstatus chapter 20.3.3.3.1.4 Others: 0 = valid, non-zero = invalid
22	8	double		gam	Relativedeviationofpredictedcarrierfre-
30	8				inal
38	8				time
46	24				tweenL1andL2
70	24				tbinPZ-90.02coordi- eSVattbinPZ-90.02co-
94	24			acc	AccelerationvectoroftheSVattbinPZ-90.02 coordinates sys
118	1			fcn	Frequencyslot.FCN+8(thatis[1..14]).0or 0xFF for invalid
119	1			iod	Issueofdata.Equaltothe7bitsoftheimme- diate data word t_b
	120				Total Payload Length

Table 6.6.36: MSG_EPHEMERIS_GLO_DEP_D 0x0088 message structure



Field 6.6.16 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

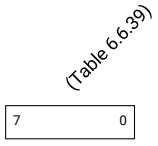
Table 6.6.37: values (common.sid.code[0:7])

MSG_EPHEMERIS_GLO — 0x008B — 139

The ephemeris message returns a set of satellite orbit parameters that is used to calculate GLO satellite position, velocity, and clock offset. Please see the GLO ICD 5.1 ”Table 4.5 Characteristics of words of immediate information (ephemeris parameters)” for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8		common.sid.code	Signalconstellation,bandandcode
2	4	u32	s	common.toe.tow	SecondssincestartofGPSweek
6	2	u16	week	common.toe.wn	GPSweeknumber
8	4	float	m	common.ura	UserRangeAccuracy
12	4	u32	s	common.fit_interval	Curvefitinterval
16	1	u8		common.valid	Statusofephemeris,1=valid,0=invalid
17	1	u8		common.health_bits	Satellitehealthstatus chapter 20.3.3.3.1.4 SBAS: 0 = valid, non-zero = invalid GLO: 0 = valid, non-zero = invalid
18	4	float		gam	Relativedeviationofpredictedcarrierfre-
22	4				inal time
26	4				tweenL1andL2
30	24				tbinPZ-90.02coordi-
54	24				eSVattbinPZ-90.02co-
78	12			acc	AccelerationvectoroftheSVattbinPZ-90.02 coordinates sys
90	1			fcn	Frequencyslot.FCN+8(thatis[1..14]).0or 0xFF for invalid
91	1			iod	Issueofdata.Equaltothe7bitsoftheimme- diate data word t_b
	92				Total Payload Length

Table 6.6.38: MSG_EPHEMERIS_GLO 0x008B message structure



Field 6.6.17 : Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 6.6.39: values (common.sid.code[0:7])

MSG_IONO — 0x0090 — 144

The ionospheric parameters which allow the ”L1 only” or ”L2 only” user to utilize the ionospheric model for computation of the ionospheric delay. Please see ICD-GPS-200 (Chapter 20.3.3.5.1.7) for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	s	t_nmct.tow	Seconds since start of GPS week
4	2	u16	week	t_nmct.wn	GPS week number
6	8	double	s	a0 a1 a2 a3	
14	8	double	s/semi-circle	b0 b1 b2 b3	
22	8	double	s/(semi-circle)^2		
30	8	double	s/(semi-circle)^3		
38	8	double	s		
46	8	double	s/semi-circle		
54	8	double	s/(semi-circle)^2		
62	8	double	s/(semi-circle)^3		
	70				Total Payload Length

Table 6.6.40: MSG_IONO 0x0090 message structure

MSG_SV_CONFIGURATION_GPS_DEP — 0x0091 — 145

Please see ICD-GPS-200 (Chapter 20.3.3.5.1.4) for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 6	4 2 4	u32	s	t_nmct.tow	SecondssincestartofGPSweek
		u16	week	t_nmct.wn	GPSweeknumber
		u32		l2c_mask	L2CcapabilitymaskSV32bitbeingMSBSV1 bit being LSB
	10				Total Payload Length

Table 6.6.41: MSG_SV_CONFIGURATION_GPS_DEP 0x0091 message structure

MSG_GNSS_CAPB — 0x0096 — 150

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	s	t_nmct.tow	SecondssincestartofGPSweek
4	2	u16	week	t_nmct.wn	GPSweeknumber
6	8	u64		gc.gps_active	GPSSVactivemask
14	8	u64		gc.gps_l2c	GPSL2Cactivemask
22	4	u64		gc.gps_l5	GPSL5activemask
30	4	u32		gc.glo_active	GLOactivemask
34	8	u32		gc.glo_l2of	GLOL2OFactivemask
38	4	u32		gc.glo_l3	GLOL3activemask
42	8	u64		gc.sbas_active	SBAS active mask (PRNs 120..158, AN 7/62.2.2-18/18 Table B-23, https://www.caat.or.th/wp-content/uploads/2018/03/SL-2018.18.E-1.pdf)
50	8	u64		gc.sbas_l5	SBAS L5 active mask (PRNs 120..158, AN 7/62.2.2-18/18 Table B-23, https://www.caat.or.th/wp-content/uploads/2018/03/SL-2018.18.E-1.pdf)
58	8	u64		gc.bds_active	BDSactivemask
66	8	u64		gc.bds_d2nav	BDSD2NAVactivemask
74	4	u64		gc.bds_b2	BDSB2activemask
82	8	u64		gc.bds_b2a	BDSB2Aactivemask
90	110	u32		gc.qzss_active	QZSSactivemask
94		u64		gc.gal_active	GALactivemask
102		u64		gc.gal_e5	GALE5activemask
					Total Payload Length

Table 6.6.42: MSG_GNSS_CAPB 0x0096 message structure

MSG_GROUP_DELAY_DEP_A—0x0092—146

Please see ICD-GPS-200 (30.3.3.3.1.1) for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 6 7	4 2 1 1	u32	ms	t_op.tow	Milliseconds since start of GPS week
		u16	week	t_op.wn	GPS week number
		u8		prn	Satellite number
		u8		valid	bit-field indicating validity of the values, LSB indicating tgd validity etc. 1 = value is valid, 0 = value is not valid.
8	2	s16	s * 2^-35	tgd	
10	2	s16	s * 2^-35	isc_l1ca	
12	2	s16	s * 2^-35	isc_l2c	
	14				Total Payload Length

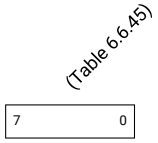
Table 6.6.43: MSG_GROUP_DELAY_DEP_A 0x0092 message structure

MSG_GROUP_DELAY_DEP_B—0x0093—147

Please see ICD-GPS-200 (30.3.3.3.1.1) for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 6	4 2 2	u32 u16 u16	s week	t_op.tow t_op.wn sid.sat	Seconds since start of GPS week GPS week number Constellation-specific satellite identifier. Note: unlike GnssSignal, GPS satellites are encoded as (PRN - 1). Other constellations do not have this offset.
8	1	u8		sid.code	Signal constellation, band and code
9	1	u8		sid.reserved	Reserved
10	1	u8		valid	bit-field indicating validity of the values, LSB indicating tgd validity etc. 1 = value is valid, 0 = value is not valid.
11	2	s1 6	s * 2^-35	tgd	
13	2	6	s * 2^-35	isc_l1ca	
15	2	s1 6	s * 2^-35	isc_l2c	
	17	s1 6			Total Payload Length

Table 6.6.44: MSG_GROUP_DELAY_DEP_B 0x0093 message structure



Field 6.6.18: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P

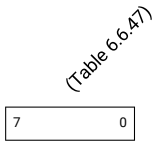
Table 6.6.45: values (sid.code[0:7])

MSG_GROUP_DELAY — 0x0094 — 148

Please see ICD-GPS-200 (30.3.3.3.1.1) for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 6	4 2 1	u32 u16 u8	s week	t_op.tow t_op.wn sid.sat	Seconds since start of GPS week GPS week number Constellation-specific satellite identifier. This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
7	1	u8		sid.code	Signal constellation, band and code
8	1	u8		valid	bit-field indicating validity of the values, LSB indicating tgd validity etc. 1 = value is valid, 0 = value is not valid.
9	2	s1 6	s * 2^-35	tgd	
11	2	s1 6	s * 2^-35	isc_l1ca	
13	2	s1 6	s * 2^-35	isc_l2c	
	15				Total Payload Length

Table 6.6.46: MSG_GROUP_DELAY 0x0094 message structure



Field 6.6.19: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

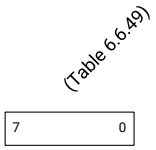
Table 6.6.47: values (sid.code[0:7])

MSG_ALMANAC_GPS — 0x0072 — 114

The almanac message returns a set of satellite orbit parameters. Almanac data is not very precise and is considered valid for up to several months. Please see the Navstar GPS Space Segment/Navigation user interfaces (ICD-GPS-200, Chapter 20.3.3.5.1.2 Almanac Data) for more details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.1his field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8 u32		common.sid.code	Signalconstellation,bandandcode
2	4	u16	s	common.toa.tow	SecondssincestartofGPSweek
6	2	double	week	common.toa.wn	GPSweeknumber
8	8	u32 u8	m	common.ura	UserRangeAccuracy
16	4	u8	s	common.fit_interval	Curvefitinterval
20	1			common.valid	Statusofalmanac,1=valid,0=invalid
21	1			common.health_bits	SatellitehealthstatusforGPS:-bits5-7:NAV data health status. See IS-GPS-200H Table 20-VII: NAV Data Health Indications. - bits 0-4: Signal health status. See IS-GPS-200H Table 20-VIII. Codes for Health of SV Signal Components. Satellite health status for GLO (see GLO ICD 5.1 table 5.1 for details): - bit 0: C(n), ”unhealthy” flag that is transmitted within non-immediate data and indicates overall constellation status at the moment of almanac uploading. ’0’ indicates malfunction of n-satellite. ’1’ indicates that n-satellite is operational. - bit 1: Bn(ln), ’0’ indicates the satellite is operational and suitable for navigation.
22	8	double	rad	m0	Meananomalyatreferencetime
30	8	double		ecc	Eccentricityofsatelliteorbit
38	8	double	mˆ(1/2	sqrta	Squarerootofthesemi-majoraxisoforbit
46	8	double	)	omega0	Longitudeofascendingnodeoforbitplaneat weekly epoch
		double		t	
54	8	double	rad/s	w	Rateofrightascension
62	8	double	rad	inc	Argumentofperigee
70	8	double	rad	af0 af1	Inclination
78	8	double	s		Polynomialclockcorrectioncoefficient(clock bias)
86	8		s/s		Polynomialclockcorrectioncoefficient(clock drift)
	94				Total Payload Length

Table 6.6.48: MSG_ALMANAC_GPS 0x0072 message structure



Field 6.6.20: Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

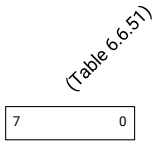
Table 6.6.49: values (common.sid.code[0:7])

MSG_ALMANAC_GLO — 0x0073 — 115

The almanac message returns a set of satellite orbit parameters. Almanac data is not very precise and is considered valid for up to several months. Please see the GLO ICD 5.1 ”Chapter 4.5 Non-immediate information and almanac” for details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		common.sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8 u32		common.sid.code	Signalconstellation,bandandcode
2	4	u16	s	common.toa.tow	SecondssincestartofGPSweek
6	2	double	week	common.toa.wn	GPSweeknumber
8	8	u32 u8	m	common.ura	UserRangeAccuracy
16	4	u8	s	common.fit_interval	Curvefitinterval
20	1			common.valid	Statusofalmanac,1=valid,0=invalid
21	1			common.health_bits	SatellitehealthstatusforGPS:-bits5-7:NAV data health status. See IS-GPS-200H Table 20-VII: NAV Data Health Indications. - bits 0-4: Signal health status. See IS-GPS-200H Table 20-VIII. Codes for Health of SV Signal Components. Satellite health status for GLO (see GLO ICD 5.1 table 5.1 for details): - bit 0: C(n), ”unhealthy” flag that is transmitted within non-immediate data and indicates overall constellation status at the moment of almanac uploading. ’0’ indicates malfunction of n-satellite. ’1’ indicates that n-satellite is operational. - bit 1: Bn(ln), ’0’ indicates the satellite is operational and suitable for navigation.
22	8	double	rad	lambda_na	Longitudeofthefirstascendingnodeofthe orbit in PZ-90.02 coordinate system
		double	s	t_lambda_na	
30	8	double	rad	i	Timeofthefirstascendingnodepassage
38	8	double	s/orbital period	t t_dot	Valueofinclinationatinstantoft_lambda
46	8	double			Value of Draconian period at instant of t_lambda
54	8	double	s/(orbital period^2)	epsilon omega	RateofchangeoftheDraconianperiod
62	8				Eccentricityatinstantoft_lambda
70	8				Argumentofperigeeatinstantoft_lambda
	78				Total Payload Length

Table 6.6.50: MSG_ALMANAC_GLO 0x0073 message structure



Field 6.6.21: Signal constellation, band and code (common.sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 6.6.51: values (common.sid.code[0:7])

MSG_GLO_BIASES — 0x0075 — 117

The GLONASS L1/L2 Code-Phase biases allows to perform GPS+GLONASS integer ambiguity resolution for baselines with mixed receiver types (e.g. receiver of different manufacturers).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 1 3 5 7	1 2 2 2 2	u8	boolean	mask	GLONASSFDMAsignalsmask
		s16	m*0.02	l1ca_bias	GLONASSL1C/ACode-PhaseBias
		s16	m*0.02	l1p_bias	GLONASSL1PCode-PhaseBias
		s16	m*0.02	l2ca_bias	GLONASSL2C/ACode-PhaseBias
		s16	m*0.02	l2p_bias	GLONASSL2PCode-PhaseBias
					Total Payload Length

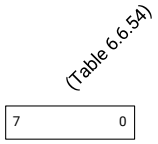
Table 6.6.52: MSG_GLO_BIASES 0x0075 message structure

MSG_SV_AZ_EL — 0x0097 — 151

Azimuth and elevation angles of all the visible satellites that the device does have ephemeris or almanac for.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
4N+ 0	1	u8		azel[N].sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
4 + 1	1	u8		azel[N].sid.code	Signalconstellation,bandandcode
N + 2	1	u8	deg*2	azel[N].az	Azimuthangle(range0..179)
4 + 3	1	s8	deg	azel[N].el	Elevationangle(range-90..90)
N 4	4				Total Payload Length
N	N				

Table 6.6.53: MSG_SV_AZ_EL 0x0097 message structure



Field 6.6.22: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

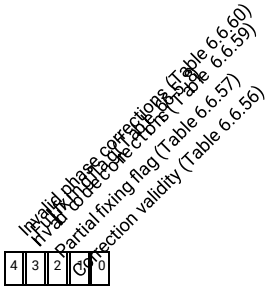
Table 6.6.54: values (sid.code[0:7])

MSG_OSR — 0x0640 — 1600

The OSR message contains network corrections in an observation-like format.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	header.t.tow	Millisecondssincestartof GPSweek
4	4	s32	ns	header.t.ns_residual	Nanosecondresidualofmillisecond-rounded TOW (ranges from -500000 to 500000)
8	2	u16	week	header.t.wn	GPSweeknumber
10	1	u8		header.n_obs	Totalnumberofobservations.Firstnibbleis the size of the sequence (n), second nibble is the zero-indexed counter (ith packet of n)
11 + 19 * N	4	u32	2cm	obs[N].P	Pseudorangeobservation
15 + 19 * N	4	s32	cycles	obs[N].L.i	Carrierphasewholecycles
19 + 19 * N	1	u8	cycles / 256	obs[N].L.f	Carrierphasefractionalpart
20 + 19 * N	1	u8		obs[N].lock	Locktimer.Thisvaluegivesanindicationof the time for which a signal has maintained continuous phase lock. Whenever a signal has lost and regained lock, this value is reset to zero. It is encoded according to DF402 from the RTCM 10403.2 Amendment 2 specification. Valid values range from 0 to 15 and the most significant nibble is reserved for future use.
21 + 19 * N	1	u8		obs[N].flags	Correctionflags.
22 + 19 * N	1	u8		obs[N].sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
23 + 19 * N	1	u8		obs[N].sid.code	Signalconstellation,bandandcode
24 + 19 * N	2	u16	5mm	obs[N].iono_std	Slantionospheriiccorrectionstandarddeviation
26 + 19 * N	2	u16	5mm	obs[N].tropo_std	Slanttroposphericcorrectionstandarddeviation
28 + 19 * N	2	u16	5mm	obs[N].range_std	Orbit/clock/bias correction projected on range standard deviation
11 + 19 * N					Total Payload Length

Table 6.6.55: MSG_OSR 0x0640 message structure



Field 6.6.23: Correction flags. (flags)

Value	Description
0	Donotusesignal
1	Validsignal

Table 6.6.56: Correction validity values (flags[0])

Value	Description
0	Partialfixingunavailable
1	Partialfixingavailable

Table 6.6.57: Partial fixing flag values (flags[1])

Value	Description
0	Fullfixingunavailable
1	Fullfixingavailable

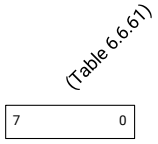
Table 6.6.58: Full fixing flag values (flags[2])

Value	Description
0	Validcodecorrections
1	Donotusecodecorrections

Table 6.6.59: Invalid code corrections values (flags[3])

Value	Description
0	Validphasecorrections
1	Donotusephasecorrections

Table 6.6.60: Invalid phase corrections values (flags[4])



Field 6.6.24: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 6.6.61: values (sid.code[0:7])

6.7 Settings

Messages for reading, writing, and discovering device settings. Settings with a ”string” field have multiple values in this field delimited with a null character (the c style null terminator). For instance, when querying the ’firmware_version’ setting in the ’system_info’ section, the following array of characters needs to be sent for the string field in MSG_SETTINGS_READ: ”system_info\0firmware_version\0”, where the delimiting null characters are specified with the escape sequence ’\0’ and all quotation marks should be omitted.

In the message descriptions below, the generic strings SECTION_SETTING and SETTING are used to refer to the two strings that comprise the identifier of an individual setting.In firmware_version example above, SECTION_SETTING is the ’system_info’, and the SETTING portion is ’firmware_version’. See the ”Software Settings Manual” on www.carnegierobotics.com/duro for detailed documentation about all settings and sections available for each Swift firmware version. Settings manuals are available for each firmware version at the following link: Piksi Multi Specifications. The latest settings document is also available at the following link: Latest settings document . See lastly settings.py , the open source python command line utility for reading, writing, and saving settings in the piksi_tools repository on github as a helpful reference and example.

MSG_SETTINGS_SAVE — 0x00A1 — 161

The save settings message persists the device’s current settings configuration to its onboard flash memory file system.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0					Total Payload Length

Table 6.7.1: MSG_SETTINGS_SAVE 0x00A1 message structure

MSG_SETTINGS_WRITE — 0x00A0 — 160

The setting message writes the device configuration for a particular setting via A NULL-terminated and NULL-delimited string with contents ”SECTION_SETTING\0SETTING\0VALUE\0” where the ’\0’ escape sequence denotes the NULL character and where quotation marks are omitted. A device will only process to this message when it is received from sender ID 0x42. An example string that could be sent to a device is ”solution\0soln_freq\010\0”.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	N	string		setting	A NULL-terminated and NULL-delimited string with contents ”SECTION_SETTING\0SETTING\0VALUE\0”
	N				Total Payload Length

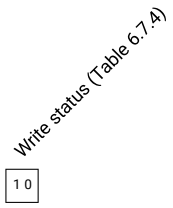
Table 6.7.2: MSG_SETTINGS_WRITE 0x00A0 message structure

MSG_SETTINGS_WRITE_RESP — 0x00AF — 175

Return the status of a write request with the new value of the setting. If the requested value is rejected, the current value will be returned. The string field is a NULL-terminated and NULL-delimited string with contents ”SECTION_SETTING\0SETTING\0VALU where the ’\0’ escape sequence denotes the NULL character and where quotation marks are omitted. An example string that could be sent from device is ”solution\0soln_freq\010\0”.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 1	1 N	u8 string		status setting	Writestatus A NULL-terminated and delimited string with contents ”SECTION_SETTING\0SETTING\0VALUE\0”
	N+ 1				Total Payload Length

Table 6.7.3: MSG_SETTINGS_WRITE_RESP 0x00AF message structure



Field 6.7.1: Write status (status)

Value	Description
0	Accepted;valueupdated
1	Rejected;valueunparsableorout-of-range
2	Rejected;requestedsettingdoesnotexist
3	Rejected;settingnamecouldnotbeparsed
4	Rejected;settingisreadonly
5	Rejected;modificationistemporarilydisabled
6	Rejected;unspecifiederror

Table6.7.4:Writestatusvalues(status[0:1])

MSG_SETTINGS_READ_REQ — 0x00A4 — 164

The setting message that reads the device configuration. The string field is a NULL-terminated and NULL-delimited string with contents ”SECTION_SETTING\0SETTING\0” where the ’\0’ escape sequence denotes the NULL character and where quotation marks are omitted. An example string that could be sent to a device is ”solution\0soln_freq\0”. A device will only respond to this message when it is received from sender ID 0x42. A device should respond with a MSG_SETTINGS_READ_RESP message (msg_id 0x00A5).

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	N	string		setting	A NULL-terminated and NULL-delimited string with contents ”SECTION_SETTING\0SETTING\0”
	N				Total Payload Length

Table 6.7.5: MSG_SETTINGS_READ_REQ 0x00A4 message structure

MSG_SETTINGS_READ_RESP — 0x00A5 — 165

The setting message with which the device responds after a MSG_SETTING_READ_REQ is sent to device. The string field is a NULL-terminated and NULL-delimited string with contents ”SECTION_SETTING\0SETTING\0VALUE\0” where the ’\0’ escape sequence denotes the NULL character and where quotation marks are omitted. An example string that could be sent from device is ”solution\0soln_freq\010\0”.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	N	string		setting	A NULL-terminated and NULL-delimited string with contents ”SECTION_SETTING\0SETTING\0VALUE\0”
	N				Total Payload Length

Table 6.7.6: MSG_SETTINGS_READ_RESP 0x00A5 message structure

MSG_SETTINGS_READ_BY_INDEX_REQ — 0x00A2 — 162

The settings message for iterating through the settings values. A device will respond to this message with a ”MSG_SETTINGS_RE

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16		index	Anindexintothedevicesettings,withvalues ranging from 0 to length(settings).
	2				Total Payload Length

Table 6.7.7: MSG_SETTINGS_READ_BY_INDEX_REQ 0x00A2 message structure

MSG_SETTINGS_READ_BY_INDEX_RESP — 0x00A7 — 167

The settings message that reports the value of a setting at an index.

In the string field, it reports NULL-terminated and delimited string with contents ”SECTION_SETTING\0SETTING\0VALUE\0FOR where the ’\0’ escape sequence denotes the NULL character and where quotation marks are omitted. The FORMAT_TYPE field is optional and denotes possible string values of the setting as a hint to the user. If included, the format type por- tion of the string has the format ”enum:value1,value2,value3”. An example string that could be sent from the device is ”simulator\0enabled\0True\0enum:True,False\0”.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16		index	Anindexintothedevicesettings,withvalues ranging from 0 to length(settings)
6.7.3	N	string		setting	A NULL-terminated and delim- ited string with contents ”SEC- TION_SETTING\0SETTING\0VALUE\0FORMAT_TYPE\0”
	N+ 2				Total Payload Length

Table 6.7.8: MSG_SETTINGS_READ_BY_INDEX_RESP 0x00A7 message structure

MSG_SETTINGS_READ_BY_INDEX_DONE — 0x00A6 — 166

The settings message for indicating end of the settings values.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0					Total Payload Length

Table 6.7.9: MSG_SETTINGS_READ_BY_INDEX_DONE 0x00A6 message structure

6.8 Solution Meta

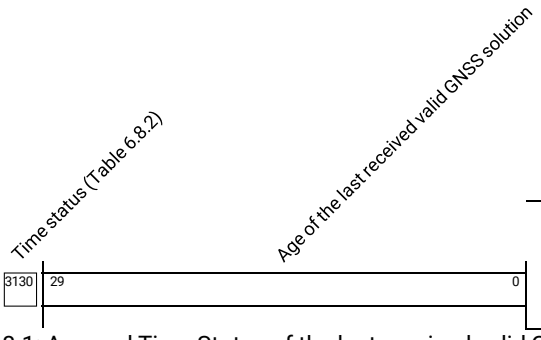
Standardized Metadata messages for Fuzed Solution from Swift Navigation devices.

MSG_SOLN_META — 0xFF0E — 65294

This message contains all metadata about the sensors received and/or used in computing the sensorfusion solution. It focuses primarily, but not only, on GNSS metadata. Regarding the age of the last received valid GNSS solution, the highest two bits are time status, indicating whether age gnss can or can not be used to retrieve time of measurement (noted TOM, also known as time of validity) If it can, subtract 'age gnss' from 'tow' in navigation messages to get TOM. Can be used before alignment is complete in the Fusion Engine, when output solution is the last received valid GNSS solution and its tow is not a TOM.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	tow	GPStimeofweekroundedtothenearestmillisecond
4	2	u16	0.01	pdop	PositionDilutionofPrecisionasperlastavailable DOPS from PVT engine (0xFFFF indicates invalid)
6	2	u16	0.01	hdop	HorizontalDilutionofPrecisionasperlast available DOPS from PVT engine (0xFFFF indicates invalid)
8	2	u16	0.01	vdop	VerticalDilutionofPrecisionasperlastavailable DOPS from PVT engine (0xFFFF indicates invalid)
10	2	u16	deciseconds	age_corrections	Age of corrections as per last available AGE_CORRECTIONS from PVT engine (0xFFFF indicates invalid)
12	4	u32	ms	age_gnss	AgeandTimeStatusofthelastreceivedvalid GNSS solution.
2 + 16 N + 17	1 1	u8 u8	(XX)InputType	sol_in[N].sensor_type sol_in[N].flags	Thetypeofsensor RefertoeachInputTypedescription
2 N	2N+ 16				Total Payload Length

Table 6.8.1: MSG_SOLN_META 0xFF0E message structure



Field 6.8.1: Age and Time Status of the last received valid GNSS solution.(age_gnss)

Value	Description
0	AgecannotbeusedtoretrieveTOM
1	AgecanbeusedtoretrieveTOM
2	Reserved
3	Reserved

Table 6.8.2: Time status values (age_gnss[30:31])

Field 6.8.2: The type of sensor (sol_in[N].sensor_type)

Value	Description
0	Invalid
1	GNSSPosition(seeGNSSInputType)
2	GNSSVelocityDisplacement(seeGNSSInputType)
3	GNSSVelocityDoppler(seeGNSSInputType)
4	OdometryTicks(seeOdoInputType)
5	OdometrySpeed(seeOdoInputType)
6	IMUSensor(seeIMUInputType)
7	Reserved

Table 6.8.3: Sensor Type values s(ol_in[N].sensor_type[0:2])

Value	Description
0	Unknown
1	Received and used
2	Received but not used

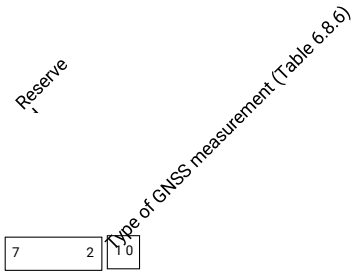
Table 6.8.4: Sensor Usage values (sol_in[N].sensor_type[3:4])

GNSSInputType

Metadata around the GNSS sensors involved in the fuzed solution. Accessible through sol_in[N].flags in a MSG_SOLN_META.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		flags	flagsthatstoreallrelevantinfospecifictothis sensor type.
	1				Total Payload Length

Table 6.8.5: GNSSInputType message structure



Field 6.8.3: flags that store all relevant info specific to this sensor type.(flags)

Value	Description
0	GNSSPosition
1	GNSSVelocityDoppler
2	GNSSVelocityDisplacement

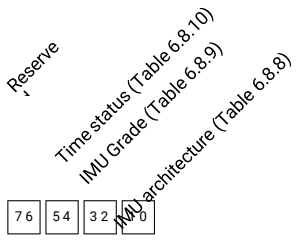
Table 6.8.6: Type of GNSS measurement values (flags[0:1])

IMUInputType

Metadata around the IMU sensors involved in the fuzed solution. Accessible through sol_in[N].flags in a MSG_SOLN_META.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		flags	Instrumenttime,grade,andarchitecturefora sensor.
	1				Total Payload Length

Table 6.8.7: IMUInputType message structure



Field 6.8.4: Instrument time, grade, and architecture for a sensor. (flags)

Value	Description
0	6-axisMEMS
1	Othertype

Table 6.8.8: IMU architecture values (flags[0:1])

Value	Description
0	ConsumerGrade
1	Tacticalgrade
2	IntermediateGrade
3	Superior(Marine/Aviation)Grade

Table6.8.9:IMUGradevalues(flags[2:3])

Value	Description
0	ReferenceepochisstartofcurrentGPSweek
1	Referenceepochistimeofsystemstartup
2	Referenceepochisunknown
3	ReferenceepochislastPPS

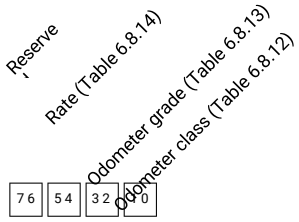
Table6.8.10:Timestatusvalues(flags[4:5])

OdoInputType

Metadata around the Odometry sensors involved in the fuzed solution. Accessible through sol_in[N].flags in a MSG_SOLN_META.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1 1	u8		flags	InstrumentODOrate,grade,andquality.
					Total Payload Length

Table 6.8.11: OdoInputType message structure



Field 6.8.5: Instrument ODO rate, grade, and quality. (flags)

Value	Description
0	Singleoraveragedticks
1	Singleoraveragedspeed
2	Multi-dimensionalticks
3	Multi-dimensionalspeed

Table 6.8.12: Odometer class values (flags[0:1])

Value	Description
0	LowGrade(e.g.quantizedCAN)
1	MediumGrade
2	SuperiorGrade
3	Reserved

Table 6.8.13: Odometer grade values (flags[2:3])

Value	Description Fixedincomingrate
0	Triggeredbyminimumdistanceorspeed
1	Reserved
2	Reserved
3	

Table6.8.14:Ratevalues(flags[4:5])

6.9 System

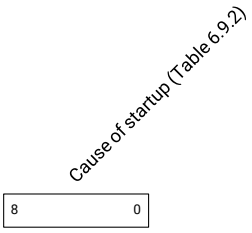
Standardized system messages from Swift Navigation devices.

MSG_STARTUP — 0xFF00 — 65280

The system start-up message is sent once on system start-up. It notifies the host or other attached devices that the system has started and is now ready to respond to commands or configuration requests.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		cause	Causeofstartup
1	1	u8		startup_type	Startuptype
2	2	u16		reserved	Reserved
4					Total Payload Length

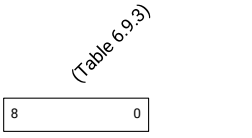
Table 6.9.1: MSG_STARTUP 0xFF00 message structure



Field 6.9.1: Cause of startup (cause)

Value	Description
0	Poweron
1	Softwarereset
2	Watchdogreset

Table 6.9.2: Cause of startup values (cause[0:8])



Field 6.9.2: Startup type (startup_type)

Value	Description
0	Coldstart
1	Warmstart
2	Hotstart

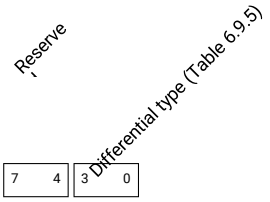
Table 6.9.3: values (startup_type[0:8])

MSG_DGNSS_STATUS — 0xFF02 — 65282

This message provides information about the receipt of Differential corrections. It is expected to be sent with each receipt of a complete corrections packet.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 1 3 4	1 2 1 N	u8		flags	Statusflags
	N	u16	deci-seconds	latency	Latencyofobservationreceipt
		u8		num_signals	Numberofsignalsfrombasestation
		string		source	Correctionssourcestring
	+ 4				Total Payload Length

Table 6.9.4: MSG_DGNSS_STATUS 0xFF02 message structure



Field 6.9.3: Status flags (flags)

Value	Description
0	Invalid
1	CodeDifference
2	RTK

Table 6.9.5: Differential type values (flags[0:3])

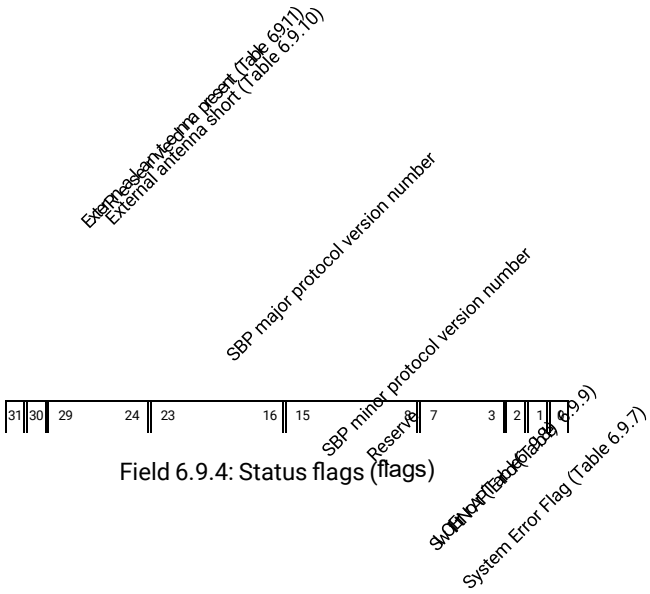
MSG_HEARTBEAT — 0xFFFF — 65535

The heartbeat message is sent periodically to inform the host or other attached devices that the system is running. It is used to monitor system malfunctions. It also contains status flags that indicate to the host the status of the system and whether it is operating correctly. Currently, the expected heartbeat interval is 1 sec.

The system error flag is used to indicate that an error has occurred in the system. To determine the source of the error, the remaining error flags should be inspected.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4 4	u32		flags	Statusflags
					Total Payload Length

Table 6.9.6: MSG_HEARTBEAT 0xFFFF message structure



Field 6.9.4: Status flags (flags)

Value	Description
0	SystemHealthy
1	Anerrorhasoccurred

Table 6.9.7: System Error Flag values (flags[0])

Value	Description
0	SystemHealthy
1	AnIOerrorhasoccurred

Table 6.9.8: IO Error values (flags[1])

Value	Description
0	SystemHealthy
1	AnerrorhasoccurredintheSwiftNAP

Table6.9.9:SwiftNAPErrorvalues(flags[2])

Value	Description
0	Noshortdetected
1	Shortdetected

Table 6.9.10: External antenna short values (flags[30])

Value	Description
0	Noexternalantennadetected
1	Externalantennaispresent

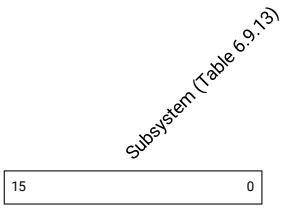
Table 6.9.11: External antenna present values (flags[31])

SubSystemRepor t

Report the general and specific state of a sub-system. If the generic state is reported as initializing, the specific state should be ignored.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 2 3	2 1 1	u16		component	Identityofreportingsubsystem
	4	u8		generic	Genericformstatusreport
		u8		specific	Subsystemspecificstatuscode
					Total Payload Length

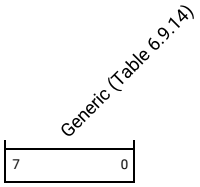
Table 6.9.12: SubSystemReport message structure



Field 6.9.5: Identity of reporting subsystem (component)

Value	Description
0	PrimaryGNSSAntenna
1	MeasurementEngine
2	CorrectionsClient
3	DifferentialGNSSEngine
4	CAN
5	WheelOdometry
6	SensorFusionEngine

Table 6.9.13: Subsystem values (component[0:15])



Field 6.9.6: Generic form status report (generic)

Value	Description
0	OK/Nominal
1	Initializing
2	Unknown
3	Degraded
4	Unusable

Table 6.9.14: Generic values (generic[0:7])

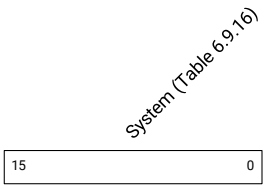
MSG_STATUS_REPORT — 0xFFFE — 65534

The status report is sent periodically to inform the host or other attached devices that the system is running. It is used to monitor system malfunctions. It contains status reports that indicate to the host the status of each sub-system and whether it is operating correctly.

Interpretation of the subsystem specific status code is product dependent, but if the generic status code is initializing, it should be ignored. Refer to product documentation for details.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 2 4 8 4N 4N 4N	2 2 4 4 2 1 1 4N	u16 u16 u32 u32 u16 u8 u8		reporting_system sbp_version sequence uptime status[N].component status[N].generic status[N].specific	Identityofreportingsystem SBPprotocolversion Incrementsoneachstatusreportsent Numberoftimesthesubsystemstarted up Identityofreportingsubsystem Genericformstatusreport Subsystemspecificstatuscode
+ 12					Total Payload Length

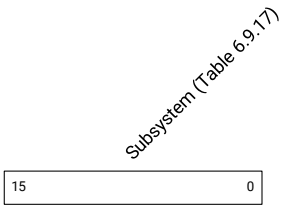
Table 6.9.15: MSG_STATUS_REPORT 0xFFFE message structure



Field 6.9.7: Identity of reporting system (reporting_system)

Value	Description
0	Starling
1	PrecisionGNSSModule(PGM)

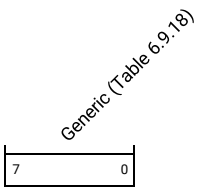
Table 6.9.16: System values (reporting_system[0:15])



Field 6.9.8: Identity of reporting subsystem (component)

Value	Description
0	PrimaryGNSSAntenna
1	MeasurementEngine
2	CorrectionsClient
3	DifferentialGNSSEngine
4	CAN
5	WheelOdometry
6	SensorFusionEngine

Table 6.9.17: Subsystem values (component[0:15])



Field 6.9.9: Generic form status report (generic)

Value	Description
0	OK/Nominal
1	Initializing
2	Unknown
3	Degraded
4	Unusable

Table 6.9.18: Generic values (generic[0:7])

MSG_INS_STATUS — 0xFF03 — 65283

The INS status message describes the state of the operation and initialization of the inertial navigation system.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4 4	u32		flags	Statusflags
					Total Payload Length

Table 6.9.19: MSG_INS_STATUS 0xFF03 message structure

Value	Description
0	Awaitinginitialization
1	Dynamicallyaligning
2	Ready
3	GNSSOutageexceedsmaxduration
4	FastStartseeding
5	FastStartvalidating
6	Validatingunsafefaststartseed

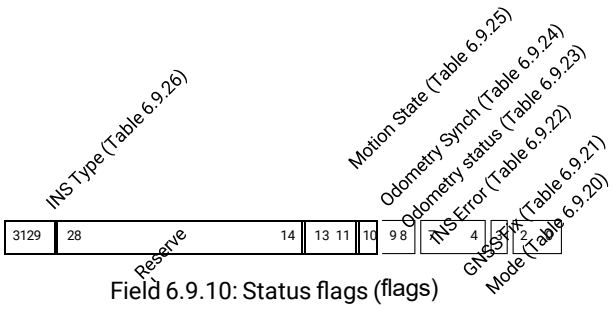
Table6.9.20:Modevalues(flags[0:2])

Value	Description
0	NoGNSSfixavailable
1	GNSSfix

Table 6.9.21: GNSS Fix values (flags[3])

Value	Description
0	Reserved
1	IMUDataError
2	INSLicenseError
3	IMUCalibrationDataError

Table 6.9.22: INS Error values (flags[4:7])



Field 6.9.10: Status flags (flags)

Value	Description
0	NoOdometry
1	Odometryreceivedwithinlastsecond
2	Odometrynotreceivedwithinlastsecond

Table6.9.23:Odometrystatusvalues(flags[8:9])

Value	Description
0	Odometrytimestampnominal
1	Odometrytimestampoutofbounds

Table 6.9.24: Odometry Synch values (flags[10])

Value	Description
0	UnknownorInit
1	ArbitraryMotion
2	StraightMotion
3	Stationary

Table 6.9.25: Motion State values (flags[11:13])

Value	Description
0	SmoothposeLooselyCoupled
1	Starling

Table 6.9.26: INS Type values (flags[29:31])

MSG_GNSS_TIME_OFFSET — 0xFF07 — 65287

The GNSS time offset message contains the information that is needed to translate messages tagged with a local timestamp (e.g. IMU or wheeltick messages) to GNSS time for the sender producing this message.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	s16	weeks	weeks	Weeksportionofthetimeoffset
2	4	s32	ms	milliseconds	Millisecondsportionofthetimeoffset
6	2	s16	microseconds	microseconds	Microsecondsportionofthetimeoffset
8	1	u8		flags	Statusflags(reserved)
	9				Total Payload Length

Table 6.9.27: MSG_GNSS_TIME_OFFSET 0xFF07 message structure

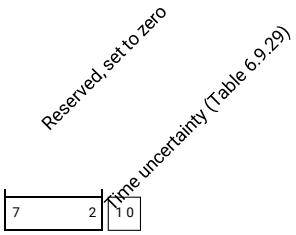
MSG_PPS_TIME — 0xFF08 — 65288

The PPS time message contains the value of the sender's local time in microseconds at the moment a pulse is detected on the PPS input. This is to be used for syncronisation of sensor data sampled with a local timestamp (e.g. IMU or wheeltick messages) where GNSS time is unknown to the sender.

The local time used to timestamp the PPS pulse must be generated by the same clock which is used to timestamp the IMU/wheel sensor data and should follow the same roll-over rules. A separate MSG_PPS_TIME message should be sent for each source of sensor data which uses PPS-relative timestamping. The sender ID for each of these MSG_PPS_TIME messages should match the sender ID of the respective sensor data.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	8	u64	microseconds	time	Localtimeinmicroseconds
8	1	u8		flags	Statusflags
9					Total Payload Length

Table 6.9.28: MSG_PPS_TIME 0xFF08 message structure



Field 6.9.11: Status flags (flags)

Value	Description
0	Unknown
1	+/-10milliseconds
2	+/-10microseconds
3	<1microseconds

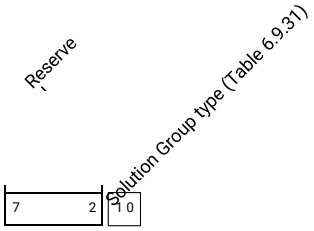
Table 6.9.29: Time uncertainty values (flags[0:1])

MSG_GROUP_META — 0xFF0A — 65290

This leading message lists the time metadata of the Solution Group. It also lists the atomic contents (i.e. types of messages included) of the Solution Group.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8 u8 u8		group_id flags	IdoftheMsgsGroup,0isUnknown,1isBestpos, 2 is Gnss
1	1	u16[N]		n_group_msgs	Statusflags(reserved)
2	1			group_msgs	Sizeoflistgroup_msgs
3	N				Anin-orderlistofmessagetypesincludedin the Solution Group, including GROUP_META itself
	2N+ 3				Total Payload Length

Table 6.9.30: MSG_GROUP_META 0xFF0A message structure



Field 6.9.12: Status flags (reserved) (flags)

Value	Description
0	None(invalid)
1	GNSSonly
2	GNSS+INS(Fuzed)
3	Reserved

Table 6.9.31: Solution Group type values (flags[0:1])

7 Draft Message Definitions

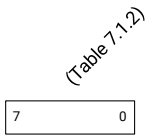
7.1 Acquisition

Satellite acquisition messages from the device.

MSG ACQ RESULT — 0x002F — 47
This message describes the results from an attempted GPS signal acquisition search for a satellite PRN over a code phase/carrier frequency range. It contains the parameters of the point in the acquisition search space with the best carrier-to-noise (CN/0) ratio.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 12	4 4 4 1	float float float u8	dBHz chips hz	cn0 cp cf sid.sat	CN/0ofbestpoint Codephaseofbestpoint Carrierfrequencyofbestpoint Constellation-specificsatelliteidentifier.Thisfield for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
13	1	u8		sid.code	Signalconstellation,bandandcode
	14				Total Payload Length

Table 7.1.1: MSG_ACQ_RESULT 0x002F message structure



Field 7.1.1: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 7.1.2: values (sid.code[0:7])

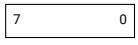
MSG ACQ SV PROFILE — 0x002E — 46

The message describes all SV profiles during acquisition time. The message is used to debug and measure the performance.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
33N + 0	1	u8		acq_sv_profile[N].job_type	SVsearchjobtype(deep,fallback,etc)
33N + 1	1	u8		acq_sv_profile[N].status	Acquisition status 1 is Success, 0 is Failure
33N + 2	2	u16	dB-Hz*10	acq_sv_profile[N].int_time	CN0value.Onlyvalidifstatusis'1'
33N + 4	1	u8	ms	acq_sv_profile[N].sid.sat	Acquisitionintegrationtime
33N + 5	1	u8			Constellation-specificsatelliteidentifier. This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
33N + 6	1	u8		acq_sv_profile[N].sid.code	Signalconstellation,bandandcode
33N + 7	2	u16	Hz	acq_sv_profile[N].bin_width	Acqfrequencybinwidth
33N + 9	4	u32	ms	acq_sv_profile[N].timestamp	Timestampofthejobcompleteevent
33N + 13	4	u32	us	acq_sv_profile[N].time_spent	Timespenttosearchforsid.code
33N + 17	4	s32	Hz	acq_sv_profile[N].cf_min	Dopplerrangelowestfrequency
33N + 21	4	s32	Hz	acq_sv_profile[N].cf_max	Dopplerrangehighestfrequency
33N + 25	4	s32	chips*10	acq_sv_profile[N].cp	Dopplervalueofdetectedpeak.Only valid if status is '1'
33N + 29	4	u32			Codephaseofdetectedpeak. Only valid if status is '1'
33N	33N				Total Payload Length

Table 7.1.3: MSG_ACQ_SV_PROFILE 0x002E message structure

(Table 7.1.4)



Field 7.1.2: Signal constellation, band and code (acq_sv_profile[N].sid.code)

Value	Description
0	GPS L1CA
1	GPS L2CM
2	SBAS L1CA
3	GLO L1CA
4	GLO L2CA
5	GPS L1P
6	GPS L2P
12	BDS2 B1
13	BDS2 B2
14	GAL E1B
20	GAL E7I
47	BDS3 B2a

Table 7.1.4: values (acq_sv_profile[N].sid.code[0:7])

7.2 File IO

Messages for using device's onboard flash filesystem functionality. This allows data to be stored persistently in the device's program flash with wear-levelling using a simple filesystem interface. The file system interface (CFS) defines an abstract API for reading directories and for reading and writing files.

Note that some of these messages share the same message type ID for both the host request and the device response.

MSG FILEIO READ REQ — 0x00A8 — 168
The file read message reads a certain length (up to 255 bytes) from a given offset into a file, and returns the data in a MSG_FILEIO_READ_RESP message where the message length field indicates how many bytes were successfully read. The sequence number in the request will be returned in the response. If the message is invalid, a followup MSG_PRINT message will print "Invalid fileio read message". A device will only respond to this message when it is received from sender ID 0x42.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 9	4 4 1 N	u32		sequence	Readsequencenumber
	N	u32	bytes	offset	Fileoffset
		u8	bytes	chunk_size	Chunksizetoread
		string		filename	Nameofthefiletoreadfrom
	+ 9				Total Payload Length

Table 7.2.1: MSG_FILEIO_READ_REQ 0x00A8 message structure

MSG FILEIO READ RESP — 0x00A3 — 163

The file read message reads a certain length (up to 255 bytes) from a given offset into a file, and returns the data in a message where the message length field indicates how many bytes were successfully read. The sequence number in the response is preserved from the request.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32		sequence	Readsequencenumber
4	N	u8[N]		contents	Contentsofreadfile
	+ 4				Total Payload Length

Table 7.2.2: MSG_FILEIO_READ_RESP 0x00A3 message structure

MSG FILEIO READ DIR REQ — 0x00A9 — 169

The read directory message lists the files in a directory on the device's onboard flash file system. The offset parameter can be used to skip the first n elements of the file list. Returns a MSG_FILEIO_READ_DIR_RESP message containing the directory listings as a NULL delimited list. The listing is chunked over multiple SBP packets. The sequence number in the request will be returned in the response. If message is invalid, a followup MSG_PRINT message will print "Invalid fileio read message". A device will only respond to this message when it is received from sender ID 0x42.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8	4 4 N	u32		sequence	Readsequencenumber
	N	u32		offset	Theoffsettoskipthefirstnelementsofthefilelist
		string		dirname	Nameofthedirectorytolist
	+ 8				Total Payload Length

Table 7.2.3: MSG_FILEIO_READ_DIR_REQ 0x00A9 message structure

MSG FILEIO READ DIR RESP — 0x00AA — 170

The read directory message lists the files in a directory on the device's onboard flash file system. Message contains the directory listings as a NULL delimited list. The listing is chunked over multiple SBP packets and the end of the list is identified by an packet with no entries. The sequence number in the response is preserved from the request.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32		sequence	Readsequencenumber
4	N	u8[N]		contents	Contentsofreaddirectory
	+ 4				Total Payload Length

Table 7.2.4: MSG_FILEIO_READ_DIR_RESP 0x00AA message structure

MSG FILEIO REMOVE — 0x00AC — 172
The file remove message deletes a file from the file system. If the message is invalid, a followup MSG_PRINT message will print ”Invalid fileio remove message”. A device will only process this message when it is received from sender ID 0x42.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	N N	string		filename	Nameofthefiletodelete
					Total Payload Length

Table 7.2.5: MSG_FILEIO_REMOVE 0x00AC message structure

MSG FILEIO WRITE REQ — 0x00AD — 173

The file write message writes a certain length (up to 255 bytes) of data to a file at a given offset. Returns a copy of the original MSG_FILEIO_WRITE_RESP message to check integrity of the write. The sequence number in the request will be returned in the response. If message is invalid, a followup MSG_PRINT message will print ”Invalid fileio write message”. A device will only process this message when it is received from sender ID 0x42.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 9	4 4 N N	u32		sequence	Writesequencenumber
	N	u32	bytes	offset	Offsetintothefileatwhichtostartwritinginbytes
		string		filename	Nameofthefiletowriteto
		u8[N]		data	Variable-lengtharrayofdatatowrite
	+ 9				Total Payload Length

Table 7.2.6: MSG_FILEIO_WRITE_REQ 0x00AD message structure

MSG FILEIO WRITE RESP — 0x00AB — 171
The file write message writes a certain length (up to 255 bytes) of data to a file at a given offset. The message is a copy of the original MSG_FILEIO_WRITE_REQ message to check integrity of the write. The sequence number in the response is preserved from the request.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4 4	u32		sequence	Writesequencenumber
					Total Payload Length

Table 7.2.7: MSG_FILEIO_WRITE_RESP 0x00AB message structure

MSG FILEIO CONFIG REQ — 0x1001 — 4097
Requests advice on the optimal configuration for a FileIO transfer. Newer version of FileIO can support greater throughput by supporting a large window of FileIO data that can be in-flight during read or write operations.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4 4	u32		sequence	Advicesequencenumber
					Total Payload Length

Table 7.2.8: MSG_FILEIO_CONFIG_REQ 0x1001 message structure

MSG FILEIO CONFIG RESP — 0x1002 — 4098
The advice on the optimal configuration for a FileIO transfer. Newer version of FileIO can support greater throughput by supporting a large window of FileIO data that can be in-flight during read or write operations.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32		sequence	Advicesequencenumber
4	4	u32		window_size	ThenumberofSBPpacketsinthedatain-flight window
8	4	u32		batch_size	ThenumberofSBPpacketssentinonePDU
12	4	u32		fileio_version	TheversionofFileIOthatissupported
	16				Total Payload Length

Table 7.2.9: MSG_FILEIO_CONFIG_RESP 0x1002 message structure

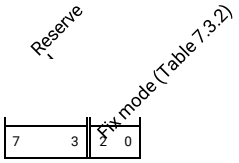
7.3 Orientation

Orientation Messages

MSG BASELINE HEADING — 0x020F — 527
This message reports the baseline heading pointing from the base station to the rover relative to True North. The full GPS time is given by the preceding MSG_GPS_TIME with the matching time-of-week (tow). It is intended that time-matched RTK mode is used when the base station is moving.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 9	4 4 1 1	u32	ms	tow	GPSTimeofWeek
10		u32	mdeg	heading	Heading
		u8		n_sats	Numberofsatellitesusedinsolution
		u8		flags	Statusflags
					Total Payload Length

Table 7.3.1: MSG_BASELINE_HEADING 0x020F message structure



Field 7.3.1: Status flags (flags)

Value	Description
0	Invalid
1	Reserved
2	DifferentialGNSS(DGNSS)
3	FloatRTK
4	FixedRTK

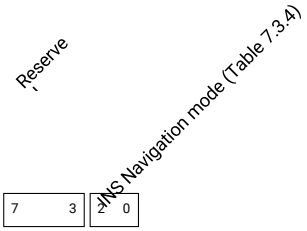
Table 7.3.2: Fix mode values (flags[0:2])

MSG ORIENT QUAT — 0x0220 — 544

This message reports the quaternion vector describing the vehicle body frame's orientation with respect to a local-level NED frame. The components of the vector should sum to a unit vector assuming that the LSB of each component as a value of 2^-31. This message will only be available in future INS versions of Carnegie Robotics Products and is not produced by Piksi Multi or Duro.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description GPSTimeofWeek
0 4 8 12 16 20 24 28 32 36	4 4 4 4 4 4 4 4 4 1	u32	ms	tow	Realcomponent
		s32	2^-3	w	1stimaginarycomponent
		s32	1	x	2ndimaginarycomponent
		s32	2^-3	y	3rdimaginarycomponent
		s32	1	z	Estimatedstandarddeviationofw
		float	2^-3	w_accuracy	Estimatedstandarddeviationofx
		float	1	x_accuracy	Estimatedstandarddeviationofy
		float	2^-3	y_accuracy	Estimatedstandarddeviationofz
		float	1	z_accuracy	Statusflags
		u8	N/A	flags	Total Payload Length
			N/A		
			N/A		
			N/A		

Table 7.3.3: MSG_ORIENT_QUAT 0x0220 message structure



Field 7.3.2: Status flags (flags)

Value	Description
0	Invalid
1	Valid

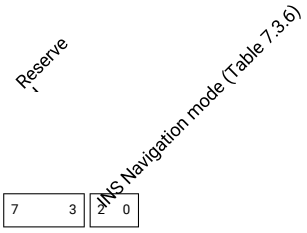
Table 7.3.4: INS Navigation mode values (flags[0:2])

MSG ORIENT EULER — 0x0221 — 545

This message reports the yaw, pitch, and roll angles of the vehicle body frame. The rotations should applied intrinsically in the order yaw, pitch, and roll in order to rotate the from a frame aligned with the local-level NED frame to the vehicle body frame. This message will only be available in future INS versions of Carnegie Robotics Products and is not produced by Piksi Multi or Duro.

Offset (bytes)	Size (bytes)	Format	Units ms	Name	Description GPSTimeofWeek
0 4 8 12 16 20	4 4 4 4 4 4	u32	microdegrees	tow	rotationabouttheforwardaxisofthevehicle
24 28	1	s32	microdegrees	roll	rotationabouttherightwardaxisofthevehicle
	29	s32	microdegrees	pitch	rotationabouttheddownwardaxisofthevehicle
		s32	degrees	yaw	Estimatedstandarddeviationofroll
		float	degrees	roll_accuracy	Estimatedstandarddeviationofpitch
		float	degrees	pitch_accuracy	Estimatedstandarddeviationofyaw
		float		yaw_accuracy	Statusflags
		u8		flags	Total Payload Length

Table 7.3.5: MSG_ORIENT_EULER 0x0221 message structure



Field 7.3.3: Status flags (flags)

Value	Description
0	Invalid
1	Valid

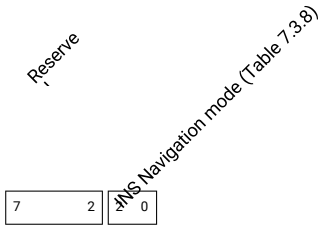
Table 7.3.6: INS Navigation mode values (flags[0:2])

MSG ANGULAR RATE — 0x0222 — 546

This message reports the orientation rates in the vehicle body frame. The values represent the measurements a strapped down gyroscope would make and are not equivalent to the time derivative of the Euler angles. The orientation and origin of the user frame is specified via device settings. By convention, the vehicle x-axis is expected to be aligned with the forward direction, while the vehicle y-axis is expected to be aligned with the right direction, and the vehicle z-axis should be aligned with the down direction. This message will only be available in future INS versions of Carnegie Robotics Products and is not produced by Piksi Multi or Duro.

Offset (bytes)	Size (bytes)	Format	Units ms	Name	Description
0 4 8 12 16	4 4 4 4 1	u32	microdegrees/s	tow	GPSTimeofWeek
	17	s32	microdegrees/s	x	angularrateaboutxaxis
		s32	microdegrees/s	y	angularrateaboutyaxis
		s32		z	angularrateaboutzaxis
		u8		flags	Statusflags Total
					Payload Length

Table 7.3.7: MSG_ANGULAR_RATE 0x0222 message structure



Field 7.3.4: Status flags (flags)

Value	Description
0	Invalid
1	Valid

Table 7.3.8: INS Navigation mode values (flags[0:2])

7.4 Piksi

System health, configuration, and diagnostic messages specific to the Piksi L1 receiver, including a variety of legacy messages that may no longer be used.

MSG ALMANAC — 0x0069 — 105

This is a legacy message for sending and loading a satellite alamanac onto the Piksi's flash memory from the host.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
	0				Total Payload Length

Table 7.4.1: MSG_ALMANAC 0x0069 message structure

MSG SET TIME — 0x0068 — 104

This message sets up timing functionality using a coarse GPS time estimate sent by the host.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
	0				Total Payload Length

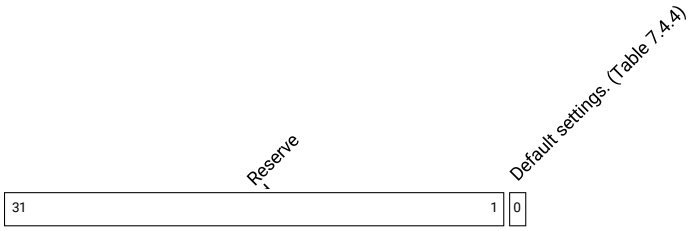
Table 7.4.2: MSG_SET_TIME 0x0068 message structure

MSG RESET — 0x00B6 — 182

This message from the host resets the Piksi back into the bootloader.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4 4	u32		flags	Resetflags
					Total Payload Length

Table 7.4.3: MSG_RESET 0x00B6 message structure



Field 7.4.1: Reset flags (flags)

Value	Description
0	Preserveexistingsettings.
1	Resoredefaultsettings.

Table 7.4.4: Default settings. values (flags[0])

MSG RESET DEP — 0x00B2 — 178

This message from the host resets the Piksi back into the bootloader.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
	0				Total Payload Length

Table 7.4.5: MSG_RESET_DEP 0x00B2 message structure

MSG CW RESULTS — 0x00C0 — 192

This is an unused legacy message for result reporting from the CW interference channel on the SwiftNAP. This message will be removed in a future release.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
	0				Total Payload Length

Table 7.4.6: MSG_CW_RESULTS 0x00C0 message structure

MSG CW START — 0x00C1 — 193
This is an unused legacy message from the host for starting the CW interference channel on the SwiftNAP. This message will be removed in a future release.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
	0				Total Payload Length

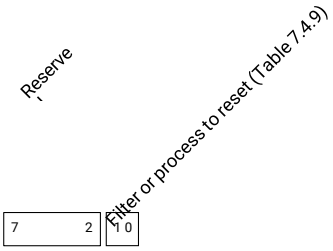
Table 7.4.7: MSG_CW_START 0x00C1 message structure

MSG RESET FILTERS — 0x0022 — 34

This message resets either the DGNSS Kalman filters or Integer Ambiguity Resolution (IAR) process.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1 1	u8		filter	Filterflags
					Total Payload Length

Table 7.4.8: MSG_RESET_FILTERS 0x0022 message structure



Field 7.4.2: Filter flags (filter)

Value	Description
0	DGNSSfilter
1	IARprocess
2	Inertialfilter

Table 7.4.9: Filter or process to reset values (filter[0:1])

MSG INIT BASE DEP — 0x0023 — 35
Deprecated

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
	0				Total Payload Length

Table 7.4.10: MSG_INIT_BASE_DEP 0x0023 message structure

MSG THREAD STATE — 0x0017 — 23
The thread usage message from the device reports real-time operating system (RTOS) thread usage statistics for the named thread. The reported percentage values must be normalized.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	20	string		name	Threadname(NULLterminated)
20	2	u16		cpu	Percentagecpuuseforthisthread.Valuesrange from 0 - 1000 and needs to be renormalized to 100
22	4	u32	bytes	stack_free	Freestackspaceforthisthread
	26				Total Payload Length

Table 7.4.11: MSG_THREAD_STATE 0x0017 message structure

MSG UART STATE — 0x001D — 29

The UART message reports data latency and throughput of the UART channels providing SBP I/O. On the default Piksi configuration, UARTs A and B are used for telemetry radios, but can also be host access ports for embedded hosts, or other interfaces in future. The reported percentage values must be normalized. Observations latency and period can be used to assess the health of the differential corrections link. Latency provides the timeliness of received base observations while the period indicates their likelihood of transmission.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	float	kB/s	uart_a.tx_throughput	UARTtransmitthroughput
4	4	float	kB/s	uart_a.rx_throughput	UARTreceivethroughput
8	2	u16		uart_a.crc_error_count	UARTCRCerrorcount
10	2	u16		uart_a.io_error_count	UARTIOerrorcount
12	1	u8		uart_a.tx_buffer_level	UARTtransmitbufferpercentageutilization (ranges from 0 to 255)
13	1	u8		uart_a.rx_buffer_level	UARTreceivebufferpercentageutilization (ranges from 0 to 255)
14	4	float	kB/s	uart_b.tx_throughput uart_b.rx_throughput	UARTtransmitthroughput
18	4	float	kB/s	uart_b.crc_error_count	UARTreceivethroughput
22	2	u16		uart_b.io_error_count	UARTCRCerrorcount
24	2	u16		uart_b.tx_buffer_level	UARTIOerrorcount
26	1	u8		uart_b.rx_buffer_level	UARTtransmitbufferpercentageutilization (ranges from 0 to 255)
27	1	u8		uart_ftdi.tx_throughput uart_ftdi.rx_throughput	UARTreceivebufferpercentageutilization (ranges from 0 to 255)
28	4	float	kB/s	uart_ftdi.crc_error_count	UARTtransmitthroughput
32	4	float	kB/s	uart_ftdi.io_error_count	UARTreceivethroughput
36	2	u16		uart_ftdi.tx_buffer_level	UARTCRCerrorcount
38	2	u16			UARTIOerrorcount
40	1	u8		uart_ftdi.rx_buffer_level	UARTtransmitbufferpercentageutilization (ranges from 0 to 255)
41	1	u8		latency.avg latency.lmin latency.lmax latency.current	UARTreceivebufferpercentageutilization (ranges from 0 to 255)
42	4	s32	ms	obs_period.avg	Averagelatency
46	4	s32	ms	obs_period.pmin	Minimumlatency
50	4	s32	ms	obs_period.pmax	Maximumlatency
54	4	s32	ms	obs_period.current	Smoothedestimateofthecurrentlatency
58	4	s32	ms		Averageperiod
62	4	s32	ms		Minimumperiod
66	4	s32	ms		Maximumperiod
70	4				Smoothedestimateofthecurrentperiod
	74				Total Payload Length

Table 7.4.12: MSG_UART_STATE 0x001D message structure

MSG UART STATE DEPA — 0x0018 — 24
Deprecated

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 8 10 12	4	float	kB/s	uart_a.tx_throughput	UARTtransmitthroughput
	4	float	kB/s	uart_a.rx_throughput	UARTreceivethroughput
	2	u16		uart_a.crc_error_count	UARTCRCerrorcount
	2	u16		uart_a.io_error_count	UARTIOerrorcount
	1	u8		uart_a.tx_buffer_level	UARTtransmitbufferpercentageutilization (ranges from 0 to 255)
13	1	u8		uart_a.rx_buffer_level	UARTreceivebufferpercentageutilization (ranges from 0 to 255)
14	4	float	kB/s	uart_b.tx_throughput	UARTtransmitthroughput
18	4	float	kB/s	uart_b.rx_throughput	UARTreceivethroughput
22	2	u16		uart_b.crc_error_count	UARTCRCerrorcount
24	2	u16		uart_b.io_error_count	UARTIOerrorcount
26	1	u8		uart_b.tx_buffer_level	UARTtransmitbufferpercentageutilization (ranges from 0 to 255)
27	1	u8		uart_b.rx_buffer_level	UARTreceivebufferpercentageutilization (ranges from 0 to 255)
28	4	float	kB/s	uart_ftdi.tx_throughput	UARTtransmitthroughput
32	4	float	kB/s	uart_ftdi.rx_throughput	UARTreceivethroughput
36	2	u16		uart_ftdi.crc_error_count	UARTCRCerrorcount
38	2	u16		uart_ftdi.io_error_count	UARTIOerrorcount
40	1	u8		uart_ftdi.tx_buffer_level	UARTtransmitbufferpercentageutilization (ranges from 0 to 255)
41	1	u8		uart_ftdi.rx_buffer_level	UARTreceivebufferpercentageutilization (ranges from 0 to 255)
42	4	s32	ms	latency.avg	Averagelatency
46	4	s32	ms	latency.lmin	Minimumlatency
50	4	s32	ms	latency.lmax	Maximumlatency
54	4	s32	ms	latency.current	Smoothedestimateofthecurrentlatency
	58				Total Payload Length

Table 7.4.13: MSG_UART_STATE_DEPA 0x0018 message structure

MSG IAR STATE — 0x0019 — 25
This message reports the state of the Integer Ambiguity Resolution (IAR) process, which resolves unknown integer ambiguities from double-differenced carrier-phase measurements from satellite observations.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32		num_hyps	Numberofintegerambiguityhypothesesremaining
	4				Total Payload Length

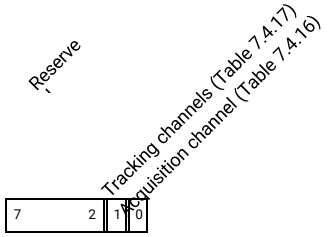
Table 7.4.14: MSG_IAR_STATE 0x0019 message structure

MSG MASK SATELLITE — 0x002B — 43

This message allows setting a mask to prevent a particular satellite from being used in various Piksi subsystems.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 1	1 1	u8 u8		mask sid.sat	Maskofsystemsthatshouldignorethissatellite. Constellation-specificsatelliteidentifier.Thisfield for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
2	1	u8		sid.code	Signalconstellation,bandandcode
	3				Total Payload Length

Table 7.4.15: MSG_MASK_SATELLITE 0x002B message structure



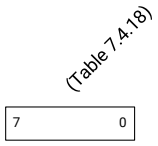
Field 7.4.3: Mask of systems that should ignore this satellite. (mask)

Value	Description
0	Enabled
1	Skipthissatelliteonfutureacquisitions

Table7.4.16:Acquisitionchannelvalues(mask[0])

Value	Description
0	Enabled
1	DropthisPRNifcurrentlytracking

Table 7.4.17: Tracking channels values (mask[1])



Field 7.4.4: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 7.4.18: values (sid.code[0:7])

MSG DEVICE MONITOR — 0x00B5 — 181

This message contains temperature and voltage level measurements from the processor's monitoring system and the RF frontend die temperature if available.

Offset (bytes)	Size (bytes)	Format	Units V/1000	Name	Description DeviceV_in
0 2 4 6	2 2 2 2	s16 s16 s16 s16 s16	V/1000 V/1000 degreesC/ 100 degreesC/ 100	dev_vin cpu_vint cpu_vaux cpu_temperature fe_temperature	ProcessorV_int ProcessorV_aux Processortemperature Frontendtemperature(ifavailable)
8	2				Total Payload Length
	10				

Table 7.4.19: MSG_DEVICE_MONITOR 0x00B5 message structure

MSG COMMAND REQ — 0x00B8 — 184
Request the recipient to execute an command. Output will be sent in MSG_LOG messages, and the exit code will be returned with MSG_COMMAND_RESP.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32		sequence	Sequencenumber
4	N	string		command	Commandlinetoexecute
	+ 4				Total Payload Length

Table 7.4.20: MSG_COMMAND_REQ 0x00B8 message structure

MSG COMMAND RESP — 0x00B9 — 185

The response to MSG_COMMAND_REQ with the return code of the command. A return code of zero indicates success.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32		sequence	Sequencenumber
4	4	s32		code	Exitcode
8					Total Payload Length

Table 7.4.21: MSG_COMMAND_RESP 0x00B9 message structure

MSG COMMAND OUTPUT — 0x00BC — 188
Returns the standard output and standard error of the command requested by MSG_COMMAND_REQ. The sequence number can be used to filter for filtering the correct command.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4	4 N	u32 string		sequence line	Sequencenumber Lineofstandardoutputorstandarderror
	+ 4				Total Payload Length

Table 7.4.22: MSG_COMMAND_OUTPUT 0x00BC message structure

MSG NETWORK STATE REQ — 0x00BA — 186

Request state of Piksi network interfaces. Output will be sent in MSG_NETWORK_STATE_RESP messages.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0					Total Payload Length

Table 7.4.23: MSG_NETWORK_STATE_REQ 0x00BA message structure

MSG NETWORK STATE RESP — 0x00BB — 187

The state of a network interface on the Piksi. Data is made to reflect output of ifaddrs struct returned by getifaddrs in c.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 5 21 22 26 30 46	4 1 16 1 4 4 16 4 50	u8[4] u8 u8[16] u8 u32 u32 string u32		ipv4_address ipv4_mask_size ipv6_address ipv6_mask_size rx_bytes tx_bytes interface_name flags	IPv4address(allzerowhenunavailable) IPv4netmaskCIDRnotation IPv6address(allzerowhenunavailable) IPv6netmaskCIDRnotation NumberofRxbytes NumberofTxbytes InterfaceName InterfaceflagsfromSIOCGIFFLAGS
					Total Payload Length

Table 7.4.24: MSG_NETWORK_STATE_RESP 0x00BB message structure

MSG NETWORK BANDWIDTH USAGE — 0x00BD — 189

The bandwidth usage, a list of usage by interface.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
40N+ 0	8	u64	ms	interfaces[N].duration	Durationoverwhichthemeasurement was collected
40N+ 8	8	u64		interfaces[N].total_bytes	Numberofbyteshandledintotalwithin period
40N+ 16	4	u32		interfaces[N].rx_bytes	Numberofbytestransmittedwithinpe-riod
40 + 20	4	u32		interfaces[N].tx_bytes	Numberofbytesreceivedwithinperiod
N + 24	16	string		interfaces[N].interface_name	InterfaceName
40 N	40N				Total Payload Length

Table 7.4.25: MSG_NETWORK_BANDWIDTH_USAGE 0x00BD message structure

MSG CELL MODEM STATUS — 0x00BE — 190

If a cell modem is present on a piksi device, this message will be send periodically to update the host on the status of the modem and its various parameters.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	s8	dBm	signal_strength	Receivedcellsignalstrengthind Bm,zero translates to unknown
1	4	float		signal_error_rate	BERasreportedbythemodem,zerotrans-lates to unknown
5	N	u8[N]		reserved	UnspecifieddataTBDforthisschema
	N+ 5				Total Payload Length

Table 7.4.26: MSG_CELL_MODEM_STATUS 0x00BE message structure

MSG SPECAN — 0x0051 — 81
Spectrum analyzer packet.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 2 6	2 4 4	u16		channel_tag	ChannelID
		u32	ms	t.tow	MillisecondssincestartofGPSweek
		s32	ns	t.ns_residual	Nanosecondresidualofmillisecond-rounded TOW (ranges from -500000 to 500000)
		u16	week	t.wn	GPSweeknumber
10	2	float	MHz	freq_ref	Referencefrequencyofthispacket
12	4	float	MHz	freq_step	Frequencystepofpointsinthispacket
16	4	float	dB	amplitude_ref	Referenceamplitudeofthispacket
20	4	float	dB	amplitude_unit	Amplitudeunitvalueofpointsinthispacket
24	4	u8[N]		amplitude_value	Amplitudevalues(intheaboveunits)ofpoints in this packet
28	N				
	N+ 28				Total Payload Length

Table 7.4.27: MSG_SPECAN 0x0051 message structure

MSG FRONT END GAIN — 0x00BF — 191

This message describes the gain of each channel in the receiver frontend. Each gain is encoded as a non-dimensional percentage relative to the maximum range possible for the gain stage of the frontend. By convention, each gain array has 8 entries and the index of the array corresponding to the index of the rf channel in the frontend. A gain of 127 percent encodes that rf channel is not present in the hardware. A negative value implies an error for the particular gain stage as reported by the frontend.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 8	8 8	s8[8] s8[8]	percent percent	rf_gain if_gain	RFgainforeachfrontendchannel Intermediatefrequencygainforeachfrontend channel
	16				Total Payload Length

Table 7.4.28: MSG_FRONT_END_GAIN 0x00BF message structure

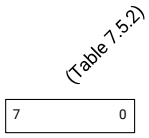
7.5 Sbas

SBAS data

MSG SBAS RAW — 0x7777 — 30583
This message is sent once per second per SBAS satellite. ME checks the parity of the data block and sends only blocks that pass the check.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	1	u8		sid.sat	Constellation-specificsatelliteidentifier. This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
1	1	u8		sid.code	Signalconstellation,bandandcode
2	4	u32	ms	tow	GPStime-of-weekatthestartofthedatablock.
6	1	u8		message_type	SBASmessagetype(0-63)
7	27	u8[27]		data	RawSBASdatafieldof212bits(lastbytepadded with zeros).
	34				Total Payload Length

Table 7.5.1: MSG_SBAS_RAW 0x7777 message structure



Field 7.5.1: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 7.5.2: values (sid.code[0:7])

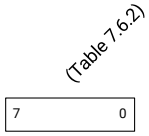
7.6 Ssr

Precise State Space Representation (SSR) corrections format

MSG SSR ORBIT CLOCK — 0x05DD — 1501
The precise orbit and clock correction message is to be applied as a delta correction to broadcast ephemeris and is an equivalent to the 1060 /1066 RTCM message types.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 6	4 2 1	u32 u16 u8	s week	time.tow time.wn sid.sat	SecondssincestartofGPSweek GPSweeknumber Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
7	1	u8		sid.code	Signalconstellation,bandandcode
8	1	u8		update_interval	Updateintervalbetweenconsecutivecorrec-tions. Encoded following RTCM DF391 speci-fication.
9	1	u8		iod_ssr	IODoftheSSRcorrection.AchangeofIssue Of Data SSR is used to indicate a change in the SSR generating configuration
10	4	u32		iod radial	IssueofbroadcastephemerisdataorIODCRC (Beidou)
14	4	s32	0.1mm	along	
18	4	s32	0.4mm	cross	Orbitradialdeltacorrection
22	4	s32	0.4mm	dot_radial	Orbitalongdeltacorrection
26	4	s32	0.001mm/s	dot_along	Orbitalongdeltacorrection
30	4	s32	0.004mm/s	dot_cross	Velocityoforbitradialdeltacorrection
34	4	s32	0.004mm/s	c0 c1 c2	Velocityoforbitalongdeltacorrection
38	4	s32	0.1mm		Velocityoforbitcrossdeltacorrection
42	4	s32	0.001mm/s 0.00002 mm/sˆ-2		C0polynomialcoefficientforcorrectionof broadcast satellite clock C1polynomialcoefficientforcorrectionof broadcast satellite clock
46	4				C2polynomialcoefficientforcorrectionof broadcastsatelliteclock
	50				Total Payload Length

Table 7.6.1: MSG_SSR_ORBIT_CLOCK 0x05DD message structure



Field 7.6.1: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

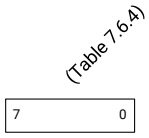
Table 7.6.2: values (sid.code[0:7])

MSG SSR CODE BIASES — 0x05E1 — 1505

The precise code biases message is to be added to the pseudorange of the corresponding signal to get corrected pseudorange. It is an equivalent to the 1059 / 1065 RTCM message types.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 6	4 2 1	u32 u16 u8	s week	time.tow time.wn sid.sat	SecondssincestartofGPSweek GPSweeknumber Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
7	1	u8		sid.code	Signalconstellation,bandandcode
8	1	u8		update_interval	Updateintervalbetweenconsecutivecorrections. Encoded following RTCM DF391 specification.
9	1	u8		iod_ssr	IODoftheSSRcorrection.AchangeofIssue Of Data SSR is used to indicate a change in the SSR generating configuration
3N+ 10	1	u8 s16		biases[N].code biases[N].value	SignalencodedfollowingRTCMspecifications (DF380, DF381, DF382 and DF467).
3N+ 11	2		0.01m		Codebiasvalue
	3N+ 10				Total Payload Length

Table 7.6.3: MSG_SSR_CODE_BIASES 0x05E1 message structure



Field 7.6.2: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

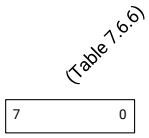
Table 7.6.4: values (sid.code[0:7])

MSG SSR PHASE BIASES — 0x05E6 — 1510

The precise phase biases message contains the biases to be added to the carrier phase of the corresponding signal to get corrected carrier phase measurement, as well as the satellite yaw angle to be applied to compute the phase wind-up correction. It is typically an equivalent to the 1265 RTCM message types.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 4 6	4 2 1	u32	s	time.tow	Seconds since start of GPS week
		u16	week	time.wn	GPS week number
		u8		sid.sat	Constellation specific satellite identifier. This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
7	1	u8		sid.code	Signal constellation, band and code
8	1	u8		update_interval	Update interval between consecutive corrections. Encoded following RTCM DF391 specification.
9	1	u8		iod_ssr	IOAD of the SSR correction. change of Issue Of Data SSR is used to indicate a change in the SSR generating configuration
10	1	u8		dispersive_bias	Indicator for the dispersive phase biases property.
11	1	u8		mw_consistency	Consistency indicator for Melbourne-Wubbena linear combinations
12	2	u16	1 / 256 semi-circle	yaw	Satellite yaw angle
14	1	s8	1 / 8192 semi-circle / s	yaw_rate	Satellite yaw angle rate
8N+ 15	1	u8		biases[N].code	Signal encoded following RTCM specifications (DF380, DF381, DF382 and DF467)
8 + 16	1	u8		biases[N].integer_indicator	Indicator for integer property
N + 17	1	u8		biases[N].widelane_integer_indicator	Indicator for two groups of Wide-Lane(s) integer property
8		u8		biases[N].discontinuity_counter	
8N+ 18	1				Signal phase discontinuity counter. Increased for every discontinuity in phase.
8N+ 19	4	s32	0.1mm	biases[N].bias	Phase bias for specified signal
	8N+ 15				Total Payload Length

Table 7.6.5: MSG_SSR_PHASE_BIASES 0x05E6 message structure



Field 7.6.3: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 7.6.6: values (sid.code[0:7])

MSG SSR STEC CORRECTION — 0x05FB — 1531

The Slant Total Electron Content per space vehicle, given as polynomial approximation for a given tile. This should be combined with the MSG_SSR_GRIDDED_CORRECTION message to get the state space representation of the atmospheric delay.
It is typically equivalent to the QZSS CLAS Sub Type 8 messages.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16		header.tile_set_id header.tile_id	Unique identifier of the tile set this tile belongs to.
2	2	u16		header.time.tow header.time.wn	Unique identifier of this tile in the tile set.
4	4	u32	s	header.num_msgs	Seconds since start of GPS week
8	2	u16	week	header.seq_num	GPS week number
10	1	u8		header.update_interval	Number of messages in the dataset
11	1	u8			Position of this message in the dataset
12	1	u8			Update interval between consecutive corrections. Encoded following RTCM DF391 specification.
13	1	u8		header.iod_atmo	IOD of the SSR atmospheric correction
11N+ 14	1	u8		stec_sat_list[N].sv_id.satId	ID of the space vehicle within its constellation
11N+ 15	1	u8		stec_sat_list[N].sv_id.constellation	Constellation ID to which the SV belongs
11N+ 16	1	u8		stec_sat_list[N].stec_quality_indicator	Quality of the STEC data. Encoded following RTCM DF389 specification but in units of TECU instead of m.
11N+ 17	8	s16[4]	C00 = 0.05 TECU, C01/C10 = 0.02 TECU/deg, C11 0.02 TECU/degˆ2	stec_sat_list[N].stec_coeff	Coefficients of the STEC polynomial in the order of C00, C01, C10, C11
	11N+ 14				Total Payload Length

Table 7.6.7: MSG_SSR_STEC_CORRECTION 0x05FB message structure

MSG SSR GRIDDED CORRECTION — 0x05FC — 1532
STEC residuals are per space vehicle, troposphere is not.
It is typically equivalent to the QZSS CLAS Sub Type 9 messages.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16		header.tile_set_id header.tile_id	Unique identifier of the tile set this tile belongs to.
2	2	u16		header.time.tow header.time.wn	Unique identifier of this tile in the tile set.
4	4	u32	s	header.num_msgs	Seconds since start of GPS week
8	2	u16	week	header.seq_num	GPS week number
10	2	u16		header.update_interval	Number of messages in the dataset
12	2	u16			Position of this message in the dataset
14	1	u8			Update interval between consecutive corrections. Encoded following RTCM DF391 specification.
15	1	u8		header.iod_atmo header.tropo_quality_indicator	IOD of the SSR atmospheric correction
16	1	u8			Quality of the troposphere data. Encoded following RTCM DF389 specification in units of m.
17	2	u16		index	Index of the grid point.
19	2	s16	4mm (2a.3ddm to get actual vertical hydro delay)	tropo_delay_correction.hydro	Hydrostatic vertical delay
21	1	s8	4 mm (add 0.252 m to get actual vertical wet delay)	tropo_delay_correction.wet	Wet vertical delay
22	1	u8	modified DF389 scale; class is upper 3 bits, value is lower 5 stddev <= (3^class * (1 + value/16) - 1) mm	tropo_delay_correction.stddev	stddev
5N+ 23	1	u8		stec_residuals[N].sv_id.satId	ID of the space vehicle within its constellation
5N+ 24	1	u8		stec_residuals[N].sv_id.constellation	Constellation ID to which the SV belongs
5N+ 25	2	s16	0.04 TECU	stec_residuals[N].residual	STEC residual
5N+ 27	1	u8	modified DF389 scale; class is upper 3 bits, value is lower 5 stddev <= (3^class * (1 + value/16)	stec_residuals[N].stddev	stddev

MSG SSR TILE DEFINITION — 0x05F6 — 1526

Provides the correction point coordinates for the atmospheric correction values in the MSG_SSR_STEC_CORRECTION and MSG_SSR_GRIDDED_CORRECTION messages.
Based on ETSI TS 137 355 V16.1.0 (LTE Positioning Protocol) information element GNSS-SSR-CorrectionPoints. SBP only supports gridded arrays of correction points, not lists of points.

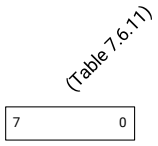
Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	2	u16		tile_set_id	Uniqueidentifierofthetilesetthistilebelongs to.
2	2	u16		tile_id	Uniqueidentifierofthistileinthetileset.See GNSS-SSR-ArrayOfCorrectionPoints field correctionPointSetID.
4	2	s16	encoded degrees	corner_nw_lat	North-Westcornercorrectionpointlatitude. TherelationbetweenthelatitudeXintherange [-90, 90] and the coded number N is: N = floor((X / 90) * 2^14) See GNSS-SSR-ArrayOfCorrectionPoints field referencePointLatitude.
6	2	s16	encoded degrees	corner_nw_lon	North-Westcornercorrectionpointlongitude. TherelationbetweenthelongitudeXinthe range [-180, 180] and the coded number N is: N = floor((X / 180) * 2^15) See GNSS-SSR-ArrayOfCorrectionPoints field referencePointLongitude.
8	2	u16	0.01degrees	spacing_lat	Spacingofthecorrectionpointsinthelatitude direction. See GNSS-SSR-ArrayOfCorrectionPoints field stepOfLatitude.
10	2	u16	0.01degrees	spacing_lon	Spacingofthecorrectionpointsinthelongitude direction. See GNSS-SSR-ArrayOfCorrectionPoints field stepOfLongitude.
12	2	u16		rows	Numberofstepsinthelatitudedirection. See GNSS-SSR-ArrayOfCorrectionPoints field numberOfStepsLatitude.
14	2	u16		cols	Numberofstepsinthelongitudedirection. See GNSS-SSR-ArrayOfCorrectionPoints field numberOfStepsLongitude.
16	8	u64		bitmask	Specifiestheavailabilityofcorrectiondataat the correction points in the array. If a specific bit is enabled (set to 1), the correction is not available. Only the first rows * cols bits are used, the remainder are set to 0. If there are more then 64 correction points the remaining corrections are always available. Starting with the northwest corner of the array (top left on a north oriented map) the correction points are enumerated with row precedence - first row west to east, second row west to east, until last row west to east - ending with the southeast corner of the array. SfieeldGNSS-SSR-ArrayOfCorrectionPoints bitmaskOfGrids but note the definition of the bits is inverted.
	24				Total Payload Length

Table 7.6.9: MSG_SSR_TILE_DEFINITION 0x05F6 message structure

MSG SSR SATELLITE APC — 0x0604 — 1540

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
32N+ 0	1	u8		apc[N].sid.sat	Constellation-specificsatelliteidentifier.This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
32 + 1	1	u8		apc[N].sid.code	Signalconstellation,bandandcode
N + 2	1	u8		apc[N].sat_info	Additionalsatelliteinformation
32 + 3 N	2	u16 s16[3]		apc[N].svn apc[N].pco	SatelliteCode,asdefinedbyIGS.Typicallythe space vehicle number.
32N+ 5 N	6		1mm		Meanphasecenteroffset,XYandZaxes.See IGS ANTEX file format description for coordinate system definition.
32N+ 11	21	s8[21]	1mm	apc[N].pcv	Elevationdependentphasecentervariations. First element is 0 degrees separation from the Z axis, subsequent elements represent elevation variations in 1 degree increments.
	32N				Total Payload Length

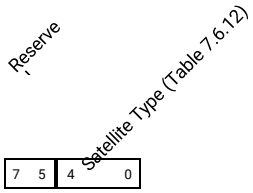
Table 7.6.10: MSG_SSR_SATELLITE_APC 0x0604 message structure



Field 7.6.4: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 7.6.11: values (sid.code[0:7])



Field 7.6.5: Additional satellite information (sat_info)

Value	Description
0	UnknownType
1	GPSI
2	GPSII
3	GPSIIA
4	GPSIIR
5	GPSIIF
6	GPSIII
7	GLONASS
8	GLONASSM
9	GLONASSK1
10	GALILEO
11	BEIDOU2G
12	BEIDOU2I
13	BEIDOU2M
14	BEIDOU3M,SECM
15	BEIDOU3G,SECM
16	BEIDOU3M,CAST
17	BEIDOU3G,CAST
18	BEIDOU3I,CAST
19	QZSS

Table 7.6.12: Satellite Type values (sat_info[0:4])

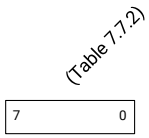
7.7 Tracking

Satellite code and carrier-phase tracking messages from the device.

MSG TRACKING STATE — 0x0041 — 65
The tracking message returns a variable-length array of tracking channel states. It reports status and carrier-to-noise density measurements for all tracked satellites.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
4N+ 0	1	u8		states[N].sid.sat	Constellation-specific satellite identifier. This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
4 + 1	1	u8		states[N].sid.code	Signalconstellation,bandandcode
N + 2	1	u8		states[N].fcn	Frequencychannelnumber(GLONASSonly)
4 + 3	1	u8	dBHz/4	states[N].cn0	Carrier-to-Noisedensity.Zeroimpliesinvalid
N					cn0.
4 N	4N				Total Payload Length

Table 7.7.1: MSG_TRACKING_STATE 0x0041 message structure



Field 7.7.1: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

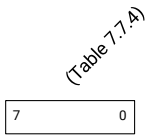
Table 7.7.2: values (sid.code[0:7])

MSG MEASUREMENT STATE — 0x0061 — 97

The tracking message returns a variable-length array of tracking channel states. It reports status and carrier-to-noise density measurements for all tracked satellites.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
3N+ 0	1	u8		states[N].mesid.sat	Constellation-specific satellite identifier. This field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
3 + 1	1	u8		states[N].mesid.code	Signalconstellation,bandandcode
N + 2	1	u8	dBHz/4	states[N].cn0	Carrier-to-Noisedensity. Zeroimpliesin-valid cn0.
3 N	3N				Total Payload Length

Table 7.7.3: MSG_MEASUREMENT_STATE 0x0061 message structure



Field 7.7.2: Signal constellation, band and code (mesid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

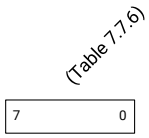
Table 7.7.4: values (mesid.code[0:7])

MSG TRACKING IQ — 0x002D — 45

When enabled, a tracking channel can output the correlations at each update interval.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 1	1 1	u8 u8		channel sid.sat	Trackingchanneloforigin CTohnisstellation-specificsatelliteidentifier. field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
2	1	u8		sid.code	Signalconstellation,bandandcode
4 + 3	2	s16		corrs[N].I	In-phasecorrelation
N + 5	2	s16		corrs[N].Q	Quadraturecorrelation
4 N	4 + 3				Total Payload Length
	N				

Table 7.7.5: MSG_TRACKING_IQ 0x002D message structure



Field 7.7.3: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

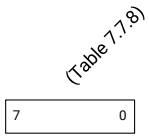
Table 7.7.6: values (sid.code[0:7])

MSG TRACKING IQ DEP B — 0x002C — 44

When enabled, a tracking channel can output the correlations at each update interval.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0 1	1 1	u8 u8		channel sid.sat	Trackingchanneloforigin CTohnisstellation-specificsatelliteidentifier. field for Glonass can either be (100+FCN) where FCN is in [-7,+6] or the Slot ID in [1,28].
2	1	u8		sid.code	Signalconstellation,bandandcode
8 + 3	4	s32		corrs[N].I	In-phasecorrelation
N + 7	4	s32		corrs[N].Q	Quadraturecorrelation
8 N	8 + 3 N				Total Payload Length

Table 7.7.7: MSG_TRACKING_IQ_DEP_B 0x002C message structure



Field 7.7.4: Signal constellation, band and code (sid.code)

Value	Description
0	GPSL1CA
1	GPSL2CM
2	SBASL1CA
3	GLOL1CA
4	GLOL2CA
5	GPSL1P
6	GPSL2P
12	BDS2B1
13	BDS2B2
14	GALE1B
20	GALE7I
47	BDS3B2a

Table 7.7.8: values (sid.code[0:7])

7.8 User

Messages reserved for use by the user.

MSG USER DATA — 0x0800 — 2048
This message can contain any application specific user data up to a maximum length of 255 bytes per message.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	N N	u8[N]		contents	Userdatapayload
					Total Payload Length

Table 7.8.1: MSG_USER_DATA 0x0800 message structure

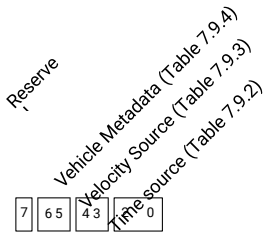
7.9 Vehicle

Messages from a vehicle.

MSG ODOMETRY — 0x0903 — 2307
Message representing the x component of vehicle velocity in the user frame at the odometry reference point(s) specified by the user. The offset for the odometry reference point and the definition and origin of the user frame are defined through the device settings interface. There are 4 possible user-defined sources of this message which are labeled arbitrarily source 0 through 3. If using ”processor time” time tags, the receiving end will expect a ‘MSG_GNSS_TIME_OFFSET‘ when a PVT fix becomes available to synchronise odometry measurements with GNSS. Processor time shall roll over to zero after one week.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	4	u32	ms	tow	Timefieldrepresentingeithermillisecondsinthe GPS Week or local CPU time from the producing system in milliseconds. See the tow_source flag for the exact source of this timestamp.
4	4	s32	mm/s	velocity	Thesignedforwardcomponentofvehiclevelocity.
8	1	u8		flags	Statusflags
	9				Total Payload Length

Table 7.9.1: MSG_ODOMETRY 0x0903 message structure



Field 7.9.1: Status flags (flags)

Value	Description
0	None(invalid)
1	GPSSolution(msinweek)
2	ProcessorTime

Table 7.9.2: Time source values (flags[0:2])

Value	Description
0	Source0
1	Source1
2	Source2
3	Source3

Table 7.9.3: Velocity Source values (flags[3:4])

Value	Description
0	Unavailable
1	Forward
2	Reverse
3	Park

Table 7.9.4: Vehicle Metadata values (flags[5:6])

MSG WHEELTICK — 0x0904 — 2308

Message containing the accumulated distance travelled by a wheel located at an odometry reference point defined by the user. The offset for the odometry reference point and the definition and origin of the user frame are defined through the device settings interface. The source of this message is identified by the source field, which is an integer ranging from 0 to 255. The timestamp associated with this message should represent the time when the accumulated tick count reached the value given by the contents of this message as accurately as possible. If using ”local CPU time” time tags, the receiving end will expect a ‘MSG_GNSS_TIME_OFFSET‘ when a PVT fix becomes available to synchronise wheeltick measurements with GNSS. Local CPU time shall roll over to zero after one week.

Offset (bytes)	Size (bytes)	Format	Units	Name	Description
0	8	u64	us	time	Timefieldrepresentingeithermicrosecondssince the last PPS, microseconds in the GPS Week or local CPU time from the producing system in microseconds. See the synch_type field for the exact meaning of this timestamp.
8	1	u8		flags	Fieldindicatingthetypeoftimestampcontainedin
9	1	u8		source	the time field. IDofthesensorproducingthismessage
10	4	s32	arbitrary distanceunits	ticks	Free-runningcounteroftheaccumulateddistance forthissensor.Thecountershouldbeincrementing if travelling into one direction and decrementing when travelling in the opposite direction.
	14				Total Payload Length

Table 7.9.5: MSG_WHEELTICK 0x0904 message structure

Field 7.9.2: Field indicating the type of timestamp contained in thetimefield.(flags)

Value	Description
0	microsecondssincelastPPS
1	microsecondsinGPSweek
2	localCPUtimeinnominalmicroseconds

Table 7.9.6: Synchronization type values (flags[0:1])

Value	Description
0	Unavailable
1	Forward
2	Reverse
3	Park

Table 7.9.7: Vehicle Metadata values (flags[2:3])