



FusionEngine Message Specification

Version 0.25 (2026-3-13)

Compatible with FusionEngine Protocol version 1.26.0

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Appendix A. Document Version History.....134



1. Overview

This document describes the messages used by Point One's FusionEngine software.

Point One FusionEngine messages are used for both input and output. The messages are a highly compact binary format that contain detailed information about the PVT solution, attitude solution, and other important receiver and navigation statuses. The messages are also used for configuration of the target device, including enabling and disabling other protocols, streams, etc.

Open-source examples of this protocol are available in the repository linked below. While this manual contains the full descriptions for each message, it is highly recommended to use the existing library whenever possible as it has been thoroughly tested across Point One's products.

The Point One FusionEngine Protocol is available as
an open-source library for C++ and Python:

<https://github.com/PointOneNav/fusion-engine-client>

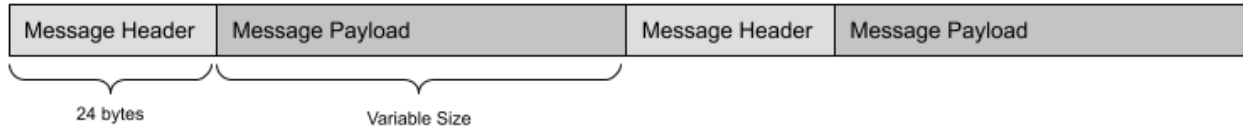
Source code documentation is available at:

<https://docs.pointonnav.com/docs/fusion-engine-client/>



2. Message Structure

All FusionEngine messages consist of a Message Header and Message Payload. Messages are aligned to 4-byte boundaries, so the size of a message will *always* be a multiple of 4 bytes. This means that messages will contain padding bytes if necessary.



2.1 Data Types

Data Type	Size in bytes	Description
bool	1	Boolean Value (0 or 1)
u8	1	Unsigned Integer
u16	2	Unsigned Integer
u32	4	Unsigned Integer
u8[N]	N	Reserved/Padding Bytes
i8	1	Signed Integer
i16	2	Signed Integer
i32	4	Signed Integer
i64	8	Signed Integer
f32	4	IEEE Single-Precision Floating Point
f64	8	IEEE Double-Precision Floating Point
str	Variable	Character String (Not Null-Terminated)

2.2 Byte Ordering

All FusionEngine messages are constructed using little endian (Intel) encoding.



2.3 Message Header

The message header is 24 bytes in length and contains synchronization bytes and information required to decode or encode the Message Payload.

Field	Data Type	Description
Sync Byte 0	u8	Always 0x2E (ASCII ".")
Sync Byte 1	u8	Always 0x31 (ASCII "1")
Reserved	u8 [2]	<i>Reserved for future use.</i>
CRC	u32	The 32-bit CRC of all bytes from and including the protocol version field to the last byte in the message, including the message payload. This uses the standard CRC-32 generator polynomial in reversed order (0xEDB88320).
Protocol Version	u8	The version of the FusionEngine Protocol. Currently set to 2 always.
Message Version	u8	The version of message type structure being used. New versions of a given message type maintain backwards compatibility by either using previously reserved space in older version definitions or by extending the message length. It should be safe to interpret a newer version using an older message definition and ignoring the new fields.
Message Type	u16	Uniquely identifies each message type. The combination of message type and version should be used to determine how to decode the payload.
Sequence Number	u32	A sequence number that is incremented with each message.
Payload Size	u32	Size of the payload to follow in bytes.
Source Identifier	u32	Identifies the source of the message when applicable. This definition can change depending on the message type. Typically set to 0 for measurement input messages, or 0xFFFFFFFF (invalid) for non-measurement messages.



2.4 CRC Calculation Details

Below is an abbreviated example of the CRC algorithm. Note that some hardware may have dedicated accelerators for this algorithm but that is out of scope of this document. See `crc.cc` in the open-source library for a complete reference.

Generation of the *CRC Table*

```
// This table can be pre-computed once and reused for all messages.
// It does not depend on data content.
const uint32_t polynomial = 0xEDB88320;
for (uint32_t i = 0; i < 256; i++) {
    uint32_t c = i;
    for (size_t j = 0; j < 8; j++) {
        if (c & 1) {
            c = polynomial ^ (c >> 1);
        } else {
            c >>= 1;
        }
    }
    crc_table[i] = c;
}
```

Calculating the CRC on a *buffer of known length*

```
uint32_t initial_value = 0;
uint32_t c = initial_value ^ 0xFFFFFFFF;
for (size_t i = 0; i < length; ++i) {
    c = crc_table[(c ^ buffer[i]) & 0xFF] ^ (c >> 8);
}
return c ^ 0xFFFFFFFF;
```



2.5 Timing

All Point One devices generate a common time base called Point One time (P1 time). P1 time is used to coordinate all sensor measurement and solution data within the system.

P1 time may be driven by a microcontroller (MCU), or a local monotonic CPU clock provided by the operating system. P1 time is synthetic and may be adjusted dynamically based on internal clock models as the system operates. Users should not assume that P1 time is equal to the source clock (MCU, OS, or POSIX time), or to GPS time.

In addition to P1 time, some messages may optionally include additional timestamps where applicable, including GPS system time, POSIX time, and platform OS time. See Section 2.6.2 for more details.



2.6 Common Data Structure/Enumeration Definitions

This section defines some of the common data structures and enumerations that are used within multiple message types.



2.6.1 Timestamp

This structure may be used to convey P1 time values (referenced to the start of the device), GPS times (referenced to January 6, 1980), POSIX times (referenced to January 1, 1970), or embedded device system timestamps (platform-specific). The type of time will be specified by the SystemTimeSource (see Section 2.6.2).

Timestamp (8B):

Field	Data Type	Description
Seconds	u32	The number of integer seconds since the reference epoch. Set to 0xFFFFFFFF if invalid.
Fraction	u32	The fractional part of the timestamp in nanoseconds. Set to 0xFFFFFFFF if invalid.



2.6.2 SystemTimeSource

Represents the time base used for a message timestamp. When a measurement is supplied externally, it may either contain a timestamp generated by the sender or it can be timestamped by FusionEngine when the packet arrives.

SystemTimeSource (u8):

Type	Value	Description
Invalid	0x0	Timestamp not valid. Message will be timestamped on arrival.
P1 Time	0x1	Measurement timestamped in P1 time.
Timestamped on Reception	0x2	Message timestamped in device system time at the time of arrival.
Sender System Time	0x3	Timestamp was generated from a monotonic clock of an external system.
GPS Time	0x4	Message timestamped in GPS time, referenced to 1980/1/6.
Reserved	0x5-0xFF	<i>Reserved for future use.</i>



2.6.3 SensorDataSource

Sensor data may come from a variety of different sources. This value identifies the sensor data source and can be useful for verification purposes when viewing output messages.

SensorDataSource (u8):

Type	Value	Description
Unknown	0x0	The data source is unknown.
Internal	0x1	Sensor data captured internally within the device (embedded IMU, internal GNSS receiver, etc.)
Hardware IO	0x2	Sensor data generated via hardware voltage signal measured directly by the device (hardware wheel tick, external event, etc.).
CAN	0x3	Sensor data captured from a platform CAN bus.
Serial	0x4	Sensor data input over a serial (UART) connection
Network	0x5	Sensor data input over a network (Ethernet, Wi-Fi, etc.)
Reserved	0x6-0xFF	<i>Reserved for future use.</i>



2.6.4 MeasurementDetails

All messages containing sensor measurements, either external inputs to a FusionEngine device or "raw" (uncorrected) measurement output messages, begin with a `MeasurementDetails` structure. This structure describes the time of applicability of the sensor data.

Where possible, the user may provide known P1, GPS, or system timestamps indicating the time at which the sensor data applies. If a timestamp cannot be provided, the incoming sensor data will be timestamped by FusionEngine on arrival.

Note that measurements timestamped on arrival are subject to unknown latency due to the capture and transmission of the sensor data, including latency introduced by the data interface. Excessive latency may result in performance degradation.

Once the message is received, the specified measurement time will be converted to P1 time automatically by FusionEngine using its internal clock models. The user should not populate the output P1 time field when sending measurement data to a device. Any value in the P1 time field will be ignored.

`MeasurementDetails` (20B):

Field	Data Type	Description
Measurement Time	Timestamp (8B)	The time of applicability of the measurement data. Interpretation dictated by Time Source.
Time Source	SystemTimeSource (u8)	The source of the measurement timestamp. See Section 2.6.2.
Sensor Data Source	SensorDataSource (u8)	The source of the sensor. See Section 2.6.3
Reserved	u8[2]	<i>Reserved for future use.</i>
Output P1 Time	Timestamp (8B)	Leave invalid when sending measurements to the device. On output, this will be the calculated P1 time corresponding with the measurement timestamp.



2.6.5 GNSS System/Signal Type Definitions

2.6.5.1 GNSS Constellations (*SatelliteType*)

The following enumeration is used to specify GNSS systems (constellations).

Note: *SatelliteType* is limited to 4 bits, and values above 15 are not allowed.

For each enumeration value, there is a corresponding bit mask ($1 \ll \text{value}$) that is used in some messages. For example, the SetConfig (13100) message to enable/disable GNSS constellations uses a single bit mask. The mask 0x12 enables GPS and Galileo, and disables all other constellations.

SatelliteType (u8) :

Name	Enum Value (u8)	Bit Mask (u16)	Description
UNKNOWN	0	N/A	GNSS constellation not known.
GPS	1	0x002	
GLONASS	2	0x004	
LEO	3	0x008	<i>Not currently used.</i>
GALILEO	4	0x010	
BEIDOU	5	0x020	
QZSS	6	0x040	
MIXED	7	0x080	<i>Not currently used.</i>
SBAS	8	0x100	
IRNSS	9	0x200	Also known as NavIC.
Reserved	10-15		<i>Reserved for future use.</i>

2.6.5.2 GNSS Frequency Bands (*FrequencyBand*)

The following enumeration is used to specify GNSS systems frequency bands. Each band spans a range of GNSS frequencies, which can typically be captured by a single antenna element, as shown below.

Note: *FrequencyBand* is limited to 4 bits, and values above 15 are not allowed.

For each enumeration value, there is a corresponding bit mask ($1 \ll \text{value}$) that is used in some messages. For example, the SetConfig (13100) message to enable/disable GNSS frequency bands uses a single bit mask. The mask 0x5 enables L1 and L5 bands, and disables all other frequency bands.

FrequencyBand (u8) :

Name	Enum Value (u8)	Bit Mask (u16)	Description
------	-----------------	----------------	-------------



L1	0	0x001	1561.098 MHz (B1) -> 1602.0 (G1) Includes: <ul style="list-style-type: none"> • GPS/QZSS L1 (1575.42 MHz) • Galileo E1 (1575.42 MHz) • BeiDou B1I (1561.098 MHz) • BeiDou B1C (1575.42 MHz) • GLONASS G1 (1602.0 MHz)
L2	1	0x002	1202.025 MHz (G3) -> 1248.06 (G2) Includes: <ul style="list-style-type: none"> • GPS L2 (1227.6 MHz) • Galileo E5b (1207.14 MHz) • BeiDou B2I (1207.14 MHz) • GLONASS G2 (1246.0 MHz) • GLONASS G3 (1202.25 MHz)
L5	2	0x004	1176.45 MHz (L5/E5a/B2a) Includes: <ul style="list-style-type: none"> • GPS/QZSS L5 (1176.45 MHz) • Galileo E5a (1176.45 MHz) • BeiDou B2a (1176.45 MHz) • IRNSS L5 (1176.45 MHz)
L6	3	0x008	1262.52 MHz (B3) -> 1278.75 (L6/E6) Includes: <ul style="list-style-type: none"> • Galileo E6 (1278.75 MHz) • BeiDou B3 (1268.52 MHz) • QZSS L6 (1278.75 MHz)
L1-L2 Wide Lane	4	0x010	296.67 MHz (QZSS L6) -> 373.395 MHz (G3)
L1-L5 Wide Lane	5	0x020	398.97 MHz (L5)
S	6	0x040	S band 2.0 -> 4.0 GHz IRNSS S band is 2492.028 MHz
Reserved	7-15		<i>Reserved for future use.</i>



2.6.5.3 GNSS Signal Names (*SignalName)

The following enumerations are used to indicate different signal types within a given GNSS constellation. See also [2.6.5.5 GNSS Signal Types \(GNSSSignalType\)](#).

Note: GNSS signal name enumerations are limited to 3 bits, and values above 7 are not allowed.

GPSSignalName (u8):

Name	Enum Value (u8)	Bit Mask (u8)
L1 C/A	0	0x01
L1 P(Y)	1	0x02
L1C	2	0x04
L2C	3	0x08
L2 P(Y)	4	0x10
L5	5	0x20
Reserved	6-7	0x40-0x80

GLONASSSignalName (u8):

Name	Enum Value (u8)	Bit Mask (u8)
L1 C/A	0	0x01
L1 P	1	0x02
L2 C/A	2	0x04
L2 P	3	0x08
Reserved	4-7	0x10-0x80

GalileoSignalName (u8):

Name	Enum Value (u8)	Bit Mask (u8)
E1-A	0	0x01
E1-BC	1	0x02
E5a	2	0x04
E5b	3	0x08
E6-A	4	0x10
E6-BC	5	0x20
Reserved	6-7	0x40-0x80



BeiDouSignalName (u8):

Name	Enum Value (u8)	Bit Mask (u16)
B1I	0	0x01
B1C	1	0x02
B2I	2	0x04
B2b	3	0x08
B2a	4	0x10
B3I	5	0x20
Reserved	6-7	0x40-0x80

SBASSignalName (u8):

Name	Enum Value (u8)	Bit Mask (u16)
L1 C/A	0	0x01
L5	1	0x02
Reserved	2-7	0x04-0x80

QZSSSignalName (u8):

Name	Enum Value (u8)	Bit Mask (u16)
L1 C/A	0	0x01
L1C	1	0x02
L2C	2	0x04
L5	3	0x08
L6	4	0x10
Reserved	5-7	0x20-0x80

2.6.5.4 GNSS Signal Pilot/Data Components (GNSSComponent)

The following enumeration is used to indicate which component of a transmitted GNSS signal is being tracked by the GNSS receiver.

Note: GNSSComponent is limited to 2 bits, and values above 3 are not allowed.

GNSSComponent (u8):

Name	Enum Value (u8)	Description
------	-----------------	-------------



COMBINED	0	The receiver is tracking the combination of both the data and pilot components. This value is also used for signals that do not have multiple components (e.g., GPS L1 C/A code).
DATA	1	The receiver is tracking the data signal.
PILOT	2	The receiver is tracking the pilot signal.
Reserved	3	<i>Reserved for future use.</i>

2.6.5.5 GNSS Signal Types (*GNSSSignalType*)

The following enumeration is a representation of an individual GNSS signal type/component being tracked by the GNSS receiver. It combines the constellation ([2.6.5.1 SatelliteType](#)), frequency band ([2.6.5.2 FrequencyBand](#)), signal name ([2.6.5.3 *SignalName](#)), and component being tracked ([2.6.5.4 GNSSComponent](#)).

This enum is organized as a u16 bit mask, defined as follows:

```
{SatelliteType (4b), Reserved (2b), FrequencyBand (4b), Reserved (1b), *SignalName (3b), GNSSComponent (2b)}
```

Note that the *SignalName mappings are specific to each constellation (SatelliteType). For example, use GPSSignalName for GPS signal definitions.

GNSSSignalType (u8):

Name	Enum Value (dec)	Enum Value (hex)
Unknown	0	0x0000
<i>GPS</i>		
<i>L1 Band</i>		
GPS L1 C/A	4096	0x1000
GPS L1 P(Y)	4100	0x1004
GPS L1C	4104	0x1008
GPS L1C-D (Data)	4105	0x1009
GPS L1C-P (Pilot)	4106	0x100A
<i>L2 Band</i>		
GPS L2C	4172	0x104C
GPS L2C-M (Data)	4173	0x104D
GPS L2C-L (Data)	4174	0x104E
GPS L2 P(Y)	4176	0x1050



<i>L5 Band</i>		
GPS L5	4244	0x1094
GPS L5-I (Data)	4245	0x1095
GPS L5-Q (Pilot)	4246	0x1096
<i>GLONASS</i>		
<i>L1 Band</i>		
GLONASS L1 C/A	8192	0x2000
GLONASS L1P	8196	0x2004
<i>L2 Band</i>		
GLONASS L2 C/A	8264	0x2048
GLONASS L2P	8268	0x204C
<i>Galileo</i>		
<i>L1 Band</i>		
Galileo E1-A	16384	0x4000
Galileo E1-B/C	18388	0x4004
Galileo E1-B (Data)	16389	0x4005
Galileo E1-C (Pilot)	16390	0x4006
<i>L2 Band</i>		
Galileo E5b	16460	0x404C
Galileo E5b-I (Data)	16461	0x404D
Galileo E5b-Q (Pilot)	16462	0x404E
<i>L5 Band</i>		
Galileo E5a	16520	0x4088
Galileo E5a-I (Data)	16521	0x4089
Galileo E5a-Q (Pilot)	16522	0x408A
<i>L6 Band</i>		



Galileo E6-A	16592	0x40D0
Galileo E6-B/C	16596	0x40D4
Galileo E6-B (Data)	16597	0X40D5
Galileo E6-C (Pilot)	16598	0x40D6
<i>BeiDou</i>		
<i>L1 Band</i>		
BeiDou B1I	20480	0x5000
BeiDou B1C	20484	0x5004
BeiDou B1C-D (Data)	20485	0x5005
BeiDou B1C-P	20486	0x5006
<i>L2 Band</i>		
BeiDou B2I	20552	0x5048
BeiDou B2b	20556	0x504C
<i>L5 Band</i>		
BeiDou B2a	20624	0x5090
BeiDou B2a-D (Data)	20625	0x5091
BeiDou B2a-P (Pilot)	20626	0x5092
<i>L6 Band</i>		
BeiDou B3I	20692	0x50D4
<i>QZSS</i>		
<i>L1 Band</i>		
QZSS C/A	24576	0x6000
QZSS L1C	24580	0x6004



QZSS L1C-D (Data)	24581	0x6005
QZSS L1C-P (Pilot)	24582	0x6006
<i>L2 Band</i>		
QZSS L2C	24648	0x6048
QZSS L2C-M (Data)	24649	0x6049
QZSS L2C-L (Pilot)	24650	0x604A
QZSS L6	24656	0x6050
QZSS L6-M (Data)	24657	0x6051
QZSS L6-L	24658	0x6052
<i>L5 Band</i>		
QZSS L5	24716	0x608C
QZSS L5-I (Data)	24717	0x608D
QZSS L5-Q (Pilot)	24718	0x608E
<i>SBAS</i>		
<i>L1 Band</i>		
SBAS C/A	32768	0x8000
<i>L5 Band</i>		
SBAS L5	32900	0x8084
SBAS L5-I (Data)	32901	0x8085
SBAS L5-Q (Pilot)	32902	0x8086



2.6.6 Transmission Gear Type (GearType)

The following enumeration defines the “gear” in a vehicle transmission.

GearType (u8):

Stage	Value	Description
Unknown	0x0	Transmission gear not known, or gear does not map to one of the values defined below.
Forward	0x1	Vehicle in a forward gear.
Reverse	0x2	Vehicle in a reverse gear.
Park	0x3	Vehicle is parked.
Neutral	0x4	Vehicle is in neutral.
Reserved	0x5-0xFF	<i>Reserved for future use.</i>



2.6.7 I/O Interface ID (InterfaceID)

Describes an individual I/O interface (e.g., serial UART 1, TCP socket 3).

InterfaceID (u32) :

Field	Data Type	Description
Transport Type	TransportType (u8)	The type of the IO interface.
Index	u8	The ID of the IO interface. For UARTs, typically UART1 is index 1.
Reserved	u8 [2]	<i>Reserved for future use.</i>

TransportType (u8) :

Describes the type of transport used by an I/O interface.

Name	Value	Description
Invalid	0x0	Not used
Serial	0x1	A serial data interface (e.g. an RS232 connection).
File	0x2	An interface that writes to or reads from a file.
Reserved	0x3	<i>Reserved for future use.</i>
TCP	0x4	A TCP client or server.
UDP	0x5	A UDP client or server.
Reserved	0x6	<i>Reserved for future use.</i>
WebSocket	0x7	A WebSocket client or server.
UNIX Domain Socket	0x8	A UNIX domain socket client or server.
Current	0xFE	The interface on which the command was received (used to query transport or message rate settings for the interface currently being used).
All	0xFF	Wildcard to get/set ALL interfaces. <i>Not supported for all commands.</i>



2.6.8 Stored Data Type (DataType)

Identifies the type of data stored on the device.

DataType (u8) :

Data Type	Data Type	Description
CALIBRATION_STATE	0x0	Active configuration settings currently in use by the device.
CRASH_LOG	0x1	Diagnostic information reported in the case of an unexpected crash.
FILTER_STATE	0x2	Filter state parameters.
USER_CONFIG	0x3	User configuration parameters.
INVALID	0xFF	Invalid value.



2.6.9 Data Version Number (DataVersion)

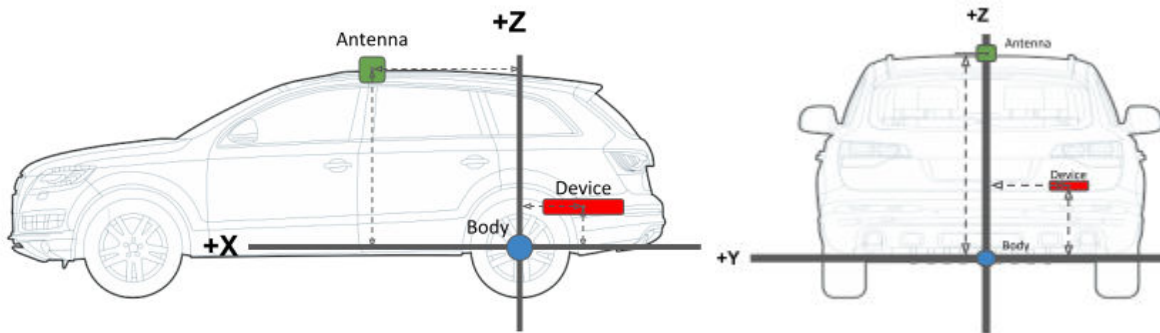
Defines the version of the data structure definition currently in use by the device.

DataVersion (u32):

Field	Data Type	Description
Reserved	u8	Must be set to 0xFF for backwards compatibility.
Major Version	u8	Major version number. Set to 0xFF if invalid.
Minor Version	u16	Minor version number. Set to 0xFFFF if invalid.



2.7 Vehicle Body Coordinate Frame And Attitude Angles



The vehicle body axes used in all FusionEngine messages are defined as:

- +X forward
- +Y left
- +Z up

The attitude angles used in all messages are defined with respect to the local ENU (East, North, Up) reference frame as follows:

- Yaw – A right-hand (counter-clockwise) rotation around the Z axis, starting in the east.
For example, a yaw of $+90^\circ$ indicates the vehicle X axis is pointing to the north.
 - Heading with respect to true north can be computed as: $\text{heading} = 90 - \text{yaw}$
- Pitch – A right-hand rotation around the Y axis. A positive pitch angle points the nose of the vehicle down relative to the horizon, while a negative pitch points the vehicle up.
- Roll – A right-hand rotation around the X axis. A positive roll angle indicates a roll to the right when looking towards the front of the vehicle, a negative roll indicates a roll to the left.

These angles are intrinsic Euler-321 angles. The order in which the rotations are applied is important. The correct order is: yaw, pitch, then roll.



2.8 NMEA-0183 Message Types

The following table lists the 16-bit (u16) message IDs assigned to each supported NMEA-0183 message, used to configure output interface settings. All other values are reserved for future use.

See also 4 Proprietary NMEA Sentence Definitions.

NMEA Message Type	Message ID
Invalid	0
<i>Standard NMEA-0183 Messages</i>	
GGA	1
GLL	2
GSA	3
GSV	4
RMC	5
VTG	6
ZDA	7
<i>Point One Proprietary Messages</i>	
P1CALSTATUS	1000
P1MSG	1001
<i>Quectel Proprietary Messages</i>	
PQTMVERNO	1200
PQTMVER	1201
PQTMGNSS	1202
PQTMVERNO_SUB	1203
PQTMVER_SUB	1204
PQTMTXT	1205



3. FusionEngine Message Definitions

3.1 Command/Control Messages (Input)

These are messages sent from the host device to the FusionEngine software. They are primarily used to control the device and to change or query configuration settings.



3.1.1 MessageRequest (13001)

Message ID: 13001

Protocol Version: 2

Message Version: 0

Description: Request transmission of a specific message type. Unless otherwise stated, the response will be generated on the same interface.

On-demand message transmission is not supported for all message types.

Field	Data Type	Description
Message Type	u16	The type of the message requested.
Reserved	u8 [2]	<i>Reserved for future use.</i>

Expected Response(s):

Responding Message Type	Responding Message ID
<Requested Message Type>	<Requested Message Type ID>

Note: If the specified message type cannot be requested, a 3.2.1 COMMANDRESPONSE (13000) will be returned with a *Value Error*.



3.1.2 ResetRequest (13002)

Message ID: 13002

Protocol Version: 2

Message Version: 0

Description: Command the system to perform one or more reset operations.

Field	Data Type	Description
Reset Mask	u32	Bit mask indicating the components to be reset.

Reset Mask Bits:

Bit Number	Name	Reset Triggered When Set
0	RESTART_NAVIGATION_ENGINE	Restart the navigation engine, but do not clear its position estimate.
1	RESET_GNSS_CORRECTIONS	Delete all GNSS corrections information.
2	RESET_GNSS_TIME	Delete all GNSS time information.
3-7	Reserved	<i>Reserved for future use.</i>
8	RESET_POSITION_DATA	Reset the navigation engine's estimate of position, velocity, and orientation.
9	RESET_EPHEMERIS	Delete all saved satellite ephemeris.
10	RESET_FAST_IMU_CORRECTIONS	Reset bias estimates, and other IMU corrections that are typically estimated quickly.
11	Reserved	<i>Reserved for future use.</i>
12	RESET_NAVIGATION_ENGINE_DATA	Reset all stored navigation engine data, including position, velocity, and orientation state, as well all IMU corrections (fast and slow) and other training data.
13	RESET_CALIBRATION_DATA	Reset the device calibration data. Note: This does not reset any existing navigation engine state. It is recommended that you set <code>RESET_NAVIGATION_ENGINE_DATA</code> as well under normal circumstances.
14-19	Reserved	<i>Reserved for future use.</i>



20	RESET_CONFIG	Reset all configuration settings back to factory defaults.
21-23	Reserved	<i>Reserved for future use.</i>
24	REBOOT_GNSS_MEASUREMENT_ENGINE	Reboot the GNSS measurement engine, in addition to performing any other requested resets. If no other resets are specified, the GNSS receiver will reboot and should perform a hot start.
25	REBOOT_NAVIGATION_PROCESSOR	Reboot the processor on which the navigation software is executed.
26	DIAGNOSTIC_LOG_RESET	Perform a diagnostic log reset to guarantee deterministic performance for data post-processing and diagnostic support.
26-31	Reserved	<i>Reserved for future use.</i>



Special Mask Values:

Value	Name	Description
0x00000001	HOT_START	<p>Perform a device hot start.</p> <p>A hot start is typically used to restart the navigation engine in a deterministic state, using previously stored position and time information. The device will begin navigating immediately if possible.</p> <p>To be reset:</p> <ul style="list-style-type: none"> ● The navigation engine <p>Not reset:</p> <ul style="list-style-type: none"> ● All runtime data (GNSS corrections, etc.) ● GNSS time information ● Position, velocity, orientation state ● GNSS ephemeris data ● Fast IMU corrections ● Training parameters (slowly estimated IMU corrections, temperature compensation, etc.) ● Calibration data ● User configuration settings ● GNSS measurement engine ● Navigation processor



<p>0x00000201</p>	<p>WARM_START</p>	<p>Perform a device warm start.</p> <p>During a warm start, the device retains its knowledge of approximate position and time, plus almanac data if available, but resets all ephemeris data. As a result, the device will need to download ephemeris data before continuing to navigate.</p> <p>To be reset:</p> <ul style="list-style-type: none"> ● The navigation engine ● GNSS ephemeris data <p>Not reset:</p> <ul style="list-style-type: none"> ● All runtime data (GNSS corrections, etc.) ● GNSS time information ● Position, velocity, orientation state ● Fast IMU corrections ● Training parameters (slowly estimated IMU corrections, temperature compensation, etc.) ● Calibration data ● User configuration settings ● GNSS measurement engine ● Navigation processor
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<p>0x00000FFF</p>	<p>COLD_START</p>	<p>Perform a device cold start.</p> <p>A cold start is typically used to reset the device's state estimate in the case of an error that cannot be resolved by a warm start.</p> <p>To be reset:</p> <ul style="list-style-type: none"> ● The navigation engine ● All runtime data (GNSS corrections, etc.) ● GNSS time information ● Position, velocity, orientation state ● Fast IMU corrections ● GNSS ephemeris data <p>Not reset:</p> <ul style="list-style-type: none"> ● Training parameters (slowly estimated IMU corrections, temperature compensation, etc.) ● Calibration data ● User configuration settings ● GNSS measurement engine ● Navigation processor
<p>0x000001FB</p>	<p>POSE_RESET</p>	<p>Resets the kinematic portion of the navigation engine state. Useful for error recovery.</p> <p>To be reset:</p> <ul style="list-style-type: none"> ● The navigation engine ● All runtime data (GNSS corrections, etc.) ● Position, velocity, orientation state <p>Not reset:</p> <ul style="list-style-type: none"> ● GNSS time information ● GNSS ephemeris data ● Fast IMU corrections ● Training parameters (slowly estimated IMU corrections, temperature compensation, etc.) ● Calibration data ● User configuration settings ● GNSS measurement engine ● Navigation processor
<p>0xFFFFFFFF</p>	<p>FACTORY_RESET</p>	<p>Restart mask to set all persistent data, including position/orientation, calibration state, and user configuration, back to factory defaults.</p>



Expected Response(s):

3.2.1 COMMANDRESPONSE (13000)

Example Usage

Example 1: Perform a device cold start

This will reset the navigation engine including saved position, velocity, and orientation state, as well as the GNSS measurement engine, but will not reset training data, calibration data, or user configuration parameters, by setting the reset mask to 0x00000FFF.

```
2e31 0000 0acf ee8f 0200 ca32 0000 0000  
0400 0000 0000 0000 ff0f 0001
```

Example 2: Perform a factory reset

Reset all settings, state, and calibration data to factory defaults by setting the reset mask to 0xFFFFFFFF.

```
2e31 0000 b39e 0bf3 0200 ca32 0000 0000  
0400 0000 0000 0000 ffff ffff
```



3.1.3 ShutdownRequest (13005)

Message ID: 13005

Protocol Version: 2

Message Version: 0

Description: Shutdown the device.

Field	Data Type	Description
Flags	u64	A bitmask of flags used to control the shutdown process. Note: if the flags field is set to zero, it will be treated as a “Stop Engine” request.
Reserved	u8[8]	<i>Reserved for future use.</i>

Flag bit definitions:

Flag	Bit	Value	Description
Stop Engine	0	0x1	Stop navigation engine and flush state to non-volatile storage.
Stop Current Log	1	0x2	If a log is being generated, end that log.
Reserved	2-63		<i>Reserved for future use.</i>

Expected Response(s):

3.2.1 COMMANDRESPONSE (13000)

Example Usage

Example 1: Stop the navigation engine

```
2e31 0000 716f 5414 0200 cd32 0000 0000
1000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000
```



3.1.4 FaultControl (13006)

Message ID: 13006

Protocol Version: 2

Message Version: 0

Description: Testing message to trigger or clear a specified system fault.

This message is intended for factory testing and development purposes only and should not be used in any production environment.

Field	Data Type	Description
Fault Type	FaultType (u8)	The type of fault/control to be performed.
Reserved	u8 [15]	<i>Reserved for future use.</i>
Value Length	u32	The length of the value to follow (in bytes).
Value	Variable	The parameter value for the specified fault type. The format of the value is listed in the FaultType table below.

FaultType (u8):

Name	Type	Value Format	Description
Clear All	0x0	None	Clear existing faults.
Crash	0x1	None	Force the device to crash. In a crash state, the device no longer produces any output on any interfaces, and will stop responding to commands. If the watchdog is enabled, the device will restart automatically after the watchdog timer elapses.
Fatal Error	0x2	None	Force the device to exhibit a fatal error. After a fatal error, the device will stop navigating and will no longer produce solution messages on any interfaces. Instead, it will output an <code>EventNotificationMessage</code> indicating the fault status. If the watchdog is enabled, the device will restart automatically after the watchdog timer elapses.



COCOM	0x3	COCOM Type (3.1.4.1) (u8)	Trigger a COCOM limit. When a COCOM limit is exceeded, the device will stop navigating and will produce Invalid solution messages. COCOM limits may be cleared via ResetRequest, or by sending a COCOM FaultControl message with the COCOMType parameter set to NONE.
Enable GNSS	0x4	bool	Enable/disable use of GNSS measurements (intended for dead reckoning performance testing).
Region Blackout	0x5	bool	Enable/disable a simulated region blackout
Line Test Mode	0x6	bool	Enable/disable factory test behavior for use with GNSS simulation.
Integrity Status	0x7	u8	Simulate a specified integrity status failure.
Reserved	0x7-0xF		<i>Reserved for future use.</i>

Expected Response(s):

3.2.1 COMMANDRESPONSE (13000)

Note that the device will crash immediately after receiving a Crash Fault Type request. It will not send a CommandResponse back to the user.

Example Usage

Example 1: Cause the device to immediately crash.

```
2e31 0000 bde4 777b 0200 ce32 0000 0000
1400 0000 0000 0000 0100 0000 0000 0000
0000 0000 0000 0000 0000 0000
```

Example 2: Trigger an artificial COCOM altitude limit.

```
2e31 0000 0bf7 0344 0200 ce32 0000 0000
1500 0000 0000 0000 0300 0000 0000 0000
0000 0000 0000 0000 0100 0000 03
```

Note that, in practice, the message sequence number should be modified, consistent with any commands sent previously, and the CRC should be updated to reflect the change.



3.1.4.1 COCOM Type (u8)

Name	Value	Description
NONE	0x0	Clear the current COCOM limit.
ACCELERATION	0x1	Trigger a maximum acceleration limit.
SPEED	0x2	Trigger a maximum speed limit.
ALTITUDE	0x3	Trigger a maximum altitude limit.
Reserved	0x4-0xFF	<i>Reserved for future use.</i>



3.1.5 StartupRequest (13008)

Message ID: 13008

Protocol Version: 2

Message Version: 0

Description: Startup the device.

Field	Data Type	Description
Flags	u64	A bitmask of flags used to control the startup process. Note: For backwards-compatibility, if set to 0x0, the navigation engine will be started.
Reserved	u8[8]	<i>Reserved for future use.</i>

Flag bit definitions:

Flag	Bit	Value	Description
Start Engine	0	0x1	Start navigation engine if not currently running.
Start New Log	1	0x2	If a log is not being generated, start a new log. If a log is active, end it and immediately start a new log.
Reserved	2-63		<i>Reserved for future use.</i>

Expected Response(s):

3.2.1 COMMANDRESPONSE (13000)



3.1.6 SetConfigMessage (13100)

Message ID: 13100

Protocol Version: 2

Message Version: 0

Description: Set the value of a user configuration parameter.

Field	Data Type	Description
Parameter Type	ConfigType (u16)	The parameter to be configured.
Flag	u8	Bitmask of additional flags to modify the command.
Reserved	u8	<i>Reserved for future use.</i>
Value Length	u32	The length of the value to follow (in bytes).
Value	Variable	The new value to use for the specified parameter. The format of the value is listed in the ConfigType table below.

Flag bit definitions:

Flag	Bit	Value	Description
APPLY_AND_SAVE	0	0x1	Immediately save the configuration after applying this setting.
REVERT_TO_DEFAULT	1	0x2	Reset both the active and saved configuration to default values.
Reserved	2-7		<i>Reserved for future use.</i>

ConfigType (u16):

Name	Parameter Type	Value Format	Description
Invalid	0x0	None	Invalid parameter.
Reserved	0x1-0xF		<i>Reserved for future use.</i>
Device Lever Arm	0x10	Point3f (3.1.6.1)	The location of the device IMU with respect to the vehicle body frame, resolved in the body frame, in meters.
Device Orientation	0x11	CoarseOrientation (3.1.6.2)	The orientation of the device IMU with respect to the vehicle body axes.
GNSS Lever Arm	0x12	Point3f (3.1.6.1)	The location of the primary GNSS antenna with respect to the vehicle body frame, resolved in the body frame, in meters.



Output Lever Arm	0x13	Point3f (3.1.6.1)	The offset of the desired output location with respect to the vehicle body frame, resolved in the body frame, in meters.
Vehicle Details	0x14	VehicleDetails (3.1.6.3)	Information about the vehicle including model and dimensions.
Software Wheel Config	0x15	WheelConfig (3.1.6.4)	Configuration for software wheel speed/rotation (tick) measurements (FusionEngine messages/CAN data).
Hardware Tick Config	0x16	HardwareTickConfig (3.1.6.5)	Configuration capturing hardware wheel tick measurements from an incoming voltage signal.
Heading Bias <i>(Deprecated)</i>	0x17	HeadingBias <i>(removed)</i>	Used to set horizontal (yaw) & vertical (pitch) biases (in degrees) on a dual-antenna heading platform configuration. <i>Deprecated in version 1.24.0: Use GNSS Aux Lever Arm instead.</i>
GNSS Aux Lever Arm	0x18	Point3f (3.1.6.1)	The location of the secondary GNSS antenna on a dual-antenna platform. Specified with respect to the vehicle body frame, resolved in the body frame, in meters. For dual-antenna systems, the secondary or auxiliary antenna is used to measure vehicle orientation (yaw/heading and pitch). <i>Added in version 1.24.0.</i>
Enabled GNSS Systems	0x32	u32	A bitmask indicating which GNSS systems are enabled (see 2.6.5 GNSS Systems (SatelliteType)).
Enabled GNSS Frequency Bands	0x33	u32	A bitmask indicating which GNSS frequency bands are enabled (see 2.6.6 GNSS Frequency Bands (FrequencyBand)).



Leap Second Override	0x34	i32	Specify a UTC leap second count override value to use for all UTC time conversions. Note: Setting this value will disable all internal leap second sources and should only be used for testing . Set to -1 to disable.
GPS Week Rollover Override	0x35	i32	Specify a GPS legacy week rollover count override to use when converting all legacy 10-bit GPS week numbers. Setting this value will disable all internal week rollover sources and should only be used for testing . Set to -1 to disable.
Ionosphere Config	0x36	Ionosphere Delay Model (3.1.6.7)	Configures the active ionosphere model.
Troposphere Config	0x37	Troposphere Delay Model (3.1.6.8)	Configures the active troposphere model.
Interface Config	0xC8	InterfaceConfig (3.1.6.6)	Change a configuration setting for a specified output interface.
UART 1 Baud Rate	0x100	u32	The UART 1 serial baud rate in bits/second. Deprecated: Use InterfaceConfig.
UART 2 Baud Rate	0x101	u32	The UART 2 serial baud rate in bits/second. Deprecated: Use InterfaceConfig.
UART 1 Diag Enable	0x102	bool	Enable/disable diagnostic output on UART 1. Deprecated: Use InterfaceConfig.
UART 2 Diag Enable	0x103	bool	Enable/disable diagnostic output on UART 2. Deprecated: Use InterfaceConfig.
Reserved	0x104-0x12B		<i>Reserved for future use.</i>
Watchdog Enable	0x12C	bool	Enable/disable watchdog timer to restart automatically after fatal errors.
User Device ID	0x12D	char[32]	A string for identifying a device.
Profiling Mask	0x136	u8	A bitmask indicating which profiling features are enabled. Individual bit definitions vary per device.
Reserved	0x12E-0x3FF		<i>Reserved for future use.</i>



L-band Parameters	0x400	<u>LBandConfig</u> (3.1.6.9)	Configuration of L-band Demodulator Parameters. Note: This setting is only available on devices with an L-band receiver.
Reserved	0x401-0xFFFF		<i>Reserved for future use.</i>

Expected Response(s):

3.2.1 COMMANDRESPONSE (13000)

Example Usage

Example 1: Set the output lever arm to [0.6, 0.0, 1.2] meters

```
2e31 0000 8cd8 859a 0200 2c33 0000 0000
1400 0000 0000 0000 1300 0000 0c00 0000
9a99 193f 0000 0000 9a99 993f
```

Example 2: Set the device orientation to point towards the left side of the vehicle and save to persistent storage immediately.

```
2e31 0000 0ac0 a42c 0200 2c33 0000 0000
0c00 0000 0000 0000 1100 0100 0400 0000
0204 0000
```

Example 3: Set the device UART 1 serial baud rate to 115200 bits/second.

```
2e31 0000 61ad a75c 0200 2c33 0000 0000
0c00 0000 0000 0000 0001 0100 0400 0000
00c2 0100
```

The command response will be sent at the new baud rate if the command was sent to the device on the affected UART.

Note that in practice, the message sequence number should be modified, consistent with any commands sent previously, and the CRC should be updated to reflect the change.

3.1.6.1 Three-Dimensional Vector (Point3f)

Field	Data Type	Description
X	f32	The X axis offset in meters.
Y	f32	The Y axis offset in meters.
Z	f32	The Z axis offset in meters.

3.1.6.2 Device Coarse Orientation (CoarseOrientation)

A device's orientation is defined by specifying how the +X and +Z axes of its IMU are aligned with the vehicle body axes. The vehicle body is defined with +X facing forward, +Y facing left, and +Z facing up (forward-left-up).



Field	Data Type	Description
X Direction	u8	The direction of the +X axis relative to the vehicle body axes.
Z Direction	u8	The direction of the +Z axis relative to the vehicle body axes.
Reserved	u8[2]	<i>Reserved for future use.</i>

Direction (u8):

Name	Value	Description
Forward	0x0	Aligned with the vehicle +X axis.
Backward	0x1	Aligned with the vehicle -X axis.
Left	0x2	Aligned with the vehicle +Y axis.
Right	0x3	Aligned with the vehicle -Y axis.
Up	0x4	Aligned with the vehicle +Z axis.
Down	0x5	Aligned with the vehicle -Z axis.
Reserved	0x6-0xFE	<i>Reserved for future use.</i>
Invalid	0xFF	Invalid direction value.

3.1.6.3 Vehicle Details and Physical Dimensions (VehicleDetails)

This payload is used to configure the vehicle's physical dimensions, used when applying differential wheel speed measurements, as well as select the vehicle model from a list of supported vehicles when processing vehicle CAN messages.

Field	Data Type	Description
Model	Vehicle Model (u16)	The vehicle model if one of the supported vehicles in the list below. Used to configure CAN data support. Set to 0 (unknown) if not one of the currently supported types.
Reserved	u8[10]	<i>Reserved for future use.</i>
Wheelbase	f32	The distance between the front and rear axles in meters.
Front Track Width	f32	The distance between the two front wheels in meters.
Rear Track Width	f32	The distance between the two rear wheels in meters.

VehicleModel (u16):

Value	Description
0x0	Unknown vehicle type
0x1	Dataspeed CD4 drive-by-wire system
0x2	J1939 CAN message standard



0x14	Lexus CT200H
0x28	Kia Sorento
0x29	Kia Sportage
0x3C	Audi Q7
0x3D	Audi A8L
0x50	Tesla Model X
0x51	Tesla Model 3
0x64	Hyundai Elantra
0x78	Peugeot 206
0x8C	MAN TGX
0xA0	Faction
0xA1	Faction V2
0xB4	Lincoln MKZ
0xC8	BMW 7-Series
0xC9	BMW-Motorrad
0xDC	Volkswagen ID.4
0xF0	Rivian

CAN message definitions vary by manufacturer, model, and year. The vehicles listed above may not work with every available model year.

All values not listed in the table above are reserved for future use.

3.1.6.4 Software Wheel Measurement Configuration (WheelConfig)

The `WheelConfig` payload is intended for use on vehicles where wheel speed or angle (tick) data is received via software, either using FusionEngine measurement messages, or from another software mechanism such as a vehicle CAN bus. Wheel data may be differential (measurements from each individual wheel), or scalar (a single speed measurement for the vehicle body).

When using software wheel data, you must also specify 3.1.6.3 Vehicle Details and Physical Dimensions (VehicleDetails).

See section 3.5 Sensor Measurement Input Messages for descriptions of the messages used to send wheel measurements to the device.

Note: Do not use this message for vehicles using a hardware wheel tick voltage signal. Instead, use 3.1.6.5 Hardware Wheel Tick Configuration (HardwareTickConfig).

Field	Data Type	Description
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Wheel Sensor Type	WheelSensorType (u8)	The type of vehicle/wheel speed measurements produced by the vehicle.
Applied Speed Type	AppliedSpeedType (u8)	The type of vehicle/wheel speed measurements to be applied to the navigation solution.
Steering Type	SteeringType (u8)	Indication of which of the vehicle's wheels are steered.
Reserved	u8	<i>Reserved for future use.</i>
Wheel Update Interval	f32	The nominal rate at which wheel speed measurements will be provided in seconds. Note: this parameter is required when configured for software wheel speed measurements.
Wheel Tick Output Update Interval	f32	The nominal rate at which wheel tick measurements will be used by the navigation engine (in seconds). Note: For most system configurations, it is recommended to set this value to NAN, in which the device will select the appropriate setting.
Steering Ratio	f32	The ratio between the angle of the steering wheel and the angle of the wheels on the ground.
Meters/Tick Scale Factor	f32	The scale factor to convert wheel encoder ticks to distance in meters/tick. Used for TICKS and VEHICLE_TICKS wheel sensor types only.
Wheel Tick Max Value	u32	The maximum value before the wheel tick measurement will roll over. Used for TICKS and VEHICLE_TICKS wheel sensor types only. Rollover behavior depends on the value of the Wheel Ticks Signed setting. For example, a maximum value of 10 will work as follows: <ul style="list-style-type: none"> • Wheel Ticks Signed (true): [-11, 10] • Wheel Ticks Signed (false): [0, 10] <p>Signed values are assumed to be asymmetric, consistent with a typical 2's complement rollover.</p>



Wheel Ticks Signed	u8	1 if the wheel reported wheel tick measurements should be interpreted as signed integers, or 0 if they should be interpreted as unsigned integers. Used for TICKS and VEHICLE_TICKS wheel sensor types only.
Wheel Ticks Always Increase	u8	1 if the wheel tick measurements increase by a positive amount when driving forward or backward. 0 if wheel tick measurements decrease when driving backward. Used for TICKS and VEHICLE_TICKS wheel sensor types only.
Reserved	u8[2]	<i>Reserved for future use.</i>

WheelSensorType (u8):

Name	Value	Description
NONE	0x0	Wheel/vehicle speed data not available.
Reserved	0x1	<i>Reserved for future use.</i>
TICKS	0x2	Individual rotation angle measurements for multiple wheels, reported as accumulated encoder ticks. Will be scaled to meters using the Tick/Meter Scale Factor.
WHEEL_SPEED	0x3	Individual speed measurements for multiple wheels, reported in meters/second.
VEHICLE_SPEED	0x4	A single value indicating vehicle speed in meters/second.
VEHICLE_TICKS	0x5	A single wheel rotation angle, reported as accumulated encoder ticks.
Reserved	0x6-0xFF	<i>Reserved for future use.</i>

AppliedSpeedType (u8):

Name	Value	Description
NONE	0x0	Speed data not applied to the navigation solution.
REAR_WHEELS	0x1	Apply rear wheel speed data. Recommended for most use cases.
FRONT_WHEELS	0x2	Apply front wheel speed data.
FRONT_AND_REAR_WHEELS	0x3	Apply both front and rear wheel speed data.
VEHICLE_BODY	0x4	Apply aggregate vehicle speed data.



Reserved	0x5-0xFF	<i>Reserved for future use.</i>
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SteeringType (u8):

Name	Value	Description
UNKNOWN	0x0	Steered wheels unknown/not used.
FRONT	0x1	Front wheels are steered.
FRONT_AND_REAR	0x2	Front and rear wheels are steered.
Reserved	0x3-0xFF	<i>Reserved for future use.</i>



3.1.6.5 Hardware Wheel Tick Configuration (HardwareTickConfig)

The `HardwareTickConfig` payload is intended for use on vehicles with a physical voltage signal, generated by a wheel encoder, producing a series of voltage pulses (encoder ticks) as the vehicle's wheel rotates. These ticks will be captured by the device on an input pin and used to indicate vehicle speed.

Additionally, an optional voltage signal may be provided to indicate vehicle direction. **If this signal is not connected to a real pulse (even if pulled up/down), the `TickDirection` field MUST be set to OFF otherwise there will be substantial errors in dead reckoning.**

Note: DO NOT use this configuration for vehicles using software wheel speed/tick information, including data sent using FusionEngine messages or a vehicle CAN bus. Instead, use 3.1.6.4 Software Wheel Measurement Configuration (WheelConfig).

Field	Data Type	Description
Tick Mode	<code>TickMode</code> (u8)	The signal edge to use when capturing the incoming wheel tick voltage signal. If enabled, the device will accumulate ticks received on the I/O pin and use them as an indication of vehicle speed. If specified, you must also specify the Meters/Tick Scale Factor to indicate the mapping of wheel tick encoder angle to tire circumference. All other wheel tick-related parameters such as tick capture rate, rollover value, etc. will be set internally.
Tick Direction	<code>TickDirection</code> (u8)	The way to interpret the optional direction voltage signal. If set to OFF, the incoming ticks will be treated as unsigned, meaning the tick count will continue to increase in either direction of travel. If not set to OFF, a second direction I/O pin will be used to indicate the direction of travel and the accumulated tick count will increase/decrease accordingly.
Reserved	u8	<i>Reserved for future use.</i>
Meters/Tick Scale Factor	f32	The scale factor to convert wheel encoder ticks to distance in meters/tick. Used for <code>TICKS</code> and <code>VEHICLE_TICKS</code> wheel sensor types only.



TickMode (u8):

Name	Value	Description
OFF	0x0	Hardware wheel tick capture disabled.
RISING_EDGE	0x1	Capture a tick on the rising edge of the incoming pulse.
FALLING_EDGE	0x2	Capture a tick on the falling edge of the incoming pulse.
Reserved	0x3-0xFF	<i>Reserved for future use.</i>

TickDirection (u8):

Name	Value	Description
OFF	0x0	Vehicle direction signal disabled.
FORWARD_ACTIVE_HIGH	0x1	Assume vehicle is moving forward when direction signal voltage is high, and backward when voltage is low.
FORWARD_ACTIVE_LOW	0x2	Assume vehicle is moving forward when direction signal voltage is low, and backward when voltage is high.
Reserved	0x3-0xFF	<i>Reserved for future use.</i>



3.1.6.6 Interface Config Submessage (InterfaceConfigSubmessage)

Message used to configure parameters for a particular I/O interface on the device such as baud rate, TCP port, enabling diagnostic output, etc.

Field	Data Type	Description
Interface ID	InterfaceID (u32)	The ID of the interface to be configured or queried. Note that type <i>ALL</i> is not supported.
Interface Config Type	InterfaceConfigType (u8)	The setting to be configured.
Reserved	u8[3]	<i>Reserved for future use.</i>
Interface Config Payload Data	<i>Variable</i>	The payload definition for each InterfaceConfigType is listed in the table below.

InterfaceConfigType (u8):

Specifies the configuration parameter to be set/queried for a given interface.

Name	Value	Payload Format	Description
OUTPUT_DIAGNOSTICS_MESSAGES	1	bool	Enable/disable output of diagnostic data on this interface. Note this will override the message rate/off settings for some FusionEngine messages.
BAUD_RATE	2	u32	Serial Baud Rate in bits/second. Valid for serial transports.
REMOTE_ADDRESS	3	char[64]	Configure the network address for a client to connect to, or the path to a local serial device or UNIX domain socket file. Valid for TCP, UDP, UNIX, and serial transports. String must be null-terminated.
PORT	4	u16	The network port for a client or server. Valid for TCP, UDP, and WebSocket transports.
ENABLED	5	bool	Enable/disable this interface.



DIRECTION	6	TransportDirection (u8)	Set the interface direction (client or server). Valid for TCP, UNIX, and WebSocket transports.
UNIX_SOCKET_TYPE	7	UNIXSocketType (u8)	Set the UNIX domain socket type (streaming, datagram, or sequenced). Valid for UNIX transports.

TransportDirection (u8):

Describes the direction (client/server) of an interface, where applicable.

Name	Value	Description
Invalid	0x0	Not used
Server	0x1	A server that listens for one or more incoming connections.
Client	0x2	A client that connects to a specified remote server.

UNIXSocketType (u8):

Specifies how data is transmitted when using a UNIX domain socket.

Name	Value	Description
Invalid	0x0	Not used
Stream	0x1	Operate in connection-oriented streaming mode and do not preserve message boundaries (similar to TCP).
Datagram	0x2	Operate in datagram mode, preserving message boundaries but not maintaining client connections (similar to UDP).
Sequenced Packet	0x3	Operate in sequenced packet mode, which is both connection-oriented and preserves message boundaries.



3.1.6.7 Ionosphere Delay Model Configuration (*IonosphereConfig*)

Message used to configure the ionospheric delay model.

Field	Data Type	Description
Ionosphere Delay Model	IonosphereDelayModel (u8)	The model used to predict ionospheric delays.
Reserved	u8 [3]	<i>Reserved for future use.</i>

IonosphereDelayModel (u8):

Name	Value	Description
AUTO	0x0	Uses the best available ionospheric model.
OFF	0x1	Explicitly disables an ionospheric model. This is not recommended except for use in simulation.
KLOBUCHAR	0x2	Uses the Klobuchar ionospheric model.
SBAS	0x3	Uses the SBAS gridded ionospheric model (when available).
Reserved	0x4-0xFF	<i>Reserved for future use.</i>

3.1.6.8 Troposphere Delay Model Configuration (*TroposphereConfig*)

Message used to configure the tropospheric delay model.

Field	Data Type	Description
Troposphere Delay Model	TroposphereDelayModel (u8)	The model used to predict tropospheric delays.
Reserved	u8 [3]	<i>Reserved for future use.</i>

TroposphereDelayModel (u8):

Name	Value	Description
AUTO	0x0	Uses the best available tropospheric model.
OFF	0x1	Explicitly disables a tropospheric model. This is not recommended except for use in simulation.
SAASTAMOINEN	0x2	Uses the Saastamoinen ionospheric model.
Reserved	0x3-0xFF	<i>Reserved for future use.</i>



3.1.6.9 LBandConfig

Configuration of L-band demodulator parameters.

Field	Data Type	Description
Center Frequency	f64	The center frequency of the L-band (Hz).
Search Window	f32	The size of the signal acquisition search space (in Hz) around the center frequency. For example, a value of 6000 will search +/- 3 kHz around the center frequency
Filter Data By Service ID	bool	Determines whether to only output data frames with the configured <code>Service ID</code> . If not, output all decoded frames.
Use Descrambler	bool	Enable/Disable the descrambler.
PMP Service ID	u16	The PMP service ID of the provider.
PMP Unique Word	u64	The PMP unique word used by provider.
Data Rate	u16	The transmitted data rate (bps).
Descrambler Initialization Value	u16	The initialization value for the PMP descrambling vector.



3.1.7 GetConfigMessage (13101)

Message ID: 13101

Protocol Version: 2

Message Version: 0

Description: Query the value of a user configuration parameter.

Field	Data Type	Description
Parameter Type	ConfigType (u16)	The parameter to be queried (see 3.1.6 SetConfig (13100)).
Configuration Source	ConfigurationSource (u8)	The data source to be queried (active, saved, etc.).
Reserved	u8	<i>Reserved for future use.</i>

ConfigurationSource (u8):

Configuration Source	Value	Description
ACTIVE	0x0	Active configuration settings currently in use by the device.
SAVED	0x1	Settings currently saved in persistent storage.

Expected Response(s):

3.2.2 ConfigResponseMessage (13103)



3.1.8 SaveConfigMessage (13102)

Message ID: 13102

Protocol Version: 2

Message Version: 0

Description: Save or reload configuration settings.

Field	Data Type	Description
Save Action	SaveAction (u8)	Indicates the action to perform on the saved configuration.
Reserved	u8 [3]	Reserved for future use.

SaveAction (u8):

Save Action	Value	Description
Save	0x0	Save all active parameters to persistent storage.
Revert to Saved	0x1	Revert the active configuration to previously saved values.
Revert to Default	0x2	Reset both the active and saved configuration to default values.

Expected Response(s):

3.2.1 COMMANDRESPONSE (13000)

Example Usage

Example 1: Save configuration changes to persistent storage

```
2e31 0000 c48c 1ee8 0200 2e33 0000 0000
0400 0000 0000 0000 0000 0000
```

Example 2: Reset configuration settings to factory defaults

```
2e31 0000 4f44 1742 0200 2e33 0000 0000
0400 0000 0000 0000 0200 0000
```

This has the same effect as issuing a 3.1.2 ResetRequest (13002) with the bit mask set to RESET_CONFIG.



3.1.9 ImportDataMessage (13110)

Message ID: 13110

Protocol Version: 2

Message Version: 0

Description: Import data from the host to the device.

Field	Data Type	Description
Data Type	DataType (u8)	The type of data being imported.
Configuration Source	Configuration Source (u8)	The source of the parameter value (active, saved, etc.). If the Data Type parameter does not separate active and saved data, this will be ignored.
Reserved	u8[2]	<i>Reserved for future use.</i>
Data Version	DataVersion (u16)	Version of the data contents.
Reserved	u8[4]	<i>Reserved for future use.</i>
Data Length	u32	The number of bytes to update.
Value	<i>Variable</i>	Array of bytes for the data contents.



3.1.10 ExportDataMessage (13111)

Message ID: 13222

Protocol Version: 2

Message Version: 0

Description: Export data from the device to the host.

Field	Data Type	Description
Data Type	DataType (u8)	The type of data to be exported.
Configuration Source	Configuration Source (u8)	The source of the parameter value (active, saved, etc.). If the Data Type parameter does not separate active and saved data, this will be ignored.
Reserved	u8[2]	<i>Reserved for future use.</i>



3.1.11 SetMessageRate (13220)

Message ID: 13220

Protocol Version: 2

Message Version: 0

Description: Enable/disable an individual message on a specified output interface or configure its output rate.

Some messages can only be generated on change, and do not support rate control requests.

Note: If the `DIAGNOSTICS_ENABLED` configuration setting is set for the interface being configured, the specified rate may be temporarily overridden. This can be verified using the `GetMessageRate (13221)` command.

For a list of `u16` message IDs corresponding with supported NMEA-0183 messages, see 2.8 NMEA-0183 Message Types.

Field	Data Type	Description
Interface ID	InterfaceID (u32)	The ID of the interface to be configured.
Protocol Type	ProtocolType (u8)	The message protocol to be configured. If ALL (255) is specified, set the rate for all protocols and messages on the specified interface.
Flags	u8	A bitmask of flags to modify the command (see the table below).
Message ID	u16	The ID of the message type to be configured. If ALL (65535) is specified, set the rate for all supported messages for the specified protocol.
Message Rate	MessageRate (u8)	The desired output rate or on/off status. If the rate is an interval, and Message ID or Protocol Type is set to a wildcard, the command will only affect messages that are currently enabled. To modify all messages, including disabled messages, set the <code>FLAG INCLUDE DISABLED MESSAGES</code> flag.
Reserved	u8 [3]	<i>Reserved for future use.</i>

ProtocolType (u8):

The framing protocol of a message.

Protocol	Value
Invalid	0x0
FusionEngine	0x1



NMEA	0x2
RTCM	0x3
ALL	0xFF

Flag bit definitions:

Flag	Bit	Value	Description
APPLY_AND_SAVE	0	0x01	Setting this bit saves the updated configuration to persistent storage immediately on success.
INCLUDE_DISABLE_MESSAGES	1	0x02	Setting this bit applies bulk interval changes to all supported messages instead of only currently enabled messages.
Reserved	2-7		Reserved for future use.

MessageRate (u8):

Message Rate	Value
Off	0x0
On Change	0x1
10 ms	0x2
20 ms	0x3
40 ms	0x4
50 ms	0x5
100 ms	0x6
200 ms	0x7
500 ms	0x8
1 second	0x9
2 seconds	0xA
5 seconds	0xB
10 seconds	0xC
30 seconds	0xD
60 seconds	0xE
Device Default	0xFF

Expected Response(s):

3.2.1 COMMANDRESPONSE (13000)

Example Usage

Example 1: Enable FusionEngine PoseMessage output at its max rate on serial port 1 (UART1)



```
2e31 0000 6a84 7724 0200 a433 0000 0000
0c00 0000 0000 0000 0101 0000 0100 1027
0100 0000
```

Example 2: Enable FusionEngine PoseMessage output at its max rate on serial port 1 (UART1) then save the change to persistent memory.

```
2e31 0000 de8f 0082 0200 a433 0000 0000
0c00 0000 0000 0000 0101 0000 0101 1027
0100 0000
```

Example 3: Set all message rates on all interfaces to their factory default values.

```
2e31 0000 aa8d 150d 0200 a433 0000 0000
0c00 0000 0000 0000 ff00 0000 ff02 ffff
ff00 0000
```

Note that if FLAG_INCLUDE_DISABLED_MESSAGES is not set, only the messages already enabled will be modified.

Example 4: On UART 1, set all enabled NMEA messages that support rate control to output at 1Hz.

```
2e31 0000 a936 db31 0200 a433 0000 0000
0c00 0000 0000 0000 0101 0000 0200 ffff
0900 0000
```



3.1.12 GetMessageRate (13221)

Message ID: 13221

Protocol Version: 2

Message Version: 0

Description: Query the configuration for the requested message type on the specified interface.

Field	Data Type	Description
Interface ID	InterfaceID (u32)	The ID of the interface to be queried.
Protocol Type	ProtocolType (u8)	The message protocol to be queried. If the ALL (255) is specified, return the rate for all protocols and messages on the specified interface.
Configuration Source	ConfigurationSource (u8)	The data source to be queried.
Message ID	u16	The ID of the message type to be queried. If ALL (65535) is specified, return the rate for all supported messages for the specified protocol.

ConfigurationSource (u8):

Configuration Source	Value	Description
ACTIVE	0x0	Active configuration settings currently in use by the device.
SAVED	0x1	Settings currently saved in persistent storage.

Expected Response(s):

3.2.4 MessageRateResponse (13222)



3.2 Command Response Messages (Output)

These are messages sent by the device in response to requests or commands from the host.



3.2.1 CommandResponseMessage (13000)

Message ID: 13000

Protocol Version: 2

Message Version: 0

Description: Response to user commands.

Field	Data Type	Description
Source Sequence Number	u32	The sequence number of the command that triggered this response.
Response Code	Response (u8)	Indicates the type of the response.
Reserved	u8 [3]	<i>Reserved for future use.</i>

Response (u8) :

Response Type	Response Code
OK	0
Unsupported Message Version	1
Unsupported Feature	2
Value Error	3
Insufficient Space	4
Execution Failure	5
Inconsistent Payload Length	6
Data Corrupted	7
No Data Stored	8
Unavailable	9
Unsupported Interface	10



3.2.2 ConfigResponseMessage (13103)

Message ID: 13103

Protocol Version: 2

Message Version: 0

Description: The response to a 3.1.7 GETCONFIGMESSAGE (13101).

The Response Code field will indicate the status of the requested value. If the response is not OK, the parameter value may be omitted and the Value Length field will be 0.

If an invalid or unsupported parameter was requested, the Response Code will indicate that the parameter type is invalid or unsupported.

Field	Data Type	Description
Configuration Source	Configuration Source (u8)	The source of the parameter value (active, saved, etc.).
Active Differs From Saved	u8	1 if the active value for this parameter differs from the value saved in persistent storage. 0 if the active and saved values are the same.
Parameter Type	ConfigType (u16)	The type of parameter being returned. Will always reflect the ConfigType in the corresponding GetConfigMessage.
Response Code	Response (u8)	Indicates the status of the response on success or failure (see 3.2.1 CommandResponse (13000)).
Reserved	u8 [3]	<i>Reserved for future use.</i>
Value Length	u32	The length of the value to follow (in bytes).
Value	Variable	The current value of the requested parameter. The format of the value is listed in the ConfigType table in 3.1.6 SetConfigMessage (13100)

ConfigurationSource (u8) :

Configuration Source	Value	Description
ACTIVE	0x0	Active configuration settings currently in use by the device.
SAVED	0x1	Settings currently saved in persistent storage.



3.2.3 PlatformStorageDataMessage (13113)

Message ID: 13113

Protocol Version: 2

Message Version: 3

Description: Message for reporting platform storage data.

Field	Data Type	Description
Data Type	DataType (u8)	The type of data contained in this message.
Response	Response (u8)	The status of the specified data type on the device.
Configuration Source	ConfigurationSource (u8)	The source of the returned contents (active settings, saved, etc.). If the Data Type parameter does not distinguish between active and saved data, this will be ignored.
Flags	u8	A field describing additional details about the returned contents. The definition of this field depends on the Data Type.
Data Version	DataVersion (u16)	Version of the data contents.
Data Length	u32	The number of bytes in data contents
Value	Variable	Array of bytes for the data contents.

Flag definitions (DataType::USER_CONFIG):

Flag	Value	Description
Platform Not Specified	0	Platform type not indicated for the returned data.
POSIX Platform	1	User configuration data for FusionEngine on a POSIX platform.
Embedded Platform	2	User configuration data for FusionEngine on an embedded device.
Embedded SSR Client	3	User configuration data for Point One SSR Client on an embedded device.
SSR Client	4	User configuration data for Point One SSR Client desktop application or library.



3.2.4 MessageRateResponse (13222)

Message ID: 13222

Protocol Version: 2

Message Version: 0

Description: Response to a [3.1.12 GetMessageRate \(13221\)](#) message.

Field	Data Type	Description
Configuration Source	ConfigurationSource (u8)	The source of the parameter value (active, saved, etc.).
Response Code	Response (u8)	Indicates the type of the response.
Number of Rates	u16	The number of rates being reported in this message.
Interface ID	InterfaceID (u32)	The ID of the interface described by this message.
Rates	MessageRateResponseEntry [Number of Rates]	A repeated field containing Number of Rates entries, one for each message in the response.

3.2.7.1 Message Rate Response Entry (MessageRateResponseEntry)

Field	Data Type	Description
Protocol Type	ProtocolType (u8)	The message protocol.
Flags	u8	A bitmask of flags to modify the command (see the table below).
Message ID	u16	The ID of the message type.
Configured Rate	MessageRate (u8)	The configured output rate or on/off status.
Effective Rate	MessageRate (u8)	The actual output rate for this message, factoring in effects of additional configuration settings that may override the configured rate such as enabling diagnostic output. In general, this will be equal to the configured rate.
Reserved	u8[2]	<i>Reserved for future use.</i>

Flag bit definitions:

Flag	Bit	Value	Description
ACTIVE_DIFFERS_FROM_SAVED	0	0x01	Flag to indicate the active value for this configuration differs from the value saved to persistent memory.



Reserved	1-7		<i>Reserved for future use.</i>
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3.2.5 SupportedIOInterfacesMessage (13223)

Message ID: 13223

Protocol Version: 2

Message Version: 0

Description: List the available interfaces supported by the device.

The maximum number of each type of interface supported by a given device depends on the type of device and the FusionEngine software version. For example, a Point One Atlas device might support up to 5 configurable TCP sockets (client or server), along with other transport types, while an embedded Quectel LG69T-AP device only supports 2 fixed serial UART connections.

This message is sent in response to a 3.1.1 MessageRequest (13001) message.

Field	Data Type	Description
Number of Interfaces	u8	Number of interfaces, N, reported by this message
Reserved	u8[7]	<i>Reserved for future use.</i>
Interface Descriptions	InterfaceID[N]	Descriptions of each interface supported by the device. E.g., Serial 1, Serial 2, TCP, etc.



3.3 Navigation Solution Messages (Output)

These messages contain the navigation solution calculated by FusionEngine, along with other related information (GNSS signal tracking and usage status, etc.).



3.3.1 PoseMessage (10000)

Message ID: 10000

Protocol Version: 2

Message Version: 2

Description: Position, velocity, and attitude (orientation) solution.

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
GPS Time	Timestamp (8B)	The GPS time of the solution, if available.
Solution Type	SolutionType (u8)	The type of the position solution (see below).
Flags	u8	A bitmask of flags associated with the pose data. <i>Added in PoseMessage version 1.2.</i>
Undulation	s16	The geoid undulation at the current location in cm, defined as the height of the MSL geoid above the ellipsoid: $\text{Orthometric (MSL) Altitude} = \text{Ellipsoid Altitude} - \text{Undulation}$ where the ellipsoid altitude is in the Altitude field below. Set to -32768 if invalid. <i>Added in PoseMessage version 1.1.</i>
Latitude	f64	The geodetic latitude in degrees, expressed using the WGS-84 reference ellipsoid.
Longitude	f64	The geodetic longitude in degrees, expressed using the WGS-84 reference ellipsoid.
Altitude	f64	The geodetic altitude (height above the ellipsoid) in meters, expressed using the WGS-84 reference ellipsoid.
Position Std Dev (East)	f32	The standard deviation of the position in the East direction in meters.
Position Std Dev (North)	f32	The standard deviation of the position in the North direction in meters.
Position Std Dev (Up)	f32	The standard deviation of the position in the Up direction in meters.



Yaw	f 64	The platform yaw in degrees. Positive yaw indicates a left turn, negative yaw indicates a right turn.
Pitch	f 64	The platform pitch in degrees. Positive pitch points the nose of the vehicle down, negative pitch points the nose up.
Roll	f 64	The platform roll in degrees. Positive roll indicates a roll toward the right, negative roll is a roll to toward the left.
Yaw Std Dev	f 32	Yaw standard deviation in degrees.
Pitch Std Dev	f 32	Pitch standard deviation in degrees.
Roll Std Dev	f 32	Roll standard deviation in degrees.
Forward Velocity	f 64	Body forward velocity in meters/second. Set to NAN if body orientation information is not available.
Left Velocity	f 64	Body left velocity in meters/second. Set to NAN if body orientation information is not available.
Up Velocity	f 64	Body up velocity in meters/second. Set to NAN if body orientation information is not available.
Forward Velocity Std Dev	f 32	Forward velocity standard deviation in meters/second.
Left Velocity Std Dev	f 32	Left velocity standard deviation in meters/second.
Up Velocity Std Dev	f 32	Up velocity standard deviation in meters/second.
Aggregate Protection Level	f 32	The estimated 3D protection level in meters.
Horizontal Protection Level	f 32	The estimated 2D horizontal protection level in meters.
Vertical Protection Level	f 32	The estimated vertical level in meters.

SolutionType (u8) :

Type	Value	Description
Invalid	0x0	Invalid, no position available.
AutonomousGPS	0x1	Standalone GNSS fix, no corrections data used.
DGPS	0x2	Differential GNSS pseudorange solution using a local RTK base station, SSR corrections data, or SBAS corrections data.
Reserved	0x3	<i>Reserved for future use.</i>
RTK Fixed	0x4	GNSS RTK solution with fixed integer carrier phase ambiguities (most accurate position solution).



RTK Float	0x5	GNSS RTK solution with floating point carrier phase ambiguities.
Integrate	0x6	Dead reckoned position, computed by integrating IMU data or an internal motion model.
Reserved	0x7-0x8	<i>Reserved for future use.</i>
Visual	0x9	Position solution using vision measurement inputs.
PPP	0xA	GNSS precise point positioning (PPP) pseudorange/carrier phase solution.
Reserved	0xB-xFF	<i>Reserved for future use.</i>

Flag bit definitions:

Flag	Bit	Value	Description
STATIONARY	0	0x01	Set if the device is currently stationary.
Reserved	1-7		<i>Reserved for future use.</i>



3.3.2 GNSSInfoMessage (10001)

Message ID: 10001

Protocol Version: 2

Message Version: 1

Description: Information about the GNSS data used in the corresponding PoseMessage (10000).

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
GPS Time	Timestamp (8B)	The GPS time of the solution.
Leap Second	u8	The current UTC leap second (offset between UTC and GPS time), if known. Set to 0xFF if invalid.
Number of Satellites	u8	The number of satellites used in the current position solution.
Reserved	u8 [2]	Reserved
Corrections Age	u16	The age of the most recently received GNSS corrections data (in 0.1 seconds). Set to 0xFFFF if invalid.
Baseline Distance	u16	The distance between the device and the GNSS corrections base station. Stored in units of 10 meters: $baseline_distance_m = baseline_distance * 10$ Set to 0xFFFF if invalid.
Reference Station ID	u32	The ID of the differential base station, if used. Set to 0xFFFFFFFF if invalid.
GDOP	f32	The geometric dilution of precision (GDOP).
PDOP	f32	The position dilution of precision (PDOP).
HDOP	f32	The horizontal dilution of precision (HDOP).
VDOP	f32	The vertical dilution of precision (VDOP).
GPS Time Std Dev	f32	The standard deviation of the GPS time solution (i.e., the GPS clock bias estimate) in seconds.



3.3.3 GNSSSatelliteMessage (10002)

Message ID: 10002

Protocol Version: 2

Message Version: 1

Description: Information about the individual GNSS satellites used in the corresponding PoseMessage (10000) and GNSSInfoMessage (10001).

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
GPS Time	Timestamp (8B)	The GPS time of the solution.
Number Of Satellites	u16	The total number of available satellites (N).
Reserved	u8[2]	<i>Reserved for future use.</i>
Satellite Info Entries	SatelliteInfo[N]	A repeated instance of SatelliteInfo blocks describing the satellites used in the solution.

SatelliteInfo:

Field	Data Type	Description
Satellite Type	SatelliteType (u8)	The GNSS constellation to which this satellite belongs (see Section 2.6.5)
PRN	u8	The satellite identifier (PRN).
Usage Mask	u8	A bitmask indicating how this satellite was used in the position solution (see below).
C/N0	u8	The carrier-to-noise density ratio (C/N0) for the L1 signal on the satellite in dB-Hz. Set to 0 if invalid. If the satellite is not tracking L1 (or the near-L1 equivalent signal for the constellation), but is tracking a signal on another frequency, that signal's C/N0 value will be reported.
Azimuth	f32	The azimuth of the satellite in degrees.
Elevation	f32	The elevation of the satellite in degrees.

Usage mask (u8):

Bit	Description
0	One or more signals from this satellite used in the position solution.
1-7	<i>Reserved for future use.</i>



3.3.4 PoseAux (10003)

Message ID: 10003

Protocol Version: 2

Message Version: 0

Description: Auxiliary position solution information.

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
Position Std Dev (Forward)	f32	The standard deviation of the position resolved in the vehicle body forward direction in meters.
Position Std Dev (Left)	f32	The standard deviation of the position resolved in the vehicle body left direction in meters.
Position Std Dev (Up)	f32	The standard deviation of the position resolved in the vehicle body up direction in meters.
Position Covariance	f64 [9]	The 3x3 position covariance matrix (in meters ²), resolved in the local ENU frame and stored in row-major order.
Attitude Quaternion	f64 [4]	The platform body orientation with respect to the local ENU frame, represented as a quaternion with the scale component last (x, y, z, w).
East Velocity	f64	Platform velocity in the East direction in meters/second.
North Velocity	f64	Platform velocity in the North direction in meters/second.
Up Velocity	f64	Platform velocity in the Up direction in meters/second.
East Velocity Std Dev	f32	East velocity standard deviation in meters/second.
North Velocity Std Dev	f32	North velocity standard deviation in meters/second.
Up Velocity Std Dev	f32	Up velocity standard deviation in meters/second.



3.3.5 CalibrationStatus (10004)

Message ID: 10004

Protocol Version: 2

Message Version: 1S

Description: Current device calibration status.

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
Calibration Stage	Calibration Stage (u8)	The current calibration stage (see below).
Reserved	u8 [3]	<i>Reserved for future use.</i>
Yaw Mounting Angle	f32	The estimated IMU yaw mounting angle offset in degrees.
Pitch Mounting Angle	f32	The estimated IMU pitch mounting angle offset in degrees.
Roll Mounting Angle	f32	The estimated IMU roll mounting angle offset in degrees.
Yaw Std Dev	f32	The estimated yaw mounting angle standard deviation in degrees.
Pitch Std Dev	f32	The estimated pitch mounting angle standard deviation in degrees.
Roll Std Dev	f32	The estimated roll mounting angle standard deviation in degrees.
Travel Distance	f32	The accumulated calibration travel distance in meters.
Reserved	u8 [24]	<i>Reserved for future use.</i>
State Verified	u8	1 if the navigation engine state has been verified after initialization, 0 otherwise.
Reserved	u8 [3]	<i>Reserved for future use.</i>
Gyro Bias Percent	u8	The completion percentage for IMU gyro bias estimation, stored in units of 0.5% (range [0, 200]).
Accel Bias Percent	u8	The completion percentage for IMU accelerometer bias estimation, stored in units of 0.5% (range [0, 200]).
Mounting Angle Bias Percent	u8	The completion percentage for IMU mounting angle estimation, stored in units of 0.5% (range [0, 200]).
Reserved	u8 [5]	<i>Reserved for future use.</i>



Min Travel Distance	f32	The minimum travel distance needed to complete mounting angle calibration in meters.
Max Yaw Std Dev	f32	The maximum yaw mounting angle standard deviation (in degrees), above which calibration is incomplete.
Max Pitch Std Dev	f32	The maximum pitch mounting angle standard deviation (in degrees), above which calibration is incomplete.
Max Roll Std Dev	f32	The maximum roll mounting angle standard deviation (in degrees), above which calibration is incomplete.

CalibrationStage (u8):

Stage	Value	Description
Unknown	0x0	Calibration stage not known.
Mounting Angle	0x1	Estimating IMU mounting angles.
Reserved	0x2-0xFE	<i>Reserved for future use.</i>
Done	0xFF	Calibration complete.



3.3.6 RelativeENUPosition (10005)

Message ID: 10005

Protocol Version: 2

Message Version: 0

Description: Rover position relative to a local RTK base station, expressed in the ENU frame centered at the base station.

Note: this message represents the relationship between the navigation engine's position solution and the location of a nearby RTK base station. It is not used to convey vehicle orientation measurements when using multiple GNSS antennas. See [3.6.2 RawGNSSAttitudeOutput \(11006\)](#) instead.

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
GPS Time	Timestamp (8B)	The GPS time of the solution.
Solution Type	SolutionType (u8)	The type of the position solution (see 3.3.1 Pose (10000)).
Reserved	u8[3]	<i>Reserved for future use.</i>
Reference Station ID	u32	The ID of the differential base station, if used. Set to 0xFFFFFFFF if invalid.
East Position	f64	The position offset in the East direction relative to the local base station position (in meters).
North Position	f64	The position offset in the North direction relative to the local base station position (in meters).
Up Position	f64	The position offset in the Up direction relative to the local base station position (in meters).
Position Std Dev (East)	f32	The standard deviation of the position in the East direction in meters.
Position Std Dev (North)	f32	The standard deviation of the position in the North direction in meters.
Position Std Dev (Up)	f32	The standard deviation of the position in the Up direction in meters.



3.3.7 GNSSSignalsMessage (10006)

Message ID: 10006

Protocol Version: 2

Message Version: 1

Description: Information about the individual GNSS satellites and signals used in the corresponding PoseMessage (10000) and GNSSInfoMessage (10001).

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
GPS Time	Timestamp (8B)	The GPS time of the solution.
GPS TOW	u32	The approximate GPS time of week in ms.
GPS Week	u16	The GPS week number.
Number Of Signals	u16	The total number of available signals (S).
Number Of Satellites	u8	The total number of available satellites (N).
Reserved	u8 [7]	<i>Reserved for future use.</i>
Satellite Info Entries	GNSSSatelliteInfo [N]	A repeated instance of GNSSSatelliteInfo blocks describing the satellites used in the solution.
Signal Info Entries	GNSSSignalInfo [S]	A repeated instance of GNSSSignalInfo blocks describing the satellites used in the solution.

GNSSSatelliteInfo:

Field	Data Type	Description
Satellite Type	SatelliteType (u8)	The GNSS constellation to which this satellite belongs (see Section 2.6.5)
PRN	u8	The satellite identifier (PRN).
Status Flags	u8	A bitmask indicating how this satellite was used and what information was available for it (see below).
Reserved	u8 [1]	<i>Reserved for future use.</i>
Elevation	i16	The elevation of the satellite [-90,90] in hundredths of a degree (0.01 deg). Set to -128 if invalid.
Azimuth	u16	The azimuth of the satellite [0,359] in hundredths of a degree (0.01 deg). Set to 0xFFFF if invalid.



Satellite status flags (u8):

Bit	Value	Description
0	0x01	Satellite is used in the position solution.
1	0x02	Satellite is reported as unhealthy.
2	0x04	Satellite is non-line-of-sight.
3	0x08	<i>Reserved for future use.</i>
4	0x10	Satellite has ephemeris data available.
5	0x20	Satellite has SBAS corrections available.
6-7	0x04-0x08	<i>Reserved for future use.</i>

GNSSSignalInfo:

Field	Data Type	Description
Signal Type	GNSSSignalType (u16)	The type of signal being reported.
PRN	u8	The satellite identifier (PRN).
C/N0	u8	The carrier-to-noise density ratio (C/N0). Set to 0 if invalid. Stored in units of 0.25 dB-Hz. The range of this field is 0.25-63.75 dB-Hz. Values outside of this range will be clipped to the min/max values.
Status Flags	u16	A bitmask indicating how this signal was used and what information was available for it (see below).
Reserved	u8 [2]	<i>Reserved for future use.</i>

Signal status flags (u16):

Bit	Value	Description
0	0x0001	Pseudorange measurements from this signal were used in the position solution.
1	0x0002	Doppler measurements from this signal were used in the position solution.
2	0x0004	Carrier phase measurements from this signal were used in the position solution.
3	0x0008	Carrier phase integer ambiguity was resolved for this signal.
4	0x0010	Signal has valid pseudorange measurements.
5	0x0020	Signal has valid Doppler measurements.
6	0x0040	Signal has valid carrier phase measurements. Implies tracking loop is phase-locked and half-cycle data symbol phase ambiguity has been resolved.



7	0x0080	<i>Reserved for future use.</i>
8	0x0100	Signal has RTK corrections available.
9	0x0200	Signal has SBAS corrections available.
10	0x0400	Signal has ephemeris data available.
11-15	0x0800-0x8000	<i>Reserved for future use.</i>



3.4 Corrected Sensor Measurement Output Messages

These are the primary sensor outputs that are compensated, calibrated, and filtered outputs of the system. In general these are the best outputs to use for upstream processing. For raw (uncorrected) measurements, see Section 3.6.



3.4.1 IMUOutput (11000)

Message ID: 11000

Protocol Version: 2

Message Version: 0

Description: Corrected IMU measurement data.

The data contained in this message has been corrected for estimated accelerometer and gyro errors, including biases and scale factors, and has been rotated into the vehicle body frame from the original IMU orientation.

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
X Acceleration	f64	The vehicle X acceleration in meters/second ² .
Y Acceleration	f64	The vehicle Y acceleration in meters/second ² .
Z Acceleration	f64	The vehicle Z acceleration in meters/second ² .
X Acceleration Std Dev	f64	The standard deviation of X acceleration in meters/second ² .
Y Acceleration Std Dev	f64	The standard deviation of Y acceleration in meters/second ² .
Z Acceleration Std Dev	f64	The standard deviation of Z acceleration in meters/second ² .
X Rotation Rate	f64	The vehicle X axis gyroscope rate of rotation in radians/second.
Y Rotation Rate	f64	The vehicle Y axis gyroscope rate of rotation in radians/second.
Z Rotation Rate	f64	The vehicle Z axis gyroscope rate of rotation in radians/second.
X Rotation Std Dev	f64	The standard deviation of the X rate of rotation in radians/second.
Y Rotation Std Dev	f64	The standard deviation of the Y rate of rotation in radians/second.
Z Rotation Std Dev	f64	The standard deviation of the Z rate of rotation in radians/second.



3.4.2 GNSSAttitudeOutput (11005)

Message ID: 11005

Protocol Version: 2

Message Version: 0

Description: Vehicle orientation measured using the relative position relationship of two or more GNSS antennas.

When lever arms are configured correctly for each antenna, the values in this message will be corrected to account for the angular offset between the two antennas such that the reported yaw, pitch, and roll values represent the vehicle body. If the antennas are not installed inline with the vehicle +X axis and lever arms are not configured, the reported yaw, pitch, and roll values will not reflect the orientation of the vehicle. See GNSS Lever Arm and GNSS Aux Lever Arm in [3.1.6 SetConfigMessage \(13100\)](#).

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Solution Type	SolutionType (u8)	Invalid: Heading not available RTKFixed: Heading available See section 3.3.1 PoseMessage (10000).
Reserved	u8[3]	<i>Reserved for future use.</i>
Flags	u8	A bitmask of flags associated with the solution.
Yaw	f32	The measured yaw angle (in degrees).
Pitch	f32	The measured pitch angle (in degrees).
Roll	f32	The measured roll angle (in degrees).
Yaw Std Dev	f32	Yaw standard deviation (in degrees).
Pitch Std Dev	f32	Pitch standard deviation (in degrees).
Roll Std Dev	f32	Roll standard deviation (in degrees).
Baseline Distance	f32	The distance between the primary and secondary antennas (in m). Set to NaN if unavailable.
Baseline Std Dev	f32	The standard deviation of the baseline distance (in m).

Flag bit definitions:

Flag	Bit	Value	Description
Reserved	0-7		<i>Reserved for future use.</i>



3.4.3 WheelSpeedOutput (11135)

Message ID: 11135

Protocol Version: 2

Message Version: 0

Description: This message is an output from the device that contains the speed of each individual wheel, after applying any estimated corrections (wheel scale factor, sign, etc).

Wheel odometry may be received via a software input from a host machine, a vehicle CAN bus, or a hardware voltage signal (wheel ticks). The Data Source field indicates which type of data source was provided to the system.

Note: When odometry is provided using hardware wheel ticks, the output rate of this message may differ from the wheel tick input rate. For higher accuracy applications, FusionEngine may integrate tick counts over longer time intervals to improve performance.

Field	Data Type	Description
P1 Time	Timestamp (8B)	P1 Time corresponding to the sensor measurement.
Sensor Data Source	SensorDataSource (u8)	The source of the incoming data, if known.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Flags	u8	Bitmask of flags associated with measurement data.
Reserved	u8	<i>Reserved for future use.</i>
Front Left Speed	f32	The front left wheel speed (in m/s). Set to NaN if unavailable.
Front Right Speed	f32	The front right wheel speed (in m/s). Set to NaN if unavailable.
Rear Left Speed	f32	The rear left wheel speed (in m/s). Set to NaN if unavailable.
Rear Right Speed	f32	The rear right wheel speed (in m/s). Set to NaN if unavailable.

Flag bit definitions:

Flag	Bit	Value	Description
SIGNED	0	0x01	Set to 1 if the speed values are signed (positive forward), 0 if unsigned.
Reserved	1-7		<i>Reserved for future use.</i>



3.4.4 VehicleSpeedOutput (11136)

Message ID: 11136

Protocol Version: 2

Message Version: 0

Description: This message is an output from the device that contains along-track speed of the vehicle (forward or backward) and applying any estimated corrections (scale factor, etc).

Odometry data may be received via software input from a host machine, a vehicle CAN bus, or a hardware voltage signal (encoder ticks). Data Source will indicate the data source providing the odometry measurements.

Note: When odometry is provided using hardware wheel ticks, the output rate of this message may differ from the wheel tick input rate. For higher accuracy applications, FusionEngine may integrate tick counts over longer time intervals to improve performance.

Field	Data Type	Description
P1 Time	Timestamp (8B)	P1 Time corresponding to the sensor measurement.
Sensor Data Source	SensorDataSource (u8)	The source of the incoming data, if known.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Flags	u8	Bitmask of flags associated with measurement data.
Reserved	u8	<i>Reserved for future use.</i>
Vehicle Speed	f32	Vehicle body velocity (in m/s). Set to NaN if unavailable.

Flag bit definitions:

Flag	Bit	Value	Description
SIGNED	0	0x01	Set to 1 if the speed value is signed (positive forward), 0 if unsigned.
Reserved	1-7		<i>Reserved for future use.</i>



3.5 Sensor Measurement Input Messages

For various sensor types, it is possible to send externally captured measurements to the device through software using defined FusionEngine measurement input messages. For example, a vehicle may measure wheel speed on an external processor and send the measurements to the FusionEngine device using a WheelSpeedInput message. Note that this is separate from the FusionEngine device capturing wheel tick voltage pulses in hardware or decoding incoming CAN data on its own.

In order to use software sensor measurements, you must set the corresponding configuration in the 3.1.6 SetConfigMessage (13100).

Software Wheel Speed Support

FusionEngine supports integration of several types of vehicle speed information to improve dead reckoning and navigation performance.

Wheel **speeds** are defined as rate sensors that have an indication of the velocity of each wheel. Wheel **ticks** are defined as counters that increment a fixed amount per rotation of the wheel, commonly found on anti-lock braking systems.

Vehicle messages are used to convey a single speed or tick value, indicating the forward velocity of the vehicle. **Wheel** messages are used to convey measurements for each individual wheel.

For best performance, we recommend differential rear wheel speed or tick data (e.g., left and right rear wheels) and vehicle gear position.

Only one type of speed or tick measurement should be provided to the device at a time.



3.5.1 IMUInput (11004)

Message ID: 11004

Protocol Version: 2

Message Version: 0

Description: Used to convey raw IMU measurements. See 3.1.5 SetConfigMessage (13100).

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Reserved	u8 [6]	<i>Reserved for future use.</i>
Temperature	i16	The IMU temperature (in deg Celsius * 2e-7). Set to 0x7FFF if invalid.
X Acceleration	i32	The vehicle X acceleration in m/s ² * 2e-16. Set to 0x7FFFFFFF if invalid.
Y Acceleration	i32	The vehicle Y acceleration in m/s ² * 2e-16. Set to 0x7FFFFFFF if invalid.
Z Acceleration	i32	The vehicle Z acceleration in m/s ² * 2e-16. Set to 0x7FFFFFFF if invalid.
X Rotation Rate	i32	The vehicle X rotation rate in radians/s * 2e-20. Set to 0x7FFFFFFF if invalid.
Y Rotation Rate	i32	The vehicle Y rotation rate in radians/s * 2e-20. Set to 0x7FFFFFFF if invalid.
Z Rotation Rate	i32	The vehicle Z rotation rate in radians/s * 2e-20. Set to 0x7FFFFFFF if invalid.



3.5.2 ExternalPoseInput (11007)

Message ID: 11007

Protocol Version: 2

Message Version: 0

Description: This message contains position, velocity, and orientation inputs supplied by an external source/user. Each component is optional. When available, these values will be used by the navigation engine as needed to bootstrap initialization, and may be used to augment the navigation solution depending on the device configuration.

The message must reflect the position and orientation of the configured output location on the vehicle.

If the navigation engine is already initialized, this message may be ignored. To reset the engine and use this message for initialization, set the `FLAG_RESET_POSITION_DATA` flag.

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Solution Type	SolutionType (u8)	The type of pose solution. See section 3.3.1 PoseMessage (10000).
Reserved	u8 [3]	<i>Reserved for future use.</i>
Flags	u32	A bitmask of flags associated with the solution.
ECEF Position	f64 [3]	The ECEF position corresponding to the output lever arm on the receiving device (in meters).
ECEF Position Std Dev	f32 [3]	The standard deviation of the ECEF position (in meters).
Yaw/Pitch/Roll	f32 [3]	The Euler angles in the local ENU frame (in degrees).
Yaw/Pitch/Roll Std Dev	f32 [3]	The standard deviation of the Euler angles (in degrees).
ENU Velocity	f32 [3]	The local tangent East/North/Up velocity (in meters/second).
ENU Velocity Std Dev	f32 [3]	The standard deviation of the East/North/Up velocity (in meters/second).

Flag bit definitions:

Flag	Bit	Value	Description
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FLAG_RESET_POSITION_DATA	0	0x00000001	Reset the navigation engine position, velocity, and orientation estimates.
Reserved	1-31		<i>Reserved for future use.</i>



3.5.3 WheelTickInput (11103)

Message ID: 11103

Protocol Version: 2

Message Version: 0

Description: Conveys the wheel encoder tick counts for one or more wheels. The number and type of wheels expected, and the interpretation of the tick count values varies by vehicle. You must configure vehicle dimensions and a description of the sensor configuration (number of wheels, etc.). See 3.1.5 SetConfigMessage (13100).

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Front Left Tick Count	u32	The front left wheel tick count.
Front Right Tick Count	u32	The front right wheel tick count.
Rear Left Tick Count	u32	The rear left wheel tick count.
Rear Right Tick Count	u32	The rear right wheel tick count.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Reserved	u8 [3]	<i>Reserved for future use.</i>



3.5.4 VehicleTickInput(11104)

Message ID: 11104

Protocol Version: 2

Message Version: 0

Description: A single wheel encoder tick count that corresponds to forward vehicle movement. You must configure a description of the sensor configuration (tick rollover value, etc.). See SetConfigMessage (13100).

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Tick Count	u32	The current encoder tick count.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Reserved	u8[3]	<i>Reserved for future use.</i>



3.5.5 WheelSpeedInput (11105)

Message ID: 11105

Protocol Version: 2

Message Version: 0

Description: Used to convey the speed of each individual wheel on the vehicle. The number and type of wheels expected varies by vehicle. You must configure a description of the sensor configuration in SetConfigMessage (13100).

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Front Left Speed	i32	The front left wheel speed (in m/s * 2 ⁻¹⁰). Set to 0x7FFFFFFF if unavailable.
Front Right Speed	i32	The front right wheel speed (in m/s * 2 ⁻¹⁰). Set to 0x7FFFFFFF if unavailable.
Rear Left Speed	i32	The rear left wheel speed (in m/s * 2 ⁻¹⁰). Set to 0x7FFFFFFF if unavailable.
Rear Right Speed	i32	The rear right wheel speed (in m/s * 2 ⁻¹⁰). Set to 0x7FFFFFFF if unavailable.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Flags	u8	A bitmask of flags associated with the measurement data.
Reserved	u8[2]	<i>Reserved for future use.</i>

Flag bit definitions:

Flag	Bit	Value	Description
SIGNED	0	0x01	Set to 1 if the speed values are signed (positive forward), 0 if unsigned.
Reserved	1-7		<i>Reserved for future use.</i>



3.5.6 VehicleSpeedInput (11106)

Message ID: 11106

Protocol Version: 2

Message Version: 0

Description: A single number (usually an average of the non-steered wheels) that corresponds to forward vehicle velocity. Note that only using a single wheel as “vehicle speed” can result in suboptimal performance while the vehicle is turning.

You must configure a description of the sensor configuration (tick rollover value, etc.). See SetConfigMessage (13100).

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Vehicle Speed	i32	The vehicle speed estimate (in m/s * 2 ⁻¹⁰). Set to 0x7FFFFFFF if unavailable.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Flags	u8	Bitmask of flags associated with measurement data.
Reserved	u8 [2]	<i>Reserved for future use.</i>

Flag bit definitions:

Flag	Bit	Value	Description
SIGNED	0	0x01	Set to 1 if the speed value is signed (positive forward), 0 if unsigned.
Reserved	1-7		<i>Reserved for future use.</i>



3.6 Raw (Uncorrected) Sensor Measurement Output Messages

Raw outputs are available for offboard processing. These messages are *not* compensated for any offset or calibration. The only additional processing is the calculation of the P1 Time, which is populated in the message's MeasurementDetails structure.



3.6.1 RawIMUOutput (11002)

Message ID: 11002

Protocol Version: 2

Message Version: 0

Description: Raw IMU measurement data.

This message is an output from the device containing raw IMU acceleration and rotation rate measurements. These measurements come directly from the sensor and do not have any corrections, calibration, or rotations applied.

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Reserved	u8[6]	Reserved for future use.
Temperature	i16	The IMU temperature (in Celsius * 2 ⁻⁷). Set to 0x7FFF if invalid
X Acceleration	i32	Measured x acceleration (in meters/second ² * 2 ⁻¹⁶), resolved in the sensor measurement frame. Set to 0x7FFFFFFF if invalid
Y Acceleration	i32	Measured y acceleration (in meters/second ² * 2 ⁻¹⁶), resolved in the sensor measurement frame. Set to 0x7FFFFFFF if invalid
Z Acceleration	i32	Measured z acceleration (in meters/second ² * 2 ⁻¹⁶), resolved in the sensor measurement frame. Set to 0x7FFFFFFF if invalid
X Rotation Rate	i32	Measured x rate of rotation (in radians/second * 2 ⁻²⁰), resolved in the sensor measurement frame. Set to 0x7FFFFFFF if invalid.
Y Rotation Rate	i32	Measured y rate of rotation (in radians/second * 2 ⁻²⁰), resolved in the sensor measurement frame. Set to 0x7FFFFFFF if invalid.
Z Rotation Rate	i32	Measured z rate of rotation (in radians/second * 2 ⁻²⁰), resolved in the sensor measurement frame. Set to 0x7FFFFFFF if invalid.



3.6.2 RawGNSSAttitudeOutput (11006)

Message ID: 11006

Protocol Version: 2

Message Version: 0

Description: The relative position vector between two GNSS antennas in a multi-antenna device, used to measure the orientation of a vehicle. The coordinates are expressed in the local ENU reference frame.

See also [3.4.2 GNSSAttitudeOutput \(11005\)](#).

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Solution Type	SolutionType (u8)	Invalid: Heading not available RTKFixed: Heading available See section 3.3.1 PoseMessage (10000).
Reserved	u8[3]	<i>Reserved for future use.</i>
Flags	u32	A bitmask of flags associated with the solution.
Relative Position (East)	f32	The East component of the vector from the primary antenna to the secondary antenna (in meters).
Relative Position (North)	f32	The North component of the vector from the primary antenna to the secondary antenna (in meters).
Relative Position (Up)	f32	The Up component of the vector from the primary antenna to the secondary antenna (in meters).
Position Std Dev (East)	f32	The standard deviation of the position in the East direction in meters.
Position Std Dev (North)	f32	The standard deviation of the position in the North direction in meters.
Position Std Dev (Up)	f32	The standard deviation of the position in the Up direction in meters.

Flag bit definitions:

Flag	Bit	Value	Description
Reserved	0-7		<i>Reserved for future use.</i>



3.6.3 RawWheelTickOutput (11123)

Message ID: 11123

Protocol Version: 2

Message Version: 0

Description: This message is an output from the device that contains wheel encoder tick counts for each individual wheel on the vehicle. These measurements come directly from the sensor, and do not have any corrections or calibration applied.

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Front Left Tick Count	u32	The front left wheel tick count.
Front Right Tick Count	u32	The front right wheel tick count.
Rear Left Tick Count	u32	The rear left wheel tick count.
Rear Right Tick Count	u32	The rear right wheel tick count.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Reserved	u8[3]	<i>Reserved for future use.</i>



3.6.4 RawVehicleTickOutput(11124)

Message ID: 11124

Protocol Version: 2

Message Version: 0

Description: This message is an output from the device that contains a wheel encoder tick count representing the along-track speed of the vehicle (forward/backward). This value comes directly from the sensor, and does not have any corrections or calibration applied.

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Tick Count	u32	The current encoder tick count.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Reserved	u8[3]	<i>Reserved for future use.</i>



3.6.5 RawWheelSpeedOutput (11125)

Message ID: 11125

Protocol Version: 2

Message Version: 0

Description: This message is an output from the device that contains the speed of each individual wheel on the vehicle. These measurements come directly from the sensor, and do not have any corrections or calibration applied.

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Front Left Speed	i32	Front left wheel speed (in m/s * 2e-10). Set to 0x7fffffff if unavailable.
Front Right Speed	i32	Front right wheel speed (in m/s * 2e-10). Set to 0x7fffffff if unavailable.
Rear Left Speed	i32	Rear left wheel speed (in m/s * 2e-10). Set to 0x7fffffff if unavailable.
Rear Right Speed	i32	Rear right wheel speed (in m/s * 2e-10). Set to 0x7fffffff if unavailable.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Flags	u8	Bitmask of flags associated with measurement data.
Reserved	u8 [2]	<i>Reserved for future use.</i>

Flag bit definitions:

Flag	Bit	Value	Description
SIGNED	0	0x01	Set to 1 if the speed values are signed (positive forward), 0 if unsigned.
Reserved	1-7		<i>Reserved for future use.</i>



3.6.6 RawVehicleSpeedOutput (11126)

Message ID: 11126

Protocol Version: 2

Message Version: 0

Description: This message is an output from the device that contains the along-track speed of the vehicle (forward/backward). These measurements come directly from the sensor, and do not have any corrections or calibration applied.

Field	Data Type	Description
Measurement Details	MeasurementDetails (20B)	The time of applicability of the measurement data.
Vehicle Speed	i32	The vehicle speed estimate (in $m/s * 2e-10$). Set to $0x7fffffff$ if unavailable.
Gear	GearType (u8)	The transmission gear currently in use (0 if unavailable).
Flags	u8	Bitmask of flags associated with measurement data.
Reserved	u8 [2]	<i>Reserved for future use.</i>

Flag bit definitions:

Flag	Bit	Value	Description
SIGNED	0	0x01	Set to 1 if the speed value is signed (positive forward), 0 if unsigned.
Reserved	1-7		<i>Reserved for future use.</i>



3.6.7 InputDataWrapper (13120)

Message ID: 13120

Protocol Version: 2

Message Version: 0

Description: This message is used to record incoming binary data from sensors, RTK corrections streams, etc. in their native formats for diagnostic purposes.

The size of the content contained in this message, N, must be inferred from the payload length field in the [2.3 Message Header](#) as follows:

$N = \text{payload_length_bytes} - \text{sizeof}(\text{InputDataWrapper})$

Field	Data Type	Description
System Time	u40	The host device timestamp at which the data was captured (in 1e-2 seconds). This timestamp is not aligned with P1 time.
Reserved	u8 [1]	<i>Reserved for future use.</i>
Data Type	u16	An identifier for the type of data contained in this message.
Content	Variable (N)	The captured binary data.



3.7 Device Status Messages

Messages for indicating high-level device status (notifications, software version, etc.).



3.7.1 SystemStatus (10500)

Message ID: 10500

Protocol Version: 2

Message Version: 0

Description: This message describes the overall system status of the device running FusionEngine.

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the status message, expressed in the P1 time base.
GNSS Temperature	i16	The temperature of the GNSS receiver in Celsius * 2 ⁻⁷ . Set to 0x7FFF if invalid.
Reserved	u8[118]	<i>Reserved for future use.</i>



3.7.2 SSRStatus (10501)

Message ID: 10501

Protocol Version: 3

Message Version: 0

Description: This message contains the status of the GNSS State Space Representation (SSR) corrections data decoding and modeling process.

Field	Data Type	Description
System Time	i64	The current system timestamp in ns.
Reserved	u8[2]	<i>Reserved for future use.</i>
GPS Week	u16	The GPS week number.
GPS TOW	u32	The approximate GPS time of week in ns.
Output GPS Time	Timestamp (8B)	The GPS time corresponding with the most recently output corrections data.
Output Source	RTKOutputSource (u8)	The source of the most recent RTCM corrections data.
Reserved	u8	<i>Reserved for future use.</i>
Station ID	u16	The RTCM base station ID contained in the most recent corrections data. Set to 0xFFFF if invalid.
Base Latitude	f64	The base station latitude (in degrees).
Base Longitude	f64	The base station longitude (in degrees).
Base Altitude	f64	The base station altitude (in meters).
# Satellites	u8	The number of satellites present in the most recent corrections data.
# Signals	u8	The number of GNSS signals present in the most recent corrections data.
GNSS Systems	SatelliteType (u16)	A bitmask indicating which GNSS constellations are present in the generated corrections data.
GPS Signal Types	GPSSignalName (u16)	A bitmask indicating which GPS signal types are present in the generated corrections data.
GLO Signal Types	GLONASSSignalName (u16)	A bitmask indicating which GLONASS signal types are present in the generated corrections data.



GAL Signal Types	GalileoSignalName (u16)	A bitmask indicating which Galileo signal types are present in the generated corrections data.
BDS Signal Types	BeiDouSignalName (u16)	A bitmask indicating which BeiDou signal types are present in the generated corrections data.
Reserved	u8 [8]	<i>Reserved for future use.</i>
# GPS Ephemeris	u8	The number of GPS satellites for which ephemeris data is available.
# GLO Ephemeris	u8	The number of GLONASS satellites for which ephemeris data is available.
# GAL Ephemeris	u8	The number of Galileo satellites for which ephemeris data is available.
# BDS Ephemeris	u8	The number of BeiDou satellites for which ephemeris data is available.
Reserved	u8 [4]	<i>Reserved for future use.</i>
OSR Status	u16	A bitmask indicating the status of OSR corrections data from an external base station.
Reserved	u8 [2]	<i>Reserved for future use.</i>
SSR Status	u16	A bitmask indicating the status of incoming SSR corrections data.
Reserved	u8 [1]	<i>Reserved for future use.</i>
SSR Grid ID	u8	The ID of the local SSR corrections grid currently in use. Set to 0xFF if invalid.
SSR Enabled Components	SSRComponentMask (u16)	A bitmask indicating which SSR model components are enabled for the current region.
SSR Model Status	SSRComponentMask (u16)	A bitmask indicating the status of individual SSR model components: 0 = data not available/expired 1 = model data usable
SSR Decode Status	SSRComponentMask (u16)	A bitmask indicating the decoding status of incoming SSR data messages: 0 = waiting for data 1 = data received
Reserved	u8 [2]	<i>Reserved for future use.</i>

RTKOutputSource (u8) :



Name	Value	Description
None	0x0	No RTCM output available.
OSR	0x1	RTCM output received from an incoming RTK base station.
SSR	0x2	RTCM output generated using SSR model data.

RTKOutputSource (u8):

Name	Value	Description
None	0x0	No RTCM output available.
OSR	0x1	RTCM output received from an incoming RTK base station.
SSR	0x2	RTCM output generated using SSR model data.

OSR base station data status bitmask (u16):

Bit Number	Value	Description
0	0x0001	OSR corrections data available
1-15		<i>Reserved for future use.</i>

SSR model data status bitmask (u16):

Bit Number	Value	Description
0	0x0001	SSR model data ready for OSR generation
1-15		<i>Reserved for future use.</i>

SSRComponentMask (u16):

Bit Number	Value	Description
0	0x0001	SSR network metadata
1	0x0002	Grid definition
2	0x0004	Satellite group definition
3	0x0008	Geoid model data
4	0x0010	Antenna corrections data (ATX)
5	0x0020	High-rate satellite corrections data
6	0x0040	Low-rate satellite corrections data
7	0x0080	Global per-satellite ionosphere data (GSI)
8	0x0100	Gridded per-satellite ionosphere data (GRI)
9	0x0200	Gridded troposphere data (GRT)
10	0x0400	Regional per-satellite ionosphere data (RSI)
11	0x0800	Global vertical ionosphere data (GVI)
12	0x1000	Regional troposphere data (RT)
13-15		<i>Reserved for future use.</i>





3.7.3 VersionInfoMessage (13003)

Message ID: 13003

Protocol Version: 2

Message Version: 0

Description: Describes the version of the system and its subcomponents.

Note that the strings contained in this message are **not** null-terminated.

Field	Data Type	Description
System Time	i64	Current system time (in nanoseconds).
Firmware Version Length	u8	The length of the firmware string (in bytes).
Fusion Engine Version Length	u8	The length of the Fusion Engine string (in bytes).
Operating System (OS) Version Length	u8	The length of the operating system string (in bytes).
Receiver Version Length	u8	The length of the receiver string (in bytes).
Reserved	u8[4]	<i>Reserved for future use.</i>
Firmware String Description	str	ASCII string representing the firmware version.
Engine String Description	str	ASCII string representing the navigation software version (FusionEngine).
Operating System (OS) String Description	str	ASCII string representing the operating system, kernel, and/or bootloader version.
Receiver String Description	str	ASCII string representing the software version of the underlying measurement engine.
<Padding>	u8	This message will be padded to a length that is a multiple of 4 bytes.



3.7.4 EventNotificationMessage (13004)

Message ID: 13004

Protocol Version: 2

Message Version: 0

Description: Notification of a system event for logging purposes.

Note that the string contained in this message is **not** null-terminated.

Field	Data Type	Description
Event Type	EventType (u8)	The type of event that occurred.
Reserved	u8[3]	<i>Reserved for future use.</i>
System Time	i64	The system time when the event occurred (in nanoseconds).
Flags	u64	Additional flags or information associated with the event (if applicable).
Description Length	u16	The length of the event description string (in bytes).
Description	str	ASCII string description of the event. Not null-terminated.

EventType (u8):

Event Type	Value	Description
LOG	0x0	Event containing a logged message string from the device.
RESET	0x1	Event indicating a device reset occurred. The event flags will be set to the requested reset bitmask. The payload will contain a string describing the cause.
CONFIG_CHANGE	0x2	Notification that the user configuration has been changed.
COMMAND	0x3	Notification that the user performed a command (e.g., configuration request, fault injection enable/disable).
COMMAND_RESPONSE	0x4	Record containing the response to a user command. Response events are not output on the interface on which the command was received; that interface will receive the response itself.



3.7.5 DeviceIDMessage (13007)

Message ID: 13007

Protocol Version: 2

Message Version: 0

Description: Contains various device identifiers in the host device. Note: The strings are **not** null-terminated. Note that the ID fields may contain either a string (not null-terminated) or a binary value, depending on the type of device.

Field	Data Type	Description
System Time	i64	System Time in nanoseconds.
Device Type	DeviceType (u8)	The type of device responding.
HW ID Length	u8	Length of the hardware ID field (in bytes).
User ID Length	u8	Length of the User ID field (in bytes).
GNSS ID Length	u8	Length of the GNSS ID field (in bytes).
Reserved	u8[4]	<i>Reserved for future use.</i>
HW ID	u8[x]	The value of the hardware ID. The length of this string is defined by the HW ID Length parameter.
User ID	u8[y]	The value of the User ID. The length of this string is defined by the User ID Length parameter.
GNSS ID	u8[z]	The value of the GNSS ID. The length of this string is defined by the GNSS ID Length parameter.

DeviceType (u8):

Response Type	Response Code
Unknown	0
Point One Atlas	1
Quectel LG69T-AM	2
Quectel LG69T-AP	3
Quectel LG69T-AH	4
Nexar Beam2K	5
Point One Embedded SSR Client	6
Point One Desktop SSR Client	7



3.8 GNSS Corrections Messages

Messages containing GNSS corrections data or details.



3.8.1 LBandFrameMessage

Message ID: 14000

Protocol Version: 2

Message Version: 0

Description: L-band user data frame contents.

Field	Data Type	Description
System Time	i64	The system time when the frame was received in nanoseconds. Note: this time is not synchronized to other P1 systems or GNSS.
User Data Size	u16	Number of bytes in this data payload.
Bit Error Count	u16	Count of bit errors found in the data frame.
Signal Power	u8	Power of the signal in decibels.
Reserved	u8 [3]	<i>Reserved for future use.</i>
Doppler Offset	f32	The offset from the center frequency in hertz. This includes effects from user motion, receiver clock, and satellite clock errors.
Value	<i>Variable</i>	The beginning of the demodulated L-band frame data.



3.9 ROS Support

The messages defined in this file are intended to be translated into their corresponding ROS message structures where ROS integration is needed.

Note: The messages defined here are not guaranteed to be byte-compatible with ROS messages. They are designed to have the same or similar content, which can be easily copied into a ROS message.



3.9.1 ROSPose (12000)

Message ID: 12000

Protocol Version: 2

Message Version: 0

Description: Position, velocity, and attitude (orientation) solution, in ROS Pose message format.

Note that this message is designed to be easily convertible to a ROS Pose message, but cannot be directly cast into a ROS Pose object.

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
East Position	f64	The position offset in the East direction relative to the first valid ROS Pose (in meters).
North Position	f64	The position offset in the North direction relative to the first valid ROS Pose (in meters).
Up Position	f64	The position offset in the Up direction relative to the first valid ROS Pose (in meters).
Attitude Quaternion	f64 [4]	The platform body orientation with respect to the local ENU frame, represented as a quaternion with the scale component last (x, y, z, w).



3.9.2 ROSGPSFix (12010)

Message ID: 12010

Protocol Version: 2

Message Version: 0

Description: Information about the position, altitude, and error in the ROS GPSFix message format.

Note that this message is designed to be easily convertible to a ROS GPSFix message, but cannot be directly cast into a ROS GPSFix object.

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
Latitude	f 64	The geodetic latitude in degrees, expressed using the WGS-84 reference ellipsoid.
Longitude	f 64	The geodetic longitude in degrees, expressed using the WGS-84 reference ellipsoid.
Altitude	f 64	The geodetic altitude (height above the ellipsoid) in meters, expressed using the WGS-84 reference ellipsoid.
Track Angle	f 64	The vehicle direction from north in degrees.
Vehicle Speed	f 64	The vehicle ground speed in meters/second.
Climb Speed	f 64	The vehicle vertical speed in meters/second.
Pitch	f 64	<i>Not current supported.</i>
Roll	f 64	<i>Not current supported.</i>
Dip	f 64	<i>Not current supported.</i>
GPS Time	Timestamp (8B)	The GPS time of the solution, if available.
GDOP	f 64	The geometric dilution of precision (GDOP).
PDOP	f 64	The position dilution of precision (PDOP).
HDOP	f 64	The horizontal dilution of precision (HDOP).
VDOP	f 64	The vertical dilution of precision (VDOP).
TDOP	f 64	The time dilution of precision (TDOP).
3D Error	f 64	The spherical position uncertainty in meters.
Horizontal Error	f 64	The horizontal position uncertainty in meters.
Vertical Error	f 64	The vertical position uncertainty in meters.
Track Error	f 64	The track uncertainty in meters.
Vehicle Speed Error	f 64	The vehicle ground speed uncertainty in meters/second
Climb Speed Error	f 64	The vehicle vertical speed uncertainty in meters/second.



Time Error	f 64	The time uncertainty in seconds.
Pitch Error	f 64	The platform pitch uncertainty in degrees.
Roll Error	f 64	The platform roll uncertainty in degrees.
Dip Error	f 64	The platform dip uncertainty in degrees.
Position Covariance	f 64 [9]	The 3x3 position covariance matrix (in meters ²), resolved in the local ENU frame and stored in row-major order.
Position Covariance Type	u8	The method in which position covariance was populated (see below).
Reserved	u8 [3]	<i>Reserved for future use.</i>

CovarianceType (u8):

Type	Value	Description
Unknown	0x0	Position covariance is unknown.
Approximated	0x1	Position covariance entries are approximate.
Diagonal Known	0x2	Position covariance diagonal entries are known.
Known	0x3	Position covariance is known.
Reserved	0x4-0xFF	<i>Reserved.</i>



3.9.3 ROSIMUMessage (12011)

Message ID: 12011

Protocol Version: 2

Message Version: 0

Description: Corrected IMU measurement data in the ROS IMU message format. This data is an output from the system. It cannot be used to send IMU measurements to a FusionEngine device.

Note that this message is designed to be easily convertible to a ROS IMU message, but cannot be directly cast into a ROS IMU object.

The data contained in this message has been corrected for estimated accelerometer and gyro errors, including biases and scale factors, and has been rotated into the vehicle body frame from the original IMU orientation.

See http://docs.ros.org/api/sensor_msgs/html/msg/Imu.html for the related ROS message definition.

Field	Data Type	Description
P1 Time	Timestamp (8B)	The time of the solution, expressed in the P1 time base.
Orientation	f64 [4]	The platform body orientation with respect to the local ENU frame, represented as a quaternion with the scale component last (x, y, z, w).
Orientation Covariance	f64 [9]	The orientation covariance in row-major format about the X, Y, Z axes. Per the ROS IMU message specification: - If the a value is known but its covariance is not, its covariance matrix will be set to 0.0 - If a value is not known or not available, its covariance matrix will be set to -1.0 - The value itself will be set to `NAN`, as this is not specified in the ROS message definition Note that the ROS IMU message does not use `NAN` in the covariance matrix to represent either data or covariance not known.
X Rotation Rate	f64	The vehicle X axis gyroscope rate of rotation in radians/second.



Y Rotation Rate	f64	The vehicle Y axis gyroscope rate of rotation in radians/second.
Z Rotation Rate	f64	The vehicle Z axis gyroscope rate of rotation in radians/second.
Angular Velocity Covariance	f64 [9]	The vehicle X/Y/Z gyroscope rate of rotation covariance matrix. Each value set to -1.0 if not available.
X Acceleration	f64	The vehicle X acceleration in meters/second ² .
Y Acceleration	f64	The vehicle Y acceleration in meters/second ² .
Z Acceleration	f64	The vehicle Z acceleration in meters/second ² .
Acceleration Covariance	f64 [9]	The vehicle X/Y/Z acceleration covariance matrix. Each value set to -1.0 if not available.



3.10 Platform-Specific Messages

This section describes proprietary messages that are designed for use with specific devices, platforms, or hardware, and do not apply to all FusionEngine devices.



3.10.1 STA5635Command (14100)

Message ID: 14100

Protocol Version: 2

Message Version: 0

Description: Send a command to an attached STMicroelectronics STA5635 RF front-end.

See the STA5635 data sheet for available command, address, and data values.

Field	Data Type	Description
Command	u8	The STA5635 command code to be issued.
Address	u8	The address of the STA5635 register to be accessed.
Data	u8 [2]	The value to be sent to the device, where data[0] contains the MSB.



3.10.2 STA5635CommandResponse (14101)

Message ID: 14101

Protocol Version: 2

Message Version: 0

Description: Result from an STMicroelectronics STA5635 RF front-end sent in response to a [3.10.1 STA5635Command \(14100\)](#).

Field	Data Type	Description
System Time	i64	The system time when the response was received (in nanoseconds).
Sequence Number	u32	The address of the STA5635 register to be accessed.
Data	u8 [4]	The response from the device, where data[0] contains the first byte in the response.



3.10.3 STA5635IQData (14102)

Message ID: 14102

Protocol Version: 2

Message Version: 0

Description: IQ sample data captured by an STMicroelectronics STA5635 RF front-end.

The size of the IQ contents contained in this message, N, must be inferred from the payload length field in the [2.3 Message Header](#) as follows:

$N = \text{payload_length_bytes} - \text{sizeof}(\text{STA5635IQData})$

Field	Data Type	Description
Reserved	u8[4]	<i>Reserved for future use.</i>
Sample Data	N	The captured IQ sample data.



4 Proprietary NMEA Sentence Definitions

Point One supports a limited set of standard and proprietary NMEA-0183 messages. These messages offer a limited subset of the functionality of the FusionEngine binary protocol.



4.1 \$P1CALSTATUS

Description: Indicates the status of the internal calibration algorithm.

See also 3.3.5 CalibrationStatus (10004).

Sentence Structure

\$P1CALSTATUS,<stage>,<state_verified>,<gyro_percent_complete>,<accel_percent_complete>,<mounting_angle_percent_complete>

Field	Description
stage	Represents the current calibration stage <ul style="list-style-type: none">• 0 - Unknown/not started• 1 - Initial mounting angle convergence (performance may be slightly degraded)• 2 - Final mounting angle convergence• 255 - Done
state_verified	<ul style="list-style-type: none">• 0 - Calibration is waiting for the navigation state to be verified.• 1 - The navigation state has been verified after a hot start and calibration can proceed
gyro_percent_complete	Gyroscope correction calibration status percentage
accel_percent_complete	Accelerometer correction calibration status percentage
mounting_angle_percent_complete	IMU mounting angle correction completion percentage



4.2 \$P1MSG

Description: Notification of a system event for logging purposes.

See also 3.7.4 EventNotificationMessage (13004).

Sentence Structure

\$P1MSG,<system time ns>,<severity>,<message>

Field	Description
system_time_ns	The system/OS time when the message was generated.
severity	A number indicating the severity of the message. Lower numbers are more severe.
message	An ASCII string containing the message.



4.3 \$PQTMGNSS

Description: Quectel proprietary message to output information regarding GNSS.

Sentence Structure

\$PQTMGNSS, <TBD>

Field	Description
TBD	TBD



4.4 \$PQTMVER

Description: Quectel proprietary message to indicate the version of the software.

See also 3.7.3 VersionInfoMessage (13003).

Sentence Structure

\$PQTMVER, <TBD>

Field	Description
TBD	TBD



4.5 \$PQTMVERNO

Description: Quectel proprietary message to indicate the version of the software.

See also 3.7.3 VersionInfoMessage (13003).

Sentence Structure

\$PQTMVERNO, <TBD>

Field	Description
TBD	TBD



Appendix A. Document Version History

Version 0.25 (2026-3-13)

Compatibility with FusionEngine Protocol Release v1.26.0

- Added new ExternalPoseInput message
- Corrected TCP TransportType enum value

Version 0.24 (2026-1-15)

Compatibility with FusionEngine Protocol Release v1.25.0

- Added new GNSSSignalType and related enumerations
- Added new GNSSSignalsMessage definition
- Deprecated legacy GNSSSatelliteMessage
- Changed signal type masks in SSRStatus message to use new GNSS *SignalName enumerations

Version 0.23 (2025-8-20)

Compatibility with FusionEngine Protocol Release v1.24.0

- Corrected InputDataWrapper definition (removed incorrect flags and reserved fields)
- Clarified MessageHeader field definitions

Version 0.22 (2025-3-17)

Compatibility with FusionEngine Protocol Release v1.24.0

- Added a section describing the vehicle body axis and attitude angle definitions
- Added GNSSAttitudeOutput and RawGNSSAttitudeOutput message definitions, and removed deprecated HeadingOutput and RawHeadingOutput message definitions
- Deprecated HEADING_BIAS config type in favor of new GNSS_AUX_LEVER_ARM parameter
- Added flags field to PlatformStorageMessage to indicate user configuration data source when available
- Added type definition for NMEA-0183 ZDA messages
- Added RESET_GNSS_TIME bit definition
- Added command Response enum value for for an unsupported communication interface request
- Added flags bitmask to PoseMessage
- Added InputDataWrapper message definition
- Added STA5635 control and IQ data messages



Version 0.21 (2024-8-19)

Compatibility with FusionEngine Protocol Release v1.23.4

- Added IMUInput message definition
- Added StartupRequest message definition
- Added LBandFrame and SSRStatus message definitions
- Added ImportData, ExportData, and PlatformStorageData message definitions
- Added I/O interface ENABLED configuration parameter
- Added UNIX domain socket I/O interface support
- Added ConfigurationSource option to query default settings
- Added InterfaceConfigType definitions for enable/disable and transport direction
- Added UNIX domain socket support
- Added ionosphere model SBAS option
- Changed LBandConfig center frequency to f64, and added additional PMP configuration settings for data rate and descrambler control
- Renamed RESET_GNSS_MEASUREMENT_ENGINE ResetRequest type to REBOOT_GNSS_MEASUREMENT_ENGINE
- Added additional NMEA message types
- Added user device ID and L-band enumerations under ConfigType list
- Added additional vehicle models
- Updated SetMessageRate and GetMessageRate message definitions
- Added ResponseCode enumerations

Version 0.20 (2023-11-10)

Compatibility with FusionEngine Protocol Release v1.22.3

- Updates for wheel encoder messages
- Fixed data types for wheel encoder and velocity inputs
- Added messages for filtered velocity and wheel encoder outputs

Version 0.19 (2023-10-05)

Compatibility with FusionEngine Protocol Release v1.22.0

- Added new SupportedIOInterfaces message
- Corrected VersionInformation documentation
- Updated WheelSensorType enum values
- Correction protocol version number

Version 0.18 (2023-8-24)

Compatibility with FusionEngine Protocol Release v1.21.0



- Updated Fault Control types to include factory testing options

Version 0.17 (2023-6-9)

Compatibility with FusionEngine Protocol Release v1.18.1

- Updated ROS IMU message documentation
- Adds Heading Bias configuration
- Changed HeadingMeasurement to RawHeadingOutput (no change to struct)
- Added HeadingOutput message
- Added DeviceID message

Version 0.16 (2023-5-4)

Compatibility with FusionEngine Protocol Release v1.18.1

- Added configuration items for the troposphere and ionosphere.

Version 0.15 (2023-4-7)

Compatibility with FusionEngine Protocol Release v1.18.0

- Added leap second and GPS week rollover override configuration options
- Added UART1 Baud Rate configuration option
- Revised fields in the GNSSInfo Message to include UTC leap seconds, number of SVs, GNSS Correction age and GNSS baseline distance.
- Added MeasurementDetails definition
- Added Sensor Data Source definition for measurement inputs and outputs.
- Removed MeasurementTimestamp definition
- Removed deprecated WheelSpeed and VehicleSpeed messages
- Added RawIMUOutput, RawWheelTickOutput, RawVehicleTickOutput, RawWheelSpeedOutput, RawVehicleSpeedOutput
- Added RawWheelTickInput, RawVehicleTickInput, RawWheelSpeedInput, RawVehicleSpeedInput
- Added SystemStatus message
- Added new Diagnostic Reset functionality and modified HOT, WARM and COLD start mask definitions.
- Added Revert To Default option for configuration settings.
- Clarified definition of SaveAction in SetConfig message.

Version 0.14 (2023-3-3)

Compatibility with FusionEngine Protocol Release v1.17.0

- Added GNSS system and frequency band enable/disable settings definitions



- Clarified use of WheelConfig (software data/CAN) vs HardwareTickConfig (voltage signal)

Version 0.13 (2023-2-17)

Compatibility with FusionEngine Protocol Release v1.15.0

- Added HeadingMeasurement message definition

Version 0.12 (2022-12-6)

Compatibility with FusionEngine Protocol Release v1.13.0

- Clarified payload descriptions for SetConfig, ConfigResponse, and FaultControl messages
- Adds ROS compatible messages for ROSPose, ROSGPSFix and ROSImuMessage

Version 0.11 (2022-11-7)

Compatibility with FusionEngine Protocol Release v1.13.0

- Corrected missing reserved bytes in FaultControl definition
- Added EventNotification message definition

Version 0.10 (2022-11-4)

Compatibility with FusionEngine Protocol Release v1.13.0

- Added ALL and CURRENT TransportType enumerations
- Corrected UNSUPPORTED_VERSION response code documentation
- Added FaultControl message definition

Version 0.9 (2022-10-10)

Compatibility with FusionEngine Protocol Release v1.12.0

- Added apply-and-save flag to SetMessageRate command
- Added wildcard capabilities to SetMessageRate and GetMessageRate commands
- Removed SetOutputInterfaceConfig and GetOutputInterfaceConfig commands

Version 0.8 (2022-7-29)

Compatibility with FusionEngine Protocol Release v1.11.2

- Added watchdog enable/disable setting definition
- Added message type enumeration for NMEA-0183

Version 0.7 (2022-7-22)



Compatibility with FusionEngine Protocol Release v1.11.0

- Added Vehicle Tick Measurement definition
- Added control messages for enabling/disabling/controlling rate of individual output message types
- Changed inbound measurement timestamp definitions (MeasurementTimestamps)

Version 0.6 (2022-7-15)

Compatibility with FusionEngine Protocol Release v1.11.0

- Added WheelSpeedMeasurement, WheelTickMeasurement, and VehicleSpeedMeasurement message definitions
- Fixed missing reserved bytes in GetOutputInterfaceConfig

Version 0.5 (2022-7-11)

Compatibility with FusionEngine Protocol Release v1.10.0

- Corrected descriptions for WheelConfig, HardwareTickConfig,
- Fixed reserved bytes in SetConfig and OutputInterfaceConfigurationEntry

Version 0.4 (2022-6-22)

Compatibility with FusionEngine Protocol Release v1.10.0

- Added HardwareTickConfig configuration payload
- Compatibility with FusionEngine Release v1.10.0

Version 0.3 (2022-5-31)

Compatibility with FusionEngine Protocol Release v1.10.0

- Added RelativeENUPosition and ShutdownRequest messages
- Added reboot support to ResetRequest message

Version 0.2 (2022-5-9)

Compatibility with FusionEngine Protocol Release v1.10.0

- Added ResetRequest, SetConfig, GetConfig, and ConfigResponse message definitions.
- Added solution and measurement message definitions (Pose, PoseAux, IMUMeasurement, etc.).

Version 0.1 (2022-2-18)

Compatibility with FusionEngine Protocol Release v1.9.0

- Initial version.

