User Manual

MCOM

Data format for the efficient communication of marine navigation measurements

Measure with confidence

OXTS

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Contact details

Oxford Technical Solutions Limited

Park Farm Business Centre
Middleton Stoney
Oxfordshire
OX25 4AL
United Kingdom

Tel: +44 (0) 1869 814 253
Fax: +44 (0) 1869 251 764

Web: https://www.oxts.com
Email: support@oxts.com

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Introduction

MCOM is a data format designed by OxTS for the efficient communication of marine navigation measurements and other data. It is a very compact format and only includes core measurements, which makes it particularly suitable for inertial navigation systems.

This manual gives a description of the MCOM format so users can freely develop custom written software for specific needs and applications. As well as MCOM, we have an almost identical format called NCOM, which was developed for non-marine applications.

MCOM packet formats

The MCOM packet comprises 84 bytes that can be transmitted over Ethernet (port number 3000) or RS232 serial links. To increase efficiency, many of the data packets are sent as 24-bit signed integer words because 16-bits do not provide the range/precision required for many of the quantities, whereas 32-bit precision makes the packet much longer than required.

Important note: All words are sent in little-endian format (meaning "little-end first" or "least significant byte first" [LSB]), which is compatible with Intel microprocessors. A definition of word lengths is shown in **Error! Reference source not found.**.

Table 1: Word length definitions

Terminology	Data length
Byte (UByte)	8-bit integer (unsigned)
Short (UShort)	16-bit integer (unsigned)
Word (UWord)	24-bit integer (unsigned)
Long (ULong)	32-bit integer (unsigned)
Int64 (UInt64)	64-bit integer (unsigned)
Float	32-bit IEEE 754 floating-point
Double	64-bit IEEE 754 floating-point

Note, the U prefix indicates a value is unsigned; otherwise it is signed using 2's complement.

Two versions of the MCOM packet exist, referred to as MCOM structure-A and MCOM structure-B. Byte 21 of an MCOM packet—the navigation status byte, identifies which structure a packet employs. Structure-A packets have navigation status byte values of 0, 1, 2, 3, 4, 5, 6, 7, 10, 20, 21 or 22, and structure-B packets have navigation status byte value of 11. Packets with other navigation status bytes are reserved for future use; should they be encountered they can be discarded.

MCOM structure-A

MCOM structure-A packets are intended to be used by customers and are fully defined within this document. In MCOM structure-A packets, the navigation status (byte 21) will have a value of 0, 1, 2, 3, 4, 5, 6, 7, 10, 20, 21 or 22. The structure-A packet is defined in **Error! Not a valid bookmark self-reference.**.

Table 2. Definition of MCOM structure-A packet

Byte	Description	Notes
0	Sync	Always 0xE7
1 ⋮ 20	Batch A	Inertial output. See page 9 for a detailed description
21	Navigation status	The navigation status byte value should be 0–7, 10 or 20–22 to be valid for customer use. See page 11. A value of 11 indicates the packet follows MCOM structure-B and should be ignored.
22	Checksum 1	Checksum 1 allows the software to verify the integrity of bytes 1–21. The sync byte is ignored. In low-latency applications the inertial measurements in Batch A can be used to update a previous solution without waiting for the rest of the packet to be received. Contact Oxford Technical Solutions for source code to perform this function.

23 ⋮ 60	Batch B	Position, orientation and velocity output. See Bytes 23 to 60 of an MCOM structure-A packet are collectively called Batch B. Batch B contains measurements describing the INS position, velocity and orientation. Bytes 1 to 20 of an MCOM structure-A packet are collectively called Batch A. Batch A contains linear acceleration and angular rate measurements in the x-, y- and z-axes, as well as the time stamp for those measurements. **Error! Not a valid bookmark self-reference.** gives a detailed description of the measurements in Batch A. Table 4 gives a detailed description of the measurements in Batch B. Table 6, for a detailed description.
61	Checksum 2	Checksum 2 allows the software to verify the integrity of bytes 1–60. The sync byte is ignored. For a medium-latency output, the full navigation solution is now available without waiting for the status updates in the rest of the packet.
62 ⋮ 73	Batch C	Marine navigation output.
74	Status channel	The status channel byte identifies the status channel transmitted within Batch S.
75 ⋮ 82	Batch S	Low-rate cycling status messages. The status channel number (byte 74) defines which status messages are included in Batch S. See page 15, Table 8 for the full list.
83	Checksum 3	This is the final checksum that verifies the entire packet (bytes 1–83).

The MCOM structure-A packet is intended to be used by customers. If byte 21 (Nav. status) has a value of 11, this indicates the message uses MCOM structure-B and is intended for OxTS use only. Any packet with a Nav. status value of 11 should be ignored.

MCOM structure-B

MCOM structure-B packets are used exclusively by OxTS and are not intended for use by customers. Structure-B packets can be identified by testing the value of the navigation status (byte 21). A navigation status value of 11 indicates the packet follows structure-B, as shown in **Error! Not a valid bookmark self-reference.**.

MCOM structure-B packets are not defined within this document beyond providing the information required to identify and discard them. It is possible to prevent OxTS devices from transmitting structure-B messages over Ethernet by entering the following advance command: -udp_mcomx_0. Structure-B packets carry additional device configuration information, such as the feature table, thus disabling structure-B packets will prevent this information from being received by OxTS applications.

Table 3. Definition of MCOM structure-B packet

Byte	Description	Notes
0	Sync	Always 0xE7
1 ⋮ 20	Block A	Contents defined by Block Id
21	Nav. status	Navigation status value will be 11

22	Block Id	The Block Id number determines what information is sent in Block A and Block B. Often the 80 concatenated bytes of Block A and B will be considered as one entity
23 ⋮ 82	Block B	Contents defined by Block Id
83	Checksum 3	This is the checksum that verifies the packet

MCOM structure-B packets are not intended to be used by customers; they are used internally by OxTS. They can be disabled over Ethernet by entering the following advanced command: *-udp_mcomx_0*.

Sync byte

The first byte of an MCOM packet is the sync byte, which always has a value of 0xE8.

Note that in order to reduce the latency with RS232 serial transmissions, the sync character is transmitted at the end of the previous cycle. On the communication link there will be a pause between the transmission of the sync and next character. It is not advised to use this pause to synchronise the packet, even though the operating system should guarantee the transmission timing of the packet.

Over Ethernet the sync character is transmitted as the first character of the UDP packet.

Batch A: inertial output

Bytes 1 to 20 of an MCOM structure-A packet are collectively called Batch A. Batch A contains linear acceleration and angular rate measurements in the x-, y- and z-axes, as well as the time stamp for those measurements. **Error! Not a valid bookmark self-reference.** gives a detailed description of the measurements in Batch A.

Table 4. Batch A (inertial output) definition

Byte	Description	Notes
1–2	Time	Time is transmitted as milliseconds into the current GPS minute. The range is 0–59,999 ms
3 ⋮ 5	Acceleration x	Acceleration x is the host object’s acceleration in the x-direction (i.e. after the IMU to host attitude matrix has been applied). It is a signed word in units of 1×10^{-4} m/s^2
6 ⋮ 8	Acceleration y	Acceleration y is the host object’s acceleration in the y-direction (i.e. after the IMU to host attitude matrix has been applied). It is a signed word in units of 1×10^{-4} m/s^2
9 ⋮ 11	Acceleration z	Acceleration z is the host object’s acceleration in the z-direction (i.e. after the IMU to host attitude matrix has been applied). It is a signed word in units of 1×10^{-4} m/s^2
12 ⋮ 14	Angular rate x	Angular rate x is the host object’s angular rate about its x-axis (i.e. after the IMU to host attitude matrix has been applied). It is a signed word in units of 1×10^{-5} radians/s
15 ⋮ 17	Angular rate y	Angular rate y is the host object’s angular rate about its y-axis (i.e. after the IMU to host attitude matrix has been applied). It is a signed word in units of 1×10^{-5} radians/s
18 ⋮ 20	Angular rate z	Angular rate z is the host object’s angular rate about its z-axis (i.e. after the IMU to host attitude matrix has been applied). It is a signed word in units of 1×10^{-5} radians/s

Navigation status byte

Byte 21 of the MCOM packet is called the navigation status. The value of the navigation status byte is initially used to test the structure of the MCOM packet. If the value of the navigation status byte is 0, 1, 2, 3, 4, 5, 6, 7, 10, 20, 21 or 22 the packet format is MCOM structure-A, and can be decoded. Any other value indicates the packet should be ignored.

As well as revealing the packet structure, the navigation status byte also describes the state of inertial navigation system (INS) and when the packet was created. In the case of asynchronous MCOM packets, the value of the navigation status byte can be used to identify what triggered the packet. **Error! Not a valid bookmark self-reference.** defines the navigation status values.

For structure-A packets checksum 1 (byte 22), which immediately follows the navigation status byte, allows the measurements in Batch A, and the value of the navigation status byte, to be verified and used without waiting to receive the entire MCOM packet. This is useful in time-critical applications receiving data over RS232 as the inertial measurements can be used to update other solutions with minimal latency.

Table 5. Navigation status (byte 21) definitions

Value	Struct.	Description
0	A	All quantities in the packet are **invalid**
1	A	**Raw IMU measurements.** These are output at roughly 10 Hz before the system is initialised. They are useful for checking the communication link and verifying the operation of the accelerometers and angular rate sensors in the laboratory. In this mode *only* the accelerations and angular rates are valid, they are not calibrated or to any specification. The information in the other fields is invalid
2	A	**Initialising**. When GPS time becomes available the system starts the initialisation process. The strapdown navigator and Kalman filter are allocated, but do not yet run. Angular rates and accelerations during this time are output 1 s in arrears. There will be a 1 s pause at the start of initialisation where no output will be made (while the system fills the buffers). The system has to run 1 s in arrears at this time in order to synchronise the GNSS data with the inertial data and perform the initialisation checks During the initialising mode the time, acceleration and angular rate fields will be valid. Approximate (very inaccurate) position, velocity and angles may be output
3	A	**Locking**. The system will move to locking mode when the conditions for initialising are correct. To initialise, GPS time, position and velocity must be available; roll and pitch must be estimated (assumed approximately zero with the “vehicle level” option); heading must be estimated from forward velocity, dual antenna static initialisation or user command In locking mode the system runs in arrears but catches up by 0.1 s every 1 s; locking mode lasts 10 s. During locking mode the outputs are not real-time, but all fields are valid
4	A	**Locked**. In Locked mode the system is outputting real-time data with the specified latency guaranteed. All fields are valid
5	A	**Reserved for “unlocked” navigation output**. Do not use any values from this message
6	A	**Expired firmware**: this is output if the firmware is time limited and the expiry time has passed
7	A	**Blocked firmware**: this is output if the firmware has been blocked (by password protection)

10	A	**Status only**. Only the Batch S part of the message (Bytes 74-82) should be decoded. This is used at the start of some logged MCOM files in order to save a complete set of status messages before the real data begins
11	B	**Internal Use**. Do not use any values from this message
20	A	**Trigger packet while "initialising"** (see Navigation status 2 for more details). The Status channel (byte 74) will have a value of 24 (falling trigger), 43 (rising trigger), 65 (output trigger), 79 (falling trigger 2), 80 (rising trigger 2) or 81 (output trigger 2), depending on what triggers the packet. This packet is generated following a short variable delay (less than 0.02 s) after the corresponding navigation data output. The Time output is that of the trigger event
21	A	**Trigger packet while "locking"** (see Navigation status 2 for more details). The Status channel (byte 74) will have a value of 24 (falling trigger), 43 (rising trigger), 65 (output trigger), 79 (falling trigger 2), 80 (rising trigger 2) or 81 (output trigger 2), depending on what triggers the packet. This packet is generated following a short variable delay (less than 0.02 s) after the corresponding navigation data output. The Time output is that of the trigger event
22	A	**Trigger packet while "locked"** (see Navigation status 4 for more details). The Status channel (byte 74) will have a value of 24 (falling trigger), 43 (rising trigger), 65 (output trigger), 79 (falling trigger 2), 80 (rising trigger 2) or 81 (output trigger 2), depending on what triggers the packet. This packet is generated following a short variable delay (less than 0.02 s) after the corresponding navigation data output. The Time output is that of the trigger event. The latency of the trigger output is variable (by up to 0.02 s) due to the short variable delay
Others	A	**Reserved**: ignore any outputs which have reserved Navigation status values

Batch B: position, velocity and orientation output

Bytes 23 to 60 of an MCOM structure-A packet are collectively called Batch B. Batch B contains measurements describing the INS position, velocity and orientation. Bytes 1 to 20 of an MCOM structure-A packet are collectively called Batch A. Batch A contains linear acceleration and angular rate measurements in the x-, y- and z-axes, as well as the time stamp for those measurements. **Error! Not a valid bookmark self-reference.** gives a detailed description of the measurements in Batch A.

Table 4 gives a detailed description of the measurements in Batch B.

Table 6. Batch B (position, velocity and orientation output) definition

Byte	Quantity	Notes
23 ⋮ 30	Latitude	The Latitude of the INS. It is a double in units of radians
31 ⋮ 38	Longitude	Longitude of the INS. It is a double in units of radians
39 ⋮ 42	Altitude	Altitude of the INS. It is a float in units of metres
43 ⋮ 45	North Velocity	North velocity in units of 1×10^{-4} m/s
46 ⋮ 48	East Velocity	East velocity in units of 1×10^{-4} m/s
49 ⋮ 51	Down Velocity	Down velocity in units of 1×10^{-4} m/s
52 ⋮ 54	Heading	Heading in units of 1×10^{-6} radians. Range $\pm\pi$
55 ⋮ 57	Pitch	Pitch in units of 1×10^{-6} radians. Range $\pm\pi/2$
58 ⋮ 60	Roll	Roll in units of 1×10^{-6} radians. Range $\pm\pi$

For structure-A packets, checksum 2 (byte 61) that immediately follows the Batch B data, allows the measurements in Batch B to be verified and used without waiting to receive the entire MCOM packet. For a medium-latency output the full navigation solution is available. Only low-rate information is transmitted next. Note that checksum 2 is a continuation of checksum 1, that is, checksum 2 checks the entirety of the packet up to byte 60.

Batch C: marine navigation output

Bytes 62 to 73 of an MCOM structure-A packet are collectively called Batch C. Batch C contains an additional measurement for heave that is exclusive to the MCOM format. Table 7 gives a detailed description of Batch C.

Table 7. Batch C (marine navigation) definition

Byte	Quantity	Notes
62–63	Heave	Heave in units of 2×10^{-3} m.
64–65	Reserved	Reserved.
66–67	Counter	Cyclic packet counter for regular packets (navigation status < 10).
68	GPS status summary	GPS status summary byte Bit 0 is set when GPS position has lost lock. Bit 1 is set when GPS heading is not in an Integer mode. Bit 2 is set when a GPS heading ambiguity search is on-going. Bit 3 is set when GPS heading lock was not the result of a heading ambiguity search. Bits 4–7 are reserved.
69 ⋮ 73	Reserved	

Status channel byte

Byte 74 of an MCOM structure-A packet is referred to as the status channel byte. The value of this byte is used to identify the status messages contained within Batch S. There are so many status messages it is impossible to transmit them all in a single MCOM packet. So instead, the status messages are split into a number of groups called channels, made up of 8 bytes each—and one channel is inserted into each MCOM packet.

The value of the status channel byte defines which status message channel is contained within Batch S of a particular MCOM packet. Table 8 list the status channel values.

It is important to note that the value of the status channel byte does not increase incrementally. This is because some status channels are more important than others, and need to be transmitted more often. It is also important to note that the channel transmission order may change between software versions. However, the channel transmission list will repeat approximately once every 200 MCOM structure-A packets.

Table 8. Status channel (byte 74) definitions

Value	Status channel information within Batch S	See
0	Full time, number of satellites, position mode, velocity mode, dual antenna mode	Table 10Bytes 75 to 82 of an MCOM structure-A packet are collectively called Batch S. Batch S contains status channel information from the INS. The information transmitted in Batch S is defined by the value of the status channel byte, which defines the structure of each status channel and the information it contains. Some fields within status channels

		have special bits or values that denote ‘invalid’. The invalid values or the validity bits are noted in each table. Table 9
1	Kalman filter innovations set 1 (position, velocity, attitude)	Table 11
2	Internal information about primary GNSS receiver	Table 12
3	Position accuracy	Table 13
4	Velocity accuracy	Table 14
5	Orientation accuracy	Table 16
6	Gyro bias	Table 17
7	Accelerometer bias	Table 18
8	Gyro scale factor	Table 19
9	Gyro bias accuracy	Table 20
10	Accelerometer bias accuracy	Table 21
11	Gyro scale factor accuracy	Table 22
12	Position estimate of the primary GNSS antenna	Table 23
13	Orientation estimate of dual antenna systems	Table 24
14	Position accuracy of the primary GNSS antenna	Table 25
15	Orientation accuracy of the dual antenna systems	Table 26
16	INS to host object rotation	

		Table 27
17	Internal information about secondary GNSS receiver	Table 28
18	Internal information about inertial measurement unit (IMU)	Table 29
19	INS software version	Table 30
20	Differential correction information	Table 31
21	Disk space, size of current internal log file	Table 32
22	Internal information on timing of real-time processing	Table 33
23	System up-time, number of consecutive GNSS rejections. PTP Status	Table 34
24	Asynchronous packet triggered by falling edge of event input	Table 35
25	Reserved	–
26	Output displacement lever arm	Table 36
27	Internal information about dual antenna ambiguity searches	Table 37
28	Internal information about dual antenna ambiguity searches	Table 38
29	Initial settings defined with NAVconfig	Table 39
30	Operating system and script version information	Table 40
31	Hardware configuration information	–
32	Kalman filter innovations set 2	Table 41
33	Zero velocity lever arm	Table 42
34	Zero velocity lever arm accuracy	Table 43
35	Lateral advanced slip lever arm	Table 44
36	Lateral advanced slip lever arm accuracy	Table 45
37	Heading misalignment angle	Table 46

38	Zero velocity option settings, third serial output mode	–
39	Lateral advanced slip option settings	–
40	MCOM version Id	Table 47
41	Output baud rates. WiFI IP address	2–3 4–5 6 7 Note: The unit of the latency is 1×10^{-2} seconds. The unit of the heave period is 2×10^{-3}. Table 48
42	Heading lock options	Table 49
43	Asynchronous packet triggered by rising edge of event input	Table 35
44	Wheel speed configuration	Table 52
45	Wheel speed counts	Table 53
46	Wheel speed lever arm	Table 54
47	Wheel speed lever arm accuracy	Table 55
48	Undulation, dilution of precision (DOP) of GPS. Datum Information	Table 56
49	OmniSTAR tracking information	Table 57
50	Information sent to the command decoder	Table 58
51	Additional slip point 1 lever arm	Table 59
52	Additional slip point 2 lever arm	

		Table 59
53	Additional slip point 3 lever arm	Table 59
54	Additional slip point 4 lever arm	Table 59
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56	Information about the secondary GNSS receiver	Table 60
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59	IMU decoding status	Table 63
60	Definition of the surface angles	Table 64
61	Internal information about external GNSS receiver	Table 65
62	Information about the external GNSS receiver	Table 60
63	Angular acceleration filter settings	–
64	Hardware information and external GNSS receiver configuration	Table 66
65	Asynchronous packet triggered by camera/distance output	Table 35
66	Extended local co-ordinate definition, latitude and longitude	Table 67
67	Extended local co-ordinate definition, altitude and heading	Table 68
68	Additional slip point 5 lever arm	Table 59
69	Additional slip point 6 lever arm	Table 59
70	Additional slip point 7 lever arm	Table 59
71	Additional slip point 8 lever arm	Table 59
72	Status information	

		Table 69
73	Status information	Table 70
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75	Miscellaneous	Table 71
76	Internal information about differential corrections	Table 72
77	Differential correction configuration	Table 73
78	CAN bus status information	Table 74
79	Asynchronous packet triggered by falling edge of event input 2 (for xNAV only)	Table 35
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82	Hardware configuration information (for xNAV only)	–
83	Status information (for xNAV only)	–
84	Status information (for xNAV only)	–
85	Software version information (for ADK only)	Table 75
86	Reserved for future use (for xNAV only)	–
87	Reserved for future use	–
88	Kalman filter innovations set 3	Table 76
89	Vertical advanced slip lever arm	Table 77
90	Vertical advanced slip lever arm accuracy	Table 78
91	Pitch misalignment angle	Table 79
92	Vertical advanced slip option settings	–
93 ⋮ 255	Reserved for future use	–

Batch S: status channel definitions

Bytes 75 to 82 of an MCOM structure-A packet are collectively called Batch S. Batch S contains status channel information from the INS. The information transmitted in Batch S is defined by the value of the status channel byte, which defines the structure of each status channel and the information it contains.

Some fields within status channels have special bits or values that denote ‘invalid’. The invalid values or the validity bits are noted in each table.

Table 9. Status information, Channel 0

Byte	Format	Definition	Invalid when
0 ⋮ 3	Long	Time in minutes since GPS began (midnight, 6th January 1980)	Value < 1000
4	UByte	Total number of satellites tracked by the main GNSS receiver	Value = 255
5	UByte	Position mode of main GNSS	Value = 255
6	UByte	Velocity mode of main GNSS	Value = 255
7	UByte	Orientation mode of dual antenna systems	Value = 255

Note: For definitions of position, velocity and orientation modes see Table 10.

Table 10. Definitions of position mode, velocity mode and orientation mode

Value	Name	Definition
0	None	The GPS is not able to make this measurement
1	Search	The GPS system is solving ambiguities and searching for a valid solution
2	Doppler	The GPS measurement is based on a Doppler measurement
3	SPS	Standard Positioning Service, the GPS measurement has no additional external corrections
4	Differential	The GPS measurement used pseudo-range differential corrections
5	RTK Float	The GPS measurement used L1 carrier-phase differential corrections to give a floating ambiguity solution
6	RTK Integer	The GPS measurement used L1/L2 carrier-phase differential corrections to give an integer ambiguity solution
7	WAAS	The GPS measurement used SBAS corrections
8	OmniSTAR	The GPS measurement used OmniSTAR VBS corrections
9	OmniSTAR HP	The GPS measurement used OmniSTAR HP corrections
10	No data	No Data
11	Blanked	Blanked
12	Doppler (PP)	Doppler GPS measurement post-processed
13	SPS (PP)	SPS GPS measurement post-processed
14	Differential (PP)	Differential GPS measurement post-processed

15	RTK Float (PP)	RTK Float GPS measurement post-processed
16	RTK Integer (PP)	RTK Integer GPS measurement post-processed
17	OmniSTAR XP	The GPS measurement used OmniSTAR XP corrections
18	CDGPS	The GPS measurement used real time Canada wide DGPS service
19	Not recognised	Not recognised
20	gxDoppler	Computed by combining raw Doppler measurements
21	gxSPS	Computed by combining raw pseudo-range measurements
22	gxDifferential	Computed by combining raw pseudo-range measurements and differential corrections
23	gxFloat	Computed by combining raw pseudo-range and L1 carrier-phase measurements and differential corrections
24	gxInteger	Computed by combining raw pseudo-range and L1/L2 carrier-phase measurements and differential corrections
25	ixDoppler	Single-satellite updates from raw Doppler measurements
26	ixSPS	Single-satellite updates from raw pseudo-range measurements
27	ixDifferential	Single-satellite updates from raw pseudo-range measurements and differential corrections
28	ixFloat	Single-satellite updates from raw pseudo-range and L1 carrier-phase measurements and differential corrections
29	ixInteger	Single-satellite updates from raw pseudo-range and L1/L2 carrier-phase measurements and differential corrections
30	PPP converging	Converging PPP (Precise Point Positioning) from global PPP corrections
31	PPP	Converged PPP (Precise Point Positioning) from global PPP corrections
32	Unknown	Unknown
33 ⋮ 255		Reserved

Table 11. Status information, Channel 1

Byte	Format	Definition	Valid when
0	Byte	Bits 1–7: Position x innovation	Bit 0 = 1
1	Byte	Bits 1–7: Position y innovation	Bit 0 = 1
2	Byte	Bits 1–7: Position z innovation	Bit 0 = 1
3	Byte	Bits 1–7: Velocity x innovation	Bit 0 = 1
4	Byte	Bits 1–7: Velocity y innovation	Bit 0 = 1
5	Byte	Bits 1–7: Velocity z innovation	Bit 0 = 1
6	Byte	Bits 1–7: Orientation pitch innovation	Bit 0 = 1
7	Byte	Bits 1–7: Orientation heading innovation	Bit 0 = 1

Note: The innovations are always expressed as a proportion of the current accuracy. Units are 0.1 σ. As a general rule, innovations below 1.0σ are good; innovations above 1.0σ are poor. Usually it is best to filter the square of the innovations and display the square root of the filtered value.

Note 2: If the orientation pitch innovation and/or the orientation heading innovation are always much higher than 1.0 σ then it is likely that the system or the antennas have changed orientation in the vehicle. (Or the environment is too poor to use the dual antenna system).

Table 12. Status information, Channel 2

Byte	Format	Definition
0–1	UShort	Characters received from the primary GNSS receiver by the navigation computer
2–3	UShort	Packets received from the primary GNSS receiver by the navigation computer
4–5	UShort	Characters received from the primary GNSS receiver by the navigation computer, but not understood by the decoder
6–7	UShort	Packets received from the primary GNSS receiver by the navigation computer that could not be used to update the Kalman filter (e.g. too old)

Note: These counters are cyclic and will wrap when they exceed the limit of the format used.

Table 13. Status information, Channel 3

Byte	Format	Definition	Valid when
0–1	UShort	North position accuracy	Age < 150
2–3	UShort	East position accuracy	Age < 150
4–5	UShort	Down position accuracy	Age < 150
6	UByte	Age	
7	UByte	ABD robot UMAC interface status byte	Value ≠ 0xFF

Note: The units of the position accuracies are 1 mm.

Table 14. Status information, Channel 4

Byte	Format	Definition	Valid when
0–1	UShort	North velocity accuracy	Age < 150
2–3	UShort	East velocity accuracy	Age < 150
4–5	UShort	Down velocity accuracy	Age < 150
6	UByte	Age	Always
7	UByte	Processing method used by Blended (Table 15)	Always

Note: The units of the velocity accuracies are 1 mm/s.

Table 15. Definitions of Blended processing methods

Value	Name	Definition
0	Invalid	Invalid
1	Real-time	Generated in real-time by firmware
2	Simulated	Post-process simulation of real-time blending chronological constraints
3	Post-process forward	Post-processed in forward time direction

4	Post-process backward	Post-processed in backward time direction
5	Post-process combined	Post-processed combination of forward and backward processing results
6	Unknown	Unknown
7 ⋮ 255		Reserved

Table 16. Status information, Channel 5

Byte	Format	Definition	Valid when
0–1	UShort	Heading accuracy	Age < 150
2–3	UShort	Pitch accuracy	Age < 150
4–5	UShort	Roll accuracy	Age < 150
6	UByte	Age	Always
7		Reserved	N/A

Note: The units of the orientation accuracies are 1×10^{-5} radians.

Table 17. Status information, Channel 6

Byte	Format	Definition	Valid when
0–1	Short	Gyro bias x	Age < 150
2–3	Short	Gyro bias y	Age < 150
4–5	Short	Gyro bias z	Age < 150
6	UByte	Age	
7	UByte	Bits 0–3: number of L1 GPS measurements decoded by primary receiver Bits 4–7: number of L2 GPS measurements decoded by primary receiver	Value ≠ 0xF

Note: The units of the gyro biases are 5×10^{-6} radians/s.

Table 18. Status information, Channel 7

Byte	Format	Definition	Valid when
0–1	Short	Accelerometer bias x	Age < 150
2–3	Short	Accelerometer bias y	Age < 150
4–5	Short	Accelerometer bias z	Age < 150
6	UByte	Age	Always
7	UByte	Bits 0–3: number of L1 GPS measurements decoded by secondary receiver Bits 4–7: number of L2 GPS measurements decoded by secondary receiver	Value ≠ 0xF

Note: The units of the accelerometer biases are 0.1 mm/s^2.

Table 19. Status information, Channel 8

Byte	Format	Definition	Valid when
0–1	Short	Gyro scale factor x	Age < 150
2–3	Short	Gyro scale factor y	Age < 150
4–5	Short	Gyro scale factor z	Age < 150
6	UByte	Age	Always
7	UByte	Bits 0–3: number of L1 GPS measurements decoded by external receiver Bits 4–7: number of L2 GPS measurements decoded by external receiver	Value ≠ 0xF

Note: The units of the gyro scale factors are 1 ppm (0.0001 %).

Table 20. Status information, Channel 9

Byte	Format	Definition	Valid when
0–1	UShort	Accuracy of gyro bias x	Age < 150
2–3	UShort	Accuracy of gyro bias y	Age < 150
4–5	UShort	Accuracy of gyro bias z	Age < 150
6	UByte	Age	Always
7	UByte	Bits 0–3: number of L1 GLONASS measurements decoded by primary receiver Bits 4–7: number of L2 GLONASS measurements decoded by primary receiver	Value ≠ 0xF

Note: The units of the gyro bias accuracies are 1×10^{-6} radians/s.

Table 21. Status information, Channel 10

Byte	Format	Definition	Valid when
0–1	UShort	Accuracy of accelerometer bias x	Age < 150
2–3	UShort	Accuracy of accelerometer bias y	Age < 150
4–5	UShort	Accuracy of accelerometer bias z	Age < 150
6	UByte	Age	Always
7	UByte	Bits 0–3: number of L2 GLONASS measurements decoded by secondary receiver Bits 4–7: number of L1 GLONASS measurements decoded by secondary receiver	Value ≠ 0xF

Note: The units of the accelerometer biases are 0.01 mm/s^2.

Table 22. Status information, Channel 11

Byte	Format	Definition	Valid when
0–1	UShort	Accuracy of gyro scale factor x	Age < 150
2–3	UShort	Accuracy of gyro scale factor y	Age < 150
4–5	UShort	Accuracy of gyro scale factor z	Age < 150
6	UByte	Age	Always
7	UByte	Bits 0–3: number of L1 GLONASS measurements decoded by external receiver	Value ≠ 0xF

		Bits 4–7: number of L2 GLONASS measurements decoded by external receiver	

Note: The units of the gyro scale factors are 1 ppm (0.0001 %).

Table 23. Status information, Channel 12

Byte	Format	Definition	Valid when
0–1	Short	Distance to primary GNSS antenna in x direction	Age < 150
2–3	Short	Distance to primary GNSS antenna in y direction	Age < 150
4–5	Short	Distance to primary GNSS antenna in z direction	Age < 150
6	UByte	Age	Always
7		Reserved	N/A

Note: The unit of distance is 1 mm.

Table 24. Status information, Channel 13

Byte	Format	Definition	Valid when
0–1	Short	Heading orientation of the GNSS antennas	Age < 150
2–3	Short	Pitch orientation of the GNSS antennas	Age < 150
4–5	Short	Distance between the GNSS antennas	Age < 150
6	UByte	Age	Always
7	UByte	Bits 0–3: number of GPS satellites available (not necessarily used) in heading module Bits 4–7: number of GPS satellites used in current L1 solution in heading module	Value ≠ 0xF

Note: The unit of distance is 1 mm. Angles are given in 1×10^{-4} radians.

Table 25. Status information, Channel 14

Byte	Format	Definition	Valid when
0–1	UShort	Accuracy of distance to primary GNSS antenna in x direction	Age < 150
2–3	UShort	Accuracy of distance to primary GNSS antenna in y direction	Age < 150
4–5	UShort	Accuracy of distance to primary GNSS antenna in z direction	Age < 150
6	UByte	Age	Always
7	UByte	Bits 0–3: number of GPS satellites used in position solution Bits 4–7: number of GLONASS satellites used in position solution	Value ≠ 0xF

Note: The unit of the distance accuracy is 0.1 mm.

Table 26. Status information, Channel 15

Byte	Format	Definition	Valid when
0–1	UShort	Accuracy of heading orientation of the GNSS antennas	Age < 150
2–3	UShort	Accuracy of pitch orientation of the GNSS antennas	Age < 150
4–5	UShort	Accuracy of distance between the GNSS antennas	Age < 150

6	UByte	Age	
7	UByte	Bits 0–3: number of GLONASS satellites available (not necessarily used) in heading module Bits 4–7: number of GLONASS satellites used in current L1 solution in heading module	Value ≠ 0xF

Note: The units of the distances are 1 mm. The units of the orientation angle accuracies are 1×10^{-4} radians.

Table 27. Status information, Channel 16

Byte	Format	Definition	Valid when
0–1	Short	Heading of the vehicle in the INS co-ordinate frame	Byte 6 = 0
2–3	Short	Pitch of the vehicle in the INS co-ordinate frame	Byte 6 = 0
4–5	Short	Roll of the vehicle in the INS co-ordinate frame	Byte 6 = 0
6	UByte	Validity	Always
7	Byte	Bits 1–7: UTC time offset	Bit 0 = 1

Note: The units of the orientation angles are 1×10^{-4} radians. To compute UTC time from GPS time *add* the offset. Currently the offset is −16 seconds. (The offset is always an integer number of seconds. UTC time slips or gains a second occasionally whereas GPS time does not).

Table 28. Status information, Channel 17

Byte	Format	Definition
0–1	UShort	Characters received from the secondary GNSS receiver by the navigation computer
2–3	UShort	Packets received from the secondary GNSS receiver by the navigation computer
4–5	UShort	Characters received from the secondary GNSS receiver by the navigation computer, but not understood by the decoder
6–7	UShort	Packets received from the secondary GNSS receiver by the navigation computer that could not be used to update the Kalman filter (e.g. too old)

Note: These counters are cyclic and will wrap when they exceed the limit of the format used.

Table 29. Status information, Channel 18

Byte	Format	Definition
0–3	ULong	Characters received from the IMU by the navigation computer
4– 5	UShort	Packets received from the IMU by the navigation computer
6–7	UShort	Characters received from the IMU by the navigation computer but not understood by the decoder

Note: These counters are cyclic and will wrap when they exceed the limit of the format used.

Table 30. Status information, Channel 19

Byte	Format	Definition
0–7	8 × Byte	This is the software version or d*evelopment Id* that is running in the INS in ASCII format

Table 31. Status information, Channel 20

Byte	Format	Definition	Valid when
0–1	Short	Age of the differential corrections from the base-station	Value ≠ 0xFFFF
2–5	4 × Byte	Differential station Id in ASCII format	Always
6–7		Reserved	N/A

Note: The unit of the differential corrections is 0.01 seconds. If the differential station Id is four characters long, a null-terminator will need to be added. If the station Id is three or fewer characters the unused bytes will be zero.

Table 32. Status information, Channel 21

Byte	Format	Definition	Valid when
0–3	Long	Disk space remaining in kiB. Note that approximately 8 MB is always left spare on the disk	Value > 0
4–7	Long	Size of current logged raw data file in kiB. When there is insufficient space on the disk no more data will be written	Always

Table 33. Status information, Channel 22

Byte	Format	Definition	Valid when
0–1	UShort	Time mismatch counter. This field counts the number of times that the IMU time and the GPS time disagree. This can occur if GPS has been unavailable for a long period of time and the IMU clock has drifted compared to GPS time. It can occur when the IMU resets unexpectedly	Value ≠ 0xFFFF
2	UByte	IMU time difference (ms)	Value ≠ 0xFF
3	UByte	IMU time margin (ms)	Value ≠ 0xFF
4–5	UShort	IMU loop time (ms)	Value ≠ 0xFFFF
6–7	UShort	Output loop time (ms)	Value ≠ 0xFFFF

Table 34. Status information, Channel 23

Byte	Format	Definition	Valid when
0–1	UShort	Blended navigation system lag time: delay in the calculation of the Kalman filter compared to the targeted time (ms)	Value ≠ 0xFFFF
2–3	UShort	Indicates how long the INS has been running for. The field uses a non-linear time scale as follows: Value > 20,700: (value − 20,532) (hours) 10,800 < value ≤ 20,700: (value − 10,620) (minutes) Value ≤ 10,800: value (seconds)	Value ≠ 0xFFFF
4	UByte	Number of consecutive GPS position updates rejected	Value ≠ 0xFF
5	UByte	Number of consecutive GPS velocity updates rejected	Value ≠ 0xFF
6	UByte	Number of consecutive GPS attitude updates rejected	Value ≠ 0xFF
7	UByte	PTP Status 0: Invalid 1: Initialising 2: Faulty	0 ≤ Value ≤ 255

		3: Disabled 4: Listening 5: Pre-master 6: Master 7: Passive 8: Uncalibrated 9: Slave 10: Locked 11: Config Error 12: Critical Error 13: Unknown	

Table 35. Status information, Channels 24, 43, 65, 79, 80 and 81

Byte	Format	Definition	Valid when
0–3	Long	TRIG_MINUTE. GPS minute when the triggered occurred. Given as minutes since GPS began (midnight, 6th January 1980)	Value > 0
4–5	UShort	TRIG_MSEC. Milliseconds into TRIG_MINUTE when the triggered occurred	TRIG_MINUTE > 0
6	Byte	TRIG_USEC. Microseconds into TRIG_MSEC when the trigger occurred. Note that the unit is 4 ms	TRIG_MINUTE > 0
7	UByte	Trigger count, increments each time there is a new trigger	Value > 0

Note: To find the time a trigger occurred in GPS seconds, compute:

(TRIG_MINUTE × 60.0) + (TRIG_MSEC × 0.001) + (TRIG_USEC × 0.000004)

Table 36. Status information, Channel 26

Byte	Format	Definition	Valid when
0–1	Short	Output displacement lever arm in *x* direction	Byte 6 = 0
2–3	Short	Output displacement lever arm in *y* direction	Byte 6 = 0
4–5	Short	Output displacement lever arm in *z* direction	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the output displacement are 1 mm.

Table 37. Status information, Channel 27

Byte	Format	Definition	Valid when
0	UByte	Heading quality 0: None—no heading information 1: Poor—heading information unusable 2: RTK Float—floating ambiguity heading solution 3: RTK Integer—integer ambiguity heading solution	0 ≤ Value ≤ 3
1	UByte	Heading search type 0: Idle—not searching at the moment 1: L1—using L1 frequency for ambiguity resolution 2: L2—using L2 frequency for ambiguity resolution	0 ≤ Value ≤ 3

		3: L1/L2—using L1 and L2 frequencies for ambiguity resolution	
2	UByte	Heading search status 0: OK 1: No spare CPU 2: No seed 3: No master 4: No slave 1 5: No slave 2 6: No slave 3 7: Bad length 8: No matching ambiguities 9: Too many ambiguities 10: Lost master 11: Lost slave 1 12: Lost slave 2 13: Lost slave 3 14: Satellite constellation too poor 15: Covariance error 16: Ambiguous ambiguities 17: Lost lock 18: Disabled	0 ≤ Value ≤ 18
3	UByte	Heading search ready 0: Waiting 1: Processing	0 ≤ Value ≤ 1
4–5	UShort	Initial number of ambiguities in the heading search	Value ≠ 0xFFFF
6–7	UShort	Remaining number of ambiguities in the heading search	Value ≠ 0xFFFF

Table 38. Status information, Channel 28

Byte	Format	Definition
0	UByte	Master satellite PRN in the heading search
1	UByte	Slave 1 satellite PRN in the heading search
2	UByte	Slave 2 satellite PRN in the heading search
3	UByte	Slave 3 satellite PRN in the heading search
4–5	UShort	Heading search duration (in seconds)
6–7	UShort	Number of constraints applied in the heading search

Table 39. Status information, Channel 29

Byte	Format	Definition	Valid when
0	UByte	“Vehicle starts” option 0: Initially not level 1: Initially level (roll and pitch within 15°)	0 ≤ Value ≤ 1
1	UByte	Vibration in the environment option 0: Normal 1: High 2: Very high	0 ≤ Value ≤ 2
2	UByte	Expected GNSS accuracy or weighting 0: Some obstructions—medium GNSS weighting	0 ≤ Value ≤ 2

		1: Open sky—high GNSS weighting 2: Frequent obstructions—low GNSS weighting	
3	UByte	UDP output option 0: NCOM 1: Reserved 2: ABD robot interface 3: Reserved 4: Reserved 5: NMEA 6: Reserved 7: MCOM 8: Reserved 9: Reserved 10: Reserved 11: Reserved 12: Reserved 13: Reserved 14: Reserved 15: Reserved 16: Reserved	0 ≤ Value ≤ 16
4	UByte	Serial 1 output option See UDP output option for definitions	0 ≤ Value ≤ 10
5	UByte	Serial 2 Output option See UDP Output option for definitions	0 ≤ Value ≤ 10
6	UByte	Heading search option 0: Never compute dual-antenna heading 1: No Search but allow INS-guided dual-antenna "relock" 2: Only search after initialisation 3: Always perform heading searches	0 ≤ Value ≤ 3
7	UByte	Heave coupling mode 0: AC coupled 1: DC coupled 2: Disabled	0 ≤ Value ≤ 2

Table 40. Status information, Channel 30

Byte	Format	Definition	Valid when
0	UByte	Operating system version 1	Value ≠ 0xFF
1	UByte	Operating system version 2	Value ≠ 0xFF
2	UByte	Operating system version 3	Value ≠ 0xFF
3 ⋮ 5	Word	Start-up script version	
6–7	UShort	Serial number	Value ≠ 0xFFFF

Table 41. Status information, Channel 32

Byte	Format	Definition	Valid when
0	Byte	Bits 1–7: Zero velocity x innovation	Bit 0 = 1
1	Byte	Bits 1–7: Zero velocity y innovation	Bit 0 = 1

2	Byte	Bits 1–7: Zero velocity z innovation	Bit 0 = 1
3	Byte	Bits 1–7: Lateral advanced slip innovation	Bit 0 = 1
4	Byte	Bits 1–7: Heading lock innovation	Bit 0 = 1
5	Byte	Bits 1–7: Wheel speed innovation	Bit 0 = 1
6	Byte	Bits 1–7: Clock offset innovation	Bit 0 = 1
7	Byte	Bits 1–7: Clock drift innovation	Bit 0 = 1

Note: The innovations are always expressed as a proportion of the current accuracy. Units are 0.1 σ. As a general rule, innovations below 1.0 σ are good; innovations above 1.0 σ are poor. Usually it is best to filter the square of the innovations and display the square root of the filtered value.

Table 42. Status information, Channel 33

Byte	Format	Definition	Valid when
0–1	Short	Distance to the zero velocity point in x direction	Byte 6 = 0
2–3	Short	Distance to the zero velocity point in y direction	Byte 6 = 0
4–5	Short	Distance to the zero velocity point in z direction	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the distances are 1 mm.

Table 43. Status information, Channel 34

Byte	Format	Definition	Valid when
0–1	UShort	Accuracy of distance to the zero velocity point in x direction	Byte 6 = 0
2–3	UShort	Accuracy of distance to the zero velocity point in y direction	Byte 6 = 0
4–5	UShort	Accuracy of distance to the zero velocity point in z direction	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the distances are 0.1 mm.

Table 44. Status information, Channel 35

Byte	Format	Definition	Valid when
0–1	Short	Distance to the lateral advanced slip point in x direction	Byte 6 = 0
2–3	Short	Distance to the lateral advanced slip point in y direction	Byte 6 = 0
4–5	Short	Distance to the lateral advanced slip point in z direction	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the distances are 1 mm.

Table 45. Status information, Channel 36

Byte	Format	Definition	Valid when
0–1	UShort	Accuracy of distance to the lateral advanced slip point in x direction	Byte 6 = 0

2–3	UShort	Accuracy of distance to the lateral advanced slip point in y direction	Byte 6 = 0
4–5	UShort	Accuracy of distance to the lateral advanced slip point in z direction	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the distances are 0.1 mm.

Table 46. Status information, Channel 37

Byte	Format	Definition	Valid when
0–1	Short	Heading misalignment angle	Byte 6 = 0
2–3	UShort	Accuracy of heading misalignment angle	Byte 6 = 0
4	UByte	Total number of satellites used in position solution	Value ≠ 0xF
5	UByte	Total number of satellites used in velocity solution	Value ≠ 0xF
6	UByte	Validity	Always
7	UByte	Total number of satellites used in attitude solution	Value ≠ 0xF

Note: The unit of the angle is 1×10^{-4} radians. The unit of the angle accuracy is 1×10^{-5} radians.

Table 47. Status information, Channel 40

Byte	Format	Definition	Valid when
0–1	UShort	MCOM format encoder version (currently 22)	Value ≠ 0
2–3	UShort	Output Latency (due to buffering)	Value ≠ 0xFFFF
4–5	UShort	Delayed Heave Latency	Value ≠ 0xFFFF
6	UByte	Delayed Heave Period	Value ≠ 0xFF
7	UByte	Delayed Heave Coupling Mode 0: AC Coupled 1: DC Coupled 2: Disabled 3: Unknown	Value < 3

Note: The unit of the latency is 1×10^{-2} seconds. The unit of the heave period is 2×10^{-3}.

Table 48. Status information, Channel 41

Byte	Format	Definition	Valid when
0	UByte	Serial port 1 baud rate (see Table 50)	See Table 50
1	UByte	Serial port 2 baud rate (see Table 50)	See Table 50
2	UByte	Serial port 3 baud rate (see Table 50)	See Table 50
3	UByte	CAN bus baud rate (see Table 51)	See Table 51
4-7	4xUbyte	Configured WiFi IP Address	Each byte< 0xFF

Table 49. Status information, Channel 42

Byte	Format	Definition	Valid when
0–5		Reserved	N/A
6	UByte	Bit 0 = heading mode option raw internal Bit 1 = heading mode option attitude internal Bit 3 = heading mode option attitude external Bit 7 = valid flag for this byte	Bit 7 = 0
7		Reserved	N/A

Table 50. Definitions of serial baud rates

Value	Name	Definition
0	Disabled	The serial port is disabled or not present
1	300	The serial port outputs at 300 Bd
2	600	The serial port outputs at 600 Bd
3	1200	The serial port outputs at 1,200 Bd
4	2400	The serial port outputs at 2,400 Bd
5	4800	The serial port outputs at 4,800 Bd
6	9600	The serial port outputs at 9,600 Bd
7	19200	The serial port outputs at 19,200 Bd
8	38400	The serial port outputs at 38,400 Bd
9	57600	The serial port outputs at 57,600 Bd
10	76800	The serial port outputs at 76,800 Bd
11	115200	The serial port outputs at 115,200 Bd
12	230400	The serial port outputs at 230,400 Bd
13	460800	The serial port outputs at 460,800 Bd
14	921600	The serial port outputs at 921,600 Bd
15	14400	The serial port outputs at 14,400 Bd
16	28800	The serial port outputs at 28,800 Bd
17	153600	The serial port outputs at 153,600 Bd
18	307200	The serial port outputs at 307,200 Bd
19	614400	The serial port outputs at 614,400 Bd
20	128000	The serial port outputs at 128,000 Bd
21	256000	The serial port outputs at 256,000 Bd
22	512000	The serial port outputs at 521,000 Bd
23	250000	The serial port outputs at 250,000 Bd
24	300000	The serial port outputs at 300,000 Bd
25	500000	The serial port outputs at 500,000 Bd
26	1500000	The serial port outputs at 1,500,000 Bd
27	2000000	The serial port outputs at 2,000,000 Bd

28	2500000	The serial port outputs at 2,500,000 Bd
29	750000	The serial port outputs at 750,000 Bd
30	10000000	The serial port outputs at 1,000,0000 Bd
31	3000000	The serial port outputs at 3,000,000 Bd
32	1843200	The serial port outputs at 1843,200 Bd
33	3686400	The serial port outputs at 3,686,400 Bd
34 ⋮ 255		Reserved

Table 51. Definitions of CAN baud rates

Value	Name	Definition
0	Disabled	The CAN bus is disabled or not present
1	100000	The CAN bus operates at 100,000 Bd
2	125000	The CAN bus operates at 125,000 Bd
3	200000	The CAN bus operates at 200,000 Bd
4	250000	The CAN bus operates at 250,000 Bd
5	500000	The CAN bus operates at 500,000 Bd
6	1000000	The CAN bus operates at 1,000,000 Bd
7 ⋮ 255		Reserved

Table 52. Status information, Channel 44

Byte	Format	Definition	Valid when
0–1	UShort	Wheel speed scaling in units of 0.1 pulses per metre	Value ≠ 0xFFFF
2–3	UShort	Wheel speed scaling accuracy in units of 0.002 %	Value ≠ 0xFFFF
4 ⋮ 7		Reserved	N/A

Table 53. Status information, Channel 45

Byte	Format	Definition	Valid when
0 ⋮ 3	ULong	Cyclic wheel speed input count. This value increases each time a pulse is detected on the wheel speed input	Always
4–5	UShort	Timestamp of wheel speed input count measurement above. This time-stamp is transmitted as milliseconds into the current GPS minute	Value < 60,000
6	UByte	Time since the wheel speed count last changed, in units of 0.1 s	Value ≠ 0xFF
7		Reserved	N/A

Table 54. Status information, Channel 46

Byte	Format	Definition	Valid when
0–1	Short	Distance to the wheel speed measurement point in x direction	Byte 6 = 0
2–3	Short	Distance to the wheel speed measurement point in y direction	Byte 6 = 0
4–5	Short	Distance to the wheel speed measurement point in z direction	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the distances are 1 mm.

Table 55. Status information, Channel 47

Byte	Format	Definition	Valid when
0–1	UShort	Accuracy of distance to the wheel speed measurement point in x direction	Byte 6 = 0
2–3	UShort	Accuracy of distance to the wheel speed measurement point in y direction	Byte 6 = 0
4–5	UShort	Accuracy of distance to the wheel speed measurement point in z direction	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the distances are 0.1 mm.

Table 56. Status information, Channel 48

Byte	Format	Definition	Valid when
0–1	Short	Undulation value (difference between INS altitude and WGS-84 ellipsoidal altitude)	Value ≠ 0xFFFF
2	UByte	HDOP of GPS	Value ≠ 0xFF
3	UByte	PDOP of GPS	Value ≠ 0xFF
4-5		Reserved	N/A
6	UByte	Datum ellipsoid 0: WGS84 1: GRS80	Value ≠ 0xFF
7	UByte	Earth frame associated with datum ellipsoid 0: ITRF2008 1: ETRF2000(R08) 2: NAD83(2011)	Value ≠ 0xFF

Units of undulation are 5 mm. Units of HDOP/PDOP are 0.1.
In the default configuration the INS outputs the geoidal altitude, computed using the EGM96 lookup table. To compute the WGS-84 or elliptical altitude use the following equation:

Ellipsoidal altitude = INS altitude – undulation

Table 57. Status information, Channel 49

Byte	Format	Definition	Valid when
0–1	UShort	Frequency of OmniSTAR tracking loop	Value ≠ 0xFFFF
2	UByte	SNR of OmniSTAR signal	Value ≠ 0xFF

3	UByte	Time of continuous tracking of OmniSTAR signal	Value ≠ 0xFF
4	UByte	OmniSTAR status	Value ≠ 0xFF
5 ⋮ 7	UWord	OmniSTAR serial number	Value ≠ 0xFFFFFF

The frequency of the OmniSTAR tracking loop is 1.52 + (Value / 1 × 10^6) GHz. Units of SNR is 0.2 dB. Units of time for tracking of OmniSTAR signal are 1 s.

Table 58. Status information, Channel 50

Byte	Format	Definition
0–1	UShort	Characters received on the command port
2–3	UShort	Packets received on the command port
4–5	UShort	Characters received on the command port but not understood by the decoder
6–7	UShort	Errors received on the command port

Note: The command ports are either Ethernet UDP port 3001 or Serial 1 in some of the serial modes. These counters are cyclic and will wrap when they exceed the limit of the format used.

Table 59. Status information, Channels 51, 52, 53, 54, 68, 69, 70 and 71

Byte	Format	Definition	Valid when
0–1	Short	Distance to the additional slip point in x direction	Byte 6 = 0
2–3	Short	Distance to the additional slip point in y direction	Byte 6 = 0
4–5	Short	Distance to the additional slip point in z direction	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the distances are 1 mm.

Table 60. Status information, Channels 55, 56 and 62

Byte	Format	Definition	Valid when
0	UByte	Bits 0–3: Reserved Bits 4–5: GNSS antenna power status 0: Power on 1: Power off 2: Power unknown 3: Invalid Bits 6–7: GNSS antenna status 0: OK 1: Open 2: Short 3: Unknown or invalid	See individual bits
1	UByte	CPU load on GNSS card (percent)	Value ≠ 0xFF
2	UByte	Core noise on GNSS card (percent)	Value ≠ 0xFF
3	UByte	Baud rate of GNSS card (see Table 50)	Value < 15
4	UByte	Number of satellites tracked	Value ≠ 0xFF

5	UByte	Position mode of GNSS (see Table 10)	Value ≠ 0xFF
6	UByte	Core temperature (°C) = value − 70	Value ≠ 0xFF
7	UByte	GNSS receiver supply voltage (V) = value × 0.1	Value ≠ 0xFF

Table 61. Status information, Channel 57

Byte	Format	Definition	Valid when
0–1	Short	Distance to primary GNSS antenna in X direction	Age < 150 and scale factor ≠ 0
2–3	Short	Distance to primary GNSS antenna in Y direction	Age < 150 and scale factor ≠ 0
4–5	Short	Distance to primary GNSS antenna in Z direction	Age < 150 and scale factor ≠ 0
6	UByte	Age	Always
7	UByte	Scale factor	Always

Note: The unit of the distances is 1 mm and each value has to be multiplied by the scale factor. If the scale factor is 0xFF then the distances are saturated.

Table 62. Status information, Channel 58

Bytes	Format	Definition	Valid when
0–1	Short	Heading of output frame with reference to vehicle frame	Byte 6 = 0
2–3	Short	Pitch of output frame with reference to vehicle frame	Byte 6 = 0
4–5	Short	Roll of the output frame with reference to vehicle frame	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the orientation angles are 1×10^{-4} radians.

Table 63. Status information, Channel 59

Byte	Format	Definition	Valid when
0–1	UShort	Number of IMU packets missed	Always
2	UByte	Number of IMU resets detected	Always
3	UByte	Number of IMU errors detected	Always
4–5	UShort	Calibration date in days since GPS began (midnight, 6th January 1980)	Value ≠ 0xFFFF
6–7	UShort	IMU temperature (ºC) = value × 0.01 − 70	Value ≠ 0xFFFF

Note: In normal operation the number of packets, resets and errors detected or missed should be zero. These counters are cyclic and will reset to zero when they exceed the limit of the format used.

Table 64. Status information, Channel 60

Byte	Format	Definition	Valid when
0–1	Short	Surface angle heading rotation	Byte 6 = 0
2–3	Short	Surface angle pitch rotation	Byte 6 = 0
4–5	Short	Surface angle roll rotation	Byte 6 = 0
6	UByte	Validity	Always
7		Reserved	N/A

Note: The units of the angles are 1×10^{-4} radians.

Table 65. Status information, Channel 61

Byte	Format	Definition
0–1	UShort	Characters received from the external GNSS by the navigation computer.
2–3	UShort	Packets received from the external GNSS by the navigation computer.
4–5	UShort	Characters received from the external GNSS by the navigation computer, but not understood by the decoder.
6–7	UShort	Packets received from the external GNSS by the navigation computer that could not be used to update the Kalman filter (e.g. too old).

Note: These counters are cyclic and will wrap when they exceed the limit of the format used.

Table 66. Status information, Channel 64

Byte	Format	Definition	Valid when
0	UByte	CPU type running the navigation computer 0: TP400B 1: TP500 2: TP600 3: None 4: OMAP3503 Others unknown	Value ≠ 0xFF
1	UByte	External GNSS type 0: Novatel Millennium or BeeLine 1: Novatel OEM4 2: None 3: Novatel OEMV 4: u-blox LEA4 5: Generic 6: Trimble 5700/5800 7: Trimble AgGPS 132 8: Topcon GB-500 9: NavCom Sapphire 10: u-Blox LEA6 11: Trimble BD920 12: Leica GX1200 13: Topcon B110 14: Novatel OEM6 Others unknown	Value ≠ 0xFF
2	UByte	External GNSS format 0: Novatel OEM2 Binary 1: Novatel OEM4/OEMV Binary 2: UBX	Value ≠ 0xFF

		3: NMEA 4: GSOF 5: TSIP 6: GRIL 7: Debug 8: NCT Binary 9: OWI Others unknown	
3	UByte	Dual-port RAM status 0: Not fitted 1: Failed to initialise 2: Dead 3: Down 4: Overloaded 5: Sporadic 6: Slow 7: Acceptable 8: OK 9: Good 10: Excellent Others unknown	Value ≠ 0xFF
4	UByte	Bits 0–3: Primary GNSS expected position update rate Bits 4–7: Primary GNSS expected velocity update rate 0: Disabled 1: 1 Hz 2: 2 Hz 3: 4 Hz 4: 5 Hz 5: 10 Hz 6: 20 Hz Others unknown	Value ≠ 0xF Value ≠ 0xF
5	UByte	Bits 0–3: Primary GNSS expected raw data rate Bits 4–7: Secondary GNSS expected raw data rate 0: Disabled 1: 1 Hz 2: 2 Hz 3: 4 Hz 4: 5 Hz 5: 10 Hz 6: 20 Hz Others unknown	Value ≠ 0xF Value ≠ 0xF
6		Reserved	N/A
7	UByte	Product type 0: Default 1: Survey 2: OEM Others unknown	Value ≠ 0xFF

Table 67. Status information, Channel 66

Byte	Format	Definition	Valid when
0 ⋮ 3	Long	Local co-ordinates origin latitude	Value ≠ 0x80000000
4 ⋮ 7	Long	Local co-ordinates origin longitude	Value ≠ 0x80000000

Note: The units of the angles are 1×10^{-7} degrees.

Table 68. Status information, Channel 67

Byte	Format	Definition	Valid when
0 ⋮ 3	Long	Local co-ordinates origin altitude	Value ≠ 0x80000000
4 ⋮ 7	Long	Local co-ordinates origin heading	Value ≠ 0x80000000

Note: The unit for heading is 1×10^{-7} degrees. The unit for Altitude is 1 mm.

Table 69. Status information, Channel 72

Byte	Format	Definition	Valid when
0 ⋮ 6		Reserved	N/A
7	UByte	Bits 0–3: number of L1 GPS measurements received in differential corrections Bits 4–7: number of L2 GPS measurements received in differential corrections	Value ≠ 0xF

Table 70. Status information, Channel 73

Byte	Format	Definition	Valid when
0 ⋮ 6		Reserved	N/A
7	UByte	Bits 0–3: number of L1 GLONASS measurements received in differential corrections Bits 4–7: number of L2 GLONASS measurements received in differential corrections	Value ≠ 0xF

Table 71. Status information, Channel 75

Bytes	Format	Definition	Valid when
0–1	UShort	Expiry date in days since GPS began (midnight, 6th January 1980)	Value ≠ 0xFFFF
2	UByte	Supply voltage (V) = value × 0.2	Value ≠ 0xFF
3–4	UShort	IMU rate (Hz) = value × 0.02	Value ≠ 0xFFFF

5 ⋮ 7		Reserved	N/A

Table 72. Status information, Channel 76

Byte	Format	Definition	Valid when
0–1	UShort	Differential GPS characters received	Always
2–3	UShort	Differential GPS packets received	Always
4–5	UShort	Differential GPS characters skipped	Always
6	UByte	GPS Differential Ntrip status 0: Invalid 1: Ready to connect 2: Resolving URL to IP 3: Getting source table 4: Pasing source table 5: Providing authentication 6: Running 7: Triggering closing of connection 8: Closing connection before retrying 9: Reconfiguring and reconnecting 10: Disabled 11: Error, undefined 12: Error, Bad Authentication 13: Error, TCP connection failed 14: Error, unrecognised mount point 15: Error, unable to resolve IP 16: Error, invalid address string 17: Error, invalid port number	Value<0xFF
7	UByte	WiFi Connection Status 0: Invalid 1: Disconnected 2: Established 3: Unsupported	Value<0xFF

Note: These counters are cyclic and will wrap when they exceed the limit of the format used.

Table 73. Status information, Channel 77

Byte	Format	Definition	Valid when
0	UByte	Differential GPS format 0: None 1: RTCM 2: RTCA 3: CMR 4: RTCA2 5: RTCMv2 6: RTCMv3 7: CMR+ 8: RTCMv3.2	Value ≠ 0xFF

1	UByte	Differential GPS type 0: None 1: Pass-through primary GNSS receiver 2: Pass-through secondary GNSS receiver 3: Pass-through EGPS 4: RD 5: LOG 6: RINEX Others unknown	Value ≠ 0xFF
2	UByte	Differential GPS number of stations	Value ≠ 0xFF
3 ⋮ 7		Reserved	N/A

Table 74. Status information, Channel 78

Byte	Format	Definition	Valid when
0–1	UShort	CAN messages transmitted	Always
2–3	UShort	CAN messages received	Always
4	UByte	CAN transmit percent OK	Value ≠ 0xFF
5	UByte	CAN receive percent OK	Value ≠ 0xFF
6	UByte	CAN number of errors	Always
7	UByte	CAN last error code	Always

Note: The counters for messages transmitted, messages received and errors are cyclic and will wrap when they exceed the limit of the format used.

Table 75. ADK software version information, Channel 85

Byte	Format	Definition	Valid when
0–7	UInt64	ADK development ID	Always

Table 76. Status information, Channel 88

Byte	Format	Definition	Valid when
0	Byte	Bits 1–7: Vertical advanced slip innovation	Bit 0 = 1
1–7		Reserved	N/A

Note: The innovations are always expressed as a proportion of the current accuracy. Units are 0.1 σ. As a general rule, innovations below 1.0 σ are good; innovations above 1.0 σ are poor. Usually it is best to filter the square of the innovations and display the square root of the filtered value.

Table 77. Status information, Channel 89

Byte	Format	Definition	Valid when
0–1	Short	Distance to the vertical advanced slip point in x direction	Byte 6 = 0
2–3	Short	Distance to the vertical advanced slip point in y direction	Byte 6 = 0
4–5	Short	Distance to the vertical advanced slip point in z direction	Byte 6 = 0

6	UByte	Validity	Always
7	UByte	WiFi access point status 0: Invalid 1: Disabled 2: Enabled 3: Unsupported	Value < 0xFF

Note: The units of the distances are 1 mm.

Table 78. Status information, Channel 90

Byte	Format	Definition	Valid when
0–1	UShort	Accuracy of distance to the vertical advanced slip point in x direction	Byte 6 = 0
2–3	UShort	Accuracy of distance to the vertical advanced slip point in y direction	Byte 6 = 0
4–5	UShort	Accuracy of distance to the vertical advanced slip point in z direction	Byte 6 = 0
6	UByte	Validity	Always
7	UByte	WiFi Region 0: Invalid 1: EU 2: USA 3: China 4: Australia 5: Japan	Value < 0xFF

Note: The units of the distances are 0.1 mm.

Table 79. Status information, Channel 91

Byte	Format	Definition	Valid when
0–1	Short	Pitch misalignment angle	Byte 6 = 0
2–3	UShort	Accuracy of pitch misalignment angle	Byte 6 = 0
4–5		Reserved	N/A
6	UByte	Validity	Always
7		Reserved	N/A

Note: The unit of the angle is 1×10^{-4} radians. The unit of the angle accuracy is 1×10^{-5} radians.

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Checksum definition

Three simple checksums are calculated during each MCOM packet. Intermediate checksums 1 and 2 of structure-A packets allow users to quickly check the validity of data up to that point, in order to use it without having to wait for the whole packet to be received. To keep the computational load to a minimum, each checksum is simply the sum of bytes up to that point. Note that the Sync byte is not included in any of the checksum calculations.

Checksum 3 is calculated in the following way:

```
unsigned byte csum;

int j;


// Final checksum

for (j = 1, csum = 0; j < 83; j++)

csum += txbuf[j];

txbuf[83] = csum;
```

Checksums 1 and 2 are calculated in the same way, but only using the bytes preceding that checksum.

Asynchronous MCOM packets: triggered outputs

As well as synchronous MCOM packets delivered via Ethernet and RS232, asynchronous packets can also be transmitted (although they are only available on Ethernet).

The state of the event input pin, and/or by distance-based pulses generated by the INS on the camera output/distance output pin can be used to trigger asynchronous MCOM packets. Note that in order to generate distance based MCOM messages, the camera output/distance output pin the must be configured to less than 1 ppm (pulse per metre).

Asynchronous MCOM messages can be identified by testing the navigation status byte for values of 20, 21 or 22. The event that triggered the asynchronous MCOM message can be identified by testing the status channel (byte 74) of an MCOM packet. Messages transmitted in response to a falling edge on the event input pin will have a status channel value of 24. Messages triggered by a rising edge on the event input pin have a status channel value of 43 and messages triggered by the camera output/distance output have a status channel value of 65. Messages transmitted in response to a falling edge on the event input 2 pin will have a status channel value of 79. Messages triggered by a rising edge on the event input 2 pin have a status channel value of 80 and messages triggered by the camera output/distance output 2 have a status channel value of 81. See Table 8. Status channel (byte 74) definitions.

The INS will automatically interpolate the measurement outputs so they relate to the exact trigger time. Since the time field in Batch A only has a resolution of 1 ms, a more accurate time stamp is contained within the status information of asynchronous messages. Details of how to calculate this are given in Table 35.

Asynchronous MCOM outputs are only available in real-time on the faster TP500/TP600/OMAP3503 processor card. Even if the correct firmware is installed on an older TP400B processor card, the asynchronous MCOM outputs will not be output in real-time. On hardware revisions since 2008 and using 2009 firmware, the triggers are logged to the internal RD file and will be output by RT Post-Process. Contact OxTS if you need information on whether your hardware can support the fast triggers or not.

Revision history

Table 80. Revision history

Revision	Comment
120612	Initial version
131122	Updated navigation status and status channels descriptions in line with version 21 of MCOM transmitter. Replaced references to Char (UChar) data type with Byte (UByte). Described GPS Status Summary Byte 68. Added information about baud rates
140723	Template update. Legal notice updated, style alignment, definition update, added checksum definition
141222	Added more status channel definitions (83–92)
150611	Added several status bytes for Spring 2015 update. Style tweaks
120612	Initial version
131122	Updated navigation status and status channels descriptions in line with version 21 of MCOM transmitter. Replaced references to Char (UChar) data type with Byte (UByte). Described GPS Status Summary Byte 68. Added information about baud rates
140723	Template update. Legal notice updated, style alignment, definition update, added checksum definition
141222	Added more status channel definitions (83–92)
220830	Rebranded throughout
220907	Added additional heave measurements