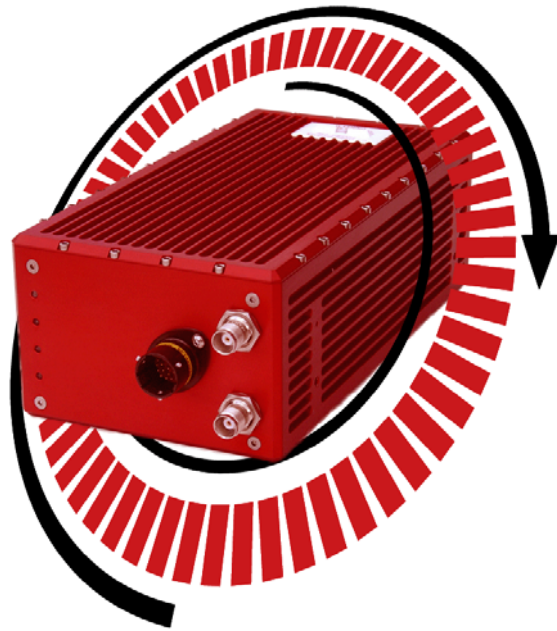# NCOM

Inertial and GNSS measurement systems

NCOM manual

Confidently. Accurately.

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Table of contents

Introduction

NCOM is a data format designed by OxTS for the efficient communication of 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. NCOM is utilised in many of our products.

This manual gives a description of the NCOM format so users can freely develop custom written software for specific needs and applications. OxTS also provides code written in C that can decode NCOM, and includes routines to rotate many of the outputs into different co-ordinate frames.

As well as NCOM, we have an almost identical format called MCOM, which was developed specifically for marine navigation. MCOM is not covered in this manual as it has its own dedicated manual.

NCOM packet formats

The NCOM packet comprises 72 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 Table 1.

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)
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 NCOM packet exist, referred to as NCOM structure-A and NCOM structure-B. Byte 21 of an NCOM 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.

NCOM structure-A

NCOM structure-A packets are intended to be used by customers and are fully defined within this document. In NCOM 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 Table 2.

Table 2. Definition of NCOM 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 10. A value of 11 indicates the packet follows NCOM 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 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	Status channel	The status channel byte identifies the status channel transmitted within Batch S.
63 ⋮ 70	Batch S	Low-rate cycling status messages. The status channel number (byte 62) defines which status messages are included in Batch S. See page 15, Table 7 for the full list.
71	Checksum 3	This is the final checksum that verifies the entire packet (bytes 1–70).

The NCOM 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 NCOM structure-B and is intended for OxTS use only. Any packet with a Nav. status value of 11 should be ignored.

NCOM structure-B

NCOM 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 Table 3.

NCOM 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_ncomx_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 NCOM 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 68 concatenated bytes of Block A and B will be consider as one entity.
23 ⋮ 70	Block B	Contents defined by Block Id.
71	Checksum 3	This is the checksum that verifies the packet.

NCOM 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_ncomx_0*.

Sync byte

The first byte of an NCOM packet is the sync byte, which always has a value of 0xE7.

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 NCOM 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. Table 4 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 NCOM packet is called the navigation status. The value of the navigation status byte is initially used to test the structure of the NCOM 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 NCOM 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 NCOM packets, the value of the navigation status byte can be used to identify what triggered the packet. Table 5 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 NCOM 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.

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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 63–70) should be decoded. This is used at the start of some logged NCOM 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 62) 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 3 for more details). The Status channel (byte 62) 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 62) 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 NCOM structure-A packet are collectively called Batch B. Batch B contains measurements describing the INS position, velocity and orientation. 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 NCOM 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.

Status channel byte

Byte 62 of an NCOM 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 NCOM 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 NCOM packet.

The value of the status channel byte defines which status message channel is contained within Batch S of a particular NCOM packet. Table 7 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 NCOM structure-A packets.

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Table 7. Status channel (byte 62) definitions

Value	Status channel information within Batch S	See
0	Full time, number of satellites, position mode, velocity mode, dual antenna mode.	Table 8
1	Kalman filter innovations set 1 (position, velocity, attitude).	Table 10
2	Internal information about primary GNSS receiver.	Table 11
3	Position accuracy.	Table 12
4	Velocity accuracy.	Table 13
5	Orientation accuracy.	Table 15
6	Gyro bias.	Table 16
7	Accelerometer bias.	Table 17
8	Gyro scale factor.	Table 18
9	Gyro bias accuracy.	Table 19
10	Accelerometer bias accuracy.	Table 20
11	Gyro scale factor accuracy.	Table 21
12	Position estimate of the primary GNSS antenna.	Table 22
13	Orientation estimate of dual antenna systems.	Table 23
14	Position accuracy of the primary GNSS antenna.	Table 24
15	Orientation accuracy of the dual antenna systems.	Table 25
16	INS to host object rotation.	Table 26
17	Internal information about secondary GNSS receiver.	Table 27
18	Internal information about inertial measurement unit (IMU).	Table 28
19	INS software version.	Table 29
20	Differential correction information.	Table 30
21	Disk space, size of current internal log file.	Table 31
22	Internal information on timing of real-time processing.	Table 32
23	System up-time, number of consecutive GNSS rejections.	Table 33
24	Asynchronous packet triggered by falling edge of event input.	Table 34
25	Reserved.	–
26	Output displacement lever arm.	Table 35
27	Internal information about dual antenna ambiguity searches.	Table 36
28	Internal information about dual antenna ambiguity searches.	Table 37
29	Initial settings defined with NAVconfig.	Table 38
30	Operating system and script version information.	Table 39
31	Hardware configuration information.	–
32	Kalman filter innovations set 2.	Table 40

33	Zero velocity lever arm.	Table 41
34	Zero velocity lever arm accuracy.	Table 42
35	Lateral advanced slip lever arm.	Table 43
36	Lateral advanced slip lever arm accuracy.	Table 44
37	Heading misalignment angle.	Table 45
38	Zero velocity option settings, third serial output mode	–
39	Lateral advanced slip option settings.	–
40	NCOM version ID.	Table 46
41	Output baud rates.	Table 47
42	Heading lock options.	Table 48
43	Asynchronous packet triggered by rising edge of event input.	Table 34
44	Wheel speed configuration.	Table 51
45	Wheel speed counts.	Table 52
46	Wheel speed lever arm.	Table 53
47	Wheel speed lever arm accuracy.	Table 54
48	Undulation, dilution of precision (DOP) of GPS.	Table 55
49	OmniSTAR tracking information.	Table 56
50	Information sent to the command decoder.	Table 57
51	Additional slip point 1 lever arm.	Table 58
52	Additional slip point 2 lever arm.	Table 58
53	Additional slip point 3 lever arm.	Table 58
54	Additional slip point 4 lever arm.	Table 58
55	Information about the primary GNSS receiver.	Table 59
56	Information about the secondary GNSS receiver.	Table 59
57	Position estimate of the primary GNSS antenna (extended range).	Table 60
58	Vehicle to output frame rotation.	Table 61
59	IMU decoding status.	Table 62
60	Definition of the surface angles.	Table 63
61	Internal information about external GNSS receiver.	Table 64
62	Information about the external GNSS receiver.	Table 59
63	Angular acceleration filter settings.	–
64	Hardware information and external GNSS receiver configuration.	Table 65
65	Asynchronous packet triggered by camera/distance output.	Table 34
66	Extended local co-ordinate definition, latitude and longitude.	Table 66
67	Extended local co-ordinate definition, altitude and heading.	Table 67
68	Additional slip point 5 lever arm.	Table 58

69	Additional slip point 6 lever arm.	Table 58
70	Additional slip point 7 lever arm.	Table 58
71	Additional slip point 8 lever arm.	Table 58
72	Status information.	Table 68
73	Status information.	Table 69
74	Linear acceleration filter settings.	–
75	Miscellaneous.	Table 70
76	Internal information about differential corrections.	Table 71
77	Differential correction configuration.	Table 72
78	CAN bus status information.	Table 73
79	Asynchronous packet triggered by falling edge of event input 2 (for xNAV only).	Table 34
80	Asynchronous packet triggered by rising edge of event input 2 (for xNAV only).	Table 34
81	Asynchronous packet triggered by camera/distance output 2 (for xNAV only).	Table 34
82	Hardware configuration information (for xNAV only).	–
83	Status information (for xNAV only)	–
84	Status information (for xNAV only)	–
85 ⋮ 87	Reserved for future use (for xNAV only).	–
88	Kalman filter innovations set 3.	Table 74
89	Vertical advanced slip lever arm.	Table 75
90	Vertical advanced slip lever arm accuracy.	Table 76
91	Pitch misalignment angle.	Table 77
92	Vertical advanced slip option settings.	–
93 ⋮ 255	Reserved for future use.	–

Batch S: status channel definitions

Bytes 63 to 70 of an NCOM 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 8. 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	Number of GPS 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 9.

Table 9. 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 10. 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 11. Status information, Channel 2

Byte	Format	Definition	Valid when
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 12. 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 13. 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	
7	UByte	Processing method used by Blended (Table 14)	

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

Table 14. Definitions of Blended processing methods

Value	Name	Definition
0	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 15. 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	
7		Reserved	

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

Table 16. 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	Value $\neq$ 0xF
		Bits 4–7: number of L2 GPS measurements decoded by primary receiver	

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

Table 17. 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	
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 18. 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	
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 19. 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	
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 20. 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	
7	UByte	Bits 0–3: number of L1 GLONASS measurements decoded by secondary receiver	Value $\neq$ 0xF
		Bits 4–7: number of L2 GLONASS measurements decoded by secondary receiver	

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

Table 21. 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	
7	UByte	Bits 0–3: number of L1 GLONASS measurements decoded by external receiver	Value $\neq$ 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 22. 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	
7		Reserved	

Note: The unit of distance is 1 mm.

Table 23. 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	
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 24. 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	
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 25. 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 26. 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	
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 27. Status information, Channel 17

Byte	Format	Definition	Valid when
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 28. Status information, Channel 18

Byte	Format	Definition	Valid when
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 29. Status information, Channel 19

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

Table 30. 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	
6–7		Reserved	

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 31. 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.	

Table 32. 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 33. 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		Reserved	

Table 34. 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 (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 μs.	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:

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

Table 35. 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.	
7		Reserved	

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

Table 36. 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	$0 \leq$ 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 3: L1/L2—using L1 and L2 frequencies for ambiguity resolution	$0 \leq$ Value ≤ 3
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	$0 \leq$ Value ≤ 18
3	UByte	Heading search ready 0: Waiting 1: Processing	$0 \leq$ Value ≤ 1
4–5	UShort	Initial number of ambiguities in the heading search	Value $\neq$ 0xFFFF
6–7	UShort	Remaining number of ambiguities in the heading search	Value $\neq$ 0xFFFF

Table 37. Status information, Channel 28

Byte	Format	Definition	Valid when
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 38. 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 1: Open sky—high GNSS weighting 2: Frequent obstructions—low GNSS weighting	0 ≤ Value ≤ 2
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 39. 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 40. 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 41. 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	
7		Reserved	

Note: The units of the distances are 1 mm.

Table 42. 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	
7		Reserved	

Note: The units of the distances are 0.1 mm.

Table 43. 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	
7		Reserved	

Note: The units of the distances are 1 mm.

Table 44. 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	
7		Reserved	

Note: The units of the distances are 0.1 mm.

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Table 45. 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	Number of satellites used in position solution	Value ≠ 0xF
5	UByte	Number of satellites used in velocity solution	Value ≠ 0xF
6	UByte	Validity	
7	UByte	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 46. Status information, Channel 40

Byte	Format	Definition	Valid when
0–1	UShort	NCOM format encoder version (currently 22)	Value ≠ 0
2–3	UShort	Reserved	
4–5	UShort	Reserved	
6–7	UShort	Reserved	

Table 47. Status information, Channel 41

Byte	Format	Definition	Valid when
0	UByte	Serial port 1 baud rate (see Table 49)	See Table 49
1	UByte	Serial port 2 baud rate (see Table 49)	See Table 49
2	UByte	Serial port 3 baud rate (see Table 49)	See Table 49
3	UByte	CAN bus baud rate (see Table 50)	See Table 50
4 ⋮ 7		Reserved	

Table 48. Status information, Channel 42

Byte	Format	Definition	Valid when
0–5		Reserved	
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	

Table 49. 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 ⋮ 255		Reserved

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Table 50. 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 51. 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	

Table 52. 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.	
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.	

Table 53. 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	
7		Reserved	

Note: The units of the distances are 1 mm.

Table 54. 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	
7		Reserved	

Note: The units of the distances are 0.1 mm.

Table 55. 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	
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 56. 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 $1.52 + (\text{Value} / 1 \times 10^6)$ GHz. Units of SNR is 0.2 dB. Units of time for tracking of OmniSTAR signal are 1 s.

Table 57. Status information, Channel 50

Byte	Format	Definition	Valid when
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 58. 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	
7		Reserved	

Note: The units of the distances are 1 mm.

Table 59. Status information, Channels 55, 56 and 62

Byte	Format	Definition	Valid when
0	UByte	Bits 0–1: GNSS antenna status 0: OK 1: Open 2: Short 3: Unknown or invalid Bits 2–3: GNSS antenna power status 0: Power on 1: Power off 2: Power unknown 3: Invalid Bits 4–7: Reserved	See individual bits
1	UByte	CPU load on GNSS card (percent)	Value $\neq$ 0xFF
2	UByte	Core noise on GNSS card (percent)	Value $\neq$ 0xFF
3	UByte	Baud rate of GNSS card (see Table 49)	Value < 15
4	UByte	Number of satellites tracked	Value $\neq$ 0xFF
5	UByte	Position mode of GNSS (see Table 9)	Value $\neq$ 0xFF
6	UByte	Core temperature (°C) = value − 70	Value $\neq$ 0xFF
7	UByte	GNSS receiver supply voltage (V) = value × 0.1	Value $\neq$ 0xFF

Table 60. 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 $\neq$ 0
2–3	Short	Distance to primary GNSS antenna in Y direction	Age < 150 and scale factor $\neq$ 0
4–5	Short	Distance to primary GNSS antenna in Z direction	Age < 150 and scale factor $\neq$ 0
6	UByte	Age	
7	UByte	Scale factor	

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.

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Table 61. 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.	
7		Reserved.	

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

Table 62. Status information, Channel 59

Byte	Format	Definition	Valid when
0–1	UShort	Number of IMU packets missed.	
2	UByte	Number of IMU resets detected.	
3	UByte	Number of IMU errors detected.	
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 63. 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	
7		Reserved	

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

Table 64. Status information, Channel 61

Byte	Format	Definition	Valid when
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.

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Table 65. 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 3: NMEA 4: GSOF 5: TSIP 6: GRIL 7: Debug 8: NCT Binary 9: OWI Others unknown	Value ≠ 0xFF
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	Value ≠ 0xF
		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
5	UByte	Bits 0–3: Primary GNSS expected raw data rate	Value ≠ 0xF
		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
6		Reserved	
7	UByte	Product type 0: Default 1: Survey 2: OEM Others unknown	Value ≠ 0xFF

Table 66. 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 67. 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 68. Status information, Channel 72

Byte	Format	Definition	Valid when
0 ⋮ 6		Reserved	
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 69. Status information, Channel 73

Byte	Format	Definition	Valid when
0 ⋮ 6		Reserved	
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 70. 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	

Table 71. Status information, Channel 76

Byte	Format	Definition	Valid when
0–1	UShort	Differential GPS characters received	
2–3	UShort	Differential GPS packets received	
4–5	UShort	Differential GPS characters skipped	
6–7		Reserved	

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

Table 72. Status information, Channel 77

Byte	Format	Definition	Valid when
0	UByte	Differential GPS format 0: None 1: RTCM 2: RTCA 3: CMR Others unknown	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	

Table 73. Status information, Channel 78

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

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 74. Status information, Channel 88

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

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

Table 75. 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	
7		Reserved	

Note: The units of the distances are 1 mm.

Table 76. 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	
7		Reserved	

Note: The units of the distances are 0.1 mm.

Table 77. 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	
6	UByte	Validity	
7		Reserved	

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

Checksum definition

Three simple checksums are calculated during each NCOM 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 < 71; j++)
csum += txbuf[j];
txbuf[71] = csum;
```

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

Asynchronous NCOM packets: triggered outputs

As well as synchronous NCOM 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 NCOM packets. Note that in order to generate distance based NCOM messages, the camera output/distance output pin the must be configured to less than 1 ppm (pulse per metre).

Asynchronous NCOM messages can be identified by testing the navigation status byte for values of 20, 21 or 22. The event that triggered the asynchronous NCOM message can be identified by testing the status channel (byte 62) of an NCOM 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 7. Status channel (byte 62) 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 34.

Asynchronous NCOM 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 NCOM 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 78. Revision history

Revision	Comment
080124	Initial version from RT manual.
090818	Updated in line with RT manual: triggering included.
090820	Added more status channel definitions (50–71).
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.