RT

Inertial+

Inertial and GPS Measurement Systems

NCOM Description

Confidently. Accurately.

Legal Notice

Copyright Notice

Revision

Document Revision: 090820 *(See Revision History for detailed information).*

Contact Details

Oxford Technical Solutions Limited
77 Heyford Park
Upper Heyford
Oxfordshire
OX25 5HD
England

Tel: +44 1869 238 015
Fax: +44 1869 238 016

http://www.oxts.co.uk
mailto:info@oxts.co.uk

Table of Contents

Introduction 4

NCOM Packet Format 5

Status Information 10

Triggered Outputs 35

Revision History 37

Introduction

NCOM is a data format designed by OxTS for the communication of data from the RT and Inertial+ products. The format is suitable for inertial navigation system measurements.

This manual gives a description of the NCOM format so that custom software can be written for specific needs and applications. OxTS provides C code that will decode the NCOM format. These drivers provide the mathematics to rotate many of the outputs in to different co-ordinate frames. NCOM is very compact and only includes the core measurements.

The Status Messages in NCOM are also output on the CAN bus.

NCOM Packet Format

The NCOM packet format is a 72 byte packet. It can be transmitted over Ethernet or RS232 serial links. The Status information is transmitted 8 bytes at a time and this format is reproduced on the CAN bus (which can support 8 bytes per message).

Using an RS232 serial link at 115,200 baud rate with 8 data bits, 1 stop bit and no parity, NCOM can be transmitted at up to 125Hz. It has an optional low-latency format where the output can be derived after the first 22 characters have been received (1.9ms additional latency). More convenient processing of the data can be achieved after 62 characters have been received (5.3ms additional latency). Full functionality requires multiple packets to be received since low data rate information is divided up and sent in 8 bytes tagged on to the end of each packet.

To save space, many of the data packets are sent as 24-bit signed integer words; 16-bit precision does not provide the range/precision required for many of the quantities whereas 32-bit precision makes the packet much longer than required. All words are sent in little-endian format (meaning "little-end first" or "LSB first"), which is compatible with Intel microprocessors.

The packet is also transmitted over Ethernet as a 72-byte UDP broadcast. The port number is 3000. Ethernet provides the lowest latency output from the system since the transmission speed is nearly 1000 times faster than the serial communications.

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 float
Double	64-bit IEEE float

Note: If a 'U' precedes the value then it is unsigned, otherwise it is signed using 2's complement.

The definition of the packet is given in Table 2, Table 3 and Table 4, below.

Note that, on RS232 serial transmissions to reduce the latency, the SYNC character, listed as the first character of the packet, 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 the 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.

Table 2. NCOM Packet Definition – Batch 1.

Byte	Quantity	Notes
0	Sync	Always E7h
1	Time	Time is transmitted as milliseconds into the minute in GPS time. Range is 0 to 59,999 ms.
2	Time	
3	Acceleration X LSB	Acceleration X is the *vehicle body-frame* acceleration in the x-direction (i.e. after the *IMU to Vehicle Attitude* matrix has been applied). It is a signed word in units of 10^{-4} m/s².
4	Acceleration X	
5	Acceleration X MSB	
6	Acceleration Y LSB	Acceleration Y is the *vehicle body-frame* acceleration in the y-direction (i.e. after the *IMU to Vehicle Attitude* matrix has been applied). It is a signed word in units of 10^{-4} m/s².
7	Acceleration Y	
8	Acceleration Y MSB	
9	Acceleration Z LSB	Acceleration Z is the *vehicle body-frame* acceleration in the z-direction (i.e. after the *IMU to Vehicle Attitude* matrix has been applied). It is a signed word in units of 10^{-4} m/s².
10	Acceleration Z	
11	Acceleration Z MSB	
12	Angular Rate X LSB	Angular Rate X is the *vehicle body-frame* angular rate in the x-direction (i.e. after the *IMU to Vehicle Attitude* matrix has been applied). It is a signed word in units of 10^{-5} radians/s.
13	Angular Rate X	
14	Angular Rate X MSB	
15	Angular Rate Y LSB	Angular Rate Y is the *vehicle body-frame* angular rate in the y-direction (i.e. after the *IMU to Vehicle Attitude* matrix has been applied). It is a signed word in units of 10^{-5} radians/s.
16	Angular Rate Y	
17	Angular Rate Y MSB	
18	Angular Rate Z LSB	Angular Rate Z is the *vehicle body-frame* angular rate in the z-direction (i.e. after the *IMU to Vehicle Attitude* matrix has been applied). It is a signed word in units of 10^{-5} radians/s.
19	Angular Rate Z	
20	Angular Rate Z MSB	
21	Nav. Status	See Table 5, below.
22	Checksum 1	This checksum allows the software to verify the integrity of the packet so far. For a low-latency output the accelerations and angular rates can be used to quickly update the previous solution. Contact Oxford Technical Solutions for source code to perform this function.

Table 3. NCOM Packet Definition – Batch 2.

Byte	Quantity	Notes
23	Latitude (Byte 0)	The Latitude of the IMU. It is a double in units of radians.
24	Latitude (Byte 1)	
25	Latitude (Byte 2)	
26	Latitude (Byte 3)	
27	Latitude (Byte 4)	
28	Latitude (Byte 5)	
29	Latitude (Byte 6)	
30	Latitude (Byte 7)	
31	Longitude (Byte 0)	Longitude of the IMU. It is a double in units of radians.
32	Longitude (Byte 1)	
33	Longitude (Byte 2)	
34	Longitude (Byte 3)	
35	Longitude (Byte 4)	
36	Longitude (Byte 5)	
37	Longitude (Byte 6)	
38	Longitude (Byte 7)	
39	Altitude (Byte 0)	Altitude of the IMU. It is a float in units of metres
40	Altitude (Byte 1)	
41	Altitude (Byte 2)	
42	Altitude (Byte 3)	
43	North Velocity (LSB)	North Velocity in units of 10^{-4} m/s.
44	North Velocity	
45	North Velocity (MSB)	
46	East Velocity (LSB)	East Velocity in units of 10^{-4} m/s.
47	East Velocity	
48	East Velocity (MSB)	
49	Down Velocity (LSB)	Down Velocity in units of 10^{-4} m/s.
50	Down Velocity	
51	Down Velocity (MSB)	
52	Heading (LSB)	Heading in units of 10^{-6} radians. Range $\pm\pi$.
53	Heading	
54	Heading (MSB)	

Byte	Quantity	Notes
55	Pitch (LSB)	Pitch in units of 10^{-6} radians. Range $\pm\pi/2$.
56	Pitch	
57	Pitch (MSB)	
58	Roll (LSB)	Roll in units of 10^{-6} radians. Range $\pm\pi$.
59	Roll	
60	Roll (MSB)	
61	Checksum 2	This checksum allows the software to verify the integrity of the packet so far. For a medium-latency output the full navigation solution is available. Only low-rate information is transmitted next.

Table 4. NCOM Packet Definition – Batch 3.

Byte	Quantity	Notes
62	Channel	The channel number determines what information is sent in Bytes 0 to 7 below.
63	Byte 0	
64	Byte 1	
65	Byte 2	
66	Byte 3	
67	Byte 4	
68	Byte 5	
69	Byte 6	
70	Byte 7	
71	Checksum 3	This is the final checksum that verifies the packet.

See the section on Status Information for the information included in Batch 3.

Table 5. NCOM Navigation Status – Byte 21

Value	Description
0	All quantities in the packet are invalid.
1	Raw IMU measurements. These are output at roughly 10Hz intervals before the system is initialised. They are useful for checking the communication link and for 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	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 1s in arrears. There will be a 1s pause at the start of initialisation where no output will be made (while the system fills the buffers). The system has to run 1s in arrears at this time in order to synchronise the GPS data with the inertial data and perform the initialisation checks. During the Initialising mode the Time, Acceleration and Angular Rate fields will be valid.
3	Locking. The system will move to the 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-antennna static initialisation or user command. In locking mode the system runs in arrears but catches up by 0.1s every 1s; locking mode lasts 10s. During locking mode the outputs are not real-time.
4	Locked. In Locked mode the system is outputting real-time data with the specified latency guaranteed. All fields are valid.
5	Reserved for "unlocked" navigation output. Do not use any values from this message.
6	Expired Firmware: this is output if the firmware is time limited and the expiry time has passed.
10	Status only: only the status part of the message 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. RT-View relies on this so that the status fields are valid right at the start of the data.
20	Trigger output while "initialising" (Navigation Status 2). The Status Channel will always be 24 (falling trigger), 43 (rising trigger) or 65 (output trigger).
21	Trigger output while "locking" (Navigation Status 3). The Status Channel will always be 24 (falling trigger), 43 (rising trigger) or 65 (output trigger).
22	Trigger output while "locked" (Navigation Status 4). The Status Channel will always be 24 (falling trigger), 43 (rising trigger) or 65 (output trigger).
Others	Reserved: ignore any outputs which have reserved Navigation Status values.

Status Information

Batch 3 of the NCOM packet transmits the Status Information of the RT. There is a lot of internally used information in the Status Information, but some of this information is useful customers.

The Status Information is transmitted at a low rate. Each cycle a different set of 8-bytes are transmitted. The *Channel* field defines which set of information is included in the 8-bytes. The order of the channels is irregular, with some channels being output more often than others. The order can change between different software versions. The channels repeat approximately once every 100 packets.

Some of the Status fields have special bits or values that denote ‘invalid’. The invalid values or the validity bits are noted in the tables.

Table 6. NCOM Packet Definition – Batch 3

Channel	Information	See
0	Full Time, Number of Satellites, Position Mode, Velocity Mode, Dual antenna Mode	Table 7
1	Kalman Filter Innovations for Position, Velocity and Attitude	Table 9
2	Internal Information about GPS1	Table 10
3	Position Accuracy	Table 11
4	Velocity Accuracy	Table 12
5	Orientation Accuracy	Table 13
6	Gyro Bias	Table 14
7	Accelerometer Bias	Table 15
8	Gyro Scale Factor	Table 16
9	Gyro Bias Accuracy	Table 17
10	Accelerometer Bias Accuracy	Table 18
11	Gyro Scale Factor Accuracy	Table 19
12	Position estimate of the Primary GPS antenna	Table 20
13	Orientation estimate of Dual antenna systems	Table 21
14	Accuracy of Position of the Primary GPS antenna	Table 22
15	Accuracy of the Orientation of Dual antenna systems	Table 23
16	RT to Vehicle Rotation	Table 24
17	Internal Information about GPS2	Table 25
18	Internal Information about Inertial Measurement Unit	Table 26
19	Software version running on RT	Table 27
20	Differential Correction Information	Table 28
21	Disk Space, Size of current internal log file	Table 29
22	Internal Information on timing of real-time processing	Table 30
23	System Up Time, Number of consecutive GPS rejections	Table 31
24	Trigger Event Timing (falling edge triggers)	Table 32
25	Reserved	–
26	Reserved	–
27	Internal Information about Dual antenna Ambiguity Searches	Table 33
28	Internal Information about Dual antenna Ambiguity Searches	Table 34
29	Details on the initial settings	Table 35
30-255	*continued on next page*	

Note: Channels with no corresponding table are not described in this manual. Contact Oxford Technical Solutions if you require specific information on these channels.

Table 6. NCOM Packet Definition – Batch 3, continued

Channel	Information	See
30	Operating System and script version information	Table 36
31	Hardware Configuration Information	–
32	Kalman filter innovations for Zero Velocity and Advanced Slip	Table 37
33	Zero Velocity Lever Arm	Table 38
34	Zero Velocity Lever Arm Accuracy	Table 39
35	Advanced Slip Lever Arm	Table 40
36	Advanced Slip Lever Arm Accuracy	Table 41
37	Advanced Slip Alignment Angle	Table 42
38	Zero Velocity Option Settings	–
39	Zero Velocity Option Settings	–
40	Reserved	–
41	Output Baud Rates	–
42	Heading Lock Options	–
43	Trigger2 Event Timing (rising edge triggers)	Table 32
44	Wheel Speed Configuration	Table 43
45	Wheel Speed Counts	Table 44
46	Wheel Speed Lever Arm	Table 45
47	Wheel Speed Lever Arm Accuracy	Table 46
48	Undulation, DOP of GPS	Table 47
49	OmniStar Tracking Information	Table 48
50	Information sent to the Command Decoder	Table 49
51	Additional Slip Point 1 Lever Arm	Table 50
52	Additional Slip Point 2 Lever Arm	Table 50
53	Additional Slip Point 3 Lever Arm	Table 50
54	Additional Slip Point 4 Lever Arm	Table 50
55	Information about the Primary GPS receiver	Table 51
56	Information about the Secondary GPS receiver	Table 51
57	Position estimate of the Primary GPS antenna (extended range)	Table 52
58	Reserved	–
59	IMU Decoding Status	Table 53
30-255	*continued on next page*	

Table 6. NCOM Packet Definition – Batch 3, continued

Channel	Information	See
60	Definition of the Surface Angles	Table 54
61	Internal Information about External GPS receiver	Table 55
62	Information about the External GPS receiver	Table 51
63	Angular Acceleration Filter settings	–
64	Hardware Information and External GPS Receiver Configuration	Table 56
65	Camera Output Event Timing	Table 32
66	Extended Local Co-ordinate Definition, Latitude, Longitude	Table 57
67	Extended Local Co-ordinate Definition, Altitude, Heading	Table 58
68	Additional Slip Point 5 Lever Arm	Table 50
69	Additional Slip Point 6 Lever Arm	Table 50
70	Additional Slip Point 7 Lever Arm	Table 50
71	Additional Slip Point 8 Lever Arm	Table 50
72 – 255	Reserved for future use	

Table 7. Status Information, Channel 0

Bytes	Format	Definition	Invalid When
0–3	Long	Time in minutes since GPS began (midnight 06/01/1980)	Value < 1000
4	UChar	Number of GPS satellites tracked by the Primary GPS receiver	Value = 255
5	UChar	Position Mode of Primary GPS	Value = 255
6	UChar	Velocity Mode of Primary GPS	Value = 255
7	UChar	Orientation Mode of Dual antenna Systems	Value = 255

Note: For the definitions of Position Mode, Velocity Mode and Orientation Mode see below.

Table 8. 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	Unknown	Unknown
21 – 255	N/A	Reserved or Invalid.

Table 9. Status Information, Channel 1

Bytes	Format	Definition	Valid When
0	Char	Bits 1 to 7: Position X Innovation	Bit 0 = 1
1	Char	Bits 1 to 7: Position Y Innovation	Bit 0 = 1
2	Char	Bits 1 to 7: Position Z Innovation	Bit 0 = 1
3	Char	Bits 1 to 7: Velocity X Innovation	Bit 0 = 1
4	Char	Bits 1 to 7: Velocity Y Innovation	Bit 0 = 1
5	Char	Bits 1 to 7: Velocity Z Innovation	Bit 0 = 1
6	Char	Bits 1 to 7: Orientation Pitch Innovation	Bit 0 = 1
7	Char	Bits 1 to 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 1.0σ 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 10. Status Information, Channel 2

Bytes	Format	Definition	Valid When
0 – 1	UShort	Characters received from GPS1 by the navigation computer	
2 – 3	UShort	Packets received from GPS1 by the navigation computer	
4 – 5	UShort	Characters received from GPS1 by the navigation computer but not understood by the decoder	
6 – 7	UShort	Packets received from GPS1 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 11. Status Information, Channel 3

Bytes	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	UChar	Age	
7		Reserved	

Note: The units of the Position Accuracies are 1mm.

Table 12. Status Information, Channel 4

Bytes	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	UChar	Age	
7		Reserved	

Note: The units of the Velocity Accuracies are 1mm/s.

Table 13. Status Information, Channel 5

Bytes	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	UChar	Age	
7		Reserved	

Note: The units of the Orientation Accuracies are 1e-5 radians.

Table 14. Status Information, Channel 6

Bytes	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	UChar	Age	
7		Reserved	

Note: The units of the Gyro Biases are 5e-6 radians.

Table 15. Status Information, Channel 7

Bytes	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	UChar	Age	
7		Reserved	

Note: The units of the Accelerometer Biases are 0.1mm/s².

Table 16. Status Information, Channel 8

Bytes	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	UChar	Age	
7		Reserved	

Note: The units of the Gyro Scale Factors are 1ppm (0.0001%).

Table 17. Status Information, Channel 9

Bytes	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	UChar	Age	
7		Reserved	

Note: The units of the Gyro Bias Accuracies are 1e-6 radians.

Table 18. Status Information, Channel 10

Bytes	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	UChar	Age	
7		Reserved	

Note: The units of the Accelerometer Biases are 0.01mm/s².

Table 19. Status Information, Channel 11

Bytes	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	UChar	Age	
7		Reserved	

Note: The units of the Gyro Scale Factors are 1ppm (0.0001%).

Table 20. Status Information, Channel 12

Bytes	Format	Definition	Valid When
0 – 1	Short	Distance to Primary GPS Antenna in X direction	Age < 150
2 – 3	Short	Distance to Primary GPS Antenna in Y direction	Age < 150
4 – 5	Short	Distance to Primary GPS Antenna in Z direction	Age < 150
6	UChar	Age	
7		Reserved	

Note: The units of the Distances are 1mm.

Table 21. Status Information, Channel 13

Bytes	Format	Definition	Valid When
0 – 1	Short	Heading Orientation of the GPS Antennas	Age < 150
2 – 3	Short	Pitch Orientation of the GPS Antennas	Age < 150
4 – 5	Short	Distance between the GPS Antennas	Age < 150
6	UChar	Age	
7		Reserved	

Note: The units of the distances are 1mm. The units of the Orientation Angles are 1e-4 radians.

Table 22. Status Information, Channel 14

Bytes	Format	Definition	Valid When
0 – 1	UShort	Accuracy of Distance to Primary GPS Antenna in X direction	Age < 150
2 – 3	UShort	Accuracy of Distance to Primary GPS Antenna in Y direction	Age < 150
4 – 5	UShort	Accuracy of Distance to Primary GPS Antenna in Z direction	Age < 150
6	UChar	Age	
7		Reserved	

Note: The units of the Distance Accuracies are 0.1mm.

Table 23. Status Information, Channel 15

Bytes	Format	Definition	Valid When
0 – 1	UShort	Accuracy of Heading Orientation of the GPS Antennas	Age < 150
2 – 3	UShort	Accuracy of Pitch Orientation of the GPS Antennas	Age < 150
4 – 5	UShort	Accuracy of Distance between the GPS Antennas	Age < 150
6	UChar	Age	
7		Reserved	

Note: The units of the distances are 1mm. The units of the Orientation Angle Accuracies are 1e-4 radians.

Table 24. Status Information, Channel 16

Bytes	Format	Definition	Valid When
0 – 1	Short	Heading of the vehicle in the RT co-ordinate frame.	Byte 6 = 0
2 – 3	Short	Pitch of the vehicle in the RT co-ordinate frame.	Byte 6 = 0
4 – 5	Short	Roll of the vehicle in the RTF co-ordinate frame.	Byte 6 = 0
6	UChar	Validity	
7	Char	Bits 1–7 UTC Time Offset	Bit 0 = 1

Note: The units of the Orientation Angles are 1e-4 radians. To compute UTC Time from GPS Time *add* the offset. Currently the offset is –14 seconds. (The offset is always an integer number of seconds. UTC Time slips or gains a second occasionally whereas GPS Time does not).

Table 25. Status Information, Channel 17

Bytes	Format	Definition	Valid When
0 – 1	UShort	Characters received from GPS2 by the navigation computer	
2 – 3	UShort	Packets received from GPS2 by the navigation computer	
4 – 5	UShort	Characters received from GPS2 by the navigation computer but not understood by the decoder	
6 – 7	UShort	Packets received from GPS2 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 26. Status Information, Channel 18

Bytes	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 27. Status Information, Channel 19

Bytes	Format	Definition	Valid When
0 – 7	8 x Char	This is the Software Version or *Development ID* that is running in the RT in ASCII format.	

Table 28. Status Information, Channel 20

Bytes	Format	Definition	Valid When
0 – 1	Short	Age of the Differential Corrections from the Base-Station	
2 – 5	4 x Char	Differential Station ID	
6 – 7		Reserved	

Note: The unit of the Differential Corrections is 0.01 seconds.

Table 29. Status Information, Channel 21

Bytes	Format	Definition	Valid When
0 – 3	Long	Disk Space Remaining on RT. Note that the RT always leaves about 2MB spare on the disk.	Value > 0
4 – 7	Long	Size of current logged raw data file. When there is insufficient space on the disk no more data will be written.	

Note: The values are output in kilobytes.

Table 30. Status Information, Channel 22

Bytes	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 not 0xFFFF
2	UChar	IMU Time Difference (in milliseconds).	Value not 0xFF
3	UChar	IMU Time Margin (in milliseconds).	Value not 0xFF
4 – 5	UShort	IMU Loop Time (in milliseconds).	Value not 0xFFFF
6 – 7	UShort	Output Loop Time (in milliseconds).	Value not 0xFFFF

Table 31. Status Information, Channel 23

Bytes	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 (in milliseconds).	Value not 0xFFFF
2 – 3	UShort	Indicates how long the RT has been running for. The field uses a non-linear time scale as follows: Value > 20700: (Value – 20532) (hours) 10800 < Value ≤ 20700: (Value – 10620) (minutes) Value ≤ 10800: Value (seconds)	Value not 0xFFFF
4	UChar	Number of consecutive GPS position updates rejected	Value not 0xFF
5	UChar	Number of consecutive GPS velocity updates rejected	Value not 0xFF
6	UChar	Number of consecutive GPS attitude updates rejected	Value not 0xFF
7		Reserved	

Table 32. Status Information, Channel 24 (Falling Trigger), Channel 43 (Rising Trigger) and Channel 65 (Output Trigger)

Bytes	Format	Definition	Valid When
0 – 3	Long	Minutes of falling edge of Event Input since GPS began (6th January 1980). `TRIG_MINUTE` variable below.	Value > 0
4 – 5	UShort	Milliseconds of falling edge of Event Input (within the minute) `TRIG_MSEC` variable below.	`TRIG_MINUTE` > 0
6	Char	Microseconds of falling edge of Event Input (within the millisecond), units of 4µs. `TRIG_USEC` variable below.	`TRIG_MINUTE` > 0
7	UChar	Trigger Count, increments each time there is a new trigger.	Value > 0

Note: To find the time of the trigger in GPS seconds compute:

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

Table 33. Status Information, Channel 27

Bytes	Format	Definition	Valid When
0	UChar	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	UChar	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 ≤ Value ≤ 3
2	UChar	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	UChar	Heading Search Ready 0: Waiting 1: Processing	0 ≤ Value ≤ 1
4 – 5	UShort	Initial number of ambiguities in the heading search	Value not 0xFFFF
6 – 7	UShort	Remaining number of ambiguities in the heading search	Value not 0xFFFF

Table 34. Status Information, Channel 28

Bytes	Format	Definition	Valid When
0	UChar	Master Satellite PRN in the Heading Search	
1	UChar	Slave 1 Satellite PRN in the Heading Search	
2	UChar	Slave 2 Satellite PRN in the Heading Search	
3	UChar	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 35. Status Information, Channel 29

Bytes	Format	Definition	Valid When
0	UChar	"Vehicle starts" option 0: Initially not level 1: Initially level (roll and pitch within 15 degrees)	0 ≤ Value ≤ 1
1	UChar	Vibration in the environment option 0: Normal 1: High 2: Very High	0 ≤ Value ≤ 2
2	UChar	Expected GPS Accuracy or weighting 0: Some Obstructions – medium GPS weighting 1: Open Sky – high GPS weighting 2: Frequent Obstructions – low GPS weighting	0 ≤ Value ≤ 2
3	UChar	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	0 ≤ Value ≤ 10
4	UChar	Serial 1 Output option See UDP Output option for definitions	0 ≤ Value ≤ 10
5	UChar	Serial 2 Output option See UDP Output option for definitions	0 ≤ Value ≤ 10
6	UChar	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		Reserved	

Table 36. Status Information, Channel 30

Bytes	Format	Definition	Valid When
0	UChar	Operating System Version 1	Value not 0xFF
1	UChar	Operating System Version 2	Value not 0xFF
2	UChar	Operating System Version 3	Value not 0xFF
3 – 5	Word	Start-up Script version	
6 – 7	UShort	Serial Number	Value not 0xFFFF

Table 37. Status Information, Channel 32

Bytes	Format	Definition	Valid When
0	Char	Bits 1 to 7: Zero Velocity X Innovation	Bit 0 = 1
1	Char	Bits 1 to 7: Zero Velocity Y Innovation	Bit 0 = 1
2	Char	Bits 1 to 7: Zero Velocity Z Innovation	Bit 0 = 1
3	Char	Bits 1 to 7: Advanced Slip Innovation	Bit 0 = 1
4	Char	Bits 1 to 7: Heading Lock Innovation	Bit 0 = 1
5	Char	Bits 1 to 7: Wheel Speed Innovation	Bit 0 = 1
6 – 7		Reserved	

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.

Table 38. Status Information, Channel 33

Bytes	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	UChar	Validity	
7		Reserved	

Note: The units of the distances are 1mm.

Table 39. Status Information, Channel 34

Bytes	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	UChar	Validity	
7		Reserved	

Note: The units of the distances are 0.1mm.

Table 40. Status Information, Channel 35

Bytes	Format	Definition	Valid When
0 – 1	Short	Distance to the Advanced Slip Point in X direction	Byte 6 = 0
2 – 3	Short	Distance to the Advanced Slip Point in Y direction	Byte 6 = 0
4 – 5	Short	Distance to the Advanced Slip Point in Z direction	Byte 6 = 0
6	UChar	Validity	
7		Reserved	

Note: The units of the distances are 1mm.

Table 41. Status Information, Channel 36

Bytes	Format	Definition	Valid When
0 – 1	UShort	Accuracy of Distance to the Advanced Slip Point in X direction	Byte 6 = 0
2 – 3	UShort	Accuracy of Distance to the Advanced Slip Point in Y direction	Byte 6 = 0
4 – 5	UShort	Accuracy of Distance to the Advanced Slip Point in Z direction	Byte 6 = 0
6	UChar	Validity	
7		Reserved	

Note: The units of the distances are 0.1mm.

Table 42. Status Information, Channel 37

Bytes	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 – 5		Reserved	
6	UChar	Validity	
7		Reserved	

Note: The unit of the Angle is 1e-4 radians. T he unit of the Angle Accuracy is 1e-5 radians.

Table 43. Status Information, Channel 44

Bytes	Format	Definition	Valid When
0 – 1	UShort	Wheelspeed scaling in units of 0.1 pulses per metre	Value not 0xFFFF
2-3	UShort	Wheelspeed scaling accuracy in units of 0.002%	Value not 0xFFFF
4-7		Reserved	Value not 0xFF

Table 44. Status Information, Channel 45

Bytes	Format	Definition	Valid When
0 – 3	ULong	Cyclic wheelspeed input counts, this value increases each time a pulse is detected on the wheelspeed input.	
4 – 5	UShort	Timestamp of wheelspeed input count measurement above. This time stamp is transmitted as milliseconds into the minute in GPS time.	Value < 60000
6	UChar	Time since the wheelspeed count last changed, in units of 0.1s,	Value not 0xFF
7		Reserved	

Table 45. Status Information, Channel 46

Bytes	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	UChar	Validity	
7		Reserved	

Note: The units of the distances are 1mm.

Table 46. Status Information, Channel 47

Bytes	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	UChar	Validity	
7		Reserved	

Note: The units of the distances are 0.1mm.

Table 47. Status Information, Channel 48

Bytes	Format	Definition	Valid When
0 – 1	Short	Undulation value (difference between RT Altitude and WGS-84 Ellipsoidal Altitude)	Value not 0xFFFF
2	UChar	HDOP of GPS	Value not 0xFF
3	UChar	PDOP of GPS	Value not 0xFF
4 – 7		Reserved	

Units of Undulation are 5mm. Units of HDOP/PDOP are 0.1.

In the default configuration the RT outputs the Geoidal Altitude, computed using the EGM96 lookup table. To compute the WGS-84 or Elliptical Altitude use the following equation:

```
Ellipsoial Altitude = RT Altitude - Undulation
```

Table 48. Status Information, Channel 49

Bytes	Format	Definition	Valid When
0 – 1	UShort	Frequency of OmniStar Tracking Loop	Value not 0xFFFF
2	UChar	SNR of OmniStar signal	Value not 0xFF
3	UChar	Time of continuous tracking of OmniStar signal	Value not 0xFF
4	UChar	OmniStar Status	Value not 0xFF
5 – 7		Reserved	

The Frequency of the OmniStar Tracking Loop is 1.52 + (Value / 1e6) GHz. Units of SNR is 0.2dB. Units of Time for tracking of OmniStar signal is 1.0 seconds.

Table 49. Status Information, Channel 50

Bytes	Format	Definition	Valid When
0 – 1	UShort	Characters received on this port	
2 – 3	UShort	Packets received on this port	
4 – 5	UShort	Characters received on this port but not understood by the decoder	
6 – 7	UShort	Errors received on this 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 50. Status Information, Channels 51, 52, 53, 54, 68, 69, 70 and 71

Bytes	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	UChar	Validity	
7		Reserved	

Note: The units of the distances are 1mm.

Table 51. Status Information, Channels 55, 56, 62

Bytes	Format	Definition	Valid When
0	UChar	Bits 0 – 1: GPS Antenna Status 0: OK 1: Open 2: Short 3: Unknown Invalid Bits 2 – 3: GPS Antenna Power Status 0: Power On 1: Power Off 2: Power Unknown 3: Invalid Bits 4 – 7: Reserved	See individual bits
1	UChar	CPU Used on GPS Card (percentage)	Value not 0xFF
2	UChar	Core Noise on GPS Card (percentage)	Value not 0xFF
3	UChar	Baud Rate of GPS Card 0: Disabled 1: 300 2: 600 3: 1200 4: 2400 5: 4800 6: 9600 7: 19200 8: 38400 9: 57600 10: 76800 11: 115200 12: 230400 13: 460800 14: 921600	Value < 15
4	UChar	Number of Satellites Tracked	Value not 0xFF
5	UChar	Position Mode of GPS (see Table 8)	Value not 0xFF
6	UChar	Core Temperature = Value – 70ºC	Value not 0xFF
7	UChar	GPS Receiver Supply Voltage = Value x 0.1V	Value not 0xFF

Table 52. Status Information, Channel 57

Bytes	Format	Definition	Valid When
0 – 1	Short	Distance to Primary GPS Antenna in X direction	Age < 150 and Scale Factor not 0
2 – 3	Short	Distance to Primary GPS Antenna in Y direction	Age < 150 and Scale Factor not 0
4 – 5	Short	Distance to Primary GPS Antenna in Z direction	Age < 150 and Scale Factor not 0
6	UChar	Age	
7	UChar	Scale Factor	

Note: The units of the Distances are 1mm and each value has to be multiplied by the Scale Factor. If the Scale Factor is 0xFF then the distances are saturated.

Table 53. Status Information, Channel 59

Bytes	Format	Definition	Valid When
0 – 1	UShort	Number of IMU Packets missed	
2	UChar	Number of IMU Resets detected	
3	UChar	Number of IMU Errors detected	

Note: In normal operation all these values should be zero. These counters are cyclic and will wrap when they exceed the limit of the format used.

Table 54. Status Information, Channel 60

Bytes	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	UChar	Validity	
7		Reserved	

Note: The units of the angles are 1e-4 radians.

Table 55. Status Information, Channel 61

Bytes	Format	Definition	Valid When
0 – 1	UShort	Characters received from the External GPS by the navigation computer	
2 – 3	UShort	Packets received from the External GPS by the navigation computer	
4 – 5	UShort	Characters received from the External GPS by the navigation computer but not understood by the decoder	
6 – 7	UShort	Packets received from the External GPS 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 56. Status Information, Channel 64

Bytes	Format	Definition	Valid When
0	UChar	CPU Type running the navigation computer 0: TP400B 1: TP500 Others unknown	Value not 0xFF
1	UChar	External GPS 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 Others unknown	Value not 0xFF
2	UChar	External GPS Format 0: Novatel OEM2 Binary 1: Novatel OEM4/OEMV Binary 2: UBX 3: NMEA 4: GSOF 5: TSIP 6: GRIL 7: Debug Others unknown	Value not 0xFF
3 – 7		Reserved	

Table 57. Status Information, Channel 66

Bytes	Format	Definition	Valid When
0 – 3	Long	Local Co-ordinates Origin Latitude	Value not 0x80000000
4 – 7	Long	Local Co-ordinates Origin Longitude	Value not 0x80000000

Note: The units of the angles are 1e-7 degrees.

Table 58. Status Information, Channel 67

Bytes	Format	Definition	Valid When
0 – 3	Long	Local Co-ordinates Origin Altitude	Value not 0x80000000
4 – 7	Long	Local Co-ordinates Origin Heading	Value not 0x80000000

Note: The units for the heading is 1e-7 degrees. The unit for the Altitude is 1mm.

Triggered Outputs

Triggered outputs are generated when a transition occurs on the Event input. The transition can be a rising or falling transition. Triggered outputs can also be configured to occur when the RT generates a pulse on the wheel speed output but only under some conditions.

The RT uses two methods of outputting triggered values. Status Information channels 24 and 43 are output periodically (over NCOM and CAN). The Status Information gives the exact time of the trigger; it is necessary to look back through the data, find the values just before and just after the trigger time, then interpolate to find the exact values.

Using NCOM over Ethernet it is possible to get higher data rate triggers (up to 50Hz). These need to be configured using the Ethernet options in RT-Config. When the Ethernet is configured to output triggered packets, additional asynchronous NCOM packets will be output when a trigger occurs. The Navigation Status for these triggered packets will be different (see Table 5) and the status channel can be used to identify if the trigger was generated by a falling edge, rising edge or relates to the time of a wheel speed output pulse.

In the triggered output packets, the RT will automatically interpolate the measurement outputs so that they relate to the exact trigger time. Since the Time field only has a resolution of 1ms, the time in the status information must be used to find the time of the trigger with a higher resolution.

The asynchronous NCOM outputs are only available in real time on the faster TP500 processor card. Even if the correct firmware is installed on an older TP400 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 59. Revision History

Revision	Comments
080124	Initial Version from RT Manual
090818	Updated in line with RT Manual: triggering included.
090820	Added more Status Channel Definitions (50 to 71)