Septentrio
satellite navigation

AsteRx2eH SBF Reference Guide

Applicable to version 3.4.0 of the GNSS Firmware

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List of Acronyms

Abbreviation	Description
AGC	Automatic Gain Control
ARP	Antenna Reference Point
ASCII	American Standard Code for Information Interchange
BGD	Broadcast Group Delay
CA	Coarse Acquisition
CMR	Compact Measurement Record
COG	Course Over Ground
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
DGPS	Differential GPS
DOP	Dilution Of Precision
DVS	Data Validity Status
ECEF	Earth-Centered Earth-Fixed
ENU	east-north-up
GEO	Geostationary Earth Orbiter
GLONASS	Global Orbiting Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GST	Galileo System Time
HDOP	Horizontal DOP
HERL	Horizontal External Reliability Level
HMI	hazardously misleading information
HPCA	HMI Probability Computation Algorithm
HPL	horizontal protection level
HS	Health Status
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
IGP	Ionospheric Grid Point

IMU	Inertial Measurement Unit
INS	Inertial Navigation System
IODC	Issue of Data - Clock
IODE	Issue Of Data Ephemeris
IP	Internet Protocol
ITRS	International Terrestrial Reference System
LBand	L-Band Receiver
L1	L1 carrier
L2	L2 carrier
L2C	L2C code
LSB	Least Significant Bit
MDB	Minimum Detectable Bias
MSB	Most Significant Bits
MT	Message Type
NATO	North Atlantic Treaty Organisation
NAV	Navigation
NAVSTAR	Navigation Satellite Timing And Ranging
NMEA	National Marine Electronics Association
P	P(Y) code
P1	P1 code
P2	P2 code
PDOP	Position DOP
PLL	Phase Locked Loop
PPP	Precise Point Positioning
PPS	Pulse Per Second
PRC	Pseudorange Correction
PRN	Pseudo Random Noise
PVT	Position, Velocity and Time
QZSS	Quasi-Zenith Satellite System
RAIM	Receiver Autonomous Integrity Monitoring
RINEX	Receiver Independent Exchange Format
RTCM	Radio Technical Commission for Maritime Services
RTK	Real-Time Kinematic

SBAS	Space-Based Augmentation System
SBF	Septentrio Binary Format
SF	Single Frequency
SIS	Signal In Space
SISA	Signal in Space Accuracy
SNMP	Simple Network Management Protocol
SV	Space Vehicle
SVID	Space Vehicle ID
TDOP	Time DOP
TOW	Time Of Week
UDRE	User Differential Range Error
UERE	User Equivalent Range Error
URA	User Range Accuracy
USB	Universal Serial Bus
UTC	Coordinated Universal Time
VDOP	Vertical DOP
VERL	Vertical External Reliability Level
VPL	vertical protection level
WGS84	World Geodetic System 1984
WN	Week Number
WNc	Week number
XERL	External Reliability Levels
XOR	Exclusive OR
XPL	Horizontal or Vertical Protection Level

1 Introduction

1.1 Scope

This document describes the format of the binary data output by Septentrio receivers, called SBF.

1.2 Typographical Conventions

abc User command name;
`abc` SBF block name and field name.

1.3 Change Log

Date	Change Description
April 30, 2014	Added new values for the `Datum` field
April 22, 2014	Added the `DiskStatus` block reporting the disk usage and free space of the disks available on the receiver
Feb 21, 2014	Added the `NTRIPClientStatus` block for the NTRIP client connection status
March 14, 2013	Added the `QualityInd` block containing various quality indicators
Feb 8, 2013	Fixed typo: field `t_oG` of `GALGstGps` changed to type `u4` and units of seconds
Jan 8, 2013	Added fields `HAccuracy`, `VAccuracy` and `Misc` to the `PVTCartesian` and `PVTGeodetic` blocks
Dec 19, 2012	Added PRNs 139 and 140 to the list of SBAS satellites (see section 2.9)
Oct 25, 2012	Added `RTCMDatum` and `PosLocal` blocks
Oct 19, 2012	Added `GEORawL5` block
Oct 1, 2012	Added new signal type for L-band and SBAS L5 signals (value 23 and 25), see section 2.10
Sep 20, 2012	Added field `PPPInfo` to the `PVTCartesian` and `PVTGeodetic` blocks
Feb 28, 2012	Added `GALSARRLM` block
Feb 6, 2012	Added QZSS signals and `QZSRawL1CA`, `QZSRawL2C` and `QZSRawL5` blocks

2 SBF Outline

SBF is the binary output format of Septentrio receivers. In this format, the data are arranged in binary blocks referred to as SBF blocks.

Each SBF block consists of a sequence of numeric or alphanumeric fields of different types and sizes. The total block size is always a multiple of 4 bytes.

The fields of an SBF block may have one of the following types:

Type	Description
u1	Unsigned integer on 1 byte (8 bits)
u2	Unsigned integer on 2 bytes (16 bits)
u4	Unsigned integer on 4 bytes (32 bits)
i1	Signed integer on 1 byte (8 bits)
i2	Signed integer on 2 bytes (16 bits)
i4	Signed integer on 4 bytes (32 bits)
f4	IEEE float on 4 bytes (32 bits)
f8	IEEE float on 8 bytes (64 bits)
c1[X]	String of X ASCII characters, right padded with bytes set to 0 if needed.

Each multi-byte binary type is transmitted as little-endian, meaning that the least significant byte is the first one to be transmitted by the receiver. Signed integers are coded as two's complement.

Every SBF block begins with an 8-byte block header, which is followed by the block body.

2.1 SBF Block Header Format

Every SBF block starts with an 8-byte header having the following contents:

Parameter	Type	Description
`Sync`	c1[2]	The Sync field is a 2-byte array always set to 0x24, 0x40. The first byte of every SBF block has hexadecimal value 24 (decimal 36, ASCII '$'). The second byte of every SBF block has hexadecimal value 40 (decimal 64, ASCII '@'). These two bytes identify the beginning of any SBF block and can be used for synchronization.
`CRC`	u2	The CRC field is the 16-bit CRC of all the bytes in an SBF block from and including the ID field to the last byte of the block. The generator polynomial for this CRC is the so-called CRC-CCITT polynomial: $x^{16} + x^{12} + x^5 + x^0$. The CRC is computed in the forward direction using a seed of 0, no reverse and no final XOR.
`ID`	u2	The ID field is a 2-byte block ID, which uniquely identifies the block type and its contents. It is a bit field with the following definition: bits 0-12: block number; bits 13-15: block revision number, starting from 0 at the initial block definition, and incrementing each time backwards-compatible changes are performed to the block (see section 2.6).
`Length`	u2	The Length field is a 2-byte unsigned integer containing the size of the SBF block. It is the total number of bytes in the SBF block including the header. It is always a multiple of 4.

2.2 List of SBF Block Names and Numbers

The structure and contents of an SBF block are unambiguously identified by the block ID. For easier readability, a block name is also defined for each block. When invoking the **`setSBFOutput`** command to enable a given block, the block name should be specified.

The following table provides the list of the SBF blocks names and numbers available on the version 3.4.0 of the GNSS Firmware receiver, and a short description of the associated contents. The block number is contained in bits 0 to 12 of the block `ID` field (see section 2.1).

The "Flex Rate" column indicates whether a given block can be output at a user-defined rate and the "esoc" column whether it can be used as an argument of the **`exeSBFOnce`** command (see also section 2.8). The "Time stamp" column indicates which type of time is encoded in the block time stamp (see section 2.3 for details).

Block name	Block No	Content description	Flex Rate	esoc	Time Stamp
Measurement Blocks					
MeasEpoch	4027	measurement set of one epoch	•	•	R
MeasExtra	4000	additional info such as observable variance	•	•	R
IQCorr	4046	real and imaginary post-correlation values	•	•	R
EndOfMeas	5922	measurement epoch marker	•	•	R
Navigation Page Blocks					
GPSRawCA	4017	GPS CA navigation subframe			S
GPSRawL2C	4018	GPS L2C navigation frame			S
GPSRawL5	4019	GPS L5 navigation frame			S
GLORawCA	4026	GLONASS CA navigation string			S
GALRawFNAV	4022	Galileo F/NAV navigation page			S
GALRawINAV	4023	Galileo I/NAV navigation page			S
GEORawL1	4020	SBAS L1 navigation message			S
GEORawL5	4021	SBAS L5 navigation message			S
QZSRawL1CA	4066	QZSS L1 CA navigation frame			S
QZSRawL2C	4067	QZSS L2C navigation frame			S
QZSRawL5	4068	QZSS L5 navigation frame			S
GPS Decoded Message Blocks					
GPSNav	5891	GPS ephemeris and clock		•	S
GPSAlm	5892	Almanac data for a GPS satellite		•	S
GPSIon	5893	Ionosphere data from the GPS subframe 5		•	S
GPSUtc	5894	GPS-UTC data from GPS subframe 5		•	S
GLONASS Decoded Message Blocks					
GLONav	4004	GLONASS ephemeris and clock		•	S
GLOAlm	4005	Almanac data for a GLONASS satellite		•	S
GLOTime	4036	GLO-UTC, GLO-GPS and GLO-UT1 data		•	S
Galileo Decoded Message Blocks					
GALNav	4002	Galileo ephemeris, clock, health and BGD		•	S
GALAlm	4003	Almanac data for a Galileo satellite		•	S
GALIon	4030	NeQuick Ionosphere model parameters		•	S
GALUtc	4031	GST-UTC data		•	S
GALGstGps	4032	GST-GPS data		•	S
GALSARRLM	4034	Search-and-rescue return link message			S
SBAS Decoded Message Blocks					
GEOMT00	5925	MT00 : SBAS Don't use for safety applications			S
GEOPRNMask	5926	MT01 : PRN Mask assignments			S

Block name	Block No	Content description	Flex Rate	esoc	Time Stamp
GEOFastCorr	5927	MT02-05/24: Fast Corrections			S
GEOIntegrity	5928	MT06 : Integrity information			S
GEOFastCorrDegr	5929	MT07 : Fast correction degradation factors			S
GEONav	5896	MT09 : SBAS navigation message		•	S
GEODegrFactors	5930	MT10 : Degradation factors			S
GEONetworkTime	5918	MT12 : SBAS Network Time/UTC offset parameters			S
GEOAlm	5897	MT17 : SBAS satellite almanac		•	S
GEOIGPMask	5931	MT18 : Ionospheric grid point mask			S
GEOLongTermCorr	5932	MT24/25 : Long term satellite error corrections			S
GEOIonoDelay	5933	MT26 : Ionospheric delay corrections			S
GEOServiceLevel	5917	MT27 : SBAS Service Message			S
GEOClockEphCovMatrix	5934	MT28 : Clock-Ephemeris Covariance Matrix			S
Position, Velocity and Time Blocks					
PVTCartesian	4006	Position, velocity, and time in Cartesian coordinates	•	•	R
PVTGeodetic	4007	Position, velocity, and time in geodetic coordinates	•	•	R
PosCovCartesian	5905	Position covariance matrix (X,Y, Z)	•	•	R
PosCovGeodetic	5906	Position covariance matrix (Lat, Lon, Alt)	•	•	R
VelCovCartesian	5907	Velocity covariance matrix (X, Y, Z)	•	•	R
VelCovGeodetic	5908	Velocity covariance matrix (North, East, Up)	•	•	R
DOP	4001	Dilution of precision	•	•	R
PosCart	4044	Position, variance and baseline in Cartesian coordinates	•	•	R
PosLocal	4052	Position in a local datum	•	•	R
PVTSatCartesian	4008	Satellite positions	•	•	R
PVTResiduals	4009	Measurement residuals	•	•	R
RAIMStatistics	4011	Integrity statistics	•	•	R
GEOCorrections	5935	Orbit, Clock and pseudoranges SBAS corrections	•	•	R
BaseVectorCart	4043	XYZ relative position and velocity with respect to base(s)	•	•	R
BaseVectorGeod	4028	ENU relative position and velocity with respect to base(s)	•	•	R
PVTSupport	4076	Reserved for maintenance and support	•	•	R
EndOfPVT	5921	PVT epoch marker	•	•	R
GNSS Attitude Blocks					
AttEuler	5938	GNSS attitude expressed as Euler angles	•	•	R
AttCovEuler	5939	Covariance matrix of attitude	•	•	R
AuxAntPositions	5942	Relative position and velocity estimates of auxiliary antennas	•	•	R
EndOfAtt	5943	GNSS attitude epoch marker	•	•	R
Receiver Time Blocks					
ReceiverTime	5914	Current receiver and UTC time	•	•	R
xPPSOffset	5911	Offset of the xPPS pulse with respect to GNSS time			R
External Event Blocks					
ExtEvent	5924	Time at the instant of an external event			E
ExtEventPVTCartesian	4037	Cartesian position at the instant of an event			E
ExtEventPVTGeodetic	4038	Geodetic position at the instant of an event			E
Differential Correction Blocks					
DiffCorrIn	5919	Incoming RTCM or CMR message			R
BaseStation	5949	Base station coordinates			R

Block name	Block No	Content description	Flex Rate	esoc	Time Stamp
RTCMDatum	4049	Datum information from the RTK service provider			R
Status Blocks					
ChannelStatus	4013	Status of the tracking for all receiver channels	•	•	R
ReceiverStatus	4014	Overall status information of the receiver	•	•	R
SatVisibility	4012	Azimuth/elevation of visible satellites	•	•	R
InputLink	4090	Statistics on input streams	•	•	R
OutputLink	4091	Statistics on output streams	•	•	R
NTRIPClientStatus	4053	NTRIP client connection status		•	R
IPStatus	4058	IP address, gateway and MAC address		•	R
QualityInd	4082	Quality indicators		•	R
DiskStatus	4059	Internal logging status		•	R
Miscellaneous Blocks					
ReceiverSetup	5902	General information about the receiver set-up		•	R
Commands	4015	Commands entered by the user		•	R
Comment	5936	Comment entered by the user		•	R
BBSamples	4040	Baseband samples			E
ASCIIIn	4075	Search-and-rescue return link message			R
Deprecated or Obsolete Bocks					
BaseLine	5950				R

2.3 SBF Block Time Stamp (TOW and WNc)

Each SBF header is directly followed by a time stamp, which consists of two fields: TOW and WNc:

Parameter	Type	Units & Scale	Do-Not-Use	Description
		Factor	Value	
TOW	u4	0.001 s	4294967295	Time-Of-Week : Time-tag, expressed in whole milliseconds from the beginning of the current Galileo/GPS week.
WNc	u2	1 week	65535	The GPS week number associated with the TOW. WNc is a continuous week count (hence the "c"). It is not affected by GPS week rollovers, which occur every 1024 weeks. By definition of the Galileo system time, WNc is also the Galileo week number plus 1024.

If the time-of-week or the week number is unknown, which is typically the case for a few seconds after start-up, the corresponding field is set to its Do-Not-Use value (see section 2.7). It does not mean that the SBF block is unusable, but simply that the receiver could not time-tag it. It is typical that the TOW field becomes valid before the WNc field.

Note that the origin of Galileo time is at the end of the 1024^{th} GPS week, i.e. Galileo system time lags GPS time by 1024 weeks. To avoid confusion, in all SBF blocks, Galileo weeks are always aligned to GPS weeks, unless otherwise specified.

The interpretation to give to the time stamp is block-dependent. Three types of time stamps are possible:

- *Receiver time stamp*: this type of time stamp is used for the SBF blocks containing synchronous data, i.e. data generated at a given epoch in the receiver time scale. Examples of such blocks are the measurement and PVT blocks (MeasEpoch and PVTCartesian). The time stamp is always a multiple of the output interval as speci-

fied by the **setSBFOutput** command (see also section 2.8). As soon as the receiver time is aligned with the GNSS time, the receiver time stamp is guaranteed to never decrease in successive SBF blocks.

- *SIS time stamp*: it is used for asynchronous blocks containing navigation message data from the signal-in-space. The time stamp corresponds to the time of reception of the end of the last navigation frame or page used to build the SBF block, rounded to the nearest multiple of the page duration. This time is expressed in the receiver time scale.
- *External time stamp*: this type of time stamp is used for SBF blocks triggered by external asynchronous events, such as the `ExtEvent` block.

For the blocks with a SIS or an external time stamp, there is no strict relation between the time stamp of the SBF blocks and their order of transmission. For example, the SBF stream may contain a `GPSNav` block with ephemeris parameters received one hour in the past (i.e. the time stamp is one hour in the past) followed by another block with a current receiver time stamp.

2.4 Sub-blocks

Some blocks contain sub-blocks. For example, the `PVTSatCartesian` block contains `N` `SatPos` sub-blocks, each sub-block containing data for one particular satellite. SBF blocks that contain sub-blocks also contain a `SBLength` field, which indicates the size of the sub-blocks in bytes.

2.5 Padding Bytes

Padding bytes are foreseen at the end of every SBF block body and sub-block, so that their total size is equal to `Length` or `SBLength` respectively. The padding bytes are just placeholders and should not be looked at by the decoding software. Their value is not defined.

2.6 SBF Revision Number

Each SBF block has an associated revision number. The revision number is incremented each time a backwards-compatible change is implemented.

As described in section 2.1, the block number is to be found in bits 0 to 12 of the `ID` field, and the revision is in bits 13 to 15 of that field.

A backwards-compatible change consists of adding one or more fields in the padding bytes, or in the fields marked as "reserved" in the block description. Such change should be unnoticed by properly written decoding software that ignore the contents of padding and reserved fields (see also section 2.12). Each time such change happens, the revision number is incremented. The revision at which a given field has been introduced is documented in the block description in chapter 3, unless that revision is 0 (see the `ReceiverSetup` block as an example). It is guaranteed that if a given field exists in revision N, it will also exist in all revisions after N: no fields are withdrawn from SBF.

2.7 Do-Not-Use Value

It might happen that one or more pieces of data in an SBF block are not known at block creation time. For example, when there are insufficient satellite measurements to compute a position solution, the position components found in the `X`, `Y` and `Z` fields of the `PVTCartesian` block will not be available. To indicate that a given data item is not available or is currently not provided by the receiver, the corresponding field is set to a 'Do-Not-Use' value that is never reached in normal operation.

When applicable, the Do-Not-Use value is mentioned in the block description. The Do-Not-Use value refers to the raw contents of the field, without applying the scale factor. A field set to its Do-Not-Use value should always be discarded by the decoding software.

2.8 Output Rate

In general, the default output rate for each SBF block is the renewal rate of the information. For instance, the `GPSNav` block is output each time a new ephemeris data set is received from a given GPS satellite. The default output rates of GNSS measurement blocks, PVT blocks and integrated INS/GNSS blocks depend on your permission set. These three rates can be checked by the command **`getReceiverCapabilities`**.

The default output rate is specified for each block in chapter 3. To instruct the receiver to output a given block at its default rate, the "`OnChange`" rate has to be specified in the **`setSBFOutput`** command. Note that the maximum rate actually available on your receiver may be lower than the one specified in chapter 3, depending on your permission set.

Some blocks can only be output at their default rate (e.g. the `GPSNav` block). Others can be decimated to a user-selectable rate (which is by nature lower than the default rate). A subset of blocks can also be output "once" using the **`exeSBFOnce`** command. This can be handy to get a one-shot overview of a particular receiver state. Whether a given block supports a user-selectable rate and whether it belongs to the "output once" set is indicated in the SBF block list in section 2.2.

Attempting to force another rate than the default one for those blocks that do not support a user-selectable rate has no effect.

2.9 Space Vehicle ID and GLONASS Frequency Number

Satellites are identified by the `SVID` (or `PRN`) and `FreqNr` fields, defined as follows:

Field	Type	Do-Not-Use Value	Description	RINEX satellite code
SVID or PRN	u1	0	Satellite ID: The following ranges are defined: 1-37: PRN number of a GPS satellite 38-61: Slot number of a GLONASS satellite with an offset of 37 62: GLONASS satellite of which the slot number is not known 71-102: PRN number of a GALILEO satellite with an offset of 70 107-119: L-Band (MSS) satellite. Corresponding satellite name can be found in the LBandBeams block. 120-140: PRN number of an SBAS satellite 141-172: PRN number of a Compass/BeiDou satellite with an offset of 140 181-187: PRN number of a QZSS satellite with an offset of 180	 *Gnn* (*nn* = SVID) *Rnn* (*nn* = SVID-37) NA *Enn* (*nn* = SVID-70) NA *Snn* (*nn* = SVID-100) *Cnn* (*nn* = SVID-140) *Jnn* (*nn* = SVID-180)
FreqNr	u1	0	GLONASS frequency number, with an offset of 8. It ranges from 1 (corresponding to an actual frequency number of -7) to 21 (corresponding to an actual frequency number of 13). For non-GLONASS satellites, FreqNr is reserved and must be ignored by the decoding software.	

2.10 Signal Type

Some sub-blocks contain a signal type field, which identify the type of signal and modulation the sub-blocks applies to. The signal numbering is defined as follows:

Signal number	Signal name	Carrier frequency (MHz)	RINEX v3.02 obs code
0	GPS_L1-CA	1575.42	1C
1	GPS_L1-P(Y)	1575.42	1W
2	GPS_L2-P(Y)	1227.60	2W
3	GPS_L2C	1227.60	2L
4	GPS_L5	1176.45	5Q
5	Reserved		
6	QZSS_L1-CA	1575.42	1C
7	QZSS_L2C	1227.60	2L
8	GLO_L1-CA	1602.00+(FreqNr-8)*9/16, with FreqNr as defined in section 2.9.	1C
9	Reserved		
10	GLO_L2-P	1246.00+(FreqNr-8)*7/16	2P
11	GLO_L2-CA	1246.00+(FreqNr-8)*7/16	2C
12	GLO_L3	1202.025	
13-16	Reserved		
17	GAL_L1BC	1575.42	1C
18	Reserved		
19	GAL_E6BC	1278.75	6C
20	GAL_E5a	1176.45	5Q
21	GAL_E5b	1207.14	7Q
22	GAL_E5	1191.795	8Q
23	LBand (MSS)	L-band beam specific	NA
24	GEO_L1CA	1575.42	1C
25	GEO_L5	1176.45	5I
26	QZSS_L5	1176.45	5Q
27	Reserved		
28	CMP_L1 (Compass/BeiDou B1)	1561.098	1I
29	CMP_E5b (Compass/BeiDou B2)	1207.14	7I
30	CMP_B3 (Compass/BeiDou B3)	1268.52	6I
31	Reserved		

2.11 Channel numbering

Some blocks contain a reference to the receiver channel number. Channel numbering starts at one. The maximum value for the channel number depends on the receiver type.

2.12 Decoding of SBF Blocks

In order to decode an SBF block, one has to identify the block boundaries in the data stream coming from the receiver. This involves searching for the initial "$@" characters that mark the beginning of each SBF block. Since the "$@" sequence can occur in the middle of an SBF block as well, additional checking is needed to make sure that a given "$@" is indeed the beginning of a block. The following procedure is recommended to decode SBF data stream.

1. Wait until the "$@" character sequence appears in the data stream from the receiver. When it is found, go to point 2.
2. Read the next two bytes. It should be the block CRC. Store this value for future reference.

3. Read the next two bytes and store them in a buffer. It should be the block ID.
4. Read the next two bytes and append them to the buffer. It should be the `Length` field of the SBF block. It should be a multiple of 4. If not, go back to point 1.
5. Read the next (`Length-8`) bytes and append them to the buffer. Compute the CRC of the buffer. The computed CRC should be equal to the CRC stored at point 2. If not, go back to point 1, else a valid SBF block has been detected and can be interpreted by the reading software.
6. If the block number (bits 0 to 12 of the `ID` field decoded at point 3) is of interest to your application, decode the SBF block.
7. Go back to point 1 and search for the new occurrence of the "$@" sequence after the end of the last byte of the block that was just identified.

To ensure compatibility with future upgrades of SBF, it is recommended that the decoding software observes the following rules:

- Only bits 0 to 12 of the `ID` field must be used to identify a block. Bits 13 to 15 represent the revision number.
- The lengths of SBF blocks and sub-blocks should not be considered constant and hard-coded in the decoding software. Instead, the decoding software must use the `Length` and `SBLength` fields encoded in the SBF block.
- Padding bytes should be ignored.
- Reserved fields and reserved bits in bit-fields should be ignored.

3 SBF Block Definitions

3.1 Measurement Blocks

MeasEpoch	Number: 4027 "OnChange" interval: 10 ms

This block contains all the GNSS measurements (observables) taken at the time given by the TOW and WNc fields.

For each tracked signal, the following measurement set is available:

- the pseudorange
- the carrier phase
- the Doppler
- the C/N0
- the lock-time.

To decrease the block size, all the measurements from a given satellite are referenced to one master measurement set. For instance, the L2 pseudorange (C2) is not much different from the L1 pseudorange (C1), such that the difference between C2 and C1 is encoded, instead of the absolute value of C2.

This is done by using a two-level sub-block structure. All the measurements from a given satellite are stored in a MeasEpochChannelType1 sub-block. The first part of this sub-block contains the master measurements, encoded as absolute values. The second part contains slave measurements, for which only the delta values are encoded in smaller MeasEpochChannelType2 sub-blocks.

Every MeasEpochChannelType1 sub-block contains a field "N2", which gives the number of nested MeasEpochChannelType2 sub-blocks. If there is only one signal tracked for a given satellite, there are no slave measurements and N2 is set to 0.

Decoding is done as follows:

1. Decode the master measurements and the N2 value from the MeasEpochChannelType1 sub-block.
2. If N2 is not 0, decode the N2 nested MeasEpochChannelType2 sub-blocks.
3. Go back to 1 till the N1 MeasEpochChannelType1 sub-blocks have been decoded.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N1	u1			Number of MeasEpochChannelType1 sub-blocks in this MeasEpoch block.
SB1Length	u1	1 byte		Length of a MeasEpochChannelType1 sub-block, excluding the nested MeasEpochChannelType2 sub-blocks
SB2Length	u1	1 byte		Length of a MeasEpochChannelType2 sub-block
CommonFlags	u1			Bit field containing flags common to all measurements. Bit 0: Multipath mitigation: if this bit is set, multipath mitigation is enabled. (see the **setMultipathMitigation** command). Bit 1: Smoothing of code: if this bit is set, at least one of the code measurements are smoothed values (see **setSmoothingInterval** command). Bit 2: Carrier phase align: if this bit is set, the fractional part of the carrier phase measurements from different modulations on the same carrier frequency (e.g. GPS L2C and L2P) are aligned, i.e. multiplexing biases (0.25 or 0.5 cycles) are corrected. Aligned carrier phase measurements can be directly included in RINEX files. If this bit is unset, this block contains raw carrier phase measurements. This bit is always set in the current firmware version. Bit 3: Clock steering: this bit is set if clock steering is active (see **setClockSyncThreshold** command). Bits 4-7: Reserved
CumClkJumps	u1	0.001 s		Cumulative millisecond clock jumps since start-up, with an ambiguity of k*256 ms. For example, if two clock jumps of -1 ms have occurred since startup, this field contains the value 254.
Reserved	u1			Reserved for future use, to be ignored by decoding software
Type1	...	...		*A succession of N1 MeasEpochChannelType1 sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

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`MeasEpochChannelType1` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`RxChannel`	u1			Receiver channel on which this satellite is currently tracked (see 2.11).
`Type`	u1			Bit field indicating the signal type and antenna ID: Bits 0-4: signal number, see 2.10. Bits 5-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
`SVID`	u1			Satellite ID, see 2.9
`Misc`	u1	4294967.296 m	0 (1)	Bit field containing the MSB of the pseudorange. Bits 0-3: `CodeMSB`: MSB of the pseudorange (this is an unsigned value). Bits 4-7: Reserved
`CodeLSB`	u4	0.001 m	0 (1)	LSB of the pseudorange. The pseudorange expressed in meters is computed as follows: PR_{type1}[m] = (`CodeMSB`*4294967296+`CodeLSB`)*0.001 where `CodeMSB` is part of the `Misc` field.
`Doppler`	i4	0.0001 Hz	−2147483648	Carrier Doppler (positive for approaching satellites). To compute the Doppler in Hz, use: D_{type1}[Hz] = `Doppler`*0.0001
`CarrierLSB`	u2	0.001 cycles	0 (2)	LSB of the carrier phase relative to the pseudorange
`CarrierMSB`	i1	65.536 cycles	−128 (2)	MSB of the carrier phase relative to the pseudorange. The full carrier phase can be computed by: L[cycles] = PR_{type1}[m]/λ +(`CarrierMSB`*65536+`CarrierLSB`)*0.001 where λ is the carrier wavelength corresponding to the frequency of the signal type in the `Type` field above: λ=299792458/f_L m, with f_L the carrier frequency as listed in section 2.10.
`CN0`	u1	0.25 dB-Hz	255	The C/N0 in dB-Hz is computed as follows, depending on the signal type in the `Type` field: C/N_0[dB-Hz] = `CN0`*0.25 if the signal number is 1 or 2 C/N_0[dB-Hz] = `CN0`*0.25+10 otherwise
`LockTime`	u2	1 s	65535	Duration of continuous carrier phase. The lock-time is reset at the initial lock of the phase-locked-loop, and whenever a loss of lock condition occurs. If the lock-time is longer than 65534s, it is clipped to 65534s. If the carrier phase measurement is not available, this field is set to its Do-Not-Use value.
`ObsInfo`	u1			Bit field: Bit 0: if set, the pseudorange measurement is smoothed Bit 1: if set, the smoothing filter has reached the requested smoothing interval Bit 2: this bit is set when the carrier phase (L) has a half-cycle ambiguity 0 Bits 3-7: `FreqNr`: for GLONASS satellites, these bits contain the frequency number with an offset of 8 (see 2.9), otherwise they are reserved and must be ignored by the decoding software.

(1) The pseudorange is invalid if both `CodeMSB` is 0 and `CodeLSB` is 0.
(2) The carrier phase is invalid if both `CarrierMSB` is -128 and `CarrierLSB` is 0.

N2	u1			Number of MeasEpochChannelType2 sub-blocks contained in this MeasEpochChannelType1 sub-block.
Padding	u1[..]			Padding bytes, see 2.5
Type2	...	...		*A succession of N2 MeasEpochChannelType2 sub-blocks, see definition below*

`MeasEpochChannelType2` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`Type`	u1			Bit field indicating the signal type and antenna ID: Bits 0-4: signal number, see 2.10. Bits 5-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
`LockTime`	u1	1 s	255	See corresponding field in the `MeasEpochChannelType1` sub-block above, except that the value is clipped to 254 instead of 65534.
`CN0`	u1	0.25 dB-Hz	255	See corresponding field in the `MeasEpochChannelType1` sub-block above.
`OffsetsMSB`	u1	 65.536 m 6.5536 Hz	 −4 (3) −16 (4)	Bit field containing the MSB of the code and of the Doppler offsets with respect to the `MeasEpochChannelType1` sub-block. Bits 0-2: `CodeOffsetMSB`: MSB of the code offset. Bits 3-7: `DopplerOffsetMSB`: MSB of the Doppler offset. `CodeOffsetMSB` and `DopplerOffsetMSB` are coded as two's complement. Refer to the `CodeOffsetLSB` and `DopplerOffsetLSB` fields to see how to use this field.
`CarrierMSB`	i1	65.536 cycles	−128 (5)	MSB of the carrier phase relative to the pseudorange.
`ObsInfo`	u1			Bit field: Bit 0: if set, the pseudorange measurement is smoothed Bit 1: if set, the smoothing filter has reached the requested smoothing interval Bit 2: this bit is set when the carrier phase (L) has a half-cycle ambiguity Bits 3-7: Reserved
`CodeOffsetLSB`	u2	0.001 m	0 (3)	LSB of the code offset with respect to pseudorange in the `MeasEpochChannelType1` sub-block. To compute the pseudorange, use: PR_{type2} [m] = PR_{type1}[m] + (`CodeOffsetMSB`*65536+`CodeOffsetLSB`)*0.001
`CarrierLSB`	u2	0.001 cycles	0 (5)	LSB of the carrier phase relative to the pseudorange. The full carrier phase can be computed by: L[cycles]= PR_{type2}[m]/λ +(`CarrierMSB`*65536+`CarrierLSB`)*0.001 where λ is the carrier wavelength corresponding to the signal type in the `Type` field.
`DopplerOffsetLSB`	u2	0.0001 Hz	0 (4)	LSB of the Doppler offset relative to the Doppler in the `MeasEpochChannelType1` sub-block. To compute the Doppler, use: D_{type2}[Hz] = D_{type1}[Hz]*α +(`DopplerOffsetMSB`*65536+`DopplerOffsetLSB`) *1e-4, where α is the ratio of the carrier frequency corresponding to the observable type in this `MeasEpochChannelType2` sub-block, and that of the master observable type in the parent `MeasEpochChannelType1` sub-block (see section 2.10 for a list of all carrier frequencies).
`Padding`	u1[..]			Padding bytes, see 2.5

(3) The pseudorange is invalid if both `CodeOffsetMSB` is -4 and `CodeOffsetLSB` is 0.
(4) The Doppler is invalid if both `DopplerOffsetMSB` is -16 and `DopplerOffsetLSB` is 0.
(5) The carrier phase is invalid if both `CarrierMSB` is -128 and `CarrierLSB` is 0.

MeasExtra	Number: 4000 "OnChange" interval: 10 ms

This block contains extra information associated with the measurements contained in the MeasEpoch block, such as the internal corrections parameters applied during the measurement pre-processing, and the noise variances.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of sub-blocks in this MeasExtra block.
SBLength	u1	1 byte		Length of a sub-block
DopplerVarFactor	f4	1 Hz^2 / $cycle^2$		Factor to be used to compute the Doppler variance from the carrier phase variance. More specifically, the Doppler variance in mHz^2 can be computed by: $\sigma^2_{\text{Doppler}}$[$mHz^2$] = CarrierVariance * DopplerVarFactor, Where CarrierVariance can be found for each measurement type in the MeasExtraChannelSub sub-blocks.
ChannelSub	...	...		*A succession of N MeasExtraChannelSub sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

MeasExtraChannelSub sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
RxChannel	u1			Receiver channel on which this satellite is currently tracked (see 2.11).
Type	u1			Bit field indicating the signal type and antenna ID: Bits 0-4: signal number, see 2.10. Bits 5-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
MPCorrection	i2	0.001 m		Multipath correction applied to the pseudorange. This number has to be added to the pseudorange to recover the raw pseudorange as it would be if multipath mitigation was not used.
SmoothingCorr	i2	0.001 m		Smoothing correction applied to the pseudorange. This number has to be added to the pseudorange to recover the raw pseudorange as it would be if smoothing was disabled.
CodeVar	u2	0.0001 m^2	65535	Estimated code tracking noise variance. If the variance is larger than 65534 cm^2, it is clipped to 65534 cm^2.
CarrierVar	u2	1 $mcycle^2$	65535	Estimated carrier tracking noise variance. This value can be multiplied by DopplerVarFactor to compute the Doppler measurement variance. If the variance is larger than 65534 $mcycles^2$, it is clipped to 65534 $mcycles^2$.

	LockTime	u2	1 s	65535	Duration of continuous carrier phase. The lock-time is reset at the initial lock after a signal (re)acquisition. If the lock-time is longer than 65534s, it is clipped to 65534s. If the carrier phase measurement is not available, this field is set to its Do-Not-Use value.
Rev 1	CumLossCont	u1			Carrier phase cumulative loss-of-continuity counter for the signal type, antenna and satellite this sub-block refers to. This counter starts at zero at receiver start-up, and is incremented at each initial lock after signal (re)acquisition, or when a cycle slip is detected.
Rev 1	Reserved	u1			Reserved.
Rev 2	Info	u1			Reserved.
	Padding	u1[..]			Padding bytes, see 2.5

IQCorr	Number: 4046 "OnChange" interval: 10 ms

This block contains punctual correlation values (real and imaginary parts) and carrier phase measurements (modulo 65.536 cycles) for all signal types except for GPS L2P and GLONASS L2P.

It is typical to output the IQCorr block at a 50-Hz or 100-Hz rate and the MeasEpoch block at 1-Hz or 10-Hz. The carrier phase measurement from the low-rate MeasEpoch block can be used to resolve the 65.536-cycle ambiguity of the carrier phase in the IQCorr block.

Note that high-rate output is only possible on USB or Ethernet connections. COM ports typically do not offer enough bandwidth to support 50-Hz IQCorr output.

Note that this feature may not be enabled on your receiver. It is under permission control.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of sub-blocks in this IQCorr block.
SBLength	u1	1 byte		Length of a sub-block
CorrDuration	u1	0.001 s		Duration over which the correlations are computed (coherent integration time, except for SBAS L1 where a non-coherent integration is used).
CumClkJumps	u1	0.001 s		Cumulative millisecond clock jumps since start-up, with an ambiguity of k*256 ms. For example, if two clock jumps of -1 ms have occurred since startup, this field contains the value 254.
Reserved	u1[2]			Reserved for future use.
ChannelSub	...	...		*A succession of N IQCorrChannelSub sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

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`IQCorrChannelSub` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`RxChannel`	u1			Receiver channel on which this satellite is currently tracked (see 2.11).
`Type`	u1			Bit field indicating the signal type and antenna ID: Bits 0-5: signal number, see 2.10. Bits 6-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
`SVID`	u1			Satellite ID, see 2.9
`CorrIQ_MSB`	u1		136 (6)	Bit field containing the MSB of the correlation values: Bits 0-3: `I_MSB`: MSB of the I correlation value, two's complement. See `CorrI_LSB` for usage. Bits 4-7: `Q_MSB`: MSB of the Q correlation value, two's complement. See `CorrQ_LSB` for usage.
`CorrI_LSB`	u1		0 (6)	LSB of the real component of the punctual correlation value, unsigned. The full I correlation value is computed by: I = `I_MSB`*256+`CorrI_LSB`
`CorrQ_LSB`	u1		0 (6)	LSB of the imaginary component of the punctual correlation value, unsigned. The full Q correlation value is computed by: Q = `Q_MSB`*256+`CorrQ_LSB`
Rev 1 `CarrierPhaseLSB`	u2	0.001 cycles		16-bit LSB of the carrier phase measurement, expressed in 0.001 cycles.
`Padding`	u1[..]			Padding bytes, see 2.5

(6) The correlation values must be ignored if `CorrIQ_MSB` is set to 136 and `CorrI_LSB` is set to 0 and `CorrQ_LSB` is set to 0 (all conditions met together).

EndOfMeas	Number: 5922 "OnChange" interval: 10 ms

This block marks the end of the transmission of all measurement-related blocks belonging to a given epoch.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Padding	u1[..]			Padding bytes, see 2.5

3.2 Navigation Page Blocks

GPSRawCA	Number: 4017 "OnChange" interval: 6s

This block contains the 300 bits of a GPS C/A subframe. It is generated each time a new subframe is received, i.e. every 6 seconds.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Not applicable
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
FreqNr	u1			Not applicable
Reserved	u1			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[10]			NAVBits contains the 300 bits of a GPS C/A subframe. Encoding: For easier parsing, the bits are stored as a succession of 10 32-bit words. Since the actual words in the subframe are 30-bit long, two unused bits are inserted in each 32-bit word. More specifically, each 32-bit word has the following format: Bits 0-5: 6 parity bits (referred to as D_{25} to D_{30} in the GPS ICD), XOR-ed with the last transmitted bit of the previous word (D^*_{30})). Bits 6-29: source data bits (referred to as d_n in the GPS ICD). The first received bit is the MSB. Bits 30-31: Reserved
Padding	u1[..]			Padding bytes, see 2.5

GPSRawL2C	Number: 4018 "OnChange" interval: 12s

This block contains the 300 bits of a GPS L2C CNAV subframe (the so-called $D_c(t)$ data stream).

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Viterbi decoder error count over the subframe
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
FreqNr	u1			Not applicable
Reserved	u1			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[10]			NAVBits contains the 300 bits of a GPS CNAV subframe. Encoding: NAVBits contains all the bits of the frame, including the preamble. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[9] must be ignored by the decoding software.
Padding	u1[..]			Padding bytes, see 2.5

GPSRawL5	Number: 4019 "OnChange" interval: 6s

This block contains the 300 bits of a GPS L5 CNAV subframe (the so-called $D_c(t)$ data stream).

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Viterbi decoder error count over the subframe
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
FreqNr	u1			Not applicable
Reserved	u1			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[10]			NAVBits contains the 300 bits of a GPS CNAV subframe. Encoding: NAVBits contains all the bits of the frame, including the preamble. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[9] must be ignored by the decoding software.
Padding	u1[..]			Padding bytes, see 2.5

GLORawCA	Number: 4026 "OnChange" interval: 2s

This block contains the 85 bits of a GLONASS L1CA or L2CA navigation string.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Not applicable
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
FreqNr	u1			Frequency number, with an offset of 8. See 2.9
Reserved	u1			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[3]			NAVBits contains the first 85 bits of a GLONASS C/A string (i.e. all bits of the string with the exception of the time mark). Encoding: The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[2] must be ignored by the decoding software.
Padding	u1[..]			Padding bytes, see 2.5

GALRawFNAV	Number: 4022 "OnChange" interval: 10s

This block contains the 244 bits of a Galileo F/NAV navigation page, after deinterleaving and Viterbi decoding.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Viterbi decoder error count over the page
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
FreqNr	u1			Not applicable
Reserved	u1			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[8]			NavBits contains the 244 bits of a Galileo F/NAV page. Encoding: NAVBits contains all the bits of the frame, with the exception of the synchronization field. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[7] must be ignored by the decoding software.
Padding	u1[..]			Padding bytes, see 2.5

GALRawINAV	Number: 4023 "OnChange" interval: 2s

This block contains the 234 bits of a Galileo I/NAV navigation page, after deinterleaving and Viterbi decoding.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Viterbi decoder error count over the page
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bit 5: Set when the nav page is the concatenation of a sub-page received from E5b, and a sub-page received from L1BC. In that case, bits 0-4 are set to L1BC. Bits 6-7: Reserved
FreqNr	u1			Not applicable
Reserved	u1			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[8]			NAVBits contains the 234 bits of an I/NAV navigation page (in nominal or alert mode). Note that the I/NAV page is transmitted as two sub-pages (the so-called even and odd pages) of duration 1 second each (120 bits each). In this block, the even and odd pages are concatenated, even page first and odd page last. The 6 tails bits at the end of the even page are removed (hence a total of 234 bits). If the even and odd pages have been received from two different carriers (E5b and L1), bit 5 of the Source field is set. Encoding: NAVBits contains all the bits of the frame, with the exception of the synchronization field. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[7] must be ignored by the decoding software.
Padding	u1[..]			Padding bytes, see 2.5

GEORawL1	Number: 4020 "OnChange" interval: 1s

This block contains the 250 bits of a SBAS L1 navigation frame, after Viterbi decoding.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Viterbi decoder error count over the navigation frame
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
FreqNr	u1			Not applicable
Reserved	u1			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[8]			NAVBits contains the 250 bits of a SBAS navigation frame. Encoding: NAVBits contains all the bits of the frame, including the preamble. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[7] must be ignored by the decoding software.
Padding	u1[..]			Padding bytes, see 2.5

GEORawL5	Number: 4021 "OnChange" interval: 1s

This block contains the 250 bits of a SBAS L5 navigation frame, after Viterbi decoding.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Viterbi decoder error count over the navigation frame
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
FreqNr	u1			Not applicable
Reserved	u1			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[8]			NAVBits contains the 250 bits of a SBAS navigation frame. Encoding: NAVBits contains all the bits of the frame, including the preamble. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[7] must be ignored by the decoding software.
Padding	u1[..]			Padding bytes, see 2.5

QZSRawL1CA	Number: 4066 "OnChange" interval: 6s

This block contains the 300 bits of a QZSS C/A subframe.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
Reserved	u1			Reserved
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
Reserved2	u1[2]			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[10]			NAVBits contains the 300 bits of a QZSS C/A subframe. Encoding: Same as GPSRawCA block.
Padding	u1[..]			Padding bytes, see 2.5

QZSRawL2C	Number: 4067 "OnChange" interval: 12s

This block contains the 300 bits of a QZSS L2C CNAV subframe.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Viterbi decoder error count over the subframe
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
Reserved	u1[2]			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[10]			NAVBits contains the 300 bits of a QZSS CNAV subframe. Encoding: NAVBits contains all the bits of the frame, including the preamble. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[9] must be ignored by the decoding software.
Padding	u1[..]			Padding bytes, see 2.5

QZSRawL5	Number: 4068 "OnChange" interval: 6s

This block contains the 300 bits of a QZSS L5 CNAV subframe.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			Satellite ID, see 2.9
CRCPassed	u1			Status of the CRC or parity check: 0: CRC or parity check failed 1: CRC or parity check passed
ViterbiCnt	u1			Viterbi decoder error count over the subframe
Source	u1			Bit field: Bits 0-4: Signal type from which the bits have been received, as defined in 2.10 Bits 5-7: Reserved
Reserved	u1[2]			Reserved for future use, to be ignored by decoding software.
NAVBits	u4[10]			NAVBits contains the 300 bits of a QZSS CNAV subframe. Encoding: NAVBits contains all the bits of the frame, including the preamble. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[9] must be ignored by the decoding software.
Padding	u1[..]			Padding bytes, see 2.5

3.3 GPS Decoded Message Blocks

GPSNav	Number:	5891
	"OnChange" interval:	block generated each time a new navigation data set is received from a GPS satellite

The GPSNav block contains the decoded navigation data for one GPS satellite. These data are conveyed in subframes 1 to 3 of the satellite navigation message. Refer to GPS ICD for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the GPS satellite of which the ephemeris is given in this block (see 2.9)
Reserved	u1			Reserved for future use, to be ignored by decoding software
WN	u2	1 week	65535	Week number (10 bits from subframe 1, word 3)
CAorPonL2	u1			Code(s) on L2 channel (2 bits from subframe 1, word 3)
URA	u1			User Range accuracy index (4 bits from subframe 1 word 3)
health	u1			6-bit health from subframe 1, word 3 (6 bits from subframe 1, word 3)
L2DataFlag	u1			Data flag for L2 P-code (1 bit from subframe 1, word 4)
IODC	u2			Issue of data, clock (10 bits from subframe 1)
IODE2	u1			Issue of data, ephemeris (8 bits from subframe 2)
IODE3	u1			Issue of data, ephemeris (8 bits from subframe 3)
FitIntFlg	u1			Curve Fit Interval, (1 bit from subframe 2, word 10)
Reserved2	u1			unused, to be ignored by decoding software
T_gd	f4	1 s		Estimated group delay differential
t_oc	u4	1 s		clock data reference time
a_f2	f4	1 s / s^2		SV clock aging
a_f1	f4	1 s / s		SV clock drift
a_f0	f4	1 s		SV clock bias
C_rs	f4	1 m		Amplitude of the sine harmonic correction term to the orbit radius
DEL_N	f4	1 semi-circle / s		Mean motion difference from computed value
M_0	f8	1 semi-circle		Mean anomaly at reference time
C_uc	f4	1 rad		Amplitude of the cosine harmonic correction term to the argument of latitude
e	f8			Eccentricity
C_us	f4	1 rad		Amplitude of the sine harmonic correction term to the argument of latitude
SQRT_A	f8	1 $m^{1/2}$		Square root of the semi-major axis

t_oe	u4	1 s		Reference time ephemeris
C_ic	f4	1 rad		Amplitude of the cosine harmonic correction term to the angle of inclination
OMEGA_0	f8	1 semi-circle		Longitude of ascending node of orbit plane at weekly epoch
C_is	f4	1 rad		Amplitude of the sine harmonic correction term to the angle of inclination
i_0	f8	1 semi-circle		Inclination angle at reference time
C_rc	f4	1 m		Amplitude of the cosine harmonic correction term to the orbit radius
omega	f8	1 semi-circle		Argument of perigee
OMEGADOT	f4	1 semi-circle / s		Rate of right ascension
IDOT	f4	1 semi-circle / s		Rate of inclination angle
WNt_oc	u2	1 week		WN associated with t_oc, modulo 1024
WNt_oe	u2	1 week		WN associated with t_oe, modulo 1024
Padding	u1[..]			Padding bytes, see 2.5

GPSAlm	Number: 5892
	"OnChange" interval: block generated each time a new almanac data set is received from a GPS satellite

The GPSAlm block contains the decoded almanac data for one GPS satellite. These data are conveyed in subframes 4 and 5 of the satellite navigation message. Refer to GPS ICD for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the GPS satellite of which the almanac is given is this block (see 2.9)
Reserved	u1			Reserved for future use, to be ignored by decoding software
e	f4			Eccentricity
t_oa	u4	1 s		almanac reference time of week
delta_i	f4	1 semi-circle		Inclination angle at reference time, relative to $i_0 = 0.3$ semi-circles
OMEGADOT	f4	1 semi-circle / s		Rate of right ascension
SQRT_A	f4	1 $m^{1/2}$		Square root of the semi-major axis
OMEGA_0	f4	1 semi-circle		Longitude of ascending node of orbit plane at weekly epoch
omega	f4	1 semi-circle		Argument of perigee
M_0	f4	1 semi-circle		Mean anomaly at reference time
a_f1	f4	1 s / s		SV clock drift
a_f0	f4	1 s		SV clock bias
WN_a	u1	1 week		Almanac reference week, to which t_oa is referenced
config	u1			Anti-spoofing and satellite configuration (4 bits from subframe 4, page 25)
health8	u1			health on 8 bits from the almanac page
health6	u1			health summary on 6 bits (from subframe 4, page 25 and subframe 5 page 25)
Padding	u1[..]			Padding bytes, see 2.5

GPSIon	Number: 5893 "OnChange" interval: block generated each time subframe 4, page 18, is received from a GPS satellite

The GPSIon block contains the decoded ionosphere data (the Klobuchar coefficients). These data are conveyed in subframes 4, page 18 of the satellite navigation message. Refer to GPS ICD for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the GPS satellite from which the coefficients have been received (see 2.9)
Reserved	u1			Reserved for future use, to be ignored by decoding software
alpha_0	f4	1 s		vertical delay coefficient 0
alpha_1	f4	1 s / semi-circle		vertical delay coefficient 1
alpha_2	f4	1 s / semi-circle^2		vertical delay coefficient 2
alpha_3	f4	1 s / semi-circle^3		vertical delay coefficient 3
beta_0	f4	1 s		model period coefficient 0
beta_1	f4	1 s / semi-circle		model period coefficient 1
beta_2	f4	1 s / semi-circle^2		model period coefficient 2
beta_3	f4	1 s / semi-circle^3		model period coefficient 3
Padding	u1[..]			Padding bytes, see 2.5

GPSUtc	Number: 5894 "OnChange" interval: block generated each time subframe 4, page 18, is received from a GPS satellite

The GPSUtc block contains the decoded UTC data. These data are conveyed in subframes 4, page 18 of the satellite navigation message. Refer to GPS ICD for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the GPS satellite from which these UTC parameters have been received (see 2.9)
Reserved	u1			Reserved for future use, to be ignored by decoding software
A_1	f4	1 s / s		first order term of polynomial
A_0	f8	1 s		constant term of polynomial
t_ot	u4	1 s		reference time for UTC data
WN_t	u1	1 week		UTC reference week number, to which t_ot is referenced
DEL_t_LS	i1	1 s		Delta time due to leap seconds whenever the effectivity time is not in the past
WN_LSF	u1	1 week		Effectivity time of leap second (week)
DN	u1	1 day		Effectivity time of leap second (day)
DEL_t_LSF	i1	1 s		Delta time due to leap seconds whenever the effectivity time is in the past
Padding	u1[..]			Padding bytes, see 2.5

3.4 GLONASS Decoded Message Blocks

GLONav	Number: 4004 "OnChange" interval: block generated each time a new navigation data set is received from a GLONASS satellite

The GLONav block contains the decoded ephemeris data for one GLONASS satellite.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			ID of the GLONASS satellite for which ephemeris is provided in this block (see 2.9).
FreqNr	u1			Frequency number of the GLONASS satellite for which ephemeris is provided in this block (see 2.9).
X	f8	1000 m		x-component of satellite position in PZ-90.02
Y	f8	1000 m		y-component of satellite position in PZ-90.02
Z	f8	1000 m		z-component of satellite position in PZ-90.02
Dx	f4	1000 m / s		x-component of satellite velocity in PZ-90.02
Dy	f4	1000 m / s		y-component of satellite velocity in PZ-90.02
Dz	f4	1000 m / s		z-component of satellite velocity in PZ-90.02
Ddx	f4	1000 m / s^2		x-component of satellite acceleration in PZ-90.02
Ddy	f4	1000 m / s^2		y-component of satellite acceleration in PZ-90.02
Ddz	f4	1000 m / s^2		z-component of satellite acceleration in PZ-90.02
gamma	f4	1 Hz / Hz		$\gamma_n(t_b)$:relative deviation of predicted carrier frequency
tau	f4	1 s		$\tau_n(t_b)$: time correction to GLONASS time
dtau	f4	1 s		$\Delta\tau_n$: time difference between L2 and L1 sub-band
t_oe	u4	1 s		reference time-of-week in GPS time frame
WN_toe	u2	1 week		reference week number in GPS time frame (modulo 1024)
P1	u1	1 minute		time interval between adjacent values of t_b
P2	u1			1-bit odd/even flag of t_b
E	u1	1 day		age of data
B	u1			3-bit health flag, satellite unhealthy if MSB set
tb	u2	1 minute		time of day (center of validity interval)
M	u1			2-bit GLONASS-M satellite identifier (01, otherwise 00)
P	u1			2-bit mode of computation of time parameters
l	u1			1-bit health flag, 0=healthy, 1=unhealthy
P4	u1			1-bit 'updated' flag of ephemeris data
N_T	u2	1 day		current day number within 4-year interval
F_T	u2	0.01 m		predicted user range accuracy at time t_b

Padding	u1[..]			Padding bytes, see 2.5

GLOAlm	Number: 4005 "OnChange" interval: block generated each time a new almanac data set is received from a GLONASS satellite

The GLOAlm block contains the decoded navigation data for one GLONASS satellite.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			ID of the GLONASS satellite for which almanac is provided in this block (see 2.9). This number corresponds to the n^A parameter in the GLONASS ICD.
FreqNr	u1			Frequency number of the GLONASS satellite for which almanac is provided in this block (see 2.9). This number corresponds to the H_n^A parameter in the GLONASS ICD.
epsilon	f4			ϵ_n^A: orbit eccentricity
t_oa	u4	1 s		Reference time-of-week in GPS time frame
Delta_i	f4	1 semi-circle		Δ i_n^A: correction to inclination
lambda	f4	1 semi-circle		λ_n^A: Longitude of first ascending node
t_ln	f4	1 s		$t_{\lambda\ n}^A$: time of first ascending node passage
omega	f4	1 semi-circle		ω_n^A: argument of perigee
Delta_T	f4	1 s / orbit-period		Δ T_n^A: correction to mean Draconian period
dDelta_T	f4	1 s / orbit-period^2		dΔ T_n^A: rate of change correction to mean Draconian period
tau	f4	1 s		τ_n^A: coarse correction to satellite time
WN_a	u1	1 week		Reference week in GPS time frame (modulo 256)
C	u1			$C_n{}^A$: 1-bit general health flag (1 indicates healthy)
N	u2	1 day		N^A: calendar day number within 4 year period
M	u1			$M_n{}^A$: 2-bit GLONASS-M satellite identifier
N_4	u1			N_4: 4 year interval number, starting from 1996
Padding	u1[..]			Padding bytes, see 2.5

GLOTime	Number: 4036 "OnChange" interval: block generated at the end of each GLONASS superframe, i.e. every 2.5 minutes.

The GLOTime block contains the decoded non-immediate data related to the difference between GLONASS and GPS, UTC and UT1 time scales.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			ID of the GLONASS satellite from which the data in this block has been decoded (see 2.9).
FreqNr	u1			Frequency number of the GLONASS satellite from which the data in this block has been decoded (see 2.9).
N_4	u1			4 year interval number, starting from 1996
KP	u1			notification of leap second
N	u2	1 day		calendar day number within 4 year period
tau_GPS	f4	1 s		difference with respect to GPS time
tau_c	f8	1 s		GLONASS time scale correction to UTC(SU)
B1	f4	1 s		difference between UT1 and UTC(SU)
B2	f4	1 s / msd		daily change of B1
Padding	u1[..]			Padding bytes, see 2.5

3.5 Galileo Decoded Message Blocks

GALNav	Number: 4002 "OnChange" interval: output each time a new navigation data batch is decoded.

The GalNav block contains the following decoded navigation data for one Galileo satellite:

- orbital elements and clock corrections
- health, Signal-In-Space Accuracy (SISA) indexes and Broadcast Group Delays (BGDs) for each carrier or carrier combinations.

The interpretation of the clock correction parameters (t_oc, a_f0, a_f1, a_f2) depends on the value of the Source field:

Source	Message type	Applicable Clock Model
2	I/NAV	(L1,E5b)
16	F/NAV	(L1,E5a)

If the receiver is decoding both the I/NAV and the F/NAV data stream, it will output a GalNav block for the I/NAV stream, containing the (L1, E5b) clock model, and a different GalNav block for the F/NAV stream, containing the (L1, E5a) clock model.

Depending on the message type being decoded, some health, SISA or BGD values may not be available (in that case they are set to their respective Do-Not-Use values). The following health, SISA and BGD values are guaranteed to be available for a given value of the Source field:

Source	Health, and availability
2 (I/NAV)	At least L1-B_{DVS}, L1-B_{HS}, E5b_{DVS},E5b_{HS}, SISA_L1E5b and BGD_L1E5b are available
16 (F/NAV)	At least E5a_{DVS},E5a_{HS}, SISA_L1E5a and BGD_L1E5a are available

The IODNav field identifies the issue of data. All orbital elements, clock parameters and SISA values in the block are guaranteed to refer to the same data batch identified by IODNav. The fields Health_OSSOL, BGD_L1E5a, BGD_L1E5b and CNAVenc are not covered by the issue of data, and the block simply contains the latest received value.

Please refer to the Galileo Signal-In-Space ICD for the interpretation and usage of the parameters contained in this SBF block.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			SVID of the Galileo satellite (see 2.9)

Source	u1			See table above: this field indicates how to interpret the clock correction parameters.
SQRT_A	f8	1 $m^{1/2}$		Square root of the semi-major axis
M_0	f8	1 semi-circle		Mean anomaly at reference time
e	f8			Eccentricity
i_0	f8	1 semi-circle		Inclination angle at reference time
omega	f8	1 semi-circle		Argument of perigee
OMEGA_0	f8	1 semi-circle		Longitude of ascending node of orbit plane at weekly epoch
OMEGADOT	f4	1 semi-circle / s		Rate of right ascension
IDOT	f4	1 semi-circle / s		Rate of inclination angle
DEL_N	f4	1 semi-circle / s		Mean motion difference from computed value
C_uc	f4	1 rad		Amplitude of the cosine harmonic correction term to the argument of latitude
C_us	f4	1 rad		Amplitude of the sine harmonic correction term to the argument of latitude
C_rc	f4	1 m		Amplitude of the cosine harmonic correction term to the orbit radius
C_rs	f4	1 m		Amplitude of the sine harmonic correction term to the orbit radius
C_ic	f4	1 rad		Amplitude of the sine harmonic correction term to the angle of inclination
C_is	f4	1 rad		Amplitude of the cosine harmonic correction term to the angle of inclination
t_oe	u4	1 s		Reference time, ephemeris
t_oc	u4	1 s		Reference time, clock. The Source field indicates which clock model t_oc refers to.
a_f2	f4	1 s / s^2		SV clock aging. The Source field indicates which clock model a_f2 refers to.
a_f1	f4	1 s / s		SV clock drift. The Source field indicates which clock model a_f1 refers to.
a_f0	f8	1 s		SV clock bias. The Source field indicates which clock model a_f0 refers to.
WNt_oe	u2	1 week		WN associated with t_oe, modulo 4096
WNt_oc	u2	1 week		WN associated with t_oc, modulo 4096
IODnav	u2			Issue of data, navigation (10 bits)
Health_OSSOL	u2			Bit field indicating the last received Health Status (HS) and Data Validity Status (DVS) of the E5a, E5b and L1-B signals: Bit 0: If set, bits 1 to 3 are valid, otherwise they must be ignored. Bit 1: 1-bit L1-B_{DVS} Bits 2-3: 2-bit L1-B_{HS} Bit 4: If set, bits 5 to 7 are valid, otherwise they must be ignored. Bit 5: 1-bit E5b_{DVS} Bits 6-7: 2-bit E5b_{HS} Bit 8: If set, bits 9 to 11 are valid, otherwise they must be ignored. Bit 9: 1-bit E5a_{DVS} Bits 10-11: 2-bit E5a_{HS} Bits 12-15: Reserved

Health_PRS	u1			Reserved
SISA_L1E5a	u1		255	Signal-In-Space Accuracy Index (L1, E5a)
SISA_L1E5b	u1		255	Signal-In-Space Accuracy Index (L1, E5b)
SISA_L1AE6A	u1		255	Reserved
BGD_L1E5a	f4	1 s	$-2 \cdot 10^{10}$	Last received broadcast group delay (L1, E5a)
BGD_L1E5b	f4	1 s	$-2 \cdot 10^{10}$	Last received broadcast group delay (L1, E5b)
BGD_L1AE6A	f4	1 s	$-2 \cdot 10^{10}$	Reserved
CNAVenc	u1		255	1-bit C/NAV encryption status from L1-B.
Padding	u1[..]			Padding bytes, see 2.5

GALAlm	Number: 4003 "OnChange" interval: output each time a new almanac set is received for a satellite.

The GalAlm block contains the decoded almanac data for one Galileo satellite.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			SVID of the Galileo satellite from which these almanac parameters have been received (see 2.9)
Source	u1			See corresponding field in the GalNav block. Source can take the value 18 to indicate that the almanac data contained in this block has been merged from INAV and FNAV pages.
e	f4			Eccentricity
t_oa	u4	1 s		almanac reference time of week
delta_i	f4	1 semi-circle		Inclination angle at reference time, relative to nominal
OMEGADOT	f4	1 semi-circle / s		Rate of right ascension
SQRT_A	f4	1 $m^{1/2}$		Square root of the semi-major axis, relative to nominal
OMEGA_0	f4	1 semi-circle		Longitude of ascending node of orbit plane at weekly epoch
omega	f4	1 semi-circle		Argument of perigee
M_0	f4	1 semi-circle		Mean anomaly at reference time
a_f1	f4	1 s / s		SV clock drift
a_f0	f4	1 s		SV clock bias
WN_a	u1	1 week		2-bit almanac reference week
SVID_A	u1			SVID of the Galileo satellite of which the almanac parameters are provided in this block.

health	u2			Bit field indicating the health status (HS) of the E5a, E5b, L1-B, L1-A and E6-A signals: Bit 0: If set, bits 1 and 2 are valid, otherwise they must be ignored. Bits 1-2: 2-bit L1-B_{HS} Bit 3: If set, bits 4 and 5 are valid, otherwise they must be ignored. Bits 4-5: 2-bit E5b_{HS} Bit 6: If set, bits 7 and 8 are valid, otherwise they must be ignored. Bits 7-8: 2-bit E5a_{HS} Bit 9: If set, bits 10 and 11 are valid, otherwise they must be ignored. Bits 10-11: 2-bit L1-A_{HS} Bit 12: If set, bits 13 and 14 are valid, otherwise they must be ignored. Bits 13-14: 2-bit E6-A_{HS} Bit 15: Reserved
IODa	u1			4-bit Issue of Data for the almanac.
Padding	u1[..]			Padding bytes, see 2.5

GALIon	Number: 4030 "OnChange" interval: output each time the ionospheric parameters are received from a Galileo satellite.

The GalIon block contains the decoded ionosphere model parameters of the Galileo system.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			SVID of the Galileo satellite from which these parameters have been received (see 2.9)
Source	u1			Message type from which the data has been decoded: 2: I/NAV 16: F/NAV
a_i0	f4	$1 \cdot 10^{-22}$ W / (m^2 Hz)		Effective ionization level, a_{i0}
a_i1	f4	$1 \cdot 10^{-22}$ W / (m^2 Hz) / deg		Effective ionization level, a_{i1}
a_i2	f4	$1 \cdot 10^{-22}$ W / (m^2 Hz) / deg^2		Effective ionization level, a_{i2}
StormFlags	u1			Bit field containing the five ionospheric storm flags: Bit 0: SF5 Bit 1: SF4 Bit 2: SF3 Bit 3: SF2 Bit 4: SF1 Bits 5-7: Reserved
Padding	u1[..]			Padding bytes, see 2.5

GALUtc	Number: 4031 "OnChange" interval: output each time the UTC offset parameters are received from a Galileo satellite.

The GalUtc block contains the decoded UTC parameter information.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			SVID of the Galileo satellite from which these parameters have been received (see 2.9)
Source	u1			Message type from which the data has been decoded: 2: I/NAV 16: F/NAV
A_1	f4	1 s / s		first order term of polynomial
A_0	f8	1 s		constant term of polynomial
t_ot	u4	1 s		reference time of week for UTC data
WN_ot	u1	1 week		UTC reference week number, to which t_ot is referenced
DEL_t_LS	i1	1 s		Delta time due to leap seconds whenever the effectivity time is not in the past
WN_LSF	u1	1 week		Effectivity time of leap second (week)
DN	u1	1 day		Effectivity time of leap second (day)
DEL_t_LSF	i1	1 s		Delta time due to leap seconds whenever the effectivity time is in the past
Padding	u1[..]			Padding bytes, see 2.5

GALGstGps	Number: 4032 "OnChange" interval: output each time valid GST-GPS offset parameters are received from a Galileo satellite.

This block contains the decoded GPS to Galileo System Time offset parameters. This block is only output if these parameters are valid in the navigation page (i.e. if they are not set to "all ones").

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			SVID of the Galileo satellite from which these parameters have been received (see 2.9)
Source	u1			Message type from which the data has been decoded: 2: I/NAV 16: F/NAV
A_1G	f4	1 s / s		Rate of change of the offset
A_0G	f4	1 s		Constant term of the offset
t_oG	u4	1 s		Reference time of week
WN_oG	u1	1 week		6-bit reference week number.
Padding	u1[..]			Padding bytes, see 2.5

GALSARRLM	Number: 4034 "OnChange" interval: generated each time a SAR RLM message is decoded.

This block contains a decoded Galileo search-and-rescue (SAR) return link message (RLM).

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
SVID	u1			SVID of the Galileo satellite from which this RLM has been received.
Source	u1			Message type from which the data has been decoded: 2: I/NAV 16: F/NAV
RLMLength	u1			Length of the RLM message in bits. RLMLength can be either 80 for a short message or 160 for a long message.
Reserved	u1[3]			Reserved for future use, to be ignored by decoding software
RLMBits	u4[*N*]			Bits in the RLM message, with the first bit being the MSB of RLMBits[0]. N is 3 for a short message (i.e. if RLMLength is 80), and 5 for a long message (i.e. if RLMLength is 160). The 16 unused bits of a short message are set to 0. These bits correspond to the 16 LSBs of RLMBits[2].
Padding	u1[..]			Padding bytes, see 2.5

3.6 SBAS Decoded Message Blocks

An SBF block is defined for each of the different message types as indicated in the table below. The description of the algorithms needed to compute the actual corrections to the satelliteŠs position, clock and range is out of the scope of this manual: it is to be found in the RTCA/DO-229 standard. A user only interested in the actual corrections leading to the SBAS-aided position should use the `GEOCorrections` block.

Message type	Corresponding SBF block
MT00	`GEOMT00` or `GEOFastCorr`
MT01	`GEOPRNMask`
MT02	`GEOFastCorr`
MT03	`GEOFastCorr`
MT04	`GEOFastCorr`
MT05	`GEOFastCorr`
MT06	`GEOIntegrity`
MT07	`GEOFastCorrDegr`
MT09	`GEONav`
MT10	`GEODegrFactors`
MT12	`GEONetworkTime`
MT17	`GEOAlm`
MT18	`GEOIGPMask`
MT24	`GEOFastCorr` and `GEOLongTermCorr`
MT25	`GEOLongTermCorr`
MT26	`GEOIonoDelay`
MT27	`GEOServiceLevel`
MT28	`GEOClockEphCovMatrix`

The raw 250 bits of the SBAS message are contained in the `GEORaw` block.

In the SBAS message blocks, the time tag of the received messages, reported in the `TOW` and `WNc` fields, always refers to the end of the last bit of the message. To get the time of transmission of the beginning of the first bit of the message, which is equal to the time of applicability of the SBAS navigation data, the user must subtract 1 second from `TOW`.

The receiver is receiving SBAS data from all the tracked SBAS satellites, but decoding of the messages is performed only from the L1 signal of the satellite that is currently used to compute corrections. Therefore all the SBF blocks below are available only for this satellite, and only if SBAS positioning mode is active (see the **`setPVTMode`** command).

GEOMT00	Number:	5925
	"OnChange" interval:	block generated each time an empty MT00 is received from an SBAS satellite

This block is sent to indicate that an empty SBAS message type 0 has been received.

Depending on the SBAS operational mode, message type 0 can contain the contents of message type 2. Upon reception of a message type 0, the receiver checks whether the message is empty (it contains only 0's) or whether it contains the message type 2 contents. In the former case, a GEOMT00 block will be generated. In the latter case, a GEOFastCorr block will be generated. Refer to section A.4.4.1 of the DO 229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which the message has been received (see 2.9)
Padding	u1[..]			Padding bytes, see 2.5

GEOPRNMask	Number: 5926 "OnChange" interval: block generated each time MT01 is received from an SBAS satellite

This block contains the decoded PRN mask transmitted in SBAS message type 1. Refer to section A.4.4.2 of the DO 229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which the message has been received (see 2.9)
IODP	u1			Issue of data - PRN.
NbrPRNs	u1			Number of PRNs designated in the mask.
PRNMask	u1[NbrPRNs]			List of the PRNs in the PRN mask. PRNMask[0] is the first PRN designated in the PRN mask (from 1 to 210), PRNMask[1] is the 2nd PRN designated in the PRN mask, etc...
Padding	u1[..]			Padding bytes, see 2.5

GEOFastCorr	Number:	5927
	"OnChange" interval:	block generated each time MT02, MT03, MT04, MT05, MT24 and possibly MT00 is received from an SBAS satellite

This block contains the decoded fast corrections transmitted in the SBAS message types 2, 3, 4, 5, 24 and possibly 0 if the type 0 message contains the type 2 contents. Refer to section A.4.4.3 and A.4.4.8 of the DO 229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which the message has been received (see 2.9)
MT	u1			Message type from which these fast corrections come, either 0, 2, 3, 4, 5 or 24.
IODP	u1			Issue of data - PRN.
IODF	u1			Issue of data - fast corrections.
N	u1			Number of fast correction sets in this message. This is the number of FastCorr sub-blocks. N depends on the message type as follows. Message type / N: MT00, MT02, MT03, MT04 / 13; MT05 / 12; MT24 / 6
SBLength	u1			Length of the FastCorr sub-blocks in bytes
FastCorr	...	...		*A succession of N FastCorr sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

FastCorr sub-block definition:

Parameter	Type	Units & Scale Factor	Description
PRNMaskNo	u1		Sequence number in the PRN mask, from 1 to 51.
UDREI	u1		User Differential Range Error Indicator for the PRN at index PRNMaskNo.
Reserved	u1[2]		Reserved for future use, to be ignored by decoding software
PRC	f4	1 m	Pseudorange correction for the PRN at index PRNMaskNo.
Padding	u1[..]		Padding bytes, see 2.5

GEOIntegrity	Number: 5928 "OnChange" interval: block generated each time MT06 is received from an SBAS satellite

This block contains the decoded integrity information transmitted in SBAS message type 6. Refer to section A.4.4.4 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which the message has been received (see 2.9)
Reserved	u1			Reserved for future use, to be ignored by decoding software
IODF	u1[4]			Issue of data - fast corrections for MT02, MT03, MT04 and MT05.
UDREI	u1[51]			User Differential Range Error Indicator for each of the 51 slots in the PRN mask.
Padding	u1[..]			Padding bytes, see 2.5

GEOFastCorrDegr	Number: 5929 "OnChange" interval: block generated each time MT07 is received from an SBAS satellite

This block contains the decoded fast correction degradation factors transmitted in SBAS message type 7. Refer to section A.4.4.5 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which the message has been received (see 2.9)
IODP	u1			Issue of data - PRN.
t_lat	u1	1 s		System latency.
ai	u1[51]			Degradation factor indicator (from 0 to 15) for each of the 51 slots in the PRN mask.
Padding	u1[..]			Padding bytes, see 2.5

GEONav	Number: 5896 "OnChange" interval: block generated each time MT09 is received from an SBAS satellite

This block contains the decoded navigation data transmitted in SBAS message type 9. Refer to section A.4.4.11 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite of which the navigation data is provided here (see 2.9)
Reserved	u1			Reserved for future use, to be ignored by decoding software
IODN	u2			Issue of data - navigation (DO 229-B) Spare (DO 229-C)
URA	u2			Accuracy exponent
t0	u4	1 s		Time of applicability (time-of-day)
Xg	f8	1 m		X position at time-of-day t0
Yg	f8	1 m		Y position at time-of-day t0
Zg	f8	1 m		Z position at time-of-day t0
Xgd	f8	1 m / s		X velocity at time-of-day t0
Ygd	f8	1 m / s		Y velocity at time-of-day t0
Zgd	f8	1 m / s		Z velocity at time-of-day t0
Xgdd	f8	1 m / s^2		X acceleration at time-of-day t0
Ygdd	f8	1 m / s^2		Y acceleration at time-of-day t0
Zgdd	f8	1 m / s^2		Z acceleration at time-of-day t0
aGf0	f4	1 s		Time offset with respect to SBAS network time
aGf1	f4	1 s / s		Time drift with respect to SBAS network time
Padding	u1[..]			Padding bytes, see 2.5

GEODegrFactors	Number: 5930 "OnChange" interval: block generated each time MT10 is received from an SBAS satellite

This block contains the decoded degradation factors transmitted in SBAS message type 10. Refer to section A.4.5 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which the message has been received (see 2.9)
Reserved	u1			Reserved for future use, to be ignored by decoding software
Brrc	f8	1 m		A parameter associated with the relative estimation noise and round-off error.
Cltc_lsb	f8	1 m		Maximum round-off error due to the LSB resolution of the orbit and clock information.
Cltc_v1	f8	1 m / s		Velocity error bound on the maximum range rate difference of missed messages due to clock and orbit rate differences.
Iltc_v1	u4	1 s		Update interval for long term corrections when the velocity code is 1.
Cltc_v0	f8	1 m		Bound on the update delta between successive long term corrections.
Iltc_v0	u4	1 s		Minimum update interval for long term messages when the velocity code is 0.
Cgeo_lsb	f8	1 m		Maximum round-off error due to the LSB resolution of the orbit and clock information.
Cgeo_v	f8	1 m / s		Velocity error bound on the maximum range rate difference of missed messages due to clock and orbit rate differences.
Igeo	u4	1 s		Update interval for GEO navigation messages.
Cer	f4	1 m		A degradation parameter.
Ciono_step	f8	1 m		Bound on the difference between successive ionospheric grid delay values.
Iiono	u4	1 s		Minimum update interval for ionospheric correction messages.
Ciono_ramp	f8	1 m / s		Rate of change of the ionospheric corrections.
RSSudre	u1			Root-sum-square flag (UDRE)
RSSiono	u1			Root-sum-square flag (IONO)
Reserved2	u1[2]			Reserved for future use, to be ignored by decoding software
Ccovariance	f8			A parameter used to compensate for the errors introduced by quantization (introduced in DO 229-C). To be multiplied by the SF parameter from the GEOClockEphCovMatrix block.
Padding	u1[..]			Padding bytes, see 2.5

GEONetworkTime	Number: 5918 "OnChange" interval: block generated each time MT12 is received from an SBAS satellite

This block contains the decoded network time offset parameters transmitted in SBAS message type 12. Refer to section A.4.4.15 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which this Network Time data was received (see 2.9)
Reserved	u1			Reserved for future use, to be ignored by decoding software
A_1	f4	1 s / s		first order term of polynomial
A_0	f8	1 s		constant term of polynomial
t_ot	u4	1 s		reference time for UTC data (time of week)
WN_t	u1	1 week		UTC reference week number, to which t_ot is referenced
DEL_t_LS	i1	1 s		Delta time due to leap seconds whenever the effectivity time is not in the past
WN_LSF	u1	1 week		Effectivity time of leap second (week)
DN	u1	1 day		Effectivity time of leap second (day)
DEL_t_LSF	i1	1 s		Delta time due to leap seconds whenever the effectivity time is in the past
UTC_std	u1			UTC Standard Identifier
GPS_WN	u2	1 week		GPS week number (modulo 1024)
GPS_TOW	u4	1 s		GPS time-of-week
GlonassID	u1			Glonass Indicator
Padding	u1[..]			Padding bytes, see 2.5

GEOAlm	Number: 5897 "OnChange" interval: block generated each time MT17 is received from an SBAS satellite

This block contains the decoded almanac data for one SBAS satellite, as transmitted in SBAS message type 17. A different GEOAlm block is generated for each of the up to three almanac data sets in MT17. Refer to section A.4.4.12 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite of which the almanac is provided here (see 2.9)
Reserved0	u1			Reserved for future use, to be ignored by decoding software
DataID	u1			Data ID
Reserved1	u1			Reserved for future use, to be ignored by decoding software
Health	u2			Health bits
t_oa	u4	1 s		Time of applicability (time-of-day)
Xg	f8	1 m		X position at time-of-day t0
Yg	f8	1 m		Y position at time-of-day t0
Zg	f8	1 m		Z position at time-of-day t0
Xgd	f8	1 m / s		X velocity at time-of-day t0
Ygd	f8	1 m / s		Y velocity at time-of-day t0
Zgd	f8	1 m / s		Z velocity at time-of-day t0
Padding	u1[..]			Padding bytes, see 2.5

GEOIGPMask	Number: 5931 "OnChange" interval: block generated each time MT18 is received from an SBAS satellite

This block contains the decoded ionospheric grid point mask transmitted in SBAS message type 18. Refer to section A.4.4.9 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which the message has been received (see 2.9)
NbrBands	u1			Number of bands being broadcast.
BandNbr	u1			Band number.
IODI	u1			Issue of data - ionosphere.
NbrIGPs	u1			Number of ionospheric grid points (IGP) designated in the mask.
IGPMask	u1[NbrIGPs]			List of the IGPs in the IGP mask. IGPMask[0] is the first IGP designated in the IGP mask (from 1 to 201), IGPMask[1] is the 2nd IGP designated in the IGP mask, etc...
Padding	u1[..]			Padding bytes, see 2.5

GEOLongTermCorr	Number: 5932
	"OnChange" interval: block generated each time MT24 or MT25 is received from an SBAS satellite

This block contains the decoded long term corrections transmitted in SBAS message types 24 and 25. Refer to section A.4.4.7 and A.4.4.8 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which the message has been received (see 2.9)
N	u1			Number of long-term corrections in this message. This is the number of LTCorr sub-blocks. N can be 0, 1, 2, 3 or 4.
SBLength	u1	1 byte		Length of the LTCorr sub-blocks in bytes
Reserved	u1[3]			Reserved for future use, to be ignored by decoding software
LTCorr	...	...		*A succession of N LTCorr sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

LTCorr sub-block definition:

Parameter	Type	Units & Scale Factor	Description
VelocityCode	u1		Velocity code (0 or 1)
PRNMaskNo	u1		Sequence in the PRN mask, from 1 to 51. Note that if the PRN mask No. from the original message is 0, the corresponding long term corrections are ignored, and hence not included in the GEOLongTermCorr block.
IODP	u1		Issue of data - PRN.
IODE	u1		Issue of data - ephemeris.
dx	f4	1 m	Satellite position offset (x).
dy	f4	1 m	Satellite position offset (y).
dz	f4	1 m	Satellite position offset (z).
dxRate	f4	1 m / s	Satellite velocity offset (x), or 0.0 if VelocityCode is 0.
dyRate	f4	1 m / s	Satellite velocity offset (y), or 0.0 if VelocityCode is 0.
dzRate	f4	1 m / s	Satellite velocity offset (z), or 0.0 if VelocityCode is 0.
da_f0	f4	1 s	Satellite clock offset.
da_f1	f4	1 s / s	Satellite drift correction, or 0.0 if VelocityCode is 0.
t_oe	u4	1 s	Time-of-day of applicability, or 0 if VelocityCode is 0.
Padding	u1[..]		Padding bytes, see 2.5

GEOIonoDelay	Number: 5933 "OnChange" interval: block generated each time MT26 is received from an SBAS satellite

This block contains the decoded ionospheric delays transmitted in SBAS message type 26. Refer to section A.4.4.10 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which the message has been received (see 2.9)
BandNbr	u1			Band number
IODI	u1			Issue of data - ionosphere.
N	u1			Number of ionospheric delay corrections in this message. This is the number of IDC sub-blocks. N is always 15.
SBLength	u1	1 byte		Length of the IDC sub-blocks in bytes.
Reserved	u1			Reserved for future use, to be ignored by decoding software
IDC	...	...		*A succession of N IDC sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

IDC sub-block definition:

Parameter	Type	Units & Scale Factor	Description
IGPMaskNo	u1		Sequence number in the IGP mask (see GEOIGPMask block), from 1 to 201.
GIVEI	u1		Grid Ionospheric Vertical Error Indicator, from 0 to 15
Reserved	u1[2]		Reserved for future use, to be ignored by decoding software
VerticalDelay	f4	1 m	IGP vertical delay estimate.
Padding	u1[..]		Padding bytes, see 2.5

GEOServiceLevel	Number: 5917 "OnChange" interval: block generated each time MT27 is received from an SBAS satellite

This block contains a decoded service level message for a geostationary SBAS satellite as sent in message type 27. Refer to section A.4.4.13 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			ID of the SBAS satellite from which this service level message was received (see 2.9)
Reserved	u1			Reserved for future use, to be ignored by decoding software
IODS	u1			Issue of Data Service level, ranging from 0 to 7
nrMessages	u1			Number of service messages (MT27), from 1 to 8
MessageNR	u1			Service message number, from 1 to 8
PriorityCode	u1			Priority Code, from 0 to 3
dUDREI_In	u1			δUDRE Indicator for users inside the service region, from 0 to 15
dUDREI_Out	u1			δUDRE Indicator for users outside the service region, from 0 to 15
N	u1			Number of Regions in this message. This is the number of ServiceRegion sub-blocks. Ranging from 0 to 7
SBLength	u1	1 byte		Length of the ServiceRegion sub-blocks in bytes
Regions	...	...		*A succession of N ServiceRegion sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

ServiceRegion sub-block definition:

Parameter	Type	Units & Scale Factor	Description
Latitude1	i1	1 degree	Coordinate 1 latitude, from -90 to +90
Latitude2	i1	1 degree	Coordinate 2 latitude, from -90 to +90
Longitude1	i2	1 degree	Coordinate 1 longitude, from -180 to +180
Longitude2	i2	1 degree	Coordinate 2 longitude, from -180 to +180
RegionShape	u1		Region Shape: 0=triangular, 1=square
Padding	u1[..]		Padding bytes, see 2.5

GEOClockEphCovMatrix	Number: 5934 "OnChange" interval: block generated each time MT28 is received from an SBAS satellite

This block contains the decoded clock-ephemeris covariance Cholesky factor matrix transmitted in SBAS message type 28. Refer to section A.4.4.16 of the DO-229 standard for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	SIS time stamp, see 2.3
WNc	u2	1 week	65535	
PRN	u1			
IODP	u1			Issue of data - PRN.
N	u1			Number of covariance matrices in this message. This is the number of CovMatrix sub-blocks. N can be 1 or 2.
SBLength	u1	1 byte		Length of the CovMatrix sub-blocks in bytes
Reserved	u1[2]			Reserved for future use, to be ignored by decoding software
CovMatrix	...	...		*A succession of N CovMatrix sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

CovMatrix sub-block definition:

Parameter	Type	Units & Scale Factor	Description
PRNMaskNo	u1		Sequence number in the PRN mask, from 1 to 51. Note that if the PRN mask No. from the original message is 0, the corresponding matrix is ignored, and hence not included in the GEOClockEphCovMatrix block.
Reserved	u1[2]		Reserved for future use, to be ignored by decoding software
ScaleExp	u1		Scale exponent; scale factor (= $2^{(\text{scale exponent - 5})}$)
E11	u2		$E_{1,1}$
E22	u2		$E_{2,2}$
E33	u2		$E_{3,3}$
E44	u2		$E_{4,4}$
E12	i2		$E_{1,2}$
E13	i2		$E_{1,3}$
E14	i2		$E_{1,4}$
E23	i2		$E_{2,3}$
E24	i2		$E_{2,4}$
E34	i2		$E_{3,4}$
Padding	u1[..]		Padding bytes, see 2.5

3.7 Position, Velocity and Time Blocks

PVTCartesian	Number: 4006 "OnChange" interval: 10 ms

This block contains the position, velocity and time (PVT) solution at the time specified in the TOW and WNc fields. The time of applicability is specified in the receiver time frame.

The computed position (x, y, z) and velocity (v_x, v_y, v_z) are reported in a Cartesian coordinate system using the datum indicated in the Datum field. The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

The PVT solution is also available in ellipsoidal form in the PVTGeodetic block.

The variance-covariance information associated with the reported PVT solution can be found in the PosCovCartesian and VelCovCartesian blocks.

If no PVT solution is available, the Error field indicates the cause of the unavailability and all fields after the Error field are set to their respective Do-Not-Use values.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
X	f8	1 m	$-2\cdot10^{10}$	Marker X coordinate in coordinate frame specified by Datum
Y	f8	1 m	$-2\cdot10^{10}$	Marker Y coordinate in coordinate frame specified by Datum
Z	f8	1 m	$-2\cdot10^{10}$	Marker Z coordinate in coordinate frame specified by Datum
Undulation	f4	1 m	$-2\cdot10^{10}$	Geoid undulation computed from the global geoid model defined in the document 'Technical Characteristics of the NAVSTAR GPS, NATO, June 1991'
Vx	f4	1 m / s	$-2\cdot10^{10}$	Velocity in the X direction
Vy	f4	1 m / s	$-2\cdot10^{10}$	Velocity in the Y direction

Vz	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the Z direction
COG	f4	1 degree	$-2 \cdot 10^{10}$	Course over ground: this is defined as the angle of the vehicle with respect to the local level North, ranging from 0 to 360, and increasing towards east. Set to the do-not-use value when the speed is lower than 0.1m/s.
RxClkBias	f8	1 ms	$-2 \cdot 10^{10}$	Receiver clock bias relative to system time reported in the TimeSystem field. To transfer the receiver time to the system time, use: $t_{GPS/GST} = t_{rx}$ - RxClkBias
RxClkDrift	f4	1 ppm	$-2 \cdot 10^{10}$	Receiver clock drift relative to system time (relative frequency error)
TimeSystem	u1		255	Time system of which the offset is provided in this sub-block: 0: GPS time 1: Galileo time 3: GLONASS time
Datum	u1		255	This field defines in which datum the coordinates are expressed: 0: WGS84/ITRS 19: Datum equal to that used by the DGNSS/RTK base station 30: ETRS89 (ETRF2000 realization) 31: NAD83(2011), North American Datum (2011) 32: NAD83(PA11), North American Datum, Pacific plate (2011) 33: NAD83(MA11), North American Datum, Marianas plate (2011) 34: GDA94(2010), Geocentric Datum of Australia (2010)
NrSV	u1		255	Total number of satellites used in the PVT computation.
WACorrInfo	u1		0	Bit field providing information about which wide area corrections have been applied: Bit 0: set if orbit and satellite clock correction information is used Bit 1: set if range correction information is used Bit 2: set if ionospheric information is used Bit 3: set if orbit accuracy information is used (UERE/SISA) Bit 4: set if DO229 Precision Approach mode is active Bits 5-7: Reserved
ReferenceID	u2		65535	This field indicates the reference ID of the differential information used. In case of DGPS or RTK operation, this field is to be interpreted as the base station identifier. In SBAS operation, this field is to be interpreted as the PRN of the geostationary satellite used. If multiple base stations or multiple geostationary satellites are used the value is set to 65534.
MeanCorrAge	u2	0.01 s	65535	In case of DGPS or RTK, this field is the mean age of the differential corrections. In case of SBAS operation, this field is the mean age of the 'fast corrections' provided by the SBAS satellites.
SignalInfo	u4		0	Bit field indicating the type of GNSS signals having been used in the PVT computations. If a bit i is set, the signal type having index i has been used. The signal numbers are listed in section 2.10. Bit 0 (GPS-C/A) is the LSB of SignalInfo.

	AlertFlag	u1		0	Bit field indicating integrity related information: Bits 0-1: RAIM integrity flag: 0: RAIM not active (integrity not monitored) 1: RAIM integrity test successful 2: RAIM integrity test failed 3: Reserved Bit 2: set if integrity has failed as per Galileo HPCA (HMI Probability Computation Algorithm) Bit 3: Reserved Bit 4: set if either the horizontal or the vertical 2DRMS accuracy is higher than the horizontal or vertical alert limits set by the **setNWALevels** command. Bits 5-7: Reserved
	NrBases	u1		0	Number of base stations used in the PVT computation.
Rev 1	PPPInfo	u2	1 s	0	Bit field containing PPP-related information: Bits 0-11: Age of the last seed, in seconds. The age is clipped to 4091s. This field must be ignored when the seed type is 0 (see bits 13-15 below). Bit 12: Reserved Bits 13-15: Type of last seed: 0: Not seeded or not in PPP positioning mode 1: Manual seed 2: Seeded from DGPS 3: Seeded from RTKFixed
Rev 2	Latency	u2	0.0001 s	65535	Reserved for future use
	HAccuracy	u2	0.01 m	65535	2DRMS horizontal accuracy: twice the root-mean-square of the horizontal distance error. The horizontal distance between the true position and the computed position is expected to be lower than HAccuracy with a probability of at least 95%. The value is clipped to 65534 =655.34m
	VAccuracy	u2	0.01 m	65535	2DRMS vertical accuracy: twice the root-mean-square of the vertical error. The vertical distance between the true position and the computed position is expected to be lower than VAccuracy with a probability of at least 95%. The value is clipped to 65534 =655.34m.
	Misc	u1			Bit field containing miscellaneous flags: Bit 0: In DGNSS or RTK mode, set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown. Bit 1: In RTK mode, set if the phase center variation is compensated for at the rover, unset if not or unknown. Bit 2: Proprietary. Bit 3: Proprietary. Bits 4-7: Reserved
	Padding	u1[..]			Padding bytes, see 2.5

PVTGeodetic	Number: 4007 "OnChange" interval: 10 ms

This block contains the position, velocity and time (PVT) solution at the time specified in the TOW and WNc fields. The time of applicability is specified in the receiver time frame.

The computed position (ϕ,λ,h) and velocity (v_n, v_e, v_u) are reported in an ellipsoidal coordinate system using the datum indicated in the Datum field. The velocity vector is expressed relative to the local-level Cartesian coordinate frame with north-, east-, up-unit vectors. The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

The PVT solution is also available in Cartesian form in the PVTCartesian block. If coordinate transformation parameters are available, coordinates in the local datum are available in the PosLocal block.

The variance-covariance information associated with the reported PVT solution can be found in the PosCovGeodetic and VelCovGeodetic blocks.

If no PVT solution is available, the Error field indicates the cause of the unavailability and all fields after the Error field are set to their respective Do-Not-Use values.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
Latitude	f8	1 rad	$-2\cdot10^{10}$	Marker latitude, from $-\pi/2$ to $+\pi/2$, positive North of Equator
Longitude	f8	1 rad	$-2\cdot10^{10}$	Marker longitude, from $-\pi$ to $+\pi$, positive East of Greenwich
Height	f8	1 m	$-2\cdot10^{10}$	Marker ellipsoidal height (with respect to the ellipsoid specified by Datum)
Undulation	f4	1 m	$-2\cdot10^{10}$	Geoid undulation computed from the global geoid model defined in the document 'Technical Characteristics of the NAVSTAR GPS, NATO, June 1991'
Vn	f4	1 m / s	$-2\cdot10^{10}$	Velocity in the North direction
Ve	f4	1 m / s	$-2\cdot10^{10}$	Velocity in the East direction

Vu	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the 'Up' direction
COG	f4	1 degree	$-2 \cdot 10^{10}$	Course over ground: this is defined as the angle of the vehicle with respect to the local level North, ranging from 0 to 360, and increasing towards east. Set to the do-not-use value when the speed is lower than 0.1m/s.
RxClkBias	f8	1 ms	$-2 \cdot 10^{10}$	Receiver clock bias relative to system time reported in the TimeSystem field. To transfer the receiver time to the system time, use: $t_{GPS/GST} = t_{rx}$ - RxClkBias
RxClkDrift	f4	1 ppm	$-2 \cdot 10^{10}$	Receiver clock drift relative to system time (relative frequency error)
TimeSystem	u1		255	Time system of which the offset is provided in this sub-block: 0: GPS time 1: Galileo time 3: GLONASS time
Datum	u1		255	This field defines in which datum the coordinates are expressed: 0: WGS84/ITRS 19: Datum equal to that used by the DGNSS/RTK base station 30: ETRS89 (ETRF2000 realization) 31: NAD83(2011), North American Datum (2011) 32: NAD83(PA11), North American Datum, Pacific plate (2011) 33: NAD83(MA11), North American Datum, Marianas plate (2011) 34: GDA94(2010), Geocentric Datum of Australia (2010)
NrSV	u1		255	Total number of satellites used in the PVT computation.
WACorrInfo	u1		0	Bit field providing information about which wide area corrections have been applied: Bit 0: set if orbit and satellite clock correction information is used Bit 1: set if range correction information is used Bit 2: set if ionospheric information is used Bit 3: set if orbit accuracy information is used (UERE/SISA) Bit 4: set if DO229 Precision Approach mode is active Bits 5-7: Reserved
ReferenceID	u2		65535	This field indicates the reference ID of the differential information used. In case of DGPS or RTK operation, this field is to be interpreted as the base station identifier. In SBAS operation, this field is to be interpreted as the PRN of the geostationary satellite used. If multiple base stations or multiple geostationary satellites are used the value is set to 65534.
MeanCorrAge	u2	0.01 s	65535	In case of DGPS or RTK, this field is the mean age of the differential corrections. In case of SBAS operation, this field is the mean age of the 'fast corrections' provided by the SBAS satellites.
SignalInfo	u4		0	Bit field indicating the type of GNSS signals having been used in the PVT computations. If a bit i is set, the signal type having index i has been used. The signal numbers are listed in section 2.10. Bit 0 (GPS-C/A) is the LSB of SignalInfo.

	AlertFlag	u1		0	Bit field indicating integrity related information: Bits 0-1: RAIM integrity flag: 0: RAIM not active (integrity not monitored) 1: RAIM integrity test successful 2: RAIM integrity test failed 3: Reserved Bit 2: set if integrity has failed as per Galileo HPCA (HMI Probability Computation Algorithm) Bit 3: Reserved Bit 4: set if either the horizontal or the vertical 2DRMS accuracy is higher than the horizontal or vertical alert limits set by the **setNWALevels** command. Bits 5-7: Reserved
	NrBases	u1		0	Number of base stations used in the PVT computation.
Rev 1	PPPInfo	u2	1 s	0	Bit field containing PPP-related information: Bits 0-11: Age of the last seed, in seconds. The age is clipped to 4091s. This field must be ignored when the seed type is 0 (see bits 13-15 below). Bit 12: Reserved Bits 13-15: Type of last seed: 0: Not seeded or not in PPP positioning mode 1: Manual seed 2: Seeded from DGPS 3: Seeded from RTKFixed
Rev 2	Latency	u2	0.0001 s	65535	Reserved for future use
	HAccuracy	u2	0.01 m	65535	2DRMS horizontal accuracy: twice the root-mean-square of the horizontal distance error. The horizontal distance between the true position and the computed position is expected to be lower than HAccuracy with a probability of at least 95%. The value is clipped to 65534 =655.34m
	VAccuracy	u2	0.01 m	65535	2DRMS vertical accuracy: twice the root-mean-square of the vertical error. The vertical distance between the true position and the computed position is expected to be lower than VAccuracy with a probability of at least 95%. The value is clipped to 65534 =655.34m.
	Misc	u1			Bit field containing miscellaneous flags: Bit 0: In DGNSS or RTK mode, set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown. Bit 1: In RTK mode, set if the phase center variation is compensated for at the rover, unset if not or unknown. Bit 2: Proprietary. Bit 3: Proprietary. Bits 4-7: Reserved
	Padding	u1[..]			Padding bytes, see 2.5

PosCovCartesian	Number: 5905 "OnChange" interval: 10 ms

This block contains the elements of the symmetric variance-covariance matrix of the position expressed relative to the Cartesian axes of the coordinate system datum requested by the user:

$$\begin{pmatrix} \sigma_x^2 & \sigma_{xy} & \sigma_{xz} & \sigma_{xb} \\ \sigma_{yx} & \sigma_y^2 & \sigma_{yz} & \sigma_{yb} \\ \sigma_{zx} & \sigma_{zy} & \sigma_z^2 & \sigma_{zb} \\ \sigma_{bx} & \sigma_{by} & \sigma_{bz} & \sigma_b^2 \end{pmatrix}$$

This variance-covariance matrix contains an indication of the accuracy of the estimated parameters (see diagonal elements) and the correlation between these estimates (see off-diagonal elements). Note that the variances and covariances are estimated: they are not necessarily indicative of the actual scatter of the position estimates at a given site.

The position variance results from the propagation of all pseudorange variances using the observation geometry. The receiver implements a stochastic error model for individual measurements, based on parameters such as the C/N_0, the satellite elevation, the pseudorange type, the URA of the broadcast ephemeris and the ionospheric model.

If the ellipsoidal height is not estimated (2D-mode), all components of the variance-covariance matrix are undefined and set to their Do-Not-Use value.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
Cov_xx	f4	1 m^2	$-2 \cdot 10^{10}$	Variance of the x estimate
Cov_yy	f4	1 m^2	$-2 \cdot 10^{10}$	Variance of the y estimate
Cov_zz	f4	1 m^2	$-2 \cdot 10^{10}$	Variance of the z estimate
Cov_bb	f4	1 m^2	$-2 \cdot 10^{10}$	Variance of the clock bias estimate
Cov_xy	f4	1 m^2	$-2 \cdot 10^{10}$	Covariance between the x and y estimates
Cov_xz	f4	1 m^2	$-2 \cdot 10^{10}$	Covariance between the x and z estimates
Cov_xb	f4	1 m^2	$-2 \cdot 10^{10}$	Covariance between the x and clock bias estimates

Cov_yz	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Covariance between the y and z estimates
Cov_yb	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Covariance between the y and clock bias estimates
Cov_zb	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Covariance between the z and clock bias estimates
Padding	u1[..]			Padding bytes, see 2.5

PosCovGeodetic	Number: 5906 "OnChange" interval: 10 ms

This block contains the elements of the symmetric variance-covariance matrix of the position expressed in the geodetic coordinates in the datum requested by the user:

$$\begin{pmatrix} \sigma_\phi^2 & \sigma_{\phi\lambda} & \sigma_{\phi h} & \sigma_{\phi b} \\ \sigma_{\lambda\phi} & \sigma_\lambda^2 & \sigma_{\lambda h} & \sigma_{\lambda b} \\ \sigma_{h\phi} & \sigma_{h\lambda} & \sigma_h^2 & \sigma_{hb} \\ \sigma_{b\phi} & \sigma_{b\lambda} & \sigma_{bh} & \sigma_b^2 \end{pmatrix}$$

Please refer to the PosCovCartesian block description for a general explanation of the contents.

Note that the units of measure for all the variances and covariances, for height as well as for latitude and longitude, are m^2 for ease of interpretation.

If the ellipsoidal height is not estimated (2D-mode), all height related components of the variance-covariance matrix are undefined and set to their Do-Not-Use value.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
Cov_latlat	f4	1 m^2	$-2 \cdot 10^{10}$	Variance of the latitude estimate
Cov_lonlon	f4	1 m^2	$-2 \cdot 10^{10}$	Variance of the longitude estimate
Cov_hgthgt	f4	1 m^2	$-2 \cdot 10^{10}$	Variance of the height estimate
Cov_bb	f4	1 m^2	$-2 \cdot 10^{10}$	Variance of the clock-bias estimate
Cov_latlon	f4	1 m^2	$-2 \cdot 10^{10}$	Covariance between the latitude and longitude estimates
Cov_lathgt	f4	1 m^2	$-2 \cdot 10^{10}$	Covariance between the latitude and height estimates
Cov_latb	f4	1 m^2	$-2 \cdot 10^{10}$	Covariance between the latitude and clock-bias estimates

Cov_lonhgt	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Covariance between the longitude and height estimates
Cov_lonb	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Covariance between the longitude and clock-bias estimates
Cov_hb	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Covariance between the height and clock-bias estimates
Padding	u1[..]			Padding bytes, see 2.5

VelCovCartesian	Number: 5907 "OnChange" interval: 10 ms

This block contains the elements of the symmetric variance-covariance matrix of the velocity expressed in the Cartesian coordinates of the coordinate system datum requested by the user:

$$\begin{pmatrix} \sigma^2_{v_x} & \sigma_{v_x v_y} & \sigma_{v_x v_z} & \sigma_{v_x d} \\ \sigma_{v_y v_x} & \sigma^2_{v_y} & \sigma_{v_y v_z} & \sigma_{v_y d} \\ \sigma_{v_z v_x} & \sigma_{v_z v_y} & \sigma^2_{v_z} & \sigma_{v_z d} \\ \sigma_{d v_x} & \sigma_{d v_y} & \sigma_{d v_z} & \sigma^2_{d} \end{pmatrix}$$

Please refer to the PosCovCartesian block description for a general explanation of the contents.

If the up-velocity is not estimated (2D-mode), all components of the variance-covariance matrix are undefined and set to their Do-Not-Use value.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
Cov_VxVx	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Variance of the x-velocity estimate
Cov_VyVy	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Variance of the y-velocity estimate
Cov_VzVz	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Variance of the z-velocity estimate
Cov_DtDt	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Variance of the clock drift estimate
Cov_VxVy	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Covariance between the x- and y-velocity estimates
Cov_VxVz	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Covariance between the x- and z-velocity estimates
Cov_VxDt	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Covariance between the x-velocity and the clock drift estimates

Cov_VyVz	f4	$1\ m^2\ /\ s^2$	$-2 \cdot 10^{10}$	Covariance between the y- and z-velocity estimates
Cov_VyDt	f4	$1\ m^2\ /\ s^2$	$-2 \cdot 10^{10}$	Covariance between the y-velocity and the clock drift estimates
Cov_VzDt	f4	$1\ m^2\ /\ s^2$	$-2 \cdot 10^{10}$	Covariance between the z-velocity and the clock drift estimates
Padding	u1[..]			Padding bytes, see 2.5

VelCovGeodetic	Number: 5908 "OnChange" interval: 10 ms

This block contains the elements of the symmetric variance-covariance matrix of the velocity expressed in the geodetic coordinates in the datum requested by the user:

$$\begin{pmatrix} \sigma^2_{v_N} & \sigma_{v_N v_E} & \sigma_{v_N v_U} & \sigma_{v_N d} \\ \sigma_{v_E v_N} & \sigma^2_{v_E} & \sigma_{v_E v_U} & \sigma_{v_E d} \\ \sigma_{v_U v_N} & \sigma_{v_U v_E} & \sigma^2_{v_U} & \sigma_{v_U d} \\ \sigma_{d v_N} & \sigma_{d v_E} & \sigma_{d v_U} & \sigma^2_{d} \end{pmatrix}$$

Please refer to the PosCovCartesian block description for a general explanation of the contents.

If the up-velocity is not estimated (2D-mode), all up-velocity related components of the variance-covariance matrix are undefined and set to their Do-Not-Use value.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
Cov_VnVn	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Variance of the north-velocity estimate
Cov_VeVe	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Variance of the east-velocity estimate
Cov_VuVu	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Variance of the up-velocity estimate
Cov_DtDt	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Variance of the clock drift estimate
Cov_VnVe	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Covariance between the north- and east-velocity estimates
Cov_VnVu	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Covariance between the north- and up-velocity estimates
Cov_VnDt	f4	1 m^2 / s^2	$-2 \cdot 10^{10}$	Covariance between the north-velocity and clock drift estimates

Cov_VeVu	f4	$1\ m^2\ /\ s^2$	$-2 \cdot 10^{10}$	Covariance between the east- and up-velocity estimates
Cov_VeDt	f4	$1\ m^2\ /\ s^2$	$-2 \cdot 10^{10}$	Covariance between the east-velocity and clock drift estimates
Cov_VuDt	f4	$1\ m^2\ /\ s^2$	$-2 \cdot 10^{10}$	Covariance between the up-velocity and clock drift estimates
Padding	u1[..]			Padding bytes, see 2.5

DOP	Number: 4001 "OnChange" interval: 10 ms

This block contains both Dilution of Precision (DOP) values and SBAS protection levels. The DOP values result from a trace of the unit position variance-covariance matrices:

$$\text{Position Dilution of Precision:} \quad PDOP = \sqrt{\mathbf{Q}_{xx} + \mathbf{Q}_{yy} + \mathbf{Q}_{zz}}$$

$$\text{Time Dilution of Precision:} \quad TDOP = \sqrt{\mathbf{Q}_{bb}}$$

$$\text{Horizontal Dilution of Precision:} \quad HDOP = \sqrt{\mathbf{Q}_{\lambda\lambda} + \mathbf{Q}_{\phi\phi}}$$

$$\text{Vertical Dilution of Precision:} \quad VDOP = \sqrt{\mathbf{Q}_{hh}}$$

In these equations, the matrix **Q** is the inverse of the unweighted normal matrix used for the computation of the position. The normal matrix equals the product of the geometry matrix A with its transpose (A^tA). The term "unweighted" implies that the DOP factor only addresses the effect of the geometric factors on the quality of the position.

The DOP values can be used to interpret the current constellation geometry. This is an important parameter for the quality of the position fix: the DOP parameter is the propagation factor of the pseudorange variance. For example, if an error of 5 m is present in the pseudorange, it will propagate into the horizontal plane with a factor expressed by the HDOP. Hence a low DOP value indicates that the satellites used for the position fix result in a low multiplication of the systematic ranging errors. A value of six (6) for the PDOP is generally considered as the maximum value allowed for an acceptable position computation.

The horizontal and vertical protection levels (HPL and VPL) indicate the integrity of the computed horizontal and vertical position components as per the DO 229 specification. In SBAS-aided PVT mode (see the `Mode` field of the `PVTCartesian` SBF block), HPL and VPL are based upon the error estimates provided by SBAS. Otherwise they are based upon internal position-mode dependent error estimates.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
NrSV	u1		0	Total number of satellites used in the DOP computation, or 0 if the DOP information is not available (in that case, the `xDOP` fields are all set to 0)
Reserved	u1			Reserved for future use, to be ignored by decoding software
PDOP	u2	0.01	0	If 0, PDOP not available, otherwise divide by 100 to obtain PDOP.
TDOP	u2	0.01	0	If 0, TDOP not available, otherwise divide by 100 to obtain TDOP.
HDOP	u2	0.01	0	If 0, HDOP not available, otherwise divide by 100 to obtain HDOP.
VDOP	u2	0.01	0	If 0, VDOP not available, otherwise divide by 100 to obtain VDOP.

HPL	f4	1 m	$-2 \cdot 10^{10}$	Horizontal Protection Level (see the DO 229 standard).
VPL	f4	1 m	$-2 \cdot 10^{10}$	Vertical Protection Level (see the DO 229 standard).
Padding	u1[..]			Padding bytes, see 2.5

PosCart	Number: 4044 "OnChange" interval: 10 ms

This block contains the absolute and relative (relative to the nearest base station) position at the time specified in the TOW and WNc fields. The time of applicability is specified in the receiver time frame.

The absolute position (X, Y, Z) is reported in a Cartesian coordinate system using the datum indicated in the Datum field. The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

For highest accuracy, the receiver tries to compute the baseline (Base2RoverX, Base2RoverY, Base2RoverZ) from rover ARP to base ARP. See the description of the BaseVectorCart block for details.

Accurate ARP-to-ARP baseline is guaranteed only if both bits 0 and 1 of the Misc field are set. Otherwise, centimeter-level offsets may arise because the receiver cannot make the distinction between phase center and ARP positions. See the Firmware User Manual for a discussion on the phase center and ARP positions.

This block also contains the variance-covariance information and DOP factors associated with the position.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
X	f8	1 m	$-2\cdot10^{10}$	Marker X coordinate in coordinate frame specified by Datum
Y	f8	1 m	$-2\cdot10^{10}$	Marker Y coordinate in coordinate frame specified by Datum
Z	f8	1 m	$-2\cdot10^{10}$	Marker Z coordinate in coordinate frame specified by Datum
Base2RoverX	f8	1 m	$-2\cdot10^{10}$	X baseline component (from base to rover)
Base2RoverY	f8	1 m	$-2\cdot10^{10}$	Y baseline component (from base to rover)
Base2RoverZ	f8	1 m	$-2\cdot10^{10}$	Z baseline component (from base to rover)
Cov_xx	f4	1 m^2	$-2\cdot10^{10}$	Variance of the x estimate

Cov_yy	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Variance of the y estimate
Cov_zz	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Variance of the z estimate
Cov_xy	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Covariance between the x and y estimates
Cov_xz	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Covariance between the x and z estimates
Cov_yz	f4	$1\ m^2$	$-2 \cdot 10^{10}$	Covariance between the y and z estimates
PDOP	u2	0.01	0	If 0, PDOP not available, otherwise divide by 100 to obtain PDOP.
HDOP	u2	0.01	0	If 0, HDOP not available, otherwise divide by 100 to obtain HDOP.
VDOP	u2	0.01	0	If 0, VDOP not available, otherwise divide by 100 to obtain VDOP.
Misc	u1			Bit field containing miscellaneous flags: Bit 0: In DGNSS or RTK mode, set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown. Bit 1: In RTK mode, set if the phase center variation is compensated for at the rover, unset if not or unknown. Bit 2: Proprietary. Bit 3: Proprietary. Bits 4-7: Reserved
Reserved	u1			Reserved for future use.
AlertFlag	u1		0	Bit field indicating integrity related information: Bits 0-1: RAIM integrity flag: 0: RAIM not active (integrity not monitored) 1: RAIM integrity test successful 2: RAIM integrity test failed 3: Reserved Bit 2: set if integrity has failed as per Galileo HPCA (HMI Probability Computation Algorithm) Bit 3: Reserved Bit 4: set if either the horizontal or the vertical 2DRMS accuracy is higher than the horizontal or vertical alert limits set by the **setNWALevels** command. Bits 5-7: Reserved
Datum	u1		255	This field defines in which datum the coordinates are expressed: 0: WGS84/ITRS 19: Datum equal to that used by the DGNSS/RTK base station 30: ETRS89 (ETRF2000 realization) 31: NAD83(2011), North American Datum (2011) 32: NAD83(PA11), North American Datum, Pacific plate (2011) 33: NAD83(MA11), North American Datum, Marianas plate (2011) 34: GDA94(2010), Geocentric Datum of Australia (2010)
NrSV	u1		255	Total number of satellites used in the PVT computation.

WACorrInfo	u1		0	Bit field providing information about which wide area corrections have been applied: Bit 0: set if orbit and satellite clock correction information is used Bit 1: set if range correction information is used Bit 2: set if ionospheric information is used Bit 3: set if orbit accuracy information is used (UERE/SISA) Bit 4: set if DO229 Precision Approach mode is active Bits 5-7: Reserved
ReferenceId	u2		65535	This field indicates the reference ID of the differential information used. In case of DGPS or RTK operation, this field is to be interpreted as the base station identifier. In SBAS operation, this field is to be interpreted as the PRN of the geostationary satellite used. If multiple base stations or multiple geostationary satellites are used the value is set to 65534.
MeanCorrAge	u2	0.01 s	65535	In case of DGPS or RTK, this field is the mean age of the differential corrections. In case of SBAS operation, this field is the mean age of the 'fast corrections' provided by the SBAS satellites.
SignalInfo	u4		0	Bit field indicating the type of GNSS signals having been used in the PVT computations. If a bit i is set, the signal type having index i has been used. The signal numbers are listed in section 2.10. Bit 0 (GPS-C/A) is the LSB of SignalInfo.
Padding	u1[..]			Padding bytes, see 2.5

PosLocal	Number: 4052 "OnChange" interval: 10 ms

This block contains the position at the time specified in the TOW and WNc fields. The time of applicability is specified in the receiver time frame.

The position (Lat, Lon, Alt) relates to the local datum identified with the Datum field. The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

The variance-covariance information associated with the reported position can be found in the PosCovGeodetic blocks.

If no position is available, the Error field indicates the cause of the unavailability and all fields after the Error field are set to their respective Do-Not-Use values.

To be able to output a position in the PosLocal block, the receiver needs to be in RTK positioning mode and must have received a complete set of datum transformation parameters from the RTK service provider. Datum transformation parameters are transmitted within the RTCM 3.x stream, in message types 1021 to 1023. If the positioning mode is not RTK or the transformation parameters are not available or not applicable, the Error field is set to value 17. See also section "Datum Transformation" in the Firmware User Manual.

The corresponding RTCMDatum block provides information on the local datum name and transformation quality indicators. The corresponding RTCMDatum block is the one of which the Datum field matches the Datum field in the PosLocal block.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions 17: Datum transformation parameters unknown Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
Lat	f8	1 rad	$-2\cdot10^{10}$	Marker latitude, from $-\pi/2$ to $+\pi/2$, positive North of Equator
Lon	f8	1 rad	$-2\cdot10^{10}$	Marker latitude, from $-\pi$ to $+\pi$, positive North of Equator
Alt	f8	1 m	$-2\cdot10^{10}$	Marker height. This can be a geometric height or a physical height. See the HeightType field of the corresponding RTCMDatum block.
Datum	u1			Reference frame to which the position relates. Internal ID of the local target datum from RTCMv3 MT1021/1022, from 20 to 24. The corresponding datum parameters can be found in the RTCMDatum block having a matching Datum field.

Padding	u1[..]			Padding bytes, see 2.5

PVTSatCartesian	Number: 4008 "OnChange" interval: 10 ms

This block contains the position and velocity of all the satellites used in the PVT solution, together with slant ionospheric and tropospheric delays. Coordinates are referred to the time of signal transmission computed by the receiver and are corrected for the Sagnac effect.

The reference frame the coordinates are related to is the one specified in the respective ICDs (WGS84 for GPS satellites, GTRF for Galileo satellites, PZ90 for GLONASS satellites, etc).

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of satellites for which satellite position is provided in this SBF block, i.e. number of SatPos sub-blocks. If N is 0, there are no satellite positions available for this epoch.
SBLength	u1	1 byte		Length of one sub-block
SatPos	...	...		*A succession of N SatPos sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

SatPos sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
SVID	u1			Satellite ID, see 2.9
FreqNr	u1		0	For GLONASS satellites, this is the frequency number, with an offset of 8. It ranges from 1 (corresponding to an actual frequency number of -7) to 21 (corresponding to an actual frequency number of 13). For non-GLONASS satellites, FreqNr is reserved and must be ignored by the decoding software.
IODE	u2			IODE of the data set used to compute the values in this sub-block.
x	f8	1 m	$-2 \cdot 10^{10}$	X coordinate
y	f8	1 m	$-2 \cdot 10^{10}$	Y coordinate
z	f8	1 m	$-2 \cdot 10^{10}$	Z coordinate
Vx	f4	1 m / s	$-2 \cdot 10^{10}$	Satellite velocity in the X direction
Vy	f4	1 m / s	$-2 \cdot 10^{10}$	Satellite velocity in the Y direction
Vz	f4	1 m / s	$-2 \cdot 10^{10}$	Satellite velocity in the Z direction
IonoMSB	i2	1 dm	-32768 (7)	Total slant ionospheric delay at the L1 carrier frequency (1575.42MHz), with a decimeter resolution.

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(7) The ionospheric delay should not be used when IonoMSB is -32768.

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TropoMSB	i2	1 dm	-32768 (8)	Total slant tropospheric delay, with a decimeter resolution.
IonoLSB	u1	$1.0/256.0$ dm	0 (7)	Sub-decimeter part of the slant ionospheric delay. The high-resolution ionospheric delay, expressed in meters, can be computed as: IonoDelay[m] = 0.1*(IonoMSB + IonoLSB/256)
TropoLSB	u1	$1.0/256.0$ dm	0 (8)	Sub-decimeter part of the slant tropospheric delay. The high-resolution tropospheric delay, expressed in meters, can be computed as: TropoDelay[m] = 0.1*(TropoMSB + TropoLSB/256)
IonoModel	u1			Model used to compute the ionospheric delay: 0: Not applicable 1: Klobuchar 2: DO229 3: NeQuick 4: Measured (from dual frequency measurements) 5: Estimated
Padding	u1[..]			Padding bytes, see 2.5

(8) The tropospheric delay should not be used when TropoMSB is -32768.

PVTResiduals	Number: 4009 "OnChange" interval: 10 ms

This block contains the residuals of all measurements used in PVT solution computed at the epoch specified in the TOW and WNc fields. The PVT solution itself can be found in the PVTCartesian or PVTGeodetic blocks.

For each measurement from each satellite and each modulation used in the PVT solution, detailed PVT residual information is output for each observable type (code phase, carrier phase and Doppler):

- a-posteriori measurement residual (e_i)
- absolute value of the w-test statistic (w_i)
- Minimal detectable bias (MDB).

In case of multi-base differential operation, a set of residuals is provided for all base stations.

This block uses a two-level sub-block structure analogous to that of the MeasEpoch block. It contains one SatSignalInfo sub-block for each satellite/signal type pair used in the PVT or attitude computation. Each SatSignalInfo sub-block contains a number of ResidualInfo sub-blocks, each of them containing the residuals of a given observable type.

The standard deviation of the residual (σ_e) for satellite i and the "a priori" measurement standard deviation (σ_y) can be computed from e_i, w_i and MDB by using the following formulas (see also the Firmware User Manual):

$$\sigma_{e_i} = \frac{|e_i|}{w_i} \text{ and } \sigma_{y_i} = \sqrt{\frac{MDB}{\sqrt{\lambda_0}}.\sigma_{e_i}}$$

where λ_0 is the non-centrality parameter and:

$$\sqrt{\lambda_0} = \sqrt{2}[\text{erfinv}(1 - P_{fa}) + \text{erfinv}(1 - 2P_{md})]$$

with P_{fa} and P_{md} being the probability of false alarm and of missed detection respectively, as set by the **setRAIMLevels** command, and the "erfinv" function being the inverse error function. The output of erfinv(x) is the value y that satisfies the following equality:

$$x = \frac{2}{\sqrt{\pi}} \int_0^y e^{-t^2} dt$$

This block can be used to monitor the quality of the measurements. Under normal circumstances, the residuals lie within -2 and +2 times the a-priori variance of the corresponding measurements.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of satellite/signal pairs for which residual blocks are provided in this SBF block, i.e. number of SatSignalInfo sub-blocks. If N is 0, there are no satellite residuals available for this epoch.
SB1Length	u1	1 byte		Length of a SatSignalInfo sub-block, excluding the nested ResidualInfoCode, ResidualInfoPhase and ResidualInfoDoppler sub-blocks
SB2Length	u1	1 byte		Length of a ResidualInfoCode, ResidualInfoPhase and ResidualInfoDoppler sub-block
Reserved	u1[3]			Reserved for future use, to be ignored by decoding software
Residuals	...	...		*A succession of N SatSignalInfo sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

`SatSignalInfo` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`SVID`	u1			Satellite ID, see 2.9
`FreqNr`	u1		0	For GLONASS satellites, this is the frequency number, with an offset of 8. It ranges from 1 (corresponding to an actual frequency number of -7) to 21 (corresponding to an actual frequency number of 13). For non-GLONASS satellites, `FreqNr` is reserved and must be ignored by the decoding software.
`Type`	u1			Bit field indicating the signal type and antenna ID: Bits 0-4: signal number as defined in 2.10. Bits 5-7: Antenna ID: 0 for the main antenna
`RefSVID`	u1		255, 62	Satellite ID of the reference satellite used for double differencing, see 2.9. Set to 255 if not in double difference mode, or set to 62 if in double difference mode, and GLONASS slot number unknown.
`RefFreqNr`	u1		255, 0	GLONASS frequency number for the reference satellite, see 2.9. Set to 255 if not in double difference mode, or set to 0 if in double difference mode, but non-GLONASS satellite.
`MeasInfo`	u1			Bit field: Bits 0-1: Type of residual this sub-block refers to: 0: zero-difference residual (standalone) 1: single-difference residual (SBAS, DGPS) 2: double-difference residual. If the antenna ID is 0 (see the `Type` field above), this sub-block contains an RTK residual, else it contains an attitude residual. Bit 2: Set if a `ResidualInfoCode` sub-block containing pseudorange residuals follows. Bit 3: Set if a `ResidualInfoPhase` sub-block containing carrier-phase residuals follows. Bit 4: Set if a `ResidualInfoDoppler` sub-block containing Doppler residuals follows. Bits 5-6: Reserved Bit 7: Set if ambiguity is fixed for the signal type identified by the `Type` field. The number of `ResidualInfo` sub-blocks to follow is equal to the number of bits set to 1 between bit 2 and bit 4. The order of these `ResidualInfo` sub-blocks is fixed: the code-phase residuals come first (if any), then the carrier phase residuals (if any), and the Doppler residuals as last.
`IODE`	u2			Issue of Data Ephemeris used for the satellite and signal type identified by `SVID` and `Type`.
`CorrAge`	u2	0.001 s	65535	Age of corrections, either from SBAS, DGPS, RTK etc, truncated to 655.34 seconds.
`ReferenceID`	u2		65535	ID of the base station the residuals apply to. Set to 65535 in case of standalone operation.
`Padding`	u1[..]			Padding bytes, see 2.5
If the `Pseudorange residuals` field is 1 then this sub block is available:				
`ResidualInfoCode`	...	...		A `ResidualInfoCode` sub-block, see definition below

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If the `Carrier-phase residuals` field is 1 then this sub block is available:				
`ResidualInfoPhase`	...	...		A `ResidualInfoPhase` sub-block, see definition below
If the `Doppler residuals` field is 1 then this sub block is available:				
`ResidualInfoDoppler`	...	...		A `ResidualInfoDoppler` sub-block, see definition below

`ResidualInfoCode` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`Residual`	f4	1 m	$-2\cdot10^{10}$	Code Residual with respect to PVT solution reported in `PVTCartesian` and/or `PVTGeodetic` block.
`W`	u2	0.001	65535	Absolute value of the w-test statistic based on probability of false alarm set by user
`MDB`	u2	0.1 m	65535	Minimal detectable bias based on probability of missed detection set by user
`Padding`	u1[..]			Padding bytes, see 2.5

`ResidualInfoPhase` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`Residual`	f4	1 cycle	$-2\cdot10^{10}$	Phase Residual with respect to PVT solution reported in `PVTCartesian` and/or `PVTGeodetic` block. Double-difference carrier phase residuals include the double difference ambiguity as long as the ambiguity is not fixed (i.e. as long as bit 7 of `MeasInfo` is not set). When the ambiguity is fixed, e_i does not contain the ambiguity anymore.
`W`	u2	0.001	65535	Absolute value of the w-test statistic based on probability of false alarm set by user
`MDB`	u2	0.01 cycles	65535	Minimal detectable bias based on probability of missed detection set by user
`Padding`	u1[..]			Padding bytes, see 2.5

`ResidualInfoDoppler` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`Residual`	f4	1 m / s	$-2\cdot10^{10}$	Doppler Residual with respect to PVT solution reported in `PVTCartesian` and/or `PVTGeodetic` block.
`W`	u2	0.001	65535	Absolute value of the w-test statistic based on probability of false alarm set by user
`MDB`	u2	0.01 m / s	65535	Minimal detectable bias based on probability of missed detection set by user
`Padding`	u1[..]			Padding bytes, see 2.5

RAIMStatistics	Number: 4011 "OnChange" interval: 10 ms

This block contains the integrity statistics that are computed by the receiver RAIM algorithm.

The output of the RAIM algorithm contains integrity information, which can be used in user applications. First, the RAIM algorithm generates its own integrity flag based on the probability of false-alarm, which can be used by a user as a receiver-level indication of positional integrity. If the internal integrity test is successful, a user has an opportunity to introduce a more stringent application-specific integrity criterion by using External Reliability Levels (XERL). The positional solution is deemed as passed an application-level integrity test if the XERLs are within user-defined (and application-dependent) alarm limits. This comparison (and the definition of alarm limits as well) takes place in a user application and is outside of the receiver scope. Please refer to the RAIM section of the Firmware User Manual for further details.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
IntegrityFlag	u1			RAIM integrity flag: 0: Integrity test successful 1: Integrity test failed 2: Integrity not available
Reserved1	u1			Reserved for future use, to be ignored by decoding software
HERL-position	f4	1 m	$-2\cdot10^{10}$	Horizontal external reliability level of the position
VERL-position	f4	1 m	$-2\cdot10^{10}$	Vertical external reliability level of the position
HERL-velocity	f4	1 m / s	$-2\cdot10^{10}$	Horizontal external reliability level of the velocity
VERL-velocity	f4	1 m / s	$-2\cdot10^{10}$	Vertical external reliability level of the velocity
OverallModel	u2	1/50000	65535 (9)	Overall model test statistic for the estimated PVT parameters divided by the test threshold
Padding	u1[..]			Padding bytes, see 2.5

(9) This field is clipped to 65534, i.e. if the actual value is larger than 65534, it is set to 65534.

GEOCorrections	Number: 5935 "OnChange" interval: 10 ms

This block contains the SBAS corrections that the receiver has applied to the pseudoranges used in the PVT computation computed at the epoch specified in the TOW and WNc fields. The PVT solution itself can be found in the PVTCartesian or PVTGeodetic blocks.

The corrections are based on the messages received from an SBAS satellite. They compensate for the following errors:

- Satellite orbit
- Satellite clock
- Ionospheric delay.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of satellites for which corrections are provided in this SBF block, i.e. number of SatCorr sub-blocks. If N is 0, there are no corrections available for this epoch.
SBLength	u1	1 byte		Length of one sub-block in bytes
SatCorr	...	...		*A succession of N SatCorr sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

SatCorr sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
SVID	u1			Satellite ID, see 2.9
IODE	u1			Issue of Data Ephemeris related to the orbit and clock corrections
Reserved	u1[2]			Reserved for future use, to be ignored by decoding software
PRC	f4	1 m		Applied pseudorange correction based on the fast correction data received in MT02-MT05 or MT24
CorrAgeFC	f4	1 s		Age of applied fast correction
DeltaX	f4	1 m		X-component of applied orbit correction based on the long term correction data received in MT24 or MT25
DeltaY	f4	1 m		Y-component of applied orbit correction based on the long term correction data received in MT24 or MT25
DeltaZ	f4	1 m		Z-component of applied orbit correction based on the long term correction data received in MT24 or MT25
DeltaClock	f4	1 s		Satellite clock correction based on the long term correction data received in MT24 or MT25
CorrAgeLT	f4	1 s		Age of applied long term correction
IonoPPlat	f4	1 rad	$-2\cdot10^{10}$	Latitude of ionospheric pierce point

IonoPPlon	f4	1 rad	$-2\cdot10^{10}$	Longitude of ionospheric pierce point
SlantIono	f4	1 m	$-2\cdot10^{10}$	Slant ionospheric delay at the L1 carrier at the ionosphere pierce point based on the data received in MT18 and MT26
CorrAgeIono	f4	1 s	$-2\cdot10^{10}$	Maximum of the ionospheric correction age at each of the grid locations used for the interpolation of the ionospheric delay.
VarFLT	f4	1 m^2	$-2\cdot10^{10}$	Variance of fast and long-term corrections (used for XPL computation)
VarUIRE	f4	1 m^2	$-2\cdot10^{10}$	Variance of ionospheric delay corrections (used for XPL computation)
VarAir	f4	1 m^2	$-2\cdot10^{10}$	Variance of unmodeled receiver errors, such as tracking noise and multipath (used for XPL computation)
VarTropo	f4	1 m^2	$-2\cdot10^{10}$	Variance of tropospheric delay corrections (used for XPL computation)
Padding	u1[..]			Padding bytes, see 2.5

BaseVectorCart	Number: 4043 "OnChange" interval: 10 ms

The BaseVectorCart block contains the relative position and orientation of one or more base stations, as seen from the rover (i.e. this receiver). The relative position is expressed in the Cartesian X, Y, Z directions.

For highest accuracy, the receiver tries to compute the baseline from rover antenna reference point (ARP) to base ARP. This requires to compensate for the phase center variation at both the base and the rover antennas. This is possible if two conditions are met:

- the base station must transmit its antenna parameters in RTCM2 message types 23 and 24 or in RTCM3 message types 1005/1006 and 1007/1008. Older RTCM2 messages and CMR do not allow phase center variation compensation.
- the base and rover antenna types must belong to the list returned by the command **lstAntennaInfo, overview**. (see the description of the commands **setAntennaOffset** and **lstAntennaInfo** for details).

Accurate ARP-to-ARP baseline is guaranteed only if both bits 0 and 1 of the Misc field are set. Otherwise, centimeter-level offsets may arise because the receiver cannot make the distinction between phase center and ARP positions. See the Firmware User Manual for a discussion on the phase center and ARP positions.

The block supports multi-base operation. It contains as many sub-blocks as available base stations, each sub-block containing the baseline relative to a single base station identified by the ReferenceID field.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of baselines for which relative position, velocity and direction are provided in this SBF block, i.e. number of VectorInfoCart sub-blocks. If N is 0, there are no baseline available for this epoch.
SBLength	u1	1 byte		Length of one sub-block
VectorInfoCart	...	...		*A succession of N VectorInfoCart sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

`VectorInfoCart` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`nrSV`	u1			Number of satellites for which corrections are available from the base station identified by the `ReferenceID` field.
`Error`	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
`Mode`	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the `Error` field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **`setPVTMode,base,auto`** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
`Misc`	u1			Bit field containing miscellaneous flags: Bit 0: Set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown. Bit 1: Set if the phase center variation is compensated for at the rover (i.e. the baseline starts from the antenna ARP), unset if not or unknown. Bit 2: Proprietary. Bits 3-7: Reserved
`DeltaX`	f8	1 m	$-2\cdot10^{10}$	X baseline component (from rover to base)
`DeltaY`	f8	1 m	$-2\cdot10^{10}$	Y baseline component (from rover to base)
`DeltaZ`	f8	1 m	$-2\cdot10^{10}$	Z baseline component (from rover to base)

DeltaVx	f4	1 m / s	$-2 \cdot 10^{10}$	X velocity of base with respect to rover
DeltaVy	f4	1 m / s	$-2 \cdot 10^{10}$	Y velocity of base with respect to rover
DeltaVz	f4	1 m / s	$-2 \cdot 10^{10}$	Z velocity of base with respect to rover
Azimuth	u2	0.01 degrees	65535	Azimuth of the base station (from 0 to 360°, increasing towards east)
Elevation	i2	0.01 degrees	−32768	Elevation of the base station (from -90° to 90°)
ReferenceID	u2			Base station ID
CorrAge	u2	0.01 s	65535	Age of the oldest differential correction used for this baseline computation.
SignalInfo	u4		0	Bit field indicating the GNSS signals for which differential corrections are available from the base station identified by ReferenceID. If bit i is set, corrections for the signal type having index i are available. The signal numbers are listed in section 2.10. Bit 0 (GPS-C/A) is the LSB of SignalInfo.
Padding	u1[..]			Padding bytes, see 2.5

BaseVectorGeod	Number: 4028 "OnChange" interval: 10 ms

The BaseVectorGeod block contains the relative position and orientation of one or more base stations, as seen from the rover (i.e. this receiver). The relative position is expressed in the East-North-Up directions.

For highest accuracy, the receiver tries to compute the baseline from rover antenna reference point (ARP) to base ARP. See the description of the BaseVectorCart block for details.

Accurate ARP-to-ARP baseline is guaranteed only if both bits 0 and 1 of the Misc field are set. Otherwise, centimeter-level offsets may arise because the receiver cannot make the distinction between phase center and ARP positions. See the Firmware User Manual for a discussion on the phase center and ARP positions.

The block supports multi-base operation. It contains as many sub-blocks as available base stations, each sub-block containing the baseline coordinates relative to a single base station identified by the ReferenceID field.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of baselines for which relative position, velocity and direction are provided in this SBF block, i.e. number of VectorInfoGeod sub-blocks. If N is 0, there are no baseline available for this epoch.
SBLength	u1	1 byte		Length of one sub-block
VectorInfoGeod	...	...		*A succession of N VectorInfoGeod sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

`VectorInfoGeod` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`NrSV`	u1			Number of satellites for which corrections are available from the base station identified by the `ReferenceID` field.
`Error`	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
`Mode`	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the `Error` field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **`setPVTMode,base,auto`** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
`Misc`	u1			Bit field containing miscellaneous flags: Bit 0: Set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown. Bit 1: Set if the phase center variation is compensated for at the rover (i.e. the baseline starts from the antenna ARP), unset if not or unknown. Bit 2: Proprietary. Bits 3-7: Reserved
`DeltaEast`	f8	1 m	$-2\cdot10^{10}$	East baseline component (from rover to base)
`DeltaNorth`	f8	1 m	$-2\cdot10^{10}$	North baseline component (from rover to base)
`DeltaUp`	f8	1 m	$-2\cdot10^{10}$	Up baseline component (from rover to base)

DeltaVe	f4	1 m / s	$-2 \cdot 10^{10}$	East velocity of base with respect to rover
DeltaVn	f4	1 m / s	$-2 \cdot 10^{10}$	North velocity of base with respect to rover
DeltaVu	f4	1 m / s	$-2 \cdot 10^{10}$	Up velocity of base with respect to rover
Azimuth	u2	0.01 degrees	65535	Azimuth of the base station (from 0 to 360°, increasing towards east)
Elevation	i2	0.01 degrees	−32768	Elevation of the base station (from -90° to 90°)
ReferenceID	u2			Base station ID
CorrAge	u2	0.01 s	65535	Age of the oldest differential correction used for this baseline computation.
SignalInfo	u4		0	Bit field indicating the GNSS signals for which differential corrections are available from the base station identified by ReferenceID. If bit i is set, corrections for the signal type having index i are available. The signal numbers are listed in section 2.10. Bit 0 (GPS-C/A) is the LSB of SignalInfo.
Padding	u1[..]			Padding bytes, see 2.5

PVTSupport	Number: 4076 "OnChange" interval: 10 ms

This block is undocumented. It is for maintenance purpose only.

EndOfPVT	Number: 5921 "OnChange" interval: 10 ms

This block marks the end of transmission of all PVT related blocks belonging to the same epoch.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Padding	u1[..]			Padding bytes, see 2.5

3.8 GNSS Attitude Blocks

AttEuler	Number: 5938 "OnChange" interval: 10 ms

The AttEuler block contains the Euler angles (pitch, roll and heading) at the time specified in the TOW and WNc fields (in the receiver time frame).

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
NrSV	u1		255	The average over all antennas of the number of satellites currently included in the attitude calculations.
Error	u1			Bit field providing error information. For each antenna baseline, two bits are used to provide error information: Bits 0-1: Error code for Main-Aux1 baseline Bits 2-3: Error code for Main-Aux2 baseline Bits 4-6: Reserved Bit 7: Set when attitude not requested by user (see command **setGNSSAttitude**). In that case, the other bits are all zero. The error codes per antenna are: 00b: no error 01b: not enough measurements 10b: antennas are aligned 11b: Inconsistency with manual antenna position information
Mode	u2			Attitude mode code: 0: No attitude 1: Heading, pitch (roll = 0), aux antenna positions obtained with float ambiguities 2: Heading, pitch (roll = 0), aux antenna positions obtained with fixed ambiguities 3: Heading, pitch, roll, aux antenna positions obtained with float ambiguities 4: Heading, pitch, roll, aux antenna positions obtained with fixed ambiguities
Reserved	u2			Reserved for future use, to be ignored by decoding software
Heading	f4	1 degree	$-2\cdot10^{10}$	Heading
Pitch	f4	1 degree	$-2\cdot10^{10}$	Pitch
Roll	f4	1 degree	$-2\cdot10^{10}$	Roll
PitchDot	f4	1 degree / s	$-2\cdot10^{10}$	Rate of change of the pitch angle
RollDot	f4	1 degree / s	$-2\cdot10^{10}$	Rate of change of the roll angle
HeadingDot	f4	1 degree / s	$-2\cdot10^{10}$	Rate of change of the heading angle
Padding	u1[..]			Padding bytes, see 2.5

AttCovEuler	Number: 5939 "OnChange" interval: 10 ms

This block contains the elements of the symmetric variance-covariance matrix of the attitude angles reported in the AttEuler block

$$\begin{pmatrix} \sigma_{\phi}^2 & \sigma_{\phi\theta} & \sigma_{\phi\psi} \\ \sigma_{\theta\phi} & \sigma_{\theta}^2 & \sigma_{\theta\psi} \\ \sigma_{\psi\phi} & \sigma_{\psi\theta} & \sigma_{\psi}^2 \end{pmatrix}$$

This variance-covariance matrix contains an indication of the accuracy of the estimated parameters (see diagonal elements) and the correlation between these estimates (see off-diagonal elements).

In case the receiver is in heading and pitch mode only, only the heading and pitch variance values will be valid. All other components of the variance-covariance matrix are set to their Do-Not-Use value.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Reserved	u1			Reserved for future use, to be ignored by decoding software
Error	u1			Bit field providing error information. For each antenna baseline, two bits are used to provide error information: Bits 0-1: Error code for Main-Aux1 baseline Bits 2-3: Error code for Main-Aux2 baseline Bits 4-6: Reserved Bit 7: Set when attitude not requested by user (see command **setGNSSAttitude**). In that case, the other bits are all zero. The error codes per antenna are: 00b: no error 01b: not enough measurements 10b: antennas are aligned 11b: Inconsistency with manual antenna position information
Cov_HeadHead	f4	1 degree^2	$-2\cdot10^{10}$	Variance of the heading estimate
Cov_PitchPitch	f4	1 degree^2	$-2\cdot10^{10}$	Variance of the pitch estimate
Cov_RollRoll	f4	1 degree^2	$-2\cdot10^{10}$	Variance of the roll estimate
Cov_HeadPitch	f4	1 degree^2	$-2\cdot10^{10}$	Covariance between Euler angle estimates. Future functionality. The values are currently set to their Do-Not-Use values.
Cov_HeadRoll	f4	1 degree^2	$-2\cdot10^{10}$	Covariance between Euler angle estimates. Future functionality. The values are currently set to their Do-Not-Use values.
Cov_PitchRoll	f4	1 degree^2	$-2\cdot10^{10}$	Covariance between Euler angle estimates. Future functionality. The values are currently set to their Do-Not-Use values.

Padding	u1[..]			Padding bytes, see 2.5

AuxAntPositions	Number: 5942 "OnChange" interval: 10 ms

The AuxAntPositions block contains the relative position and velocity of the different antennas in a multi-antenna receiver. The coordinates are expressed in the local-level ENU reference frame.

When the antenna positions cannot be estimated, the baseline vectors are set to their Do-Not-Use value.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of AuxAntPositionSub sub-blocks in this AuxAntPositions block
SBLength	u1	1 byte		Length of one sub-block in bytes
AuxAntPosition	...	...		*A succession of N AuxAntPositionSub sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

AuxAntPositionSub sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
NrSV	u1		255	Total number of satellites tracked by the antenna identified by the AuxAntID field and used in the attitude computation.
Error	u1			Aux antenna position error code. The same codes are used as for the attitude computation. See corresponding field in the AttEuler SBF block. If error is not 0, the coordinates reported later in this block are all set to their Do-Not-Use value.
AmbiguityType	u1			Aux antenna positions obtained with 0: fixed ambiguities 1: float ambiguities
AuxAntID	u1			Auxiliary antenna ID: 1 for the first auxiliary antenna, 2 for the second, etc...
DeltaEast	f8	1 m	$-2\cdot10^{10}$	Position in East direction (relative to main antenna)
DeltaNorth	f8	1 m	$-2\cdot10^{10}$	Position in North direction (relative to main antenna)
DeltaUp	f8	1 m	$-2\cdot10^{10}$	Position in Up direction (relative to main antenna)
EastVel	f8	1 m / s	$-2\cdot10^{10}$	Velocity in East direction (relative to main antenna)
NorthVel	f8	1 m / s	$-2\cdot10^{10}$	Velocity in North direction (relative to main antenna)
UpVel	f8	1 m / s	$-2\cdot10^{10}$	Velocity in Up direction (relative to main antenna)
Padding	u1[..]			Padding bytes, see 2.5

EndOfAtt	Number: 5943 "OnChange" interval: 10 ms

This block marks the end of transmission of all GNSS-attitude related blocks belonging to the same epoch.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Padding	u1[..]			Padding bytes, see 2.5

3.9 Receiver Time Blocks

ReceiverTime	Number: 5914 "OnChange" interval: 1s

The ReceiverTime block provides the current time with a 1-second resolution in the receiver time scale and UTC.

The level of synchronization of the receiver time with the satellite system time is provided in the SyncLevel field.

UTC time is provided if GPS-to-UTC or GST-to-UTC correction parameters have been received from the GPS or the Galileo satellites. If the UTC time is not available, the corresponding fields are set to their Do-Not-Use value.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
UTCYear	i1	1 year	−128	Current year in the UTC time scale (2 digits). From 0 to 99, or -128 if not available
UTCMonth	i1	1 month	−128	Current month in the UTC time scale. From 1 to 12, or -128 if not available
UTCDay	i1	1 day	−128	Current day in the UTC time scale. From 1 to 31, or -128 if not available
UTCHour	i1	1 hour	−128	Current hour in the UTC time scale. From 0 to 23, or -128 if not available
UTCMin	i1	1 minute	−128	Current minute in the UTC time scale. From 0 to 59, or -128 if not available
UTCSec	i1	1 s	−128	Current second in the UTC time scale. From 0 to 59, or -128 if not available
DeltaLS	i1	1 s	−128	Integer second difference between UTC time and GPS or Galileo system time. Positive if GPS/GST time is ahead of UTC. Set to -128 if not available.
SyncLevel	u1			Bit field indicating the synchronization level of the receiver time. If bits 0 to 2 are set, full synchronization is achieved: Bit 0: WNSET: if this bit is set, the receiver week number is synchronized with GST/GPS time. Bit 1: TOWSET: if this bit is set, the receiver time-of-week is synchronized with GST/GPS time to within 20ms. Bit 2: FINETIME: if this bit is set, the receiver time-of-week is within the limit specified by the **setClockSyncThreshold** command. Bits 3-7: Reserved
Padding	u1[..]			Padding bytes, see 2.5

xPPSOffset	Number: 5911 "OnChange" interval: PPS rate

The xPPSOffset block contains the offset between the true xPPS pulse and the actual pulse output by the receiver. It is output right after each xPPS pulse.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
SyncAge	u1	1 s		Age of the last synchronization to system time. The xPPS pulse is regularly resynchronized with system time. This field indicates the number of seconds elapsed since the last resynchronization. SyncAge is constrained to the 0-255s range. If the age is higher than 255s, SyncAge is set to 255. If the PPS is synchronized with the internal receiver time (Timescale = 3), SyncAge is always set to 0.
TimeScale	u1			Time reference to which the xPPS pulse is referenced. The following values are defined (see also the **setPPSParameters** command): 1: GNSS system time specified by the **setTimingSystem** command 2: UTC 3: receiver time 4: GLONASS time
Offset	f4	$1 \cdot 10^{-9}$ s		Offset of the xPPS output by the receiver with respect to its true position. Offset is negative when the xPPS pulse is in advance with respect to its true position. See the Firmware User Manual for an explanation of the xPPS generation principle, and for a description of the xPPS offset.
Padding	u1[..]			Padding bytes, see 2.5

3.10 External Event Blocks

These blocks report the state of the receiver applicable at the instant of a level transition on one of its “Event” pins. The receiver time is reported in the `ExtEvent` SBF block, and the receiver position is reported in the `ExtEventPVTCartesian` and the `ExtEventPVTGeodetic` blocks.

If enabled, upon detection of an event, these three blocks are output in the following order, with no other SBF blocks in between them:

1. `ExtEvent`;
2. `ExtEventPVTCartesian`;
3. `ExtEventPVTGeodetic`.

All blocks referring to the same event contain the same time stamp in the `TOW` and `WNc` fields.

ExtEvent	Number: 5924 "OnChange" interval: each time an event is detected

The ExtEvent block contains the time tag of a voltage transition on one of the "Event" input pins.

This block is only output after the first position fix is available.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	External time stamp, see 2.3
WNc	u2	1 week	65535	
Source	u1			Input pin where this external event has been detected. The following values are defined: 1: EventA 2: EventB
Polarity	u1			0: rising edge event 1: falling edge event
Offset	f4	1 s		Sub-millisecond part of the external event time. The time of week of the external event is given by: $t_{ext,rx}$ [s] = TOW/1000 + Offset $t_{ext,rx}$ refers to the receiver system time scale. Use the RxClkBias field to convert this time to the satellite time scale.
RxClkBias	f8	1 s	$-2 \cdot 10^{10}$	Receiver clock bias at the time of event. The clock bias is relative to the system time specified by the **setTimingSystem** command. To get the time of week of the external event in that system time scale, use: $t_{ext,sat}$ [s] = TOW/1000 + Offset - RxClkBias + *RFDelay*, where *RFDelay* is the RF signal group delay in the antenna and the antenna cable. This term depends on the receiver setup and needs to be measured by the user. The accuracy of the clock bias is dependent on the age of the last PVT solution. When the receiver has been unable to compute a PVT during the last 10 minutes, this field is set to its Do-Not-Use value.
PVTAge	u2	1 s		Age of the last PVT solution. If the PVT age is larger than 10 minutes (600s), this value is clipped to 600.
Padding	u1[..]			Padding bytes, see 2.5

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ExtEventPVTCartesian	Number: 4037 "OnChange" interval: each time an external event is detected

This block contains the position, velocity and time (PVT) solution applicable at the time of an external event, in a Cartesian coordinate system.

This block has the same structure and description as the PVTCartesian block, except that the TOW and WNc fields have a different meaning.

A user needing the sub-millisecond part of the event time must refer to the Offset field of the corresponding ExtEvent block. The corresponding ExtEvent block is the last of the ExtEvent blocks having been output by the receiver.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	External time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
X	f8	1 m	$-2\cdot10^{10}$	Marker X coordinate in coordinate frame specified by Datum
Y	f8	1 m	$-2\cdot10^{10}$	Marker Y coordinate in coordinate frame specified by Datum
Z	f8	1 m	$-2\cdot10^{10}$	Marker Z coordinate in coordinate frame specified by Datum
Undulation	f4	1 m	$-2\cdot10^{10}$	Geoid undulation computed from the global geoid model defined in the document 'Technical Characteristics of the NAVSTAR GPS, NATO, June 1991'
Vx	f4	1 m / s	$-2\cdot10^{10}$	Velocity in the X direction
Vy	f4	1 m / s	$-2\cdot10^{10}$	Velocity in the Y direction

Vz	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the Z direction
COG	f4	1 degree	$-2 \cdot 10^{10}$	Course over ground: this is defined as the angle of the vehicle with respect to the local level North, ranging from 0 to 360, and increasing towards east. Set to the do-not-use value when the speed is lower than 0.1m/s.
RxClkBias	f8	1 ms	$-2 \cdot 10^{10}$	Receiver clock bias relative to system time reported in the TimeSystem field. To transfer the receiver time to the system time, use: $t_{GPS/GST} = t_{rx}$ - RxClkBias
RxClkDrift	f4	1 ppm	$-2 \cdot 10^{10}$	Receiver clock drift relative to system time (relative frequency error)
TimeSystem	u1		255	Time system of which the offset is provided in this sub-block: 0: GPS time 1: Galileo time 3: GLONASS time
Datum	u1		255	This field defines in which datum the coordinates are expressed: 0: WGS84/ITRS 19: Datum equal to that used by the DGNSS/RTK base station 30: ETRS89 (ETRF2000 realization) 31: NAD83(2011), North American Datum (2011) 32: NAD83(PA11), North American Datum, Pacific plate (2011) 33: NAD83(MA11), North American Datum, Marianas plate (2011) 34: GDA94(2010), Geocentric Datum of Australia (2010)
NrSV	u1		255	Total number of satellites used in the PVT computation.
WACorrInfo	u1		0	Bit field providing information about which wide area corrections have been applied: Bit 0: set if orbit and satellite clock correction information is used Bit 1: set if range correction information is used Bit 2: set if ionospheric information is used Bit 3: set if orbit accuracy information is used (UERE/SISA) Bit 4: set if DO229 Precision Approach mode is active Bits 5-7: Reserved
ReferenceID	u2		65535	This field indicates the reference ID of the differential information used. In case of DGPS or RTK operation, this field is to be interpreted as the base station identifier. In SBAS operation, this field is to be interpreted as the PRN of the geostationary satellite used. If multiple base stations or multiple geostationary satellites are used the value is set to 65534.
MeanCorrAge	u2	0.01 s	65535	In case of DGPS or RTK, this field is the mean age of the differential corrections. In case of SBAS operation, this field is the mean age of the 'fast corrections' provided by the SBAS satellites.
SignalInfo	u4		0	Bit field indicating the type of GNSS signals having been used in the PVT computations. If a bit i is set, the signal type having index i has been used. The signal numbers are listed in section 2.10. Bit 0 (GPS-C/A) is the LSB of SignalInfo.

AlertFlag	u1		0	Bit field indicating integrity related information: Bits 0-1: RAIM integrity flag: 0: RAIM not active (integrity not monitored) 1: RAIM integrity test successful 2: RAIM integrity test failed 3: Reserved Bit 2: set if integrity has failed as per Galileo HPCA (HMI Probability Computation Algorithm) Bit 3: Reserved Bit 4: set if either the horizontal or the vertical 2DRMS accuracy is higher than the horizontal or vertical alert limits set by the **setNWALevels** command. Bits 5-7: Reserved
NrBases	u1		0	Number of base stations used in the PVT computation.
PPPInfo	u2	1 s	0	Bit field containing PPP-related information: Bits 0-11: Age of the last seed, in seconds. The age is clipped to 4091s. This field must be ignored when the seed type is 0 (see bits 13-15 below). Bit 12: Reserved Bits 13-15: Type of last seed: 0: Not seeded or not in PPP positioning mode 1: Manual seed 2: Seeded from DGPS 3: Seeded from RTKFixed
Padding	u1[..]			Padding bytes, see 2.5

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ExtEventPVTGeodetic	Number: 4038 "OnChange" interval: each time an external event is detected

This block contains the position, velocity and time (PVT) solution applicable at the time of an external event, in an ellipsoidal coordinate system.

This block has the same structure and description as the PVTGeodetic block, except that the TOW and WNc fields have a different meaning.

A user needing the sub-millisecond part of the event time must refer to the Offset field of the corresponding ExtEvent block. The corresponding ExtEvent block is the last of the ExtEvent blocks having been output by the receiver.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	External time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No PVT available (the Error field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) Bits 4-5: Reserved Bit 6: Set if the user has entered the command **setPVTMode,base,auto** and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions Note: if this field has a non-zero value, all following fields are set to their Do-Not-Use value.
Latitude	f8	1 rad	$-2\cdot10^{10}$	Marker latitude, from $-\pi/2$ to $+\pi/2$, positive North of Equator
Longitude	f8	1 rad	$-2\cdot10^{10}$	Marker longitude, from $-\pi$ to $+\pi$, positive East of Greenwich
Height	f8	1 m	$-2\cdot10^{10}$	Marker ellipsoidal height (with respect to the ellipsoid specified by Datum)
Undulation	f4	1 m	$-2\cdot10^{10}$	Geoid undulation computed from the global geoid model defined in the document 'Technical Characteristics of the NAVSTAR GPS, NATO, June 1991'
Vn	f4	1 m / s	$-2\cdot10^{10}$	Velocity in the North direction
Ve	f4	1 m / s	$-2\cdot10^{10}$	Velocity in the East direction

Vu	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the 'Up' direction
COG	f4	1 degree	$-2 \cdot 10^{10}$	Course over ground: this is defined as the angle of the vehicle with respect to the local level North, ranging from 0 to 360, and increasing towards east. Set to the do-not-use value when the speed is lower than 0.1m/s.
RxClkBias	f8	1 ms	$-2 \cdot 10^{10}$	Receiver clock bias relative to system time reported in the TimeSystem field. To transfer the receiver time to the system time, use: $t_{GPS/GST} = t_{rx}$ - RxClkBias
RxClkDrift	f4	1 ppm	$-2 \cdot 10^{10}$	Receiver clock drift relative to system time (relative frequency error)
TimeSystem	u1		255	Time system of which the offset is provided in this sub-block: 0: GPS time 1: Galileo time 3: GLONASS time
Datum	u1		255	This field defines in which datum the coordinates are expressed: 0: WGS84/ITRS 19: Datum equal to that used by the DGNSS/RTK base station 30: ETRS89 (ETRF2000 realization) 31: NAD83(2011), North American Datum (2011) 32: NAD83(PA11), North American Datum, Pacific plate (2011) 33: NAD83(MA11), North American Datum, Marianas plate (2011) 34: GDA94(2010), Geocentric Datum of Australia (2010)
NrSV	u1		255	Total number of satellites used in the PVT computation.
WACorrInfo	u1		0	Bit field providing information about which wide area corrections have been applied: Bit 0: set if orbit and satellite clock correction information is used Bit 1: set if range correction information is used Bit 2: set if ionospheric information is used Bit 3: set if orbit accuracy information is used (UERE/SISA) Bit 4: set if DO229 Precision Approach mode is active Bits 5-7: Reserved
ReferenceID	u2		65535	This field indicates the reference ID of the differential information used. In case of DGPS or RTK operation, this field is to be interpreted as the base station identifier. In SBAS operation, this field is to be interpreted as the PRN of the geostationary satellite used. If multiple base stations or multiple geostationary satellites are used the value is set to 65534.
MeanCorrAge	u2	0.01 s	65535	In case of DGPS or RTK, this field is the mean age of the differential corrections. In case of SBAS operation, this field is the mean age of the 'fast corrections' provided by the SBAS satellites.
SignalInfo	u4		0	Bit field indicating the type of GNSS signals having been used in the PVT computations. If a bit i is set, the signal type having index i has been used. The signal numbers are listed in section 2.10. Bit 0 (GPS-C/A) is the LSB of SignalInfo.

AlertFlag	u1		0	Bit field indicating integrity related information: Bits 0-1: RAIM integrity flag: 0: RAIM not active (integrity not monitored) 1: RAIM integrity test successful 2: RAIM integrity test failed 3: Reserved Bit 2: set if integrity has failed as per Galileo HPCA (HMI Probability Computation Algorithm) Bit 3: Reserved Bit 4: set if either the horizontal or the vertical 2DRMS accuracy is higher than the horizontal or vertical alert limits set by the **setNWALevels** command. Bits 5-7: Reserved
NrBases	u1		0	Number of base stations used in the PVT computation.
PPPInfo	u2	1 s	0	Bit field containing PPP-related information: Bits 0-11: Age of the last seed, in seconds. The age is clipped to 4091s. This field must be ignored when the seed type is 0 (see bits 13-15 below). Bit 12: Reserved Bits 13-15: Type of last seed: 0: Not seeded or not in PPP positioning mode 1: Manual seed 2: Seeded from DGPS 3: Seeded from RTKFixed
Padding	u1[..]			Padding bytes, see 2.5

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3.11 Differential Correction Blocks

DiffCorrIn	Number: 5919 "OnChange" interval: each time a RTCM or CMR message is received

The DiffCorrIn block contains incoming RTCM or CMR messages. The length of the block depends on the message type and contents.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Mode	u1			0: RTCMv2 1: CMRv2 2: RTCMv3 3: RTCMV (a proprietary variant of RTCM2)
Source	u1			Indicates the receiver connection from which the message has been received: 0: COM1 1: COM2 2: COM3 3: COM4 4: USB1 5: USB2 6: IP connection 7: SBF file 8: L-Band (message decoded by the built-in L-band demodulator) 9: NTRIP 12: Bluetooth 15: UHF modem 16: IPR connection
If the Mode field is 0 then this field is available:				
RTCM2Words	u4[*N*]			30-bit words of the RTCM2 message. The Data Word Length (number of 32 bit words) is variable and depends on the RTCM2 message contents. It can be computed by the following piece of C code: `N = 2 + ((RTCM2Words[1]»9) & 0x1f);` N can range from 2 to 33. The first two words are the RTCM2 message header and they are always present. Each of the words is organized as follows: Bits 0-5: 6 parity bits. They are provided for the sake of completeness. Parity doesn't need to be checked, since the DiffCorrIn block only contains valid words. Bits 6-29: 24 information-containing bits of the word. The first received bit is the MSB. Bits 30-31: bit 0 and 1 of the preceding word

If the `Mode` field is 1 then this field is available:				
`CMRMessage`	u1[*N*]			*N* depends on the CMR message type.
If the `Mode` field is 2 then this field is available:				
`RTCM3Message`	u1[*N*]			*N* depends on the RTCM 3 message type.
If the `Mode` field is 3 then this field is available:				
`RTCMVMessage`	u1[*N*]			*N* depends on the RTCMV message type.
`Padding`	u1[..]			Padding bytes, see 2.5

BaseStation	Number:	5949
	"OnChange" interval:	block generated each time a differential correction message related to the base station coordinates is received

The BaseStation block contains the ECEF coordinates of the base station the receiver is currently connected to. This block helps users accessing the base station coordinates via SBF instead of having to decode the specific differential correction message (see the DiffCorrIn SBF block above).

The interpretation to give to the X, Y, Z ECEF coordinates is dependent on the value of the Source field:

Value of Source	Interpretation of X, Y, Z
0, 4 or 10	Coordinate of the L1 phase center
2 or 8	Antenna reference point
9	Proprietary

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
BaseStationID	u2			The base station ID
BaseType	u1			Base station type: 0: Fixed 1: Moving (reserved for future use) 255: Unknown
Source	u1			Source of the base station coordinates: 0: RTCM 2.x (Msg 3) 2: RTCM 2.x (Msg 24) 4: CMR 2.x (Msg 1) 8: RTCM 3.x (Msg 1005 or 1006) 9: RTCMV (Msg 3) 10: CMR+ (Type 2)
Datum	u1		255	This field defines in which datum the coordinates are expressed: 0: WGS84/ITRS 19: Datum equal to that used by the DGNSS/RTK base station 30: ETRS89 (ETRF2000 realization) 31: NAD83(2011), North American Datum (2011) 32: NAD83(PA11), North American Datum, Pacific plate (2011) 33: NAD83(MA11), North American Datum, Marianas plate (2011) 34: GDA94(2010), Geocentric Datum of Australia (2010)
Reserved	u1			Reserved for future use, to be ignored by decoding software
X	f8	1 m		Antenna X coordinate expressed in the datum specified by the Datum field

Y	f8	1 m		Antenna Y coordinate
Z	f8	1 m		Antenna Z coordinate
Padding	u1[..]			Padding bytes, see 2.5

RTCMDatum	Number:	4049
	"OnChange" interval:	block generated each time a set of transformation parameters is received

This block reports the source and target datum names as transmitted in RTCM 3.x message types 1021 or 1022. It also reports the corresponding height and quality indicators.

This block is transmitted immediately after reception of MT1021 or MT1022 if the "Utilized Transformation Message Indicator" says that MT1023 is not used. Otherwise this block is transmitted after reception of MT1023, and the QualityInd field is set according to MT1023.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
SourceCRS	c1[32]			Name of the source Coordinate Reference System, right-padded with zeros.
TargetCRS	c1[32]			Name of the target Coordinate Reference System, right-padded with zeros.
Datum	u1			See the Datum field in the PosLocal SBF block. Datum is set to 255 if this SourceCRS/TargetCRS pair is currently not used by the receiver.
HeightType	u1			Height Indicator field from MT1021 and MT1022. This field indicates how to interpret the marker height reported in the PosLocal SBF block: 0: Geometrical height 1: Physical height (height definition in target CRS) 2: Physical height (height definition in source CRS)
QualityInd	u1			Bit field indicating the maximum approximation error after applying the transformation: Bits 0-3: horizontal quality indicator: 0: Unknown quality 1: Quality better than 21 mm (from MT1021/1022) 2: Quality 21 to 50 mm (from MT1021/1022) 3: Quality 51 to 200 mm (from MT1021/1022) 4: Quality 201 to 500 mm (from MT1021/1022) 5: Quality 501 to 2000 mm (from MT1021/1022) 6: Quality 2001 to 5000 mm (from MT1021/1022) 7: Quality worse than 5001 mm (from MT1021/1022) 9: Quality 0 to 10 mm (from MT1023) 10: Quality 11 to 20 mm (from MT1023) 11: Quality 21 to 50 mm (from MT1023) 12: Quality 51 to 100 mm (from MT1023) 13: Quality 101 to 200 mm (from MT1023) 14: Quality 201 to 500 mm (from MT1023) 15: Quality worse than 501 mm (from MT1023) Bits 4-7: vertical quality indicator, same definition as bits 0-3.

Padding	u1[..]			Padding bytes, see 2.5

3.12 Status Blocks

ChannelStatus	Number: 4013 "OnChange" interval: 10 ms

This block describes the current satellite allocation and tracking status of the active receiver channels. Active channels are channels to which a satellite has been allocated.

This block uses a two-level sub-block structure analogous to that of the MeasEpoch block. For each active channel, a ChannelSatInfo sub-block contains all satellite-dependent information such as health, azimuth and elevation. Each of these sub-blocks contains N2 ChannelStateInfo sub-blocks, N2 being the number of active antennas in a given channel (for single-antenna receivers, N2 is one). The ChannelStateInfo reports information such as the tracking status and PVT usage of a given signal type tracked on a given antenna.

Inactive channels are not contained in the ChannelStatus block.

Health, tracking and PVT status fields are available for each satellite. These status fields consist of a sequence of up to 8 two-bit fields. Each 2-bit field contains the status of one of the signals transmitted by the satellite. The position of the 2 bits corresponding to a given signal is dependent on the constellation, but is otherwise fixed. It is indicated in the tables below.

GPS:

Reserved		Reserved		Reserved		L5		L2C		P2(Y)		P1(Y)		L1CA	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

GLONASS:

Reserved		Reserved		Reserved		L3		L2CA		L2P		Reserved		L1CA	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Galileo:

Reserved		E5-AltBOC		E5b		E5a		E6BC		E6A		L1BC		L1A	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

SBAS:

Reserved		Reserved		Reserved		Reserved		Reserved		Reserved		L5		L1	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

COMPASS/BEIDOU:

Reserved		Reserved		Reserved		Reserved		Reserved		B3		B2		B1	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

QZSS:

Reserved		Reserved		Reserved		Reserved		Reserved		L5		L2C		L1CA	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of channels for which status are provided in this SBF block, i.e. number of ChannelSatInfo sub-blocks. If N is 0, there are no active channels available for this epoch.
SB1Length	u1	1 byte		Length of a ChannelSatInfo sub-block, excluding the nested ChannelStateInfo sub-blocks
SB2Length	u1	1 byte		Length of a ChannelStateInfo sub-block
Reserved	u1[3]			Reserved for future use, to be ignored by decoding software
SatInfo	...	...		*A succession of N ChannelSatInfo sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

ChannelSatInfo sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
SVID	u1			Satellite ID, see 2.9
FreqNr	u1		0	For GLONASS satellites, this is the frequency number, with an offset of 8. It ranges from 1 (corresponding to an actual frequency number of -7) to 21 (corresponding to an actual frequency number of 13). For non-GLONASS satellites, FreqNr is reserved and must be ignored by the decoding software.
Reserved1	u1[2]			Reserved for future use, to be ignored by decoding software
Azimuth/RiseSet	u2	1 degree	511 3	bit field: Bits 0-8: Azimuth [0,359]. 0 is North, and Azimuth increases towards East. Bits 9-13: Reserved Bits 14-15: Rise/Set Indicator: 0: Satellite setting 1: Satellite rising 3: Elevation rate unknown
HealthStatus	u2			Sequence of 2-bit health status fields, each of them taking one of the following values: 0 : health unknown, or not applicable 1 : healthy 3 : unhealthy The 2-bit health status is a condensed version of the health status as sent by the satellite. For SBAS, the health status is set from the almanac data (MT17).
Elevation	i1	1 degree	−128	Elevation [-90,90] relative to local horizontal plane
N2	u1			Number of ChannelStateInfo blocks following this ChannelSatInfo block. There is one ChannelStateInfo sub-block per antenna.
RxChannel	u1			Channel number, see section 2.11.

Reserved2	u1			Reserved for future use, to be ignored by decoding software
Padding	u1[..]			Padding bytes, see 2.5
StateInfo	...	...		*A succession of N2* ChannelStateInfo *sub-blocks, see definition below*

ChannelStateInfo sub-block definition:

Parameter	Type	Units & Scale Factor	Description
Antenna	u1		Antenna number (0 for main antenna)
Reserved	u1		Reserved for future use, to be ignored by decoding software
TrackingStatus	u2		Sequence of 2-bit tracking status fields, each of them taking one of the following values: 0: idle or not applicable 1: Search 2: Sync 3: Tracking
PVTStatus	u2		Sequence of 2-bit PVT status fields, each of them taking one of the following values: 0: not used 1: waiting for ephemeris 2: used 3: rejected
PVTInfo	u2		Internal info
Padding	u1[..]		Padding bytes, see 2.5

ReceiverStatus	Number: 4014 "OnChange" interval: 1s

The ReceiverStatus block provides general information on the status of the receiver.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
CPULoad	u1	1 %	255	Load on the receiver's CPU. The load should stay below 80% in normal operation. Higher loads might result in data loss.
ExtError	u1			Bit field reporting external errors, i.e. errors detected in external data. Upon detection of an error, the corresponding bit is set for a duration of one second, and then resets. Bit 0: SISERROR: set if a violation of the signal-in-space ICD has been detected for at least one satellite while that satellite is reported as healthy. Use the command "**lif,SisError**" for details. Bit 1: DIFFCORRERROR: set when an anomaly has been detected in an incoming differential correction stream, causing the receiver to fail to decode the corrections. Use the command "**lif,DiffCorrError**" for details. Bit 2: EXTSENSORERROR: set when a malfunction has been detected on at least one of the external sensors connected to the receiver. Use the command "**lif, ExtSensorError**" for details. Bit 3: SETUPERROR: set when a configuration/setup error has been detected. An example of such error is when a remote NTRIP Caster is not reachable. Use the command "**lif, SetupError**" for details. Bits 4-7: Reserved
UpTime	u4	1 s		Number of seconds elapsed since the start-up of the receiver, or since the last reset.

RxState	u4			Bit field indicating the status of key components of the receiver: Bit 0: Reserved Bit 1: Reserved Bit 2: EXT_REF: this bit is set if an external frequency reference is detected at the 10 MHz input, and cleared if the receiver uses its own internal clock. Bit 3: PPS_IN: this bit is set if a pulse has been detected on the 1PPS input connector and the receiver time has been synchronized with this pulse. Bit 4: WNSET: see corresponding bit in the SyncLevel field of the ReceiverTime block. Bit 5: TOWSET: see corresponding bit in the SyncLevel field of the ReceiverTime block. Bit 6: FINETIME: see corresponding bit in the SyncLevel field of the ReceiverTime block. Bit 7: DISK_ACTIVITY: this bit is set for one second each time data is logged to the internal disk (DSK1). If the logging rate is larger than 1 Hz, set continuously. Bit 8: DISK_FULL: this bit is set when the internal disk (DSK1) is full. A disk is full when it is filled to 95% of its total capacity. Bit 9: DISK_MOUNTED: this bit is set when the internal disk (DSK1) is mounted. Bit 10: INT_ANT: this bit is set when the RF signal is taken from the internal antenna input, and cleared when it comes from the external antenna input (only applicable on receiver models featuring an internal antenna input). Bit 11: REFOUT_LOCKED: if set, the 10-MHz frequency provided at the REF OUT connector is locked to GNSS time. Otherwise it is free-running. Bits 12-31: Reserved

	RxError	u4			Bit field indicating whether an error occurred previously. If this field is not equal to zero, at least one error has been detected. Bit 0: Reserved Bit 1: Reserved Bit 2: Reserved Bit 3: SOFTWARE: set upon detection of a software warning or error. This bit is reset by the command "**lif, error**". Bit 4: WATCHDOG: set when the watchdog expired at least once since the last power-on. Bit 5: Reserved Bit 6: CONGESTION: set when an output data congestion has been detected on at least one of the communication ports of the receiver during the last second. Bit 7: Reserved Bit 8: MISSEDEVENT: set when an external event congestion has been detected during the last second. It indicates that the receiver is receiving too many events on its EVENTx pins. Bit 9: CPUOVERLOAD: set when the CPU load is larger than 90%. If this bit is set, receiver operation may be unreliable and the user must decrease the processing load by following the recommendations in the Firmware User Manual. Bit 10: INVALIDCONFIG: set if one or more configuration file (e.g. permissions) is invalid or absent. Bit 11: OUTOFGEOFENCE: set if the receiver is currently out of its permitted region of operation (geofencing). Bits 12-31: Reserved
Rev 1	N	u1			Number of AGCState sub-blocks this block contains.
	SBLength	u1	1 byte		Length of a AGCState sub-block.
	CmdCount	u1		0	Command cyclic counter, incremented each time a command is entered that changes the receiver configuration. After the counter has reached 255, it resets to 1.
	Reserved	u1			Reserved for future use
	AGCState	...	...		*A succession of N AGCState sub-blocks, see definition below*
	Padding	u1[..]			Padding bytes, see 2.5

`AGCState` sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`FrontEndID`	u1			Bit field indicating the frontend code and antenna ID: Bits 0-4: frontend code: 0: GPSL1/E1 1: GLOL1 2: E6 3: GPSL2 4: GLOL2 5: L5/E5a 6: E5b/B2 7: E5(a+b) 8: Combined GPS/GLONASS/SBAS/Galileo L1 9: Combined GPS/GLONASS L2 10: MSS/L-band 11: B1 12: B3 Bits 5-7: antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
`Gain`	i1	1 dB	-128	AGC gain, in dB. The Do-Not-Use value is used to indicate that the frontend PLL is not locked.
`SampleVar`	u1		0	Normalized variance of the IF samples. The nominal value for this variance is 100.
`BlankingStat`	u1	1 %		Current percentage of samples being blanked by the pulse blanking unit. This field is always 0 for receiver without pulse blanking unit.
`Padding`	u1[..]			Padding bytes, see 2.5

SatVisibility	Number: 4012 "OnChange" interval: 1s

This block contains the azimuth and elevation of all the satellites above the horizon for which the ephemeris or almanac is available.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of satellites for which information is provided in this SBF block, i.e. number of SatInfo sub-blocks.
SBLength	u1	1 byte		Length of one SatInfo sub-block
SatInfo	...	...		*A succession of N SatInfo sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

SatInfo sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
SVID	u1			Satellite ID, see 2.9
FreqNr	u1		0	For GLONASS satellites, this is the frequency number, with an offset of 8. It ranges from 1 (corresponding to an actual frequency number of -7) to 21 (corresponding to an actual frequency number of 13). For non-GLONASS satellites, FreqNr is reserved and must be ignored by the decoding software.
Azimuth	u2	0.01 degrees	65535	Azimuth. 0 is North, and azimuth increases towards East.
Elevation	i2	0.01 degrees	−32768	Elevation relative to local horizontal plane.
RiseSet	u1			Rise/set indicator: 0: satellite setting 1: satellite rising 255: elevation rate unknown
SatelliteInfo	u1			Satellite visibility info based on: 1: almanac 2: ephemeris 255: unknown
Padding	u1[..]			Padding bytes, see 2.5

InputLink	Number: 4090 "OnChange" interval: 1s

The InputLink block reports statistics of the number of bytes and messages received and accepted on each active connection descriptor.

Per connection descriptor, the receiver maintains two byte counters (NrBytesReceived and NrBytesAccepted) and two message counters (NrMsgReceived and NrMsgAccepted), which are reported in the sub-blocks. These counters provide useful information on the quality of the transmission link, and of the bandwidth efficiency.

These counters (as well as the age of the last message) are reset simultaneously on the following events:

- start-up of the receiver
- overflow of one of the counters
- change of input type
- deactivation of a connection descriptor, e.g. on disconnection of USB or IP ports.

There is one sub-block per connection descriptor for which statistics is available.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of connection descriptors for which communication link statistics are included
SBLength	u1	1 byte		Length of one InputStatsSub sub-block.
InputStats	...	...		*A succession of N InputStatsSub sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

`InputStatsSub` sub-block definition:

<table>
<tr><th>Parameter</th><th>Type</th><th>Units & Scale Factor</th><th>Do-Not-Use Value</th><th>Description</th></tr>
<tr><td>CD</td><td>u1</td><td></td><td></td><td>Identifier of the connection to which these statistics apply:
<table>
<tr><th>Value of CD</th><th>Connection type</th><th>Example</th></tr>
<tr><td>0-31</td><td>COMx, with x=CD</td><td>1: COM1</td></tr>
<tr><td>32-63</td><td>USBx, with x=CD-32</td><td>33: USB1</td></tr>
<tr><td>64-95</td><td>IPx, with x=CD-54</td><td>64:IP10</td></tr>
<tr><td>96-127</td><td>DSKx, with x=CD-96</td><td>97:DSK1</td></tr>
<tr><td>128-159</td><td>NTRx, with x=CD-128 (NTRIP connections)</td><td>129:NTR1</td></tr>
<tr><td>160-191</td><td>IPSx, with x=CD-160 (IP server connections)</td><td>161:IPS1</td></tr>
<tr><td>192</td><td>BT01 (Bluetooth connection)</td><td></td></tr>
<tr><td>196</td><td>UHF1 (UHF Modem)</td><td></td></tr>
<tr><td>200-205</td><td>IPRx, with x=CD-200 (IP receive connections)</td><td>201:IPR1</td></tr>
<tr><td>206-255</td><td>Reserved</td><td></td></tr>
</table></td></tr>
<tr><td>Type</td><td>u1</td><td></td><td></td><td>Type of data:
0: none
1: DaisyChain (includes "echo" messages)
32: CMD
33: SBF
34: AsciiDisplay (see setDataInOut command)
64: NMEA
96: RTCMv2
97: RTCMv3
98: CMRv2
99: RTCMV (a proprietary variant of RTCMv2)
128: MTI (IMU sensor)
129: MMQ (IMU sensor)
160: ASCIIIn</td></tr>
<tr><td>AgeOfLastMessage</td><td>u2</td><td>1 s</td><td>65535</td><td>Age of the last accepted message.

If the age is older than 65534s, it is clipped to 65534s.</td></tr>
<tr><td>NrBytesReceived</td><td>u4</td><td>1 byte</td><td></td><td>Total number of bytes received (10)</td></tr>
<tr><td>NrBytesAccepted</td><td>u4</td><td>1 byte</td><td>4294967295</td><td>Total number of bytes (10) in messages that passed the check for this type of input (CRC, parity check, ...).

The ratio of NrBytesAccepted to NrBytesReceived gives an indication of the quality of the communication link.</td></tr>
<tr><td>NrMsgReceived</td><td>u4</td><td>1 message</td><td>4294967295</td><td>Total number of messages of type Type received.</td></tr>
<tr><td>NrMsgAccepted</td><td>u4</td><td>1 message</td><td>4294967295</td><td>Total number of messages of type Type that were interpreted and used by the receiver.

The ratio of NrMsgAccepted to NrMsgReceived gives an indication of the bandwidth usage efficiency</td></tr>
</table>

(10) Note that, for RTCM 2.x, one 8-bit byte contains 6 RTCM data bits.

Padding	u1[..]			Padding bytes, see 2.5

OutputLink	Number: 4091 "OnChange" interval: 1s

The OutputLink block reports statistics of the number of bytes sent on each active connection descriptor.

Per connection descriptor, the receiver maintains two byte counters NrBytesProduced and NrBytesSent, which are reported in the sub-block. They provide an indication of the amount of data output and data lost on a given connection.

These counters are reset simultaneously on the following events:

- start-up of the receiver
- overflow of one of the counters
- deactivation of a connection descriptor, e.g. on disconnection of USB or IP ports
- change of COM port settings.

There is one OutputStatsSub sub-block per connection descriptor for which statistics is available. Each OutputStatsSub sub-block contains a number of OutputTypeSub sub-blocks. These sub-blocks indicate which data type has been output through the connection in question during the last second. If no output happened during the last second, there is no OutputTypeSub sub-block.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N1	u1			Number of OutputStatsSub sub-blocks in this OutputLink block.
SB1Length	u1	1 byte		Length of an OutputStatsSub sub-block, excluding the nested OutputTypeSub sub-block
SB2Length	u1	1 byte		Length of an OutputTypeSub sub-block
Reserved	u1[3]			Reserved for future use
OutputStats	...	...		*A succession of N1 OutputStatsSub sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

`OutputStatsSub` sub-block definition:

<table>
<tr><th>Parameter</th><th>Type</th><th>Units & Scale Factor</th><th>Description</th></tr>
<tr><td>CD</td><td>u1</td><td></td><td>Identifier of the connection to which these statistics apply:
<table>
<tr><th>Value of CD</th><th>Connection type</th><th>Example</th></tr>
<tr><td>0-31</td><td>COMx, with x=CD</td><td>1: COM1</td></tr>
<tr><td>32-63</td><td>USBx, with x=CD-32</td><td>33: USB1</td></tr>
<tr><td>64-95</td><td>IPx, with x=CD-54</td><td>64:IP10</td></tr>
<tr><td>96-127</td><td>DSKx, with x=CD-96</td><td>97:DSK1</td></tr>
<tr><td>128-159</td><td>NTRx, with x=CD-128 (NTRIP connections)</td><td>129:NTR1</td></tr>
<tr><td>160-191</td><td>IPSx, with x=CD-160 (IP server connections)</td><td>161:IPS1</td></tr>
<tr><td>192</td><td>BT01 (Bluetooth connection)</td><td></td></tr>
<tr><td>196</td><td>UHF1 (UHF Modem)</td><td></td></tr>
<tr><td>200-205</td><td>IPRx, with x=CD-200 (IP receive connections)</td><td>201:IPR1</td></tr>
<tr><td>206-255</td><td>Reserved</td><td></td></tr>
</table></td></tr>
<tr><td>N2</td><td>u1</td><td></td><td>Number of <code>OutputTypeSub</code> sub-blocks included at the end of this <code>OutputStatsSub</code> sub-block</td></tr>
<tr><td>AllowedRate</td><td>u2</td><td>1 kbyte / s</td><td>Maximum datarate recommended on this connection</td></tr>
<tr><td>NrBytesProduced</td><td>u4</td><td>1 byte</td><td>Total number of bytes produced by the receiver</td></tr>
<tr><td>NrBytesSent</td><td>u4</td><td>1 byte</td><td>Total number of bytes actually sent (i.e. without congestions or transmission errors).

The ratio of <code>NrBytesSent</code> to <code>NrBytesProduced</code> gives an indication of the amount of bandwidth overload.</td></tr>
<tr><td>NrClients</td><td>u1</td><td></td><td>Number of clients currently connected to this connection. Most connection types can only serve one client at a time, but each IP server (IPS) port can serve up to eight simultaneous clients.

Note that when <code>NrClients</code> is more than one, the fields <code>NrBytesProduced</code> and <code>NrBytesSent</code> are the total number of bytes produced and sent to all client.</td></tr>
<tr><td>Reserved</td><td>u1[3]</td><td></td><td>Reserved for future use</td></tr>
<tr><td>Padding</td><td>u1[..]</td><td></td><td>Padding bytes, see 2.5</td></tr>
<tr><td>OutputType</td><td>...</td><td>...</td><td>A succession of N2 <code>OutputTypeSub</code> sub-blocks, see definition below</td></tr>
</table>

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`OutputTypeSub` sub-block definition:

Parameter	Type	Units & Scale Factor	Description
`Type`	u1		Type of data: 0: none 1: DaisyChain (includes "echo" messages) 32: CMD 33: SBF 34: AsciiDisplay (see **`setDataInOut`** command) 64: NMEA 96: RTCMv2 97: RTCMv3 98: CMRv2 99: RTCMV (a proprietary variant of RTCMv2) 128: MTI (IMU sensor) 129: MMQ (IMU sensor) 160: ASCIIIn
`Percentage`	u1	1 %	Percentage of the produced bytes that belong to this type (during the last second)
`Padding`	u1[..]		Padding bytes, see 2.5

NTRIPClientStatus	Number: 4053 "OnChange" interval: 1s

This block reports the current status of the NTRIP client connections.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of NTRIP client connections for which status is provided in this block, i.e. number of NTRIPClientConnection sub-blocks.
SBLength	u1	1 byte		Length of one NTRIPClientConnection sub-block
NTRIPClientConnection	...	...		*A succession of N NTRIPClientConnection sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

NTRIPClientConnection sub-block definition:

Parameter	Type	Units & Scale Factor	Description
CDIndex	u1		Index of the NTRIP connection (1 for NTR1, 2 for NTR2, etc) for which status is provided in this sub-block.
Status	u1		NTRIP client status: 0: Connection disabled 1: Initializing 2: Running, differential corrections are being received and the link statistics is available in the InputLink block. 3: Error detected, the error code is provided in the next field. 4: Retrying, client encountered an error, we are retrying to connect. The error code is provided in the next field.
ErrorCode	u1		NTRIP error code: 0: No error 1: Initialization error (e.g. source table retrieval failure) 2: Authentication error 3: Connection error 4: Mountpoint does not exist 5: Waiting for GGA 6: GGA sending disabled when required by mountpoint 7: Resolving host failed 254: Unknown error
Padding	u1[..]		Padding bytes, see 2.5

IPStatus	Number: 4058 "OnChange" interval: output each time one or more IP parameters change

This block contains the receiver's IP address, the gateway, the netmask and the MAC address.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
MACAddress	u1[6]			MAC address. The first byte corresponds to the MSB of the address.
IPAddress	u1[16]		All elements set to 0	IP address. For future upgradability, this field can contain a 128-bit IPv6 address. In the current firmware version, the first 12 bytes are always set to 0, and the last 4 bytes contain the IPv4 IP address, or are set to zero if the IP address is not known or not applicable.
Gateway	u1[16]		All elements set to 0	Gateway address. For future upgradability, this field can contain a 128-bit IPv6 address. In the current firmware version, the first 12 bytes are always set to 0, and the last 4 bytes contain the IPv4 IP address, or are set to zero if the gateway address is not known or not applicable.
Netmask	u1		255	Number of bits used to identify the network (CIDR notation).
Padding	u1[..]			Padding bytes, see 2.5

QualityInd	Number: 4082 "OnChange" interval: 1s

The QualityInd block contains quality indicators for the main functions of the receiver. Each quality indicator is a value from 0 to 10, 0 corresponding to poor quality and 10 to very high quality.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of quality indicators contained in this block
Reserved	u1			Reserved for future use, to be ignored by decoding software.
Indicators	u2[N]			N successive quality indicators, coded as follows: Bits 0-7: Quality indicator type: 0: Overall quality 1: GNSS signals from main antenna 2: GNSS signals from aux1 antenna 11: Main antenna cabling 12: Aux1 antenna cabling 21: CPU headroom Bits 8-11: Value of this quality indicator (from 0 for low quality to 10 for high quality) Bits 12-15: Reserved for future use, to be ignored by decoding software.
Padding	u1[..]			Padding bytes, see 2.5

DiskStatus	Number: 4059 "OnChange" interval: 1s

This block reports the size and usage of the disks mounted on the receiver.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u1			Number of DiskData sub-blocks this block contains.
SBLength	u1	1 byte		Length of one DiskData sub-blocks in bytes.
Reserved	u1[4]			Reserved for future use
DiskData	...	...		*A succession of N DiskData sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 2.5

DiskData sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
DiskID	u1			ID of the disk, starting at 1 for the internal SD Memory Card.
Status	u1			Bit field: Bit 0: DISK_MOUNTED: bit set when the disk is mounted. Bit 1: DISK_FULL: bit set when the disk is full. A disk is full when it is filled to 95% of its total capacity. Bit 2: DISK_ACTIVITY: bit set for one second each time data is written to the disk. If the logging rate is larger than 1 Hz, set continuously. Bit 3: LOGGING_ENABLED: bit set when at least one file is open on the disk, regardless of the logging rate. Bits 4-7: Reserved
DiskUsageMSB	u2		65535 (11)	16 MSB of the total disk usage. The disk usage in bytes is given by DiskUsageMSB*4294967296+DiskUsageLSB.
DiskUsageLSB	u4		4294967295 (11)	32 LSB of the total disk usage. The disk usage in bytes is given by DiskUsageMSB*4294967296+DiskUsageLSB.
DiskSize	u4	1 Mbyte	0	Total size of the disk, in megabytes.
CreateDeleteCount	u1			Counter incremented by one each time a file or a folder is created or deleted on this disk. This counter starts at zero at receiver start-up and restarts at zero after having reached 255.
Padding	u1[..]			Padding bytes, see 2.5

(11) The disk usage is invalid if both DiskUsageMSB is 65535 and DiskUsageLSB is 4294967295.

3.13 Miscellaneous Blocks

ReceiverSetup	Number:	5902
	"OnChange" interval:	Block generated each time the user invokes one of the following commands: **setAntennaOffset**, **setMarkerParameters** or **setObserverParameters**

The ReceiverSetup block contains parameters related to the receiver set-up. This block provides most of the information to be included in a RINEX header.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Reserved	u1[2]			2 bytes reserved for future use, to be ignored by decoding software
MarkerName	c1[60]			Name of the marker, this is a 60-character string, right padded with zeros.
MarkerNumber	c1[20]			Marker identification, this is a 20-character string, right padded with zeros
Observer	c1[20]			Observer description, this is a 20-character string, right padded with zeros.
Agency	c1[40]			Observer's agency description, this is a 40-character string, right padded with zeros
RxSerialNumber	c1[20]			Receiver serial number, this is a 20-character string, right padded with zeros.
RxName	c1[20]			Receiver core name, this is a 20-character string, right padded with zeros.
RxVersion	c1[20]			Receiver firmware version, this is a 20-character string, right padded with zeros.
AntSerialNbr	c1[20]			Serial number of the main antenna, this is a 20-character string, right padded with zeros.
AntType	c1[20]			Type of the main antenna, this is a 20-character string, right padded with zeros
deltaH	f4	1 m		δH offset of the main antenna
deltaE	f4	1 m		δE offset of the main antenna
deltaN	f4	1 m		δN offset of the main antenna
MarkerType	c1[20]			Marker type, this is a 20-character string, right padded with zeros
GNSSFWVersion	c1[40]			Version tag of the GNSS firmware installed on the receiver. This is a 40-character string, right padded with zeros.
ProductName	c1[40]			Product name. This is a 40-character string, right padded with zeros.
Padding	u1[..]			Padding bytes, see 2.5

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Commands	Number: 4015 "OnChange" interval: each time a user command is entered

Every time the user sends a command, a Commands block is output on all ports for which this block is enabled. The Commands SBF block is inserted in the SBF stream at the very moment when the command starts to take effect.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
Reserved	u1[2]			Reserved for future use, to be ignored by decoding software.
CmdData	u1[*N*]			Command data, this is the command in the SNMP' format (reserved for maintenance and support only).
Padding	u1[..]			Padding bytes, see 2.5

Comment	Number: 5936 "OnChange" interval: block generated each time a comment is entered with **setObserverComment**

The Comment block contains a comment string as entered with the **setObserverComment** command.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
CommentLn	u2			Length of the Comment string, in characters. The maximum length of a comment is 120 characters.
Comment	c1[CommentLn]			Comment string, as entered with the **setObserverComment** command. Note that this string is not terminated by the "\0" character.
Padding	u1[..]			Padding bytes, see 2.5

BBSamples	Number:	4040
	"OnChange" interval:	block generated each time new baseband samples are ready (typically at 2Hz)

The BBSamples block contains a series of successive complex baseband samples. These samples can be used for signal monitoring and for spectral analysis of the GNSS bands supported by the receiver.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
N	u2			Number of complex baseband samples contained in this block
Info	u1			Bit field as follows: Bits 0-2: Antenna ID: antenna from which the samples have been taken: 0 for main, 1 for *Aux1* and 2 for *Aux2*. Bits 3-7: Reserved
Reserved	u1[3]			Reserved for future use, to be ignored by decoding software.
SampleFreq	u4	1 Hz		Sampling frequency in Hz.
LOFreq	u4	1 Hz		Frequency of the local oscillator (LO) used to down-convert the RF signal to baseband.
Samples	u2[N]			N successive complex baseband samples (I+jQ), coded as follows: Bits 0-7: 8-bit Q component, two's complement. Bits 8-15: 8-bit I component, two's complement.
Padding	u1[..]			Padding bytes, see 2.5

ASCIIIn	Number: 4075 "OnChange" interval: block generated each time an ASCII string is received

The ASCIIIn block contains a string that has been received on one of the receiver's connection ports.

More specifically, this block is output each time an end-of-line character is received on a communication port configured to receive ASCIIIn input (with the **setDataInOut** command). The string reported in this block contains all characters received since the previous occurrence of an end-of-line character.

The maximum length of the string is 2000 characters. If there are more than 2000 characters between the occurrence of two successive end-of-line characters, the string is discarded

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
CD	u1			Identifier of the connection to which these statistics apply:

Value of CD	Connection type	Example
0-31	COMx, with x=CD	1: COM1
32-63	USBx, with x=CD-32	33: USB1
64-95	IPx, with x=CD-54	64:IP10
96-127	DSKx, with x=CD-96	97:DSK1
128-159	NTRx, with x=CD-128 (NTRIP connections)	129:NTR1
160-191	IPSx, with x=CD-160 (IP server connections)	161:IPS1
192	BT01 (Bluetooth connection)	
196	UHF1 (UHF Modem)	
200-205	IPRx, with x=CD-200 (IP receive connections)	201:IPR1
206-255	Reserved	

Reserved1	u1[3]			Reserved, contents to be ignored.
StringLn	u2			Length of ASCIIString in characters.
SensorModel	c1[20]			Not supported, reserved for future use.
SensorType	c1[20]			Not supported, reserved for future use.
Reserved2	u1[20]			Reserved, contents to be ignored.
ASCIIString	c1[StringLn]			ASCII string. Note that this string is not terminated by the "\0" character. The string does not include the end-of-line character(s) (carrier return and/or line feed).

Padding	u1[..]			Padding bytes, see 2.5

3.14 Deprecated or Obsolete Bocks

BaseLine	Number: 5950 "OnChange" interval: 10 ms

The BaseLine block contains the relative position of the receiver with respect to the base station in case of DGPS or RTK positioning.

This block is deprecated and should not be used in new designs. Use the BaseVectorGeod block instead.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync1	c1			Block Header, see 2.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 2.3
WNc	u2	1 week	65535	
BaseStationID	u2		65535	The base station ID
East	f8	1 m	$-2 \cdot 10^{10}$	East baseline component
North	f8	1 m	$-2 \cdot 10^{10}$	North baseline component
Up	f8	1 m	$-2 \cdot 10^{10}$	Up baseline component
Padding	u1[..]			Padding bytes, see 2.5

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