SBF Reference Guide

Version 1.11.0

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Table of contents

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 Global Positioning System
DOP	Dilution of Precision
DVS	Data Validity Status
ECEF	Earth-Centered Earth-Fixed
FEC	Forward Error Correction
GAL	Galileo
GEO	Geostationary Earth Orbiter
GLO	GLOnass
GLONASS	Global Orbiting Navigation Satellite System (Russian alternative for GPS)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GST	Galileo System Time
GUI	Graphical User Interface
HDOP	Horizontal Dilution Of Precision
HERL	Horizontal External Reliability Level
HMI	Hazardous or 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
IODC	Issue of Data - Clock
IODE	Issue Of Data Ephemeris
INS	Inertial Navigation System
IP	Internet Protocol
LSB	Least Significant Bit
MDB	Minimal Detctable Bias
MSB	Most Significant Bits
MT	Message Type
NA	Not Applicable
NATO	North Atlantic Treaty Organisation
NAV	Navigation
NVRAM	Non Volatile Random Access Memory
PDOP	Position Dilution Of Precision
PLL	Phase Locked Loop
PPS	Pulse Per Second
PRC	Pseudorange Correction
PRN	Pseudo Random Number
PRS	Public Regulated Service
PV	Position and Velocity
PVT	Position Velocity Time
RAIM	Receiver Autonomous Integrity Monitoring
RINEX	Receiver Independent Exchange Format
RTC	Real Time Clock
RTCA	Radio Technical Commission for Aeronautics

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 (Septentrio variant)
SV	Space Vehicle
SVID	Space Vehicle ID
TDOP	Time Dilution Of Precision
TOW	Time Of Week
TUR	Test User Receiver
UDRE	User Differential Range Error
UERE	User Equivalent Range Error
URA	User Range Accuracy
UTC	Coordinated Universal Time
VDOP	Vertical Dilution Of Precision
VERL	Vertical External Reliability Level
VPL	Vertical Protection Level
WGS	World Geodetic System
WN	Week Number
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 Septentrio Binary Format (SBF).

1.2 Typographical Conventions

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

2 SBF Outline

The Septentrio Binary Format (SBF) is the binary output format of the 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 all SBF block names and numbers 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).

For each block, a version code is indicated in the second column of the table. Please refer to section 2.6 for a discussion on SBF block versions.

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 0 for details).

The subset of blocks that a particular receiver and firmware version is supporting can be found in the Command and Log Reference Card, or can be retrieved from the receiver using the command **`lmd,SBFTable`**.

Block name	Block ver	Block No	Content description	Flex Rate	esoc	Time stamp
Measurement Blocks						
MeasEpoch	*1*	*5889*	*(obsolete)* [1]	●		**R**
ShortMeasEpoch	*1*	*5890*	*(obsolete)* [1]	●		**R**
GenMeasEpoch	*1*	*5944*	*measurement set of one epoch* [1]	●		**R**
MeasEpoch	2	4027	measurement set of one epoch	●	●	**R**
MeasExtra	1	4000	additional info such as observable variance	●	●	**R**
IQCorr	1	4046	real and imaginary post-correlation values	●	●	**R**
EndOfMeas	1	5922	measurement epoch marker	●	●	**R**
Navigation Pages						
GPSRaw	*1*	*5895*	*GPS CA navigation frame* [1]			**S**
CNAVRaw	*1*	*5947*	*GPS L2C navigation frame* [1]			**S**
GEORaw	*1*	*5898*	*SBAS L1 navigation frame* [1]			**S**
GPSRawCA	1	4017	GPS CA navigation frame			**S**
GPSRawL2C	1	4018	GPS L2C navigation frame			**S**
GPSRawL5	1	4019	GPS L5 navigation frame			**S**
GLORawCA	1	4026	GLONASS CA navigation string			**S**
GALRawFNAV	1	4022	Galileo F/NAV navigation page			**S**
GALRawINAV	1	4023	Galileo I/NAV navigation page			**S**
GALRawCNAV	1	4024	Galileo C/NAV navigation page			**S**
GEORawL1	1	4020	SBAS L1 navigation message			**S**
CMPRaw	1	4047	Compass navigation page (tentative)			**S**
GPS Decoded Messages						
GPSNav	1	5891	GPS ephemeris and clock		●	**S**
GPSAlm	1	5892	Almanac data for a GPS satellite		●	**S**
GPSIon	1	5893	Ionosphere data from the GPS subframe 5		●	**S**
GPSUtc	1	5894	GPS-UTC data from GPS subframe 5		●	**S**
GLONASS Decoded Messages						
GLONav	1	4004	GLONASS ephemeris and clock		●	**S**
GLOAlm	1	4005	Almanac data for a GLONASS satellite		●	**S**
GLOTime	1	4036	GLO-UTC, GLO-GPS and GLO-UT1 data		●	**S**
Galileo Decoded Messages						
GALNav	1	4002	Galileo ephemeris, clock, health and BGD		●	**S**
GALAlm	1	4003	Almanac data for a Galileo satellite		●	**S**
GALIon	1	4030	NeQuick Ionosphere model parameters		●	**S**
GALUtc	1	4031	GST-UTC data		●	**S**
GALGstGps	1	4032	GST-GPS data		●	**S**
SBAS Decoded Messages						
GEOMT00	1	5925	MT00 : SBAS Don’t use for safety applications			**S**
GEOPRNMask	1	5926	MT01 : PRN Mask assignments			**S**
GEOFastCorr	1	5927	MT02-05/24: Fast Corrections			**S**
GEOIntegrity	1	5928	MT06 : Integrity information			**S**
GEOFastCorrDegr	1	5929	MT07 : Fast correction degradation factors			**S**
GEONav	1	5896	MT09 : SBAS navigation message		●	**S**
GEODegrFactors	1	5930	MT10 : Degradation factors			**S**
GEONetworkTime	1	5918	MT12 : SBAS Network Time/UTC offset parameters			**S**
GEOAlm	1	5897	MT17 : SBAS satellite almanac		●	**S**
GEOIGPMask	1	5931	MT18 : Ionospheric grid point mask			**S**
GEOLongTermCor	1	5932	MT24/25 : Long term satellite error corrections			**S**
GEOIonoDelay	1	5933	MT26 : Ionospheric delay corrections			**S**
GEOServiceLevel	1	5917	MT27 : SBAS Service Message			**S**
GEOClockEphCovMatrix	1	5934	MT28 : Clock-Ephemeris Covariance Matrix			**S**
Position, Velocity and Time						
PVTCartesian	*1*	*5903*	*PVT in Cartesian coordinates* [1]	●		**R**
PVTGeodetic	*1*	*5904*	*PVT in geodetic coordinates* [1]	●		**R**

DOP	*1*	*5909*	*Dilution of precision* [1]	●		**R**
PVTResiduals	*1*	*5910*	*Measurement residuals* [1]	●		**R**
RAIMStatistics	*1*	*5915*	*Integrity statistics* [1]	●		**R**
PVTCartesian	2	4006	Position, velocity, and time in Cartesian coordinates	●	●	**R**
PVTGeodetic	2	4007	Position, velocity, and time in geodetic coordinates	●	●	**R**
PosCovCartesian	1	5905	Position covariance matrix (X,Y, Z)	●	●	**R**
PosCovGeodetic	1	5906	Position covariance matrix (Lat, Lon, Alt)	●	●	**R**
VelCovCartesian	1	5907	Velocity covariance matrix (X, Y, Z)	●	●	**R**
VelCovGeodetic	1	5908	Velocity covariance matrix (North, East, Up)	●	●	**R**
DOP	2	4001	Dilution of precision	●	●	**R**
PosCart	1	4044	Position, variance and baseline in Cartesian coordinates	●	●	**R**
PVTSatCartesian	1	4008	Satellite positions	●	●	**R**
PVTResiduals	2	4009	Measurement residuals	●	●	**R**
RAIMStatistics	2	4011	Integrity statistics	●	●	**R**
GEOCorrections	1	5935	Orbit, Clock and pseudoranges SBAS corrections	●	●	**R**
BaseVectorCart	1	4043	XYZ relative position and velocity with respect to base(s)	●	●	**R**
BaseVectorGeod	1	4028	ENU relative position and velocity with respect to base(s)	●	●	**R**
DiffCorrEpoch	1	5920	Reserved for Septentrio only	●	●	**R**
EndOfPVT	1	5921	PVT epoch marker	●	●	**R**
INS/GNSS Integrated						
IntPVCart	1	4060	Integrated PV in Cartesian coordinates	●	●	**R**
IntPVGeod	1	4061	Integrated PV in Geodetic coordinates	●	●	**R**
IntPosCovCart	1	4062	Integrated position covariance matrix (X, Y, Z)	●	●	**R**
IntVelCovCart	1	4063	Integrated velocity covariance matrix (X, Y, Z)	●	●	**R**
IntPosCovGeod	1	4064	Integrated position covariance matrix (Lat, Lon, Alt)	●	●	**R**
IntVelCovGeod	1	4065	Integrated velocity covariance matrix (North, East, Up)	●	●	**R**
IntAttEuler	1	4070	Integrated attitude in Euler angles	●	●	**R**
IntAttCovEuler	1	4072	Integrated attitude covariance matrix of Euler angles	●	●	**R**
IntPVAAGeod	1	4045	Integrated position, velocity, acceleration and attitude	●	●	**R**
GNSS Attitude						
AttEuler	1	5938	GNSS attitude expressed as Euler angles	●	●	**R**
AttCovEuler	1	5939	Covariance matrix of attitude	●	●	**R**
EndOfAtt	1	5943	GNSS attitude epoch marker	●	●	**R**
AuxAntPositions	1	5942	Relative position and velocity estimates of auxiliary antennas	●	●	**R**
Receiver Time						
ReceiverTime	1	5914	Current receiver and UTC time	●	●	**R**
xPPSOffset	1	5911	Offset of the xPPS pulse with respect to GNSS time			**R**
External Event						
ExtEvent	1	5924	Time at the instant of an external event			**E**
ExtEventPVTCartesian	1	4037	Cartesian position at the instant of an event			**E**
ExtEventPVTGeodetic	1	4038	Geodetic position at the instant of an event			**E**
Differential Corrections						
DiffCorrIn	1	5919	Incoming RTCM or CMR message			**R**
BaseStation	1	5949	Base station coordinates			**R**
L-Band Demodulator						
LBandTrackerStatus	1	4201	Status of the L-band signal tracking	●	●	**R**
LBAS1DecoderStatus	1	4202	Status of the LBAS1 L-band service			**R**
LBAS1Messages	1	4203	LBAS1over-the-air message			**R**
External Sensors						
ExtSensorMeas	1	4050	Measurement set of external sensors of one epoch	●	●	**R**
ExtSensorStatus	1	4056	Overall status of external sensors		●	**R**
ExtSensorSetup	1	4057	General information about the setup of external sensors		●	**R**
Status						
ReceiverStatus	*1*	*5913*	*Overall status information of the receiver* [1]			**R**
TrackingStatus	*1*	*5912*	*Status of the tracking for all receiver channels* [1]			**R**
ChannelStatus	1	4013	Status of the tracking for all receiver channels	●	●	**R**
ReceiverStatus	2	4014	Overall status information of the receiver	●	●	**R**
SatVisibility	1	4012	Azimuth/elevation of visible satellites	●	●	**R**
InputLink	1	4090	Statistics on input streams	●	●	**R**
OutputLink	1	4091	Statistics on output streams	●	●	**R**
Miscellaneous						
ReceiverSetup	1	5902	General information about the receiver set-up		●	**R**
Commands	1	4015	Commands entered by the user		●	**R**
Comment	1	5936	Comment entered by the user		●	**R**
BBSamples	1	4040	Baseband samples			**E**

[1] These blocks are not described in the present document. They are only used by the PolaRx2 family of Septentrio receivers. Please refer to the PolaRx2 manual for a description of these blocks.

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 Factor	Do-Not-Use Value	Description
`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 1024th 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 specified by the **`setSBF-Output`** 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 second. 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 event, such 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. These padding bytes are just placeholders and should not be looked at by the decoding software. Their value is not defined.

2.6 SBF Block Version and Revision Number

Each SBF block has an associated version and revision number. The version of a block is incremented each time a backwards-incompatible change is performed to the block. The revision number is incremented each time a backwards-compatible change is implemented.

Different versions of an SBF block are given different block numbers. Different revisions of a block share the same block number, but have different revision numbers. 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 the particular receiver you are using and on the permission set. These three rates can be checked by the command **`getReceiverCapabilities`**.

The default output rate is specified for each block in section 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.

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 latter possibility 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` and `FreqNr` fields, defined as follows:

Parameter	Type	Do Not Use value	Description
`SVID`	u1	62	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 71 - 106 : PRN number of a GALILEO satellite with an offset of 70 120 - 138 : PRN number of an SBAS satellite 141 : COMPASS M1 satellite (⚠ tentative) The value "62" is used for GLONASS satellites of which the slot number is not known.
`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 irrelevant and set to zero.

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)
0	GPS_L1-CA	1575.42
1	GPS_L1-P(Y)	1575.42
2	GPS_L2-P(Y)	1227.60
3	GPS_L2C	1227.60
4	GPS_L5	1176.45
5-7	Reserved	
8	GLO_L1-CA	1602.00+(`FreqNr`-8)*9/16, with `FreqNr` as defined in section 2.9.
9	Reserved	
10	GLO_L2-P	1246.00+(`FreqNr`-8)*7/16
11	GLO_L2-CA	1246.00+(`FreqNr`-8)*7/16
12	GLO_L3	1202.025
13-16	Reserved	
17	GAL_L1BC	1575.42
18-19	Reserved	
20	GAL_E5a	1176.45
21	GAL_E5b	1207.14
22	GAL_E5	1191.795
23	Reserved	
24	GEO_L1CA	1575.42
25-27	Reserved	
28 [(1)]	For a Compass satellite: CMP_L1 Otherwise: Reserved	1561.098
29 [(1)]	For a Compass satellite: CMP_E5b Otherwise: Reserved	1207.14
30-31	Reserved	

⚠ [(1)] COMPASS signal allocation is tentative and subject to change. Signals 28 and 29 may be shared between different constellations.

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 “$@” character sequence appears in the data stream from the receiver. When it is found, go to point 2.
2. Read the next two bytes. It should be the block CRC. Store this value for future reference.
3. Read the next two bytes and store them in a buffer. It should be the block ID.
4. Read the next two bytes and add them to the buffer. It should be the `Length` field of the SBF block. It should be a multiple of 4. If not, go back to point 1.
5. Read the next (`Length-8`) bytes and add them to the buffer. Compute the CRC of the buffer. The computed CRC should be equal to the CRC stored at point 2. If not, go back to point 1, else a valid SBF block has been detected and can be interpreted by the reading software.
6. If the block number (bits 0 to 12 of the `ID` field decoded at point 3) is of interest to your application, decode the SBF block;
7. Go back to point 1 and search for the new occurrence of the “$@” 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 (v2)	Number: "OnChange" interval:	4027 default measurements output rate (see section 2.8)

This block contains all the measurements of all tracked signal for a particular epoch.

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

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

Each measurement set is stored in a sub-block of the MeasEpoch block. A channel configured to track only, say, GPS L1 will generate one sub-block, and a channel configured to track Galileo L1, E5 and E6 will give rise to three sub-blocks: one for each of the signals.

To decrease the block size, all the measurements from a channel are referenced to one "master" measurement set. For instance, the L2 Doppler is not much different from the L1 Doppler (scaled to the L2 frequency), such that the difference is encoded, instead of the entire value.

This is done by using two types of sub-blocks: the master measurement set is encoded in a long type-1 sub-block, as entire values. The other measurement sets are encoded in shorter type-2 sub-blocks, containing only the differences with the master measurements, whenever applicable. Every channel in the receiver produces one type-1 sub-block, followed or not by a number of type-2 sub-blocks depending on the available data.

Every type-1 sub-block contains a field called "N2", which gives the number of type-2 sub-blocks that are dependent on it. These dependent type-2 blocks immediately follow the type-1 block.

The first sub-block is always of type 1. The total number of type-1 sub-blocks in the MeasEpoch block is given by the field called "N1". If there are no measurements available for an epoch (due to signal obstruction for example), the N1 field is set to 0.

Decoding is done as follows:

1. Decode the first sub-block. This is always a type-1 sub-block. Get the N2 field from this sub-block.
1. If N2 is not 0, decode the N2 following sub-blocks. These are type-2 sub-blocks.
2. Go back to 1 till the N1 type-1 sub-blocks have been decoded.

Note on GIOVE pseudoranges: the E5a, E5b and E5-AltBOC pseudoranges of the GIOVE-A and GIOVE-B satellites are encoded with an offset of 100m. To get the true pseudorange, remove 100m from the pseudorange encoded in the MeasEpoch SBF block. The true E5 pseudoranges are about 270m smaller than the L1 pseudoranges, due to interfrequency biases in these satellites.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
N1	u1		Number of type-1 sub-blocks in this MeasEpoch block. Each type-1 sub-block can be followed by a number of type-2 sub-blocks.
SB1Length	u1	1 byte	Length of a type-1 sub-block
SB2Length	u1	1 byte	Length of a type-2 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. Bit 3: Clock steering: this bit is set if clock steering is active (see **setClockSyncThreshold** command).
CumClkJumps	i1	0.001 s	Cumulative millisecond clock jumps since start-up, with an ambiguity of k*256 ms.
Reserved	u1		Reserved for future use, set to 0
sub-blocks	…	…	A succession of type-1 and type-2 sub-blocks, see definition below.
Padding	u1[..]		Padding bytes, see 2.5

rev1 (margin mark beside CumClkJumps)

type-1 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: Master signal type index, see 2.10. Bits 5-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
SVID	u1		62	Satellite ID, see 2.9
Misc	u1	4294967.296m	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, set to 0.
CodeLSB	u4	1mm	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	0.0001Hz	-2147483648	Carrier Doppler (positive for approaching satellites). To compute the Doppler in Hz, use: D_{type1}[Hz] = Doppler*0.0001
CarrierLSB	u2	0.001cycles	0 (2)	LSB of the carrier phase relative to the pseudorange
CarrierMSB	i1	65.536cycles	-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 master 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	0.25dB-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 master observable type is 1

				or 2 • C/N$_0$[dB-Hz] = CN0*0.25+10 otherwise
LockTime	u2	1s	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; bit 3-7: FreqNr: for GLONASS satellites, these bits contain the frequency number with an offset of 8 (see 2.9), otherwise they are set to 0.
N2	u1			Number of type-2 sub-blocks dependent on this type-1 sub-block. These type-2 sub-blocks immediately follow the current type-1 sub-block.
Padding	u1[..]			Padding bytes, see 2.5

(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.

type-2 sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Type	u1			See corresponding field in the type-1 sub-block above.
LockTime	u1	1s	255	See corresponding field in the type-1 sub-block above, except that the value is clipped to 254 instead of 65534.
CN0	u1	0.25dB-Hz	255	See corresponding field in the type-1 sub-block above.
OffsetsMSB	u1	 65.536m 6.5536Hz	 -4 (1) -16 (3)	Bit field containing the MSB of the code and of the Doppler offsets with respect to the type-1 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	65.536cycles	-128 (2)	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; bit 3-7: reserved.
CodeOffsetLSB	u2	1mm	0 (1)	LSB of the code offset with respect to pseudorange in the type-1 sub-block. To get the entire pseudorange, use: P_{type2} [m] = P_{type1}[m] + (CodeOffsetMSB*65536+CodeOffsetLSB)*0.001
CarrierLSB	u2	0.001cycles	0 (2)	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	0.0001Hz	0 (3)	LSB of the Doppler offset relative to the Doppler in the type-1 sub-block . To get the entire Doppler, use: D_{type2} [Hz] = D_{type1}*α +(DopplerOffsetMSB*65536+DopplerOffsetLSB) *1e-4, where α is the ratio of the carrier frequency corresponding to the observable type in this type-2 sub-block, and that of the master observable type in the preceding type-1 sub-block (see section 2.10 for a list of all carrier frequencies).
Padding	u1[..]			Padding bytes, see 2.5

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

MeasExtra (v1)	Number:	4000
	"OnChange" interval:	internal measurement rate (receiver-type dependent)

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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
`TOW`	u4	0.001 s	Receiver time stamp, see 2.3
`WNc`	u2	1 week	
`N`	u1		Number of sub-blocks in this `MeasExtra` block.
`SBLength`	u1	1 byte	Length of a sub-block
`DopplerVarFactor`	f4	$Hz^2/cycles^2$	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: $\sigma^2_{Doppler}[mHz^2]$ = `CarrierVariance*DopplerVarFactor`, Where `CarrierVariance` can be found for each measurement type in the `MeasExtraChannel` sub-blocks.
sub-blocks	…	…	A succession of `MeasExtraChannel` sub-blocks, see definition below.
`Padding`	u1[..]		Padding bytes, see 2.5

`MeasExtraChannel` 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 type index, see 2.10. Bits 5-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
`MPCorrection`	i2	1mm		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	1mm		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	$1cm^2$	65535	Estimated code tracking noise variance. If the variance is larger than 65534 cm^2, it is clipped to 65534cm^2.
`CarrierVar`	u2	$1mcycle^2$	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	1s	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.
rev1 `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.
rev2 `Reserved`	u1			Reserved.
`Info`	u1			Reserved.
`Padding`	u1[..]			Padding bytes, see 2.5

IQCorr (v1)	Number: "OnChange" interval:	4046 internal measurement rate (receiver-type dependent)

This block contains punctual correlation values (real and imaginary parts) accumulated over a time given by the CorrDuration field (equal to 20 milliseconds in the current firmware release).

Correlation values are available for all signal types except for GPS L2P and GLONASS L2P.

It is typical to output this block at a 50-Hz rate to have a continuous stream of correlation values.

Note that this feature is under permission control: please contact Septentrio to enable this option.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
N	u1		Number of sub-blocks in this MeasExtra block.
SBLength	u1	1 byte	Length of a sub-block
CorrDuration	u1	1 ms	Duration over which the correlations are computed (coherent integration time, except for SBAS L1 where a non-coherent integration is used).
rev1 CumClkJumps	i1	0.001 s	Cumulative millisecond clock jumps since start-up, with an ambiguity of k*256 ms.
Reserved	u1[2]		Reserved for future use.
sub-blocks	…	…	A succession of CorrChannel sub-blocks, see definition below.
Padding	u1[..]		Padding bytes, see 2.5

CorrChannel 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 type index, see 2.10. Bits 5-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
SVID	u1		62	Satellite ID, see 2.9
CorrIQ_MSB	u1		136(1)	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(1)	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(1)	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
rev1 CarrierPhaseLSB	u2	0.001cycles		16-bit LSB of the carrier phase measurement, expressed in 0.001 cycles.
Padding	u1[..]			Padding bytes, see 2.5

(1) 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 (v1)	Number: "OnChange" interval:	5922 internal measurement rate (receiver-type dependent)

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

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see **2.1**
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
Padding	u1[..]		Padding bytes, see 2.5

3.2 Navigation Page Blocks

GPSRawCA (v1)	Number: 4017 "OnChange" interval: 6 seconds
GPSRawL2C (v1)	Number: 4018 "OnChange" interval: 12 seconds
GPSRawL5 (v1)	Number: 4019 "OnChange" interval: 6 seconds
GLORawCA (v1)	Number: 4026 "OnChange" interval: 2 seconds
GALRawFNAV (v1)	Number: 4022 "OnChange" interval: 10 seconds
GALRawINAV (v1)	Number: 4023 "OnChange" interval: 2 seconds
GALRawCNAV (v1)	Number: 4024 "OnChange" interval: 1 second
GEORawL1 (v1)	Number: 4020 "OnChange" interval: 1 second
CMPRaw (v1)	Number: 4047 "OnChange" interval: 6 seconds

The navigation page blocks contain the raw bits of a navigation page or frame. All these blocks share the same structure.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
SVID	u1		Satellite ID, see 2.9
CRCPassed	u1		0 (CRC or parity check failed), or 1 (CRC or parity check passed)
ViterbiCount	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: set in the GALRawINAV block 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 for future use, set to 0.
FreqNr	u1		For GLONASS satellites, this is the frequency number (see 2.9). For non-GLONASS satellites, this field is reserved, and set to 0.
Reserved	u1		Reserved for future use, set to 0.
NAVBits	u4[*N*]		Navigation bits. The interpretation of this field and the value of *N* can be found in the table below.
Padding	u1[..]		Padding bytes, see 2.5

NAVBits contents:

Block name	*N*	Interpretation of the NAVBits field
GPSRawCA	10	NAVBits contains the 300 bits of a GPS CA subframe. Encoding: For easier parsing, the bits are stored as a succession of 10 32-bit words. Since the actual words in the GPS 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: Bit 31-30: unused, set to 0. Bit 29-6: information-containing bits of the word (referred to as d_n in the GPS ICD). The first received bit is the MSB. Bit 5-0: 6 parity bits.
GPSRawL2C GPSRawL5	10	NAVBits contains the 300 bits of a GPS CNAV subframe (the so-called $D_c(t)$ data stream). 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] are set to 0, and must be ignored by the decoding software.
GLORawCA	3	NAVBits contains the first 85 bits of a GLONASS CA string (i.e. all bits of the string with the exception of the time mark). Encoding: NAVBits contains all the bits of the string, with the exception of the time mark. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[2] are set to 0, and must be ignored by the decoding software.
GALRawFNAV	8	NavBits contains the 244 bits of a Galileo FNAV 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[*N*-1] are set to 0, and must be ignored by the decoding software.
GALRawINAV	8	For a Galileo satellite, NAVBits contains the 234 bits of an INAV navigation page (in nominal or alert mode). Note that the INAV 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. For a GIOVE satellite, NAVBits contains the 120 bits of a 1-second INAV navigation page. The remaining bits are set to 0 and must be ignored. Encoding: same as GALRawFNAV.
GALRawCNAV	16	NAVBits contains the 492 bits of a Galileo CNAV page. Encoding: same as GALRawFNAV.
GEORawL1	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] are set to 0, and must be ignored by the decoding software.
CMPRaw	10	NAVBits contains the 300 bits of a Compass navigation page. Encoding: NAVBits contains all the bits of the page, including the preamble. The first received bit is stored as the MSB of NAVBits[0]. The unused bits in NAVBits[9] are set to 0, and must be ignored by the decoding software. ⚠ The CMPRaw block is tentative and subject to change.

3.3 GPS Decoded Message Blocks

GPSNav (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the GPS satellite of which the ephemeris is given in this block, from 1 to 37
Reserved	u1		Reserved for future use, set to 0
WN	i2	1 week	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)
Reserved	u1		unused, set to 0
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
DELTA_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 (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the GPS satellite of which the almanac is given is this block, from 1 to 37
Reserved	u1		Reserved for future use, set to 0
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
AS_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 (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the GPS satellite from which the coefficients have been received, from 1 to 37
Reserved	u1		Reserved for future use, set to 0
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 (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the GPS satellite from which these UTC parameters have been received, from 1 to 37
Reserved	u1		Reserved for future use, set to 0
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 (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
SVID	u1		Slot and frequency number of the GLONASS satellite for which ephemeris is provided in this block (see 2.9).
FreqNr	u1		
X	f8	1 km	x-component of satellite position in PZ-90.02
Y	f8	1 km	y-component of satellite position in PZ-90.02
Z	f8	1 km	z-component of satellite position in PZ-90.02
Dx	f4	1 km/s	x-component of satellite velocity in PZ-90.02
Dy	f4	1 km/s	y-component of satellite velocity in PZ-90.02
Dz	f4	1 km/s	z-component of satellite velocity in PZ-90.02
Ddx	f4	1 km/s^2	x-component of satellite acceleration in PZ-90.02
Ddy	f4	1 km/s^2	y-component of satellite acceleration in PZ-90.02
Ddz	f4	1 km/s^2	z-component of satellite acceleration in PZ-90.02
gamma	f4	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 min	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 min	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	1 cm	predicted user range accuracy at time t_b
Padding	u1[..]		Padding bytes, see 2.5

GLOAlm (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
SVID	u1		Slot and frequency number of the GLONASS satellite for which almanac is provided in this block (see 2.9). These numbers correspond to the n^A and H_n^A parameters in the GLONASS ICD.
FreqNr	u1		
epsilon	f4		ε_n^A: orbit eccentricity
t_oa	u4	1 second	Reference time-of-week in GPS time frame
Delta_i	f4	1 semi-circle	Δi_n^A: correction to inclination
lambda	f4	1 semi-circle	λ_n^A: Longitude of first ascending node
t_ln	f4	1 second	$t_{\lambda n}^A$: time of first ascending node passage
omega	f4	1 semi-circle	ω_n^A: argument of perigee
Delta_T	f4	1 second/orbit-period	ΔT_n^A: correction to mean Draconian period
dDelta_T	f4	1 second/orbit-period^2	$d\Delta T_n^A$: rate of change correction to mean Draconian period
tau	f4	1 second	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
Reserved	u1[2]		Reserved for future use, set to 0
Padding	u1[..]		Padding bytes, see 2.5

GLOTime (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
SVID	u1		Slot and frequency number of the GLONASS satellite from which the data in this block has been decoded (see 2.9).
FreqNr	u1		
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 second	difference with respect to GPS time
tau_c	f8	1 second	GLONASS time scale correction to UTC(SU)
B1	f4	1 second	difference between UT1 and UTC(SU)
B2	f4	1 second / msd	daily change of B1
Padding	u1[..]		Padding bytes, see 2.5

3.5 Galileo Decoded Message Blocks

GalNav (v1)	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 clock correction parameters (t_oc, a_f0, a_f1, a_f2) define the satellite clock model applicable to a particular dual-frequency ionosphere-free linear combination. They depend on the message type (F/NAV, I/NAV or G/NAV). F/NAV contains the clock model valid for the L1-E5a combination, I/NAV for the L1-E5b combination and G/NAV for the L1A-E6A combination. The message type, and hence the applicable clock model, can be derived from the Source field using the table below.

Source	Message type	Clock Model
1	G/NAV	(L1-A,E6-A)
2	I/NAV	(L1,E5b)
16	F/NAV	(L1,E5a)

A receiver decoding more than one message type will transmit a different GalNav SBF block for each message type.

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, SISA and BGD availability
1 (G/NAV)	At least L1-A_{DVS}, L1-A_{HS}, E6-A_{DVS}, E6-A_{HS},, SISA_L1AE6A and BGD_L1AE6A are available
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, Health_PRS, BGD_L1E5a, BGD_L1E5b, BGD_L1AE6A and CNAVEncrypt 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
Sync	c1[2]			Block Header, see 2.1
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 71 to 106
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

DELTA_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_oc	u2	1 week		WN associated with t_oc, modulo 1024
WNt_oe	u2	1 week		WN associated with t_oe, modulo 1024
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 $L1\text{-}B_{DVS}$ Bit 2-3: 2-bit $L1\text{-}B_{HS}$ Bit 4: If set, bits 5 to 7 are valid, otherwise they must be ignored. Bit 5: 1-bit $E5b_{DVS}$ Bit 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 $E5a_{DVS}$ Bit 10-11:2-bit $E5a_{HS}$
Health_PRS	u1			Bit field indicating the last received Health Status (HS) and Data Validity Status (DVS) of the E6-A and L1-A signals: Bit 0: If set, bits 1 to 3 are valid, otherwise they must be ignored. Bit 1: 1-bit $L1\text{-}A_{DVS}$ Bit 2-3: 2-bit $L1\text{-}A_{HS}$ Bit 4: If set, bits 5 to 7 are valid, otherwise they must be ignored. Bit 5: 1-bit $E6\text{-}A_{DVS}$ Bit 6-7: 2-bit $E6\text{-}A_{HS}$
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	Signal-In-Space Accuracy Index (L1-A, E6-A)
BGD_L1E5a	f4	1 s	-2e10	Last received broadcast group delay (L1, E5a)
BGD_L1E5b	f4	1 s	-2e10	Last received broadcast group delay (L1, E5b)
BGD_L1AE6A	f4	1 s	-2e10	Last received broadcast group delay (L1-A, E6-A)
CNAVEncrypt	u1		255	1-bit C/NAV encryption status from L1-B.
Padding	u1[..]			Padding bytes, see 2.5

GalAlm (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
SVID	u1		SVID of the Galileo satellite from which these almanac parameters have been received, from 71 to 106
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
DeltaSQRT_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. Bit 1-2: 2-bit L1-B_{HS} Bit 3: If set, bits 4 and 5 are valid, otherwise they must be ignored. Bit 4-5: 2-bit E5b_{HS} Bit 6: If set, bits 7 and 8 are valid, otherwise they must be ignored. Bit 7-8: 2-bit E5a_{HS} Bit 9: If set, bits 10 and 11 are valid, otherwise they must be ignored. Bit 10-11: 2-bit L1-A_{HS} Bit 12: If set, bits 13 and 14 are valid, otherwise they must be ignored. Bit 13-14: 2-bit E6-A_{HS} Bit 15: Reserved, set to 0.
IODa	u1		4-bit Issue of Data for the almanac.
Reserved[3]	u1		Reserved for future use, set to 0
Padding	u1[..]		Padding bytes, see 2.5

GalIon (v1)	Number:	4030
	"OnChange" interval:	output each time the ionospheric parameters are received from the SIS.

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

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
SVID	u1		SVID of the Galileo satellite from which these parameters have been received, from 71 to 106
Source	u1		See corresponding fields in the GalNav block.
a_i0	f4	10^{-22} W/(m^{2}Hz)	Effective ionization level, a_{i0}
a_i1	f4	10^{-22} W/(m^{2}Hz)/deg	Effective ionization level, a_{i1}
a_i2	f4	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: SF_5 Bit 1: SF_4 Bit 2: SF_3 Bit 3: SF_2 Bit 4: SF_1 Bit 5-7: Reserved, set to 0.
Padding	u1[..]		Padding bytes, see 2.5

GalUtc (v1)	Number:	4031
	"OnChange" interval:	output each time the UTC offset parameters are received from the SIS.

The GalUtc block contains the decoded UTC parameter information.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
SVID	u1		SVID of the Galileo satellite from which these parameters have been received, from 71 to 106
Source	u1		See corresponding fields in the GalNav block.
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_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 (v1)	Number:	4032
	"OnChange" interval:	output each time valid GST-GPS offset parameters are received from the SIS.

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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
SVID	u1		SVID of the Galileo satellite from which these parameters have been received, from 71 to 106
Source	u1		See corresponding fields in the GalNav block.
A_1G	f4	1 s/s	Rate of change of the offset
A_0G	f4	1 s	Constant term of the offset
t_oG	u1	1 hour	Reference time of week
WN_oG	u1	1 week	6-bit reference week number.
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 satellite's 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 for the PRN that is currently used to compute corrections. Therefore all the SBF blocks in the above table are available only for this PRN, and only if SBAS positioning mode is active (see the **`setPVTMode`** command).

GEOMT00 (v1)	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 GEO 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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which the message has been received, from 120 to 138
Padding	u1[..]		Padding bytes, see 2.5

GEOPRNMask (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which the message has been received, from 120 to 138
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 (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which the message has been received, from 120 to 138
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
N FastCorr sub-blocks	…	…	See *FastCorr* definition below
Padding	u1[..]		Padding bytes, see 2.5

FastCorr 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, set to 0
PRC	f4	1 m	Pseudorange correction for the PRN at index PRNMaskNo.
Padding	u1[..]		Padding bytes, see 2.5

GEOIntegrity (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which the message has been received, from 120 to 138
Reserved	u1		Reserved for future use, set to 0
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 (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which the message has been received, from 120 to 138
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

GEODegrFactors (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which the message has been received, from 120 to 138
Reserved	u1		Reserved for future use, set to 0
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)
Reserved	u1[2]		Reserved for future use, set to 0
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 (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which this Network Time data was received, from 120 to 138
Reserved	u1		Reserved for future use, set to 0
A1	f4	1 s/s	first order term of polynomial
A0	f8	1 s	constant term of polynomial
t_ot	u4	1 s	reference time for UTC data (time of week)
WNt	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
UTCStdId	u1		UTC Standard Identifier
GPSWN	u2	1 week	GPS week number (modulo 1024)
GPSTOW	u4	1 s	GPS time-of-week
GLONASSind	u1		Glonass Indicator
Padding	u1[..]		Padding bytes, see 2.5

GEONav (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	Week number associated with TOW (see 2.3)
PRN	u1		PRN number of the SBAS satellite of which the navigation data is provided here, from 120 to 138
Reserved	u1		Reserved for future use, set to 0
IODN/Spare	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

GEOAlm (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite of which the almanac is provided here, from 120 to 138
Reserved	u1		Reserved for future use, set to 0
DataID	u1		Data ID
Reserved	u1		Reserved for future use, set to 0
Health	u2		Health bits
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
Padding	u1[..]		Padding bytes, see 2.5

GEOIGPMask (v1)	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	Comment
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which the message has been received, from 120 to 138
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 (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which the message has been received, from 120 to 138
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, set to 0
N LTCorr sub-blocks	…	…	See *LTCorr* definition below
Padding	u1[..]		Padding bytes, see 2.5

LTCorr 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 (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which the message has been received, from 120 to 138
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, set to 0
N IDC sub-blocks	…	…	See *IDC* definition below.
Padding	u1[..]		Padding bytes, see 2.5

IDC 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, set to 0
VerticalDelay	f4	1 m	IGP vertical delay estimate.
Padding	u1[..]		Padding bytes, see 2.5

GEOServiceLevel (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
PRN	u1		PRN number of the SBAS satellite from which this service level message was received, from 120 to 138
Reserved	u1		Reserved for future use, set to 0
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
N ServiceRegion sub-blocks	…	…	See *ServiceRegion* definition below
Padding	u1[..]		Padding bytes, see 2.5

ServiceRegion 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
Reserved	u1		Reserved for future use, set to 0
Padding	u1[..]		Padding bytes, see 2.5

GEOClockEphCovMatrix (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	SIS time stamp, see 2.3
WNc	u2	1 week	
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, set to 0
N CovMatrix sub-blocks	…	…	See *CovMatrix* definition below
Padding	u1[..]		Padding bytes, see 2.5

CovMatrix 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, set to 0
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 (v2)	Number: 4006 "OnChange" interval: default PVT output rate (see section 2.8)

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 (which corresponds to the datum requested by the user through the **setGeodeticDatum** command). 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
Sync	c1[2]			Block Header, see 2.1
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 9: Precise Point Positioning (PPP) with fixed ambiguities 10: Precise Point Positioning (PPP) with float ambiguities Bits 4-5: reserved: set to 0. 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	-2e10	Marker X coordinate in coordinate frame specified by `Datum`
`Y`	f8	1 m	-2e10	Marker Y coordinate in coordinate frame specified by `Datum`
`Z`	f8	1 m	-2e10	Marker Z coordinate in coordinate frame specified by `Datum`
`Undulation`	f4	1 m	-2e10	Local geoid undulation between the ellipsoid defined by `Datum` and the geoid defined in the document "Technical Characteristics of the NAVSTAR GPS, NATO, June 1991”
`Vx`	f4	1 m/s	-2e10	Velocity in the X direction
`Vy`	f4	1 m/s	-2e10	Velocity in the Y direction
`Vz`	f4	1 m/s	-2e10	Velocity in the Z direction
`COG`	f4	1 degree	-2e10	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 msec	-2e10	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	-2e10	Receiver clock drift relative to system time (relative frequency error)
`TimeSystem`	u1		255	This field defines which time system `RxClkBias` and `RxClkDrift` refer to: 0: GPS time 1: Galileo time The system time can be selected by the user with the **`setSystemTime`** command.
`Datum`	u1		255	This field defines in which datum the coordinates are expressed: 0: WGS-84 1: Galileo 2: PZ-90.02 250: UserDatum1 251: UserDatum2
`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 bit 5-7: reserved, set to 0
`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 type indexes are listed in section 2.10. Bit 0 (GPS-CA) is the LSB of `SignalInfo`.
`AlertFlag`	u1		0	Bit field indicating integrity related information: bit 0 : set if integrity is monitored bit 1 : set if integrity has failed due to RAIM bit 2 : set if integrity has failed due to HPCA bit 3 : set if Galileo ionospheric storm flag is active

					bit 4-7: reserved, set to 0
rev1	NrBases	u1		0	Number of base stations used in the PVT computation.
	Reserved	u1[2]			Reserved for future use, set to 0
	Padding	u1[..]			Padding bytes, see 2.5

PVTGeodetic (v2)	Number: 4007 "OnChange" interval: same as PVTCartesian block

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 (which corresponds to the datum requested by the user through the **setGeodeticDatum** command). 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.

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
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in the PVTCartesian SBF block
Error	u1			
ϕ	f8	1 rad	-2e10	Marker latitude, from –π/2 to +π/2, positive North of Equator
λ	f8	1 rad	-2e10	Marker longitude, from –π to +π, positive East of Greenwich
h	f8	1 meter	-2e10	Marker ellipsoidal height (with respect to the ellipsoid specified by Datum)
Undulation	f4	1 meter	-2e10	See corresponding field in the PVTCartesian SBF block
Vn	f4	1 m/s	-2e10	Velocity in the North direction
Ve	f4	1 m/s	-2e10	Velocity in the East direction
Vu	f4	1 m/s	-2e10	Velocity in the "Up" direction
COG	f4	1 degree	-2e10	See corresponding fields in the PVTCartesian SBF block.
RxClkBias	f8	1 msec	-2e10	
RxClkDrift	f4	1 ppm	-2e10	
TimeSystem	u1		255	
Datum	u1		255	
NrSV	u1		255	
WACorrInfo	u1		0	
ReferenceID	u2		65535	
MeanCorrAge	u2	0.01 sec	65535	
SignalInfo	u4		0	
AlertFlag	u1		0	
rev1 NrBases	u1		0	
Reserved	u1[2]			
Padding	u1[..]			Padding bytes, see 2.5

PosCovCartesian (v1)	Number:	5905
	"OnChange" interval:	same as PVTCartesian block

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.

Please use the following equation to compute the correlation factor between, say, *x* and *y* estimates:

$$r_{xy} = \frac{\sigma_{xy}}{\sqrt{\sigma_x^2 \sigma_y^2}}$$

This factor ranges from zero (0), which indicates no correlation, to one in absolute sense (1 or -1), which indicates maximal correlation.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in the PVTCartesian SBF block
Error	u1			
Cov_xx	f4	1 m^2	-2e10	Variance of the x estimate
Cov_yy	f4	1 m^2	-2e10	Variance of the y estimate
Cov_zz	f4	1 m^2	-2e10	Variance of the z estimate
Cov_bb	f4	1 m^2	-2e10	Variance of the clock bias estimate
Cov_xy	f4	1 m^2	-2e10	Covariance between the x and y estimates
Cov_xz	f4	1 m^2	-2e10	Covariance between the x and z estimates
Cov_xb	f4	1 m^2	-2e10	Covariance between the x and clock bias estimates
Cov_yz	f4	1 m^2	-2e10	Covariance between the y and z estimates
Cov_yb	f4	1 m^2	-2e10	Covariance between the y and clock bias estimates
Cov_zb	f4	1 m^2	-2e10	Covariance between the z and clock bias estimates
Padding	u1[..]			Padding bytes, see 2.5

PosCovGeodetic (v1)	Number:	5906
	"OnChange" interval:	same as PVTCartesian block

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
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in the PVTCartesian SBF block
Error	u1			
Cov_ϕϕ	f4	1 m^2	-2e10	Variance of the latitude estimate
Cov_λλ	f4	1 m^2	-2e10	Variance of the longitude estimate
Cov_hh	f4	1 m^2	-2e10	Variance of the height estimate
Cov_bb	f4	1 m^2	-2e10	Variance of the clock-bias estimate
Cov_ϕλ	f4	1 m^2	-2e10	Covariance between the latitude and longitude estimates
Cov_ϕh	f4	1 m^2	-2e10	Covariance between the latitude and height estimates
Cov_ϕb	f4	1 m^2	-2e10	Covariance between the latitude and clock-bias estimates
Cov_λh	f4	1 m^2	-2e10	Covariance between the longitude and height estimates
Cov_λb	f4	1 m^2	-2e10	Covariance between the longitude and clock-bias estimates
Cov_hb	f4	1 m^2	-2e10	Covariance between the height and clock-bias estimates
Padding	u1[..]			Padding bytes, see 2.5

VelCovCartesian (v1)	Number:	5907
	"OnChange" interval:	same as PVTCartesian block

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
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in the PVTCartesian SBF block
Error	u1			
Cov_VxVx	f4	1 m^2/s^2	-2e10	Variance of the x-velocity estimate
Cov_VyVy	f4	1 m^2/s^2	-2e10	Variance of the y-velocity estimate
Cov_VzVz	f4	1 m^2/s^2	-2e10	Variance of the z-velocity estimate
Cov_DtDt	f4	1 m^2/s^2	-2e10	Variance of the clock drift estimate
Cov_VxVy	f4	1 m^2/s^2	-2e10	Covariance between the x- and y-velocity estimates
Cov_VxVz	f4	1 m^2/s^2	-2e10	Covariance between the x- and z-velocity estimates
Cov_VxDt	f4	1 m^2/s^2	-2e10	Covariance between the x-velocity and the clock drift estimates
Cov_VyVz	f4	1 m^2/s^2	-2e10	Covariance between the y- and z-velocity estimates
Cov_VyDt	f4	1 m^2/s^2	-2e10	Covariance between the y-velocity and the clock drift estimates
Cov_VzDt	f4	1 m^2/s^2	-2e10	Covariance between the z-velocity and the clock drift estimates
Padding	u1[..]			Padding bytes, see 2.5

VelCovGeodetic (v1)	Number: 5908 "OnChange" interval: same as PVTCartesian block

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
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in the PVTCartesian SBF block
Error	u1			
Cov_VnVn	f4	1 m^2/s^2	-2e10	Variance of the north-velocity estimate
Cov_VeVe	f4	1 m^2/s^2	-2e10	Variance of the east-velocity estimate
Cov_VuVu	f4	1 m^2/s^2	-2e10	Variance of the up-velocity estimate
Cov_DtDt	f4	1 m^2/s^2	-2e10	Variance of the clock drift estimate
Cov_VnVe	f4	1 m^2/s^2	-2e10	Covariance between the north- and east-velocity estimates
Cov_VnVu	f4	1 m^2/s^2	-2e10	Covariance between the north- and up-velocity estimates
Cov_VnDt	f4	1 m^2/s^2	-2e10	Covariance between the north-velocity and clock drift estimates
Cov_VeVu	f4	1 m^2/s^2	-2e10	Covariance between the east- and up-velocity estimates
Cov_VeDt	f4	1 m^2/s^2	-2e10	Covariance between the east-velocity and clock drift estimates
Cov_VuDt	f4	1 m^2/s^2	-2e10	Covariance between the up-velocity and clock drift estimates
Padding	u1[..]			Padding bytes, see 2.5

DOP (v2)	Number:	4001
	"OnChange" interval:	same as PVTCartesian block

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:

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

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

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

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

In these equations, the matrix **Q** is the inverse of the unweighed normal matrix used for the computation of the position. The normal matrix equals the product of the geometry matrix A with its transpose ($A^t A$). The term "unweighed" 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.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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, set to 0
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	-2e10	Horizontal Protection Level (see the DO 229 standard).
VPL	f4	1 m	-2e10	Vertical Protection Level (see the DO 229 standard).
Padding	u1[..]			Padding bytes, see 2.5

PosCart (v1)	Number: 4044 "OnChange" interval: same as PVTCartesian block

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 (which corresponds to the datum requested by the user through the **setGeodeticDatum** command). 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
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fiels in the PVTCartesian SBF block.
Error	u1			
X	f8	1 m	-2e10	
Y	f8	1 m	-2e10	
Z	f8	1 m	-2e10	
Base2RoverX	f8	1 m	-2e10	X baseline component (from base to rover)
Base2RoverY	f8	1 m	-2e10	Y baseline component (from base to rover)
Base2RoverZ	f8	1 m	-2e10	Z baseline component (from base to rover)
Cov_xx	f4	1 m^2	-2e10	See corresponding fiels in the PosCovCartesian SBF block.
Cov_yy	f4	1 m^2	-2e10	
Cov_zz	f4	1 m^2	-2e10	
Cov_xy	f4	1 m^2	-2e10	
Cov_xz	f4	1 m^2	-2e10	
Cov_yz	f4	1 m^2	-2e10	
PDOP	u2	0.01	0	See corresponding fiels in the DOP SBF block.
HDOP	u2	0.01	0	
VDOP	u2	0.01	0	
Misc	u1			See corresponding field in the BaseVectorCart block.
Reserved	u1			Reserved for future use.
AlertFlag	u1		0	See corresponding fields in the PVTCartesian SBF block.
Datum	u1		255	
NrSV	u1		255	
WACorrInfo	u1		0	
ReferenceID	u2		65535	
MeanCorrAge	u2	0.01 sec	65535	
SignalInfo	u4		0	
Padding	u1[…]			Padding bytes, see 2.5

PVTSatCartesian (v1)	Number: 4008 "OnChange" interval: same as PVTCartesian block

This block contains the position and velocity of all the satellites used in the PVT solution. Coordinates are referred to the time of signal transmission computed by the receiver and are corrected for the Sagnac effect in accordance to the GPS ICD.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
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
N SatPos sub-blocks	…	…	See SatPos definition below
Padding	u1[..]		Padding bytes, see 2.5

SatPos definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
SVID	u1		62	Satellite ID, see 2.9
FreqNr	u1		0	GLONASS frequency number, see 2.9
IODE	u2			IODE of the data set used to compute the values in this sub-block.
x	f8	1 m	-2e10	X coordinate in the coordinate system specified in the Datum field of the corresponding PVTCartesian or PVTGeodetic blocks
y	f8	1 m	-2e10	Y coordinate in the coordinate system specified in the Datum field of the corresponding PVTCartesian or PVTGeodetic blocks
z	f8	1 m	-2e10	Z coordinate in the coordinate system specified in the Datum field of the corresponding PVTCartesian or PVTGeodetic blocks
Vx	f4	1 m/s	-2e10	Satellite velocity in the X direction
Vy	f4	1 m/s	-2e10	Satellite velocity in the Y direction
Vz	f4	1 m/s	-2e10	Satellite velocity in the Z direction
Padding	u1[..]			Padding bytes, see 2.5

PVTResiduals (v2)	Number: 4009 "OnChange" interval: same as PVTCartesian block

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 is followed by a number of ResidualInfo sub-blocks, each of them containing the residuals of a given observable type. Note that the units of the data contained in the ResidualInfo sub-block depend on the observation 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 User Manual):

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

where λ_0 is the non-centrality parameter and:

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

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
Sync	c1[2]			Block Header, see 2.1
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 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
SB2Length	u1	1 byte		Length of a ResidualInfo sub-block

Reserved	u1[3]			Reserved for future use, set to 0
sub-blocks	…	…		A succession of SatSignalInfo and ResidualInfo blocks, see definition below.
Padding	u1[..]			Padding bytes, see 2.5

SatSignalInfo definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Comment
SVID	u1		62	Satellite ID, see 2.9
FreqNr	u1		0	GLONASS frequency number, see 2.9
Type	u1			Bit field indicating the signal type and antenna ID: Bits 0-4: signal type index 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: bit 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 ResidualInfo sub-block containing pseudorange residuals follows. bit 3: Set if a ResidualInfo sub-block containing carrier-phase residuals follows. bit 4: Set if a ResidualInfo sub-block containing Doppler residuals follows. bit 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	0.01 s	65535	Age of corrections, either from SBAS, DGPS, RTK etc, truncated to 655.34 seconds.
rev1 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

ResidualInfo definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
e_i	f4	1 m for code 1 m/s for Doppler 1 cycle for phase	-2e10	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_i	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 for code 0.01 m/s for Doppler 0.01 cycle1 for phase	65535	Minimal detectable bias based on probability of missed detection set by user
Padding	u1[..]			Padding bytes, see 2.5

RAIMStatistics (v2)	Number: 4011 "OnChange" interval: same as PVTCartesian block

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.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Comment
Sync	c1[2]			Block Header, see 2.1
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			Global integrity flag: 0 : integrity test successful 1 : integrity test failed 2 : integrity not available
reserved	u1			Reserved for future use, set to 0
HERL-position	f4	1 m	-2e10	Horizontal external reliability level of the position
VERL-position	f4	1 m	-2e10	Vertical external reliability level of the position
HERL-velocity	f4	1 m/s	-2e10	Horizontal external reliability level of the velocity
VERL-velocity	f4	1 m/s	-2e10	Vertical external reliability level of the velocity
OverallModel	u2	1/50000	65535[1]	Overall model test statistic for the estimated PVT parameters divided by the test threshold
Reserved	u1[2]			Reserved for future use, set to 0
Padding	u1[..]			Padding bytes, see 2.5

[1] This field is clipped to 65534, i.e. if the actual value is larger than 65534, it is set to 65534.

GEOCorrections (v1)	Number: 5935 "OnChange" interval: same as PVTCartesian block

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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
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
N SatCorr sub-blocks	…	…	See *SatCorr* definition below
Padding	u1[..]		Padding bytes, see 2.5

SatCorr 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, set to 0
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	-2e10	Latitude of ionospheric pierce point
IonoPPLon	f4	1 rad	-2e10	Longitude of ionospheric pierce point
SlantIono	f4	1 m	-2e10	Slant ionospheric delay at the ionosphere pierce point based on the data received in MT18 and MT26
CorrAgeIono	f4	1 s	-2e10	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	-2e10	Variance of fast and long-term corrections (used for XPL computation)
VarUIRE	f4	1 m^2	-2e10	Variance of ionospheric delay corrections (used for XPL computation)
VarAir	f4	1 m^2	-2e10	Variance of unmodelled receiver errors, such as tracking noise and multipath (used for XPL computation)
VarTropo	f4	1 m^2	-2e10	Variance of tropospheric delay corrections (used for XPL computation)
Padding	u1[..]			Padding bytes, see 2.5

BaseVectorCart (v1)	Number: 4043 "OnChange" interval: same as PVTCartesian block

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
Sync	c1[2]			Block Header, see 2.1
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
N VectorInfoCart sub-blocks	…	…		See VectorInfoCart definition below
Padding	u1[..]			Padding bytes, see 2.5

VectorInfoCart definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
NrSV	u1		255	Number of satellites for which corrections are available from the base station identified by the ReferenceID field.
Error	u1			See corresponding fields in the PVTCartesian SBF block
Mode	u1			
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 2-7: Reserved.
ΔX	f8	1 m	-2e10	X baseline component (from rover to base)
ΔY	f8	1 m	-2e10	Y baseline component (from rover to base)
ΔZ	f8	1 m	-2e10	Z baseline component (from rover to base)
ΔVx	f4	1m/s	-2e10	X velocity of base with respect to rover
ΔVy	f4	1m/s	-2e10	Y velocity of base with respect to rover
ΔVz	f4	1m/s	-2e10	Z velocity of base with respect to rover
Azimuth	u2	0.01degrees	65535	Azimuth of the base station (from 0 to 360°, increasing towards east)
Elevation	i2	0.01degrees	-32768	Elevation of the base station (from -90° to 90°)
ReferenceID	u2			Base station ID
CorrAge	u2	0.01 s	65535	Age of the last received differential corrections.
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 type indexes are listed in section 2.10. Bit 0 (GPS-CA) is the LSB of SignalInfo.
Padding	u1[…]			Padding bytes, see 2.5

BaseVectorGeod (v1)	Number: 4028 "OnChange" interval: same as PVTCartesian block

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
Sync	c1[2]			Block Header, see 2.1
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
N VectorInfoGeod sub-blocks	…	…		See VectorInfoGeod definition below
Padding	u1[..]			Padding bytes, see 2.5

VectorInfoGeod definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
NrSV	u1		255	See corresponding fields in the BaseVectorCart block.
Error	u1			
Mode	u1			
Misc	u1			
ΔEast	f8	1 m	-2e10	East baseline component (from rover to base)
ΔNorth	f8	1 m	-2e10	North baseline component (from rover to base)
ΔUp	f8	1 m	-2e10	Up baseline component (from rover to base)
ΔVe	f4	1m/s	-2e10	East velocity of base with respect to rover
ΔVn	f4	1m/s	-2e10	North velocity of base with respect to rover
ΔVu	f4	1m/s	-2e10	Up velocity of base with respect to rover
Azimuth	u2	0.01degrees	65535	See corresponding fields in the BaseVectorCart block.
Elevation	i2	0.01degrees	-32768	
ReferenceID	u2			
CorrAge	u2	0.01 s	65535	
SignalInfo	u4		0	
Padding	u1[…]			Padding bytes, see 2.5

DiffCorrEpoch (v1)	Number:	5920
	"OnChange" interval:	same as PVTCartesian block

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

EndOfPVT (v1)	Number:	5921
	“OnChange” interval:	same as PVTCartesian block

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

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
Padding	u1[..]		Padding bytes, see 2.5

3.8 INS/GNSS Integrated Blocks

IntPVCart (v1)	Number:	4060
	"OnChange" interval:	default integrated INS/GNSS output rate (see section 2.8)

This block contains the position and velocity (PV) solution provided at the time specified in the TOW and WNc fields.

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 (which corresponds to the datum requested by the user through the **setGeodeticDatum** command). The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

The PV solution is also available in ellipsoidal form in the IntPVGeod block.

The variance-covariance information associated with the reported PV solution can be found in the IntPosCovCart and IntVelCovCart blocks.

If no PV 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
Sync	c1[2]			Block Header, see 2.1
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			Indicates the mode of the PV as provided in this block: 0: No integrated PV solution available 1: Extrapolated solution based on external sensor-only 2: Loosely-integrated solution (or integration in the GNSS PV domain) If the mode is set to 0, the Error field indicates the cause of the absence of the PV solution.
Error	u1			Integrated PV error code: 0: no error. 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 20: integrated PV not requested by user 21: not enough valid external sensor measurements 22: calibration not ready 23: alignment not ready 24: waiting for GNSS PVT
Info	u2			Bit field providing more information regarding the status and type of measurements used: Bit 0: set if acceleration measurements are used Bit 1: set if angular rate measurements are used Bits 2-10: reserved. Bit 11: set if 180-degree heading ambiguity fixed. If not set and the vehicle is moving backwards, the heading angle has a bias of 180 degrees. This bit is only relevant in the IntAttEuler SBF block. Bit 12: set if zero-velocity constraints used Bit 13: set if GNSS-based position used Bit 14: set if GNSS-based velocity used Bit 15: set if GNSS-based attitude used

NrSV	u1		255	Number of satellites used in the PV computation
NrAnt	u1		255	Number of GNSS antennas
GNSSPVTMode	u1		255	PVT mode when the last GNSS PVT was computed. See Mode field in the PVTCartesian SBF block
Datum	u1		255	See Datum field in the PVTCartesian SBF block
GNSSage	u2	0.01 sec	65535	Duration that no GNSS measurements were received and no GNSS-measurement based PVT is computed, truncated to 655.34 sec
X	f8	1 m	-2e10	Marker X coordinate in coordinate frame specified by Datum
Y	f8	1 m	-2e10	Marker Y coordinate in coordinate frame specified by Datum
Z	f8	1 m	-2e10	Marker Z coordinate in coordinate frame specified by Datum
Vx	f4	1 m/s	-2e10	Velocity in the X direction
Vy	f4	1 m/s	-2e10	Velocity in the Y direction
Vz	f4	1 m/s	-2e10	Velocity in the Z direction
COG	f4	1 degree	-2e10	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.
Padding	u1[…]			Padding bytes, see 2.5

IntPVGeod (v1)	Number:	4061
	"OnChange" interval:	same as IntPVCart

This block contains the position and velocity (PV) solution provided at the time specified in the TOW and WNc fields.

The computed position (latitude, longitude, altitude) and velocity are reported in an ellipsoidal coordinate system using the datum indicated in the Datum field (which corresponds to the datum requested by the user through the **setGeodeticDatum** command). 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 PV solution is also available in cartesian form in the IntPVCart block.

The variance-covariance information associated with the reported PV solution can be found in the IntPosCovGeod and IntVelCovGeod blocks.

If no PV 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
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in IntPVCart SBF block.
Error	u1			
Info	u2			
NrSV	u1		255	
NrAnt	u1		255	
GNSSPVTMode	u1		255	
Datum	u1		255	
GNSSage	u2	0.01 s	65535	
Lat	f8	1 rad	-2e10	Marker latitude, from –π/2 to +π/2, positive North of Equator
Long	f8	1 rad	-2e10	Marker longitude, from –π to +π, positive East of Greenwich
Alt	f8	1 m	-2e10	Marker ellipsoidal height (with respect to the ellipsoid specified by Datum)
Vn	f4	1 m/s	-2e10	Velocity in the North direction
Ve	f4	1 m/s	-2e10	Velocity in the East direction
Vu	f4	1 m/s	-2e10	Velocity in the "Up" direction
COG	f4	1 degree	-2e10	See corresponding field in IntPVCart SBF block
Padding	u1[…]			Padding bytes, see 2.5

IntPosCovCart (v1)	Number: 4062 "OnChange" interval: same as IntPVCart

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

$$\begin{pmatrix} \sigma_x^2 & \sigma_{xy} & \sigma_{xz} \\ \sigma_{yx} & \sigma_y^2 & \sigma_{yz} \\ \sigma_{zx} & \sigma_{zy} & \sigma_z^2 \end{pmatrix}$$

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).

The position variance results from the propagation of state elements, including estimated external sensor error sources. The receiver implements a stochastic error model for individual external sensor measurements, based on quality of the external sensors.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in IntPVCart SBF block.
Error	u1			
Cov_xx	f4	1 m^2	-2e10	Variance of the x estimate
Cov_yy	f4	1 m^2	-2e10	Variance of the y estimate
Cov_zz	f4	1 m^2	-2e10	Variance of the z estimate
Cov_xy	f4	1 m^2	-2e10	Covariance between the x and y estimates
Cov_xz	f4	1 m^2	-2e10	Covariance between the x and z estimates
Cov_yz	f4	1 m^2	-2e10	Covariance between the y and z estimates
Padding	u1[..]			Padding bytes, see 2.5

IntVelCovCart (v1)	Number: 4063 "OnChange" interval: same as IntPVCart

This block contains the elements of the symmetric variance-covariance matrix of the integrated INS/GNSS velocity expressed in the Cartesian coordinates in the datum requested by the user:

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

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

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in IntPVCart SBF block.
Error	u1			
Cov_VxVx	f4	1 m^2/s^2	-2e10	Variance of the x-velocity estimate
Cov_VyVy	f4	1 m^2/s^2	-2e10	Variance of the y-velocity estimate
Cov_VzVz	f4	1 m^2/s^2	-2e10	Variance of the z-velocity estimate
Cov_VxVy	f4	1 m^2/s^2	-2e10	Covariance between the x- and y-velocity estimates
Cov_VxVz	f4	1 m^2/s^2	-2e10	Covariance between the x- and z-velocity estimates
Cov_VyVz	f4	1 m^2/s^2	-2e10	Covariance between the y- and z-velocity estimates
Padding	u1[..]			Padding bytes, see 2.5

IntPosCovGeod (v1)	Number: 4064 "OnChange" interval: same as IntPVCart

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

$$\begin{pmatrix} \sigma_{\phi}^{2} & \sigma_{\phi\lambda} & \sigma_{\phi h} \\ \sigma_{\lambda\phi} & \sigma_{\lambda}^{2} & \sigma_{\lambda h} \\ \sigma_{h\phi} & \sigma_{h\lambda} & \sigma_{h}^{2} \end{pmatrix}$$

Please refer to the IntPosCovCart 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.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in IntPVCart SBF block.
Error	u1			
Cov_LatLat	f4	1 m^2	-2e10	Variance of the latitude estimate
Cov_LonLon	f4	1 m^2	-2e10	Variance of the longitude estimate
Cov_AltAlt	f4	1 m^2	-2e10	Variance of the height estimate
Cov_LatLon	f4	1 m^2	-2e10	Covariance between the latitude and longitude estimates
Cov_LatAlt	f4	1 m^2	-2e10	Covariance between the latitude and height estimates
Cov_LonAlt	f4	1 m^2	-2e10	Covariance between the longitude and height estimates
Padding	u1[..]			Padding bytes, see 2.5

IntVelCovGeod (v1)	Number: 4065 "OnChange" interval: same as IntPVCart

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:

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

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

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in IntPVCart SBF block.
Error	u1			
Cov_VnVn	f4	1 m^2/s^2	-2e10	Variance of the north-velocity estimate
Cov_VeVe	f4	1 m^2/s^2	-2e10	Variance of the east-velocity estimate
Cov_VuVu	f4	1 m^2/s^2	-2e10	Variance of the up-velocity estimate
Cov_VnVe	f4	1 m^2/s^2	-2e10	Covariance between the north- and east-velocity estimates
Cov_VnVu	f4	1 m^2/s^2	-2e10	Covariance between the north- and up-velocity estimates
Cov_VeVu	f4	1 m^2/s^2	-2e10	Covariance between the east- and up-velocity estimates
Padding	u1[..]			Padding bytes, see 2.5

IntAttEuler (v1)	Number: 4070 "OnChange" interval: same as IntPVCart

The IntAttEuler block contains the computed integrated INS/GNSS Euler angles (heading, pitch and roll) at the time specified in the TOW and WNc fields. The time of applicability is specified in the receiver time frame.

The attitude is calculated using the ellipsoid as indicated in the Datum field, using measurements from non-GNSS external sensors (e.g. gyroscopes).

An indication of the quality of the reported attitude solution can be found in the IntAttCovEuler block.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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			Indicates the mode of the attitude as provided in this block: 0: No integrated attitude solution available 1: Extrapolated solution based on external sensor-only 2: Loosely-integrated solution If the mode is set to 0, the Error field indicates the cause of the absence of the attitude solution.
Error	u1			See corresponding fields in IntPVCart SBF block.
Info	u2			
NrSV	u1		255	
NrAnt	u1		255	
Reserved	u1			
Datum	u1		255	
GNSSage	u2	0.01 s	65535	
Heading	f4	1 degree	-2e10	Heading. Remains on the "do-not-use" value till the vehicle starts moving. Heading may have a 180-degree bias if bit 11 of the Info field is not set.
Pitch	f4	1 degree	-2e10	Pitch
Roll	f4	1 degree	-2e10	Roll
PitchDot	f4	1 degree/s	-2e10	Rate of change of the pitch angle
RollDot	f4	1 degree/s	-2e10	Rate of change of the roll angle
HeadingDot	f4	1 degree/s	-2e10	Rate of change of the heading angle
Padding	u1[…]			Padding bytes, see 2.5

IntAttCovEuler (v1)	Number:	4072
	"OnChange" interval:	same as IntPVCart block

This block contains the elements of the symmetric variance-covariance matrix of the integrated INS/GNSS heading, pitch and roll attitude angles (ψ,θ,φ):

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

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).

Note that the Cov_HeadHead, Cov_HeadPitch and Cov_HeadRoll fields are set to their "do-not-use" value until the vehicle starts moving.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in the IntAttEuler block
Error	u1			
Cov_HeadHead	f4	1 degree^2	-2e10	Variance of the heading estimate
Cov_PitchPitch	f4	1 degree^2	-2e10	Variance of the pitch estimate
Cov_RollRoll	f4	1 degree^2	-2e10	Variance of the roll estimate
Cov_HeadPitch	f4	1 degree^2	-2e10	Covariance between the heading-pitch estimates
Cov_HeadRoll	f4	1 degree^2	-2e10	Covariance between the heading-roll estimates
Cov_PitchRoll	f4	1 degree^2	-2e10	Covariance between the pitch-roll estimates
Padding	u1[…]			Padding bytes, see 2.5

IntPVAAGeod (v1)	Number: 4045 "OnChange" interval: same as IntPVCart block

This block contains the INS/GNSS integrated position, velocity, acceleration and attitude (PVAA) at the time specified in the TOW and WNc fields.

The position is reported in an ellipsoidal coordinate system using the datum indicated in the Datum field (which corresponds to the datum requested by the user through the **setGeodeticDatum** command). The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

If no PVAA is available, the Error field indicates the cause of the unavailability.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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			See corresponding fields in the IntPVCart SBF block.
Error	u1			
Info	u2			
GNSSPVTMode	u1		255	
Datum	u1		255	
GNSSage	u1	1 sec	255	Duration that no GNSS measurements were received and no GNSS-measurement based PVT is computed, truncated to 254 sec
NrSVAnt	u1		255	Bit field containing the number of satellites and antennas used in the computation: Bits 0-4 : Number of satellites, clipped to 30. Bits 6-7: Number of antennas
Reserved	u1			Reserved for future use
PosFine	u1	 6.25e-9 degrees 6.25e-9 degrees	 (1) (2)	Bit field containing the sub-cm part of the latitude and longitude: Bits 0-3: LatFine (unsigned). To obtain a high-resolution latitude, in degrees, compute: Lat*1e-7+LatFine*6.25e-9 Bits 4-7 : LongFine (unsigned). To obtain a high-resolution longitude, in degrees, compute: Long*1e-7+LongFine*6.25e-9
Lat	i4	1e-7 degrees	-2147483648	Marker latitude, positive North of Equator, with a cm-level resolution. Refer to the PosFine field above if finer resolution is needed.
Long	i4	1e-7 degrees	-2147483648	Marker longitude, positive East of Greenwich, with a cm-level resolution. Refer to the PosFine field above if finer resolution is needed.
Alt	i4	0.001 m	-2147483648	Marker ellipsoidal height (with respect to the ellipsoid specified by Datum)
Vn	i4	1 mm/s	-2147483648	Velocity in the North direction
Ve	i4	1 mm/s	-2147483648	Velocity in the East direction
Vu	i4	1 mm/s	-2147483648	Velocity in the "Up" direction
Ax	i2	1cm/s^2	-32768	Acceleration in the vehicle's X direction
Ay	i2	1cm/s^2	-32768	Acceleration in the vehicle's Y direction
Az	i2	1cm/s^2	-32768	Acceleration in the vehicle's Z direction
Heading	u2	0.01degrees	65535	Heading
Pitch	i2	0.01degrees	-32768	Pitch
Roll	i2	0.01degrees	-32768	Roll
Padding	u1[…]			Padding bytes, see 2.5

(1) LatFine has no meaning when Lat is set to -2147483648.
(2) LongFine has no meaning when Long is set to -2147483648.

3.9 GNSS Attitude Blocks

AuxAntPositions (v1)	Number:	5942
	"OnChange" interval:	same as PVTCartesian block

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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
N	u1		Number of *AuxAntPosition* sub-blocks in this AuxAntPositions block
SBLength	u1	1 byte	Length of one sub-block in bytes
N AuxAntPosition sub-blocks	…	…	see AuxAntPosition definition below
Padding	u1[…]		Padding bytes, see 2.5

AuxAntPosition definition:

Parameter	Type	Units &Scale Factor	Do-Not-Use Value	Description
NrSV	u1			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…
ΔEast	f8	1 m	-2e10	Position in East direction (relative to main antenna)
ΔNorth	f8	1 m	-2e10	Position in North direction (relative to main antenna)
ΔUp	f8	1 m	-2e10	Position in Up direction (relative to main antenna)
EastVel	f8	1 m/s	-2e10	Velocity in East direction (relative to main antenna)
NorthVel	f8	1 m/s	-2e10	Velocity in North direction (relative to main antenna)
UpVel	f8	1 m/s	-2e10	Velocity in Up direction (relative to main antenna)
Padding	u1[..]			Padding bytes, see 2.5

AttEuler (v1)	Number: 5938 "OnChange" interval: same as PVTCartesian block

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). The attitude is calculated using the ellipsoid as indicated in the datum field.

This block reports the GNSS-only attitude. The integrated INS/GNSS attitude is reported in the IntAttEuler block.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
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			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, two bits are used to provide error information: Bit 0-1: Error code for Auxiliary antenna 1 Bit 2-3: Error code for Auxiliary antenna 2 Bit 4-6: Reserved for future use, equal to zero 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 on one line 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 fix ambiguities 3: Heading, pitch, roll, aux antenna positions obtained with float ambiguities 4: Heading, pitch, roll, aux antenna positions obtained with fix ambiguities
Datum	u1		255	This field expresses in which datum the attitude is expressed, for a definition, see the PVTCartesian block
Reserved	u1			Reserved for future use, set to 0
Heading	f4	1 degree	-2e10	Heading
Pitch	f4	1 degree	-2e10	Pitch
Roll	f4	1 degree	-2e10	Roll
PitchDot	f4	1 degree/s	-2e10	Rate of change of the pitch angle
RollDot	f4	1 degree/s	-2e10	Rate of change of the roll angle
HeadingDot	f4	1 degree/s	-2e10	Rate of change of the heading angle
Padding	u1[…]			Padding bytes, see 2.5

AttCovEuler (v1)	Number:	5939
	"OnChange" interval:	same as PVTCartesian block

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

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

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
Sync	c1[2]			Block Header, see 2.1
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, set to 0
Error	u1			Attitude error code. See corresponding field in the AttEuler SBF block.
Cov_HeadHead	f4	1 degree^2	-2e10	Variance of the heading estimate
Cov_PitchPitch	f4	1 degree^2	-2e10	Variance of the pitch estimate
Cov_RollRoll	f4	1 degree^2	-2e10	Variance of the roll estimate
Cov_HeadPitch	f4	1 degree^2	-2e10	Covariance between Euler angle estimates. Future functionality. The values are currently set to their Do-Not-Use values.
Cov_HeadRoll	f4	1 degree^2	-2e10	
Cov_PitchRoll	f4	1 degree^2	-2e10	
Padding	u1[…]			Padding bytes, see 2.5

EndOfAtt (v1)	Number: 5943 "OnChange" interval: same as PVTCartesian block

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

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
Padding	u1[..]		Padding bytes, see 2.5

3.10 Receiver Time Blocks

ReceiverTime (v1)	Number: 5914 “OnChange” interval: 1 second

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
Sync	c1[2]			Block Header, see 2.1
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 all the bits are set, full synchronisation is achieved: bit 0: WNSET: if this bit is set, the receiver week-number is synchronised with GST/GPS time. bit 1: TOWSET: if this bit is set, the receiver time-of-week is synchronised 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.
Reserved	u2			Reserved for future use, set to 0
Padding	u1[..]			Padding bytes, see 2.5

xPPSOffset (v1)	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	Comment
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3. This is the time stamp of the xPPS pulse, rounded to the nearest multiple of 100.
WNc	u2	1 week	
SyncAge	u1	1 s	Age of the last synchronization to system time. The xPPS pulse is regularly resynchronised with system time. This field indicates the number of seconds elapsed since the last resynchronisation. 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 ns	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 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

3.11 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 (v1)	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
Sync	c1[2]			Block Header, see 2.1
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	External time stamp: time of the event in the receiver time scale with a millisecond resolution. see 2.3 The sub-millisecond part of the event time is contained in the Offset field.
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	-2e10	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.
rev1 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.
Reserved	u1[2]			Reserved for future use, set to 0.
Padding	u1[..]			Padding bytes, see 2.5

ExtEventPVTCartesian (v1)	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.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`Sync`	c1[2]			Block Header, see 2.1
`CRC`	u2			
`ID`	u2			
`Length`	u2	1 byte		
`TOW`	u4	0.001 s	4294967295	External time stamp: time of the event in the receiver time scale with a millisecond resolution. 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` blocks is the last of the `ExtEvent` blocks having been output by the receiver.
`WNc`	u2	1 week	65535	
Structure and contents identical to those of `PVTCartesian` block, starting from the `Mode` field.				

ExtEventPVTGeodetic (v1)	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.

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Sync	c1[2]			Block Header, see 2.1
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	External time stamp. See description of the corresponding fields in the ExtEventPVTCartesian block.
WNc	u2	1 week	65535	
Structure and contents identical to those of PVTGeodetic block, starting from the Mode field.				

3.12 Differential Correction Blocks

DiffCorrIn (v1)	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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp corresponding to the time of reception of the message, see 2.3
WNc	u2	1 week	
Mode	u1		0 = RTCM2 1 = CMR 2 = RTCM3 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)
RTCM2Words or CMRMessage or RTCM3Words	u4[*n*] u1[*j*] u1[*i*]		**RTCM2Words** 30-bit words of the RTCM 2message. The number *n* of 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: Bit 31-30: bit 1 and 0 of the preceding word Bit 29-6: 24 information-containing bits of the word. The first received bit is the MSB. Bit 5-0: 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. **CMRMessage** The number *j* of bytes in the CMR message depends on the CMR message type. **RTCM3Message** The number *i* of bytes in the RTCM 3 message depends on the RTCM 3 message type.
Padding	u1[..]		Padding bytes, see 2.5

BaseStation (v1)	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 ECEFcoordinates 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	Coordinate of the L1 phase center
2	Antenna reference point
4	Coordinate of the L1 phase center
8	Antenna reference point

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
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 10: CMR+ (Type 2)
Datum	u1		Coordinate datum, see the corresponding field in the PVTCartesian block for a definition
Reserved	u1		Reserved for future use, set to 0
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.

3.13 L-Band Demodulator Blocks

LBandTrackerStatus (v1)	Number: 4201 "OnChange" interval: every second

The `LBandTrackerStatus` block provides general information on the tracking status of the L-band signals.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 seconds	Receiver time stamp, see 2.3
WNc	u2	1 week	
N	u1		Number of L-band trackers for which data is provided in this SBF block, i.e. number of `TrackData` sub-blocks.
SBLength	u1	1 byte	Length of one sub-block
N TrackData sub-blocks	…	…	See `TrackData` definition below
Padding	u1[..]		Padding bytes, see 2.5.

`TrackData` definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Frequency	u4	1 Hz	0	Nominal frequency of the beam for which data is provided in this sub-block.
Baudrate	u2	1 baud	0	Baudrate of the beam
ServiceID	u2			Service ID of the beam. Set to 0 for the LBAS1 beam. This field must be ignored if the `Status` field is set to anything else than 3 (Locked).
FreqOffset	f4	1 Hz	-2e10	Frequency offset of the demodulator, if available
CN0	u2	0.01 dB-Hz	0	Current C/N_0 value
AvgPower	i2	0.01 dB	-32768	Not applicable, always set to do-not-use value.
AGCGain	i1	1 dB	-128	Not applicable, always set to do-not-use value.
Mode	u1			Current operation mode: 0: Normal
Status	u1			Current status: 0: Idle 1: Search 2: FrameSearch 3: Locked
Reserved	u1			Reserved for future use.
LockTime (rev1)	u2	1 s		Lock time to the L-band signal, clipped to 65535 seconds.
Reserved	u2			Reserved for future use.
Padding	u1[..]			Padding bytes, see 2.5.

LBAS1DecoderStatus (v1)	Number:	4202
	"OnChange" interval:	Block generated each time a status update is received from the LBAS1 decoder

The LBAS1DecoderStatus block provides general information on the LBAS1 L-band decoder.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 seconds	Receiver time stamp, see 2.3
WNc	u2	1 week	
Reserved	u2		Reserved for future use. Set to 0
Status	u1		Status of the Decoder: 0: No Signal (more than 30 seconds no valid data) 1: Search 2: Locked
Access	u1		Access status: 0: Access disabled 1: Access enabled
GeoGatingMode	u1		GeoGating mode 0: Undefined 1: Onshore Only 2: Offshore Only
GeoGatingStatus	u1		GeoGating status. Proprietary information.
Event	u4		Bit field indicating whether an event occurred previously. If this field is not equal to zero, at least one event has occurred. bit 0: Beamtable Update bit 1: Station List Update bit 2: Access Changed bit 3: Message Received Bit 4 through 31 are reserved and set to zero
Padding	u1[..]		Padding bytes, see 2.5.

LBAS1Messages (v1)	Number:	4203
	"OnChange" interval:	Block generated each time an over-the-air message is received by the LBAS1 decoder

The LBAS1Messages block contains the over-the-air message decoder from LBAS1.

Parameter	Type	Units & Scale Factor	Description
Sync	u2		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 seconds	Receiver time stamp, see 2.3
WNc	u2	1 week	
MessageLength	u2		Length of the Message inside this Block Maximum message length is 512 bytes
Message	c1[..]		Over-The-Air message
Padding	u1[..]		Padding bytes, see 2.5.

3.14 External Sensor Blocks

ExtSensorMeas (v1)	Number:	4050
	"OnChange" interval:	default integrated INS/GNSS output rate (see section 2.8)

This block contains all acceleration and/or angular-rate measurements taken at a given epoch by external sensors. Whether a given sensor provides acceleration and/or angular rates depends on the sensor type.

Measurements are organized in measurement sets consisting of a triplet of accelerations or angular rates in the sensor X,Y,Z directions. Measurement sets are reported in the MeasSet sub-blocks. If a sensor provides both accelerations and angular rates, two MeasSet sub-blocks are generated. In systems with multiple sensors, each sensor can give rise to one or two MeasSet sub-blocks.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
N	u1		Number of sub-blocks in this ExtSensorMeas block
SBLength	u1	1 byte	Length of sub-block
N MeasSet sub-blocks	...	...	*A succession of MeasSet sub-blocks, see definition below*
Padding	u1[..]		Padding bytes, see 2.5

MeasSet sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use value	Description
Source	u1			Identification of the sensor providing the measurements in this sub-block (useful in case multiple sensors are connected to the receiver): 0: measurements from sensor connected to COM1 1: measurements from sensor connected to COM2 2: measurements from sensor connected to COM3 3: measurements from sensor connected to COM4 4: measurements from sensor connected to the ButtonPin
SensorModel	u1			Sensor model, defined as follows: 0: MMQ50 from Systron Donner 1: MTi from Xsens 20: Zero-velocity sensor 2 to 255: Reserved for future use
Type	u1			Type of measurement provided in the X, Y and Z fields: 0: X: acceleration in the sensor x-direction, in m/s^2. Y: acceleration in the sensor y-direction, in m/s^2. Z: acceleration in the sensor z-direction, in m/s^2. 1: X: angular rate in the sensor x-direction, in deg/s. Y: angular rate in the sensor y-direction, in deg/s. Z: angular rate in the sensor z-direction, in deg/s. 20: X: zero-velocity flag (1 during zero-velocity periods, 0 otherwise). Y: don't use Z: don't use
ObsInfo	u1			Bit field: Bit 0: set if measurements are temperature compensated Bit 1-7: reserved for future use, set to 0
X	f8	see Type field	-2e10	see Type field
Y	f8	see Type field	-2e10	see Type field
Z	f8	see Type field	-2e10	see Type field
Padding	u1[..]			Padding bytes, see 2.5

ExtSensorStatus (v1)	Number:	4056
	"OnChange" interval:	each time an external sensor provides status information

The ExtSensorStatus block contains status information from an external sensor. This block is primarily intended for Septentrio maintenance personnel.

The status is reported in the StatusBits field, of which the interpretation depends on the SensorModel and of the StatusType fields, as follows:

<table>
<tr><th>SensorModel</th><th>StatusType</th><th>N</th><th>Interpretation of the StatusBits field</th></tr>
<tr><td>0 (MMQ50)</td><td>0</td><td>56</td><td>StatusBits contains the 56 bytes of the MMQ50 initial BIT message.

The description of the content can be found in ["MMQ50-200-400 users's guide", Rev.C, Doc. Nbr.964919, 14-Dec-2006]</td></tr>
<tr><td>0 (MMQ50)</td><td>1</td><td>4</td><td>StatusBits contains the 4 bytes of the MMQ50 BIT status message.

The description of the content can be found in ["MMQ50-200-400 users's guide", Rev.C, Doc. Nbr.964919, 14-Dec-2006]</td></tr>
<tr><td>1 (MTi)</td><td>0</td><td>40</td><td>StatusBits combines the following MTi informational/configuration messages (DeviceID, Product code, FirmwareRev, Period in "LMT Low-Level Communication Protocol Documentation",, rev.1, Doc.Nbr. MT0101P, 08-Aug-2008]):

<table>
<tr><th>Parameter</th><th>Length</th><th>Description</th></tr>
<tr><td>SerialNr</td><td>32 bits</td><td>Serial number</td></tr>
<tr><td>productCode</td><td>240 bits</td><td>Product code</td></tr>
<tr><td>fwRevMajor</td><td>8 bits</td><td>Firmware code major</td></tr>
<tr><td>fwRevMinor</td><td>8 bits</td><td>Firmware code minor</td></tr>
<tr><td>fwRevRevision</td><td>8 bits</td><td>Firmware code revision part</td></tr>
<tr><td>Reserved</td><td>8 bits</td><td>Reserved for future use</td></tr>
<tr><td>Period</td><td>16 bits</td><td>Sampling period</td></tr>
</table>
</td></tr>
<tr><td>1 (MTi)</td><td>1</td><td>1</td><td>StatusBits contains the 8 bits of the MTi status message (Data-related message in ["LMT Low-Level Communication Protocol Documentation",, rev.1, Doc.Nbr. MT0101P, 08-Aug-2008])</td></tr>
</table>

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
Source	u1		See corresponding fields in **ExtSensorMeas** block.
SensorModel	u1		
StatusType	u1		Type of status message, see table above.
Reserved	u1[3]		Reserved for future use, set to zero.
StatusBits	u1[*N*]		Sensor status bits. The interpretation of this field and the value of N can be found in the table above.
Padding	u1[..]		Padding bytes, see 2.5

ExtSensorSetup (v1)	Number:	4057
	"OnChange" interval:	Block generated each time the user invokes the **setExtSensor-Calibration** command

The ExtSensorSetup contains the model, serial number and type of all the sensors currently connected to the receiver. This block is primarily intended for Septentrio maintenance personnel.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
N	u1		Number of sub-blocks in this ExtSensorSetup block
SBLength	u1	1 byte	Length of sub-block
N OneSensor Sub-blocks	...	...	*A succession of OneSensor sub-blocks, see definition below*
Padding	u1[..]		Padding bytes, see 2.5

OneSensor sub-block definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Source	u1			See corresponding fields in **ExtSensorMeas** block.
SensorModel	u1			
MeasType	u2			Bit field indicating the type of measurements available from this sensor (as set by the command **setExtSensorUsage**): Bit 0: set if sensor provides acceleration measurements; Bit 1: set if sensor provides angular rate measurements; Bit 2-15: reserved for future use
Padding	u1[…]			Padding bytes, see 2.5

3.15 Status Blocks

ChannelStatus (v1)	Number:	4013
	"OnChange" interval:	internal PVT rate (receiver-type dependent)

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 blocks is directly followed by 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)		CA	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

GLONASS:

Reserved		Reserved		Reserved		L3		L2CA		L2P		L1P		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		Reserved		L1	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
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 channels active available for this epoch.
SB1Length	u1	1 byte	Length of one ChannelSatInfo sub-block
SB2Length	u1	1 byte	Length of one ChannelStateInfo sub-block
Reserved	u1[3]		Reserved for future use, set to 0
sub-blocks	…	…	A succession of ChannelSatInfo and ChannelStateInfo sub-blocks, see definition below.
Padding	u1[..]		Padding bytes, see 2.5

ChannelSatInfo definition

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
SVID	u1		62	Satellite ID and frequency number, see 2.9
FreqNr	u1		0	

Reserved	u2			Reserved for future use, set to 0.
Azimuth/RiseSet	u2	1 degree	511 3	bit field: bits 0-8: azimuth [0,359]. 0 is north, and azimuth increases towards east. bits 14-15: rise/set indicator: 3 : elevation rate unknown 0 : satellite setting 1 : satellite rising
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.
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.
Reserved	u1			Reserved for future use, set to 0
Padding	u1[..]			Padding bytes, see 2.5

`ChannelStateInfo` definition

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
Antenna	u1			Antenna number (0 for main antenna)
Reserved	u1			Reserved for future use, set to 0
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			Sequence of 2-bit PVT info codes, which provide further details on the reason why a given signal type was not included in the PVT. The interpretation of the info code depends on the PVT status field. If the PVT status for a given signal is 0, the corresponding info code can take the following values: 0: no measurement available 1: deselected by user via the **`setSatelliteUsage`** or **`setElevationMask`** command 2: no differential correction available (not applicable in stand alone mode) 3: signal not healthy. If the PVT status for a given signal is 1, the corresponding info code can take the following values: 0: ephemeris not yet available 1: ephemeris outdated 2: IODE mismatch between base and rover (not applicable in stand alone mode). 3: reserved for future use. If the PVT status for a given signal is 2, the corresponding info code is always 0. If the PVT status for a given signal is 3, the corresponding info code can take the following values: 0 : outlier detected 1-3: reserved for future use.
Padding	u1[..]			Padding bytes, see 2.5

ReceiverStatus (v2)	Number: 4014 "OnChange" interval: every second

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

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
CPULoad	u1	1 %	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, ExtSensor-Error**" for details.
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. On PolaRxS receiver, this bit is always set. 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. If the logging rate is larger than 1 Hz, set continuously. bit 8: DISK_FULL: this bit is set when the internal disk is full. bit 9: DISK_MOUNTED: this bit is set when the internal disk 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.

rev1

			Bit 11 through 31 are reserved and should be ignored.
`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 watch-dog 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 EVENT*x* 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 User Manual. bit 10: INVALIDCONFIG: set if one or more configuration file (permission or channel configuration) is invalid or absent. bit 11: OUTOFGEOFENCE: set if the receiver is currently out of its permitted region of operation (geo-fencing).
`N`	u1		Number of `AGCState` sub-blocks this block contains.
`SBLength`	u1	1 byte	Length of the sub-blocks in bytes.
`Reserved`	u1[2]		Reserved for future use.
`N AGCData sub-blocks`	…	…	See `AGCData` definition below.
`Padding`	u1[..]		Padding bytes, see 2.5

`AGCData` definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
`FrontendID`	u1			Bit field indicating the frontend code and antenna ID: Bit 0-4: frontend code: 0: GPS/SBAS/Galileo L1 1: GLONASS L1 2: Galileo E6 3: GPS L2 4: GLONASS L2 5: GPS/SBAS/Galileo L5/E5a 6: Galileo E5b 7: Galileo E5 (a+b) 8: Combined GPS/GLONASS/SBAS/Galileo L1 9: Combined GPS/GLONASS L2 Bit 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 (v1)	Number: 4012 "OnChange" interval: every second

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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
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 *sub-blocks*	…	…	See SatInfo definition below
Padding	u1[..]		Padding bytes, see 2.5

SatInfo definition:

Parameter	Type	Units & Scale Factor	Do-Not-Use Value	Description
SVID	u1		62	Satellite ID and frequency number, see 2.9
FreqNr	u1		0	
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: 255: elevation rate unknown; 0: satellite setting; 1: satellite rising.
SatelliteInfo	u1			Satellite visibility info based on: 255: unknown; 1: almanac; 2: ephemeris.
Padding	u1[..]			Padding bytes, see 2.5

InputLink (v1)	Number: 4090 "OnChange" interval: every second

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;
- de-activation 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	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
N	u1		Number of connection descriptors for which communication link statistics are included
SBLength	u1	1 byte	Length of one sub-block
N InputStats sub-blocks	…	…	See InputStats definition below
Padding	u1[..]		Padding bytes, see 2.5

InputStats definition:

Parameter	Type	Units & Scale Factor	Description
CD	u1		Bit field identifying the connection to which these statistics apply: bits 0-4: connection index (starting from 1 for COM, USB and DSK connections, and from 0 for TCP/IP connections). bits 5-7: connection type: 0: COM connections 1: USB connections 2: IP connections 3: DSK connections
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)
AgeOfLastMessage	u2	1 s	Age of the last accepted message. If the age is older than 65534s, it is clipped to 65534s.
NrBytesReceived	u4	1 byte	Total number of bytes received*
NrBytesAccepted	u4	1 byte	Total number of bytes* 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.
`NrMsgReceived`	u4	1 message	Total number of messages of type `Type` received.
`NrMsgAccepted`	u4	1 message	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
`Padding`	u1[..]		Padding bytes, see 2.5

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

OutputLink (v1)	Number: 4091 "OnChange" interval: every second

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;
- de-activation of a connection descriptor, e.g. on disconnection of USB or IP ports;
- change of COM port settings.

There is one OutputStats sub-block per connection descriptor for which statistics is available. Each OutputStats sub-block is followed by a number of OutputType 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 OutputType sub-block.

Parameter	Type	Units & Scale Factor	Description
Sync	c1[2]		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
N1	u1		Number of sub-blocks in this OutputLink block.
SB1Length	u1	1 byte	Length of one OutputStats sub-block
SB2Length	u1	1 byte	Length of one OutputType sub-block
Reserved	u1[3]		Reserved for future use
sub-blocks	…	…	A succession of OutputStats and OutputType sub-blocks, see definition below.
Padding	u1[..]		Padding bytes, see 2.5

OutputStats definition:

Parameter	Type	Units & Scale Factor	Description
CD	u1		See corresponding field in the InputLink SBF block
N2	u1		Number of OutputType sub-blocks that follow after this OutputStats sub-block
AllowedRate	u2	1 kbyte/s	Maximum datarate recommended on this connection
NrBytesProduced	u4	1 byte	Total number of bytes produced by the receiver
NrBytesSent	u4	1 byte	Total number of bytes actually sent (i.e. without congestions or transmittion errors). The ratio of NrBytesSent to NrBytesProduced gives an indication of the amount of bandwidth overload.
Padding	u1[..]		Padding bytes, see 2.5

OutputType definition:

Parameter	Type	Units & Scale Factor	Description
Type	u1		Type of data: see corresponding field in the InputLink SBF block
Percentage	u1		Percentage of the produced bytes that belong to this type (during the last second)
Reserved	u1[2]		Reserved for future use
Padding	u1[..]		Padding bytes, see 2.5

3.16 Miscellaneous Blocks

ReceiverSetup (v1)	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	Description
	Sync	u2		Block Header, see 2.1
	CRC	u2		
	ID	u2		
	Length	u2	1 byte	
	TOW	u4	0.001 s	Receiver time stamp, see 2.3
	WNc	u2	1 week	
	Reserved	u1[2]		2 bytes reserved for future use, set to 0
	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
rev1	MarkerType	c1[20]		Marker type, this is a 20-character string, right padded with zeros
rev2	GNSSFWVersion	c1[40]		Version tag of the GNSS firmware installed on the receiver. This is a 40-character string, right padded with zeros.
rev3	ProductName	c1[40]		Product name. This is a 40-character string, right padded with zeros.
	Padding	u1[..]		Padding bytes, see 2.5

Commands (v1)	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	Description
Sync	u2		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
Reserved	u1[2]		Reserved for future use, set to 0.
CmdData	u1[n]		Command data, this is the command in the SNMP' format. Refer to the SNMP' Reference Guide.
Padding	u1[..]		Padding bytes, see 2.5

Comment (v1)	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	Description
Sync	u2		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	Receiver time stamp, see 2.3
WNc	u2	1 week	
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 (v1)	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	Description
Sync	u2		Block Header, see 2.1
CRC	u2		
ID	u2		
Length	u2	1 byte	
TOW	u4	0.001 s	External time stamp, see 2.3.
WNc	u2	1 week	
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, set to 0.
Reserved	u1[3]		Reserved for future use, set to 0.
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

3.17 Index Of Blocks