4.2 SBF Block Definitions

4.2.1 Measurement Blocks

GNSS observables are available in the following SBF blocks:

- the legacy `MeasEpoch` block, possibly complemented by `MeasExtra`.
- the `Meas3Ranges` block, possibly complemented by `Meas3Doppler` and `Meas3CN0HiRes`.

The `MeasEpoch` block contains pseudorange, carrier phase, C/N0 and Doppler observables. The `Meas3Ranges` block contains pseudoranges, carrier phases and C/N0, while Doppler is available in the companion `Meas3Doppler` block. The observable resolution is shown in the table below.

	`MeasEpoch`	`Meas3Ranges`
Pseudorange	1mm	1mm
Carrier phase	0.001cycles	0.001cycles
C/N0	0.25dB-Hz 0.03125dB-Hz with `MeasExtra`	1dB-Hz 0.0625dB-Hz with `Meas3CN0HiRes`
Doppler	0.0001Hz	No Doppler in `Meas3Ranges` 1mm/s with `Meas3Doppler`

The main advantage of the `Meas3` blocks is their reduced size compared to the `MeasEpoch` blocks. As an illustration, the following table shows the disk space required to log the different measurement-related blocks over one day at a 1-s interval. In this example, measurements from all GPS L1/L2/L5, GLONASS L1/L2, Galileo E1/E6/E5a/E5b and BeiDou B1/B2/B3 signals have been logged (constellation status as of beginning of 2017).

SBF Block	Disk space (1 day, 1 Hz)
`MeasEpoch`	104MB
`MeasExtra`	110MB
`Meas3Ranges`	28MB
`Meas3Doppler`	10MB
`Meas3CN0HiRes`	5MB

MeasEpoch	Number: 4027 "OnChange" interval: internal measurement rate (receiver-type dependent)

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

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

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

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

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

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

Decoding is done as follows:

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

Note that measurements in this block are scrambled if the "Measurement Availability" permission is not granted on your receiver. See also bit 7 of the CommonFlags field.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
N1	u1			Number of MeasEpochChannelType1 sub-blocks in this MeasEpoch block.
SB1Length	u1	1 byte		Length of a MeasEpochChannelType1 sub-block, excluding the nested MeasEpochChannelType2 sub-blocks
SB2Length	u1	1 byte		Length of a MeasEpochChannelType2 sub-block
CommonFlags	u1			Bit field containing flags common to all measurements. Bit 0: Multipath mitigation: if this bit is set, multipath mitigation is enabled. (see the **setMultipathMitigation** command). Bit 1: Smoothing of code: if this bit is set, at least one of the code measurements are smoothed values (see **setSmoothingInterval** command). Bit 2: Carrier phase align: if this bit is set, the fractional part of the carrier phase measurements from different modulations on the same carrier frequency (e.g. GPS L2C and L2P) are aligned, i.e. multiplexing biases (0.25 or 0.5 cycles) are corrected. Aligned carrier phase measurements can be directly included in RINEX files. If this bit is unset, this block contains raw carrier phase measurements. This bit is always set in the current firmware version. Bit 3: Clock steering: this bit is set if clock steering is active (see **setClockSyncThreshold** command). Bit 4: Not applicable. Bit 5: High dynamics: this bit is set when the receiver is in high-dynamics mode (see the **setReceiverDynamics** command). Bit 6: Reserved Bit 7: Scrambling: bit set when the measurements are scrambled. Scrambling is applied when the "Measurement Availability" permission is not granted (see the **lif,Permissions** command).
CumClkJumps	u1	0.001 s		Cumulative millisecond clock jumps since start-up, with an ambiguity of k*256 ms. For example, if two clock jumps of -1 ms have occurred since startup, this field contains the value 254.
Reserved	u1			Reserved for future use, to be ignored by decoding software
Type1	...	...		*A succession of N1 MeasEpochChannelType1 sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 4.1.5

Rev 1

MeasEpochChannelType1 sub-block definition:

Parameter	Type	Units	Do-Not-Use	Description
RxChannel	u1			Receiver channel on which this satellite is currently tracked (see 4.1.11).
Type	u1			Bit field indicating the signal type and antenna ID: Bits 0-4: SigIdxLo: if not 31, this is the signal number (see 4.1.10), otherwise the signal number can be found in the ObsInfo field below. Bits 5-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*

SVID	u1			Satellite ID, see 4.1.9
Misc	u1	4294967.296 m	0 (1)	Bit field containing the MSB of the pseudorange. Bits 0-3: CodeMSB: MSB of the pseudorange (this is an unsigned value). Bits 4-7: Reserved
CodeLSB	u4	0.001 m	0 (1)	LSB of the pseudorange. The pseudorange expressed in meters is computed as follows: PR_{type1}[m] = (CodeMSB*4294967296+CodeLSB)*0.001 where CodeMSB is part of the Misc field.
Doppler	i4	0.0001 Hz	−2147483648	Carrier Doppler (positive for approaching satellites). To compute the Doppler in Hz, use: D_{type1}[Hz] = Doppler*0.0001
CarrierLSB	u2	0.001 cycles	0 (2)	LSB of the carrier phase relative to the pseudorange
CarrierMSB	i1	65.536 cycles	−128 (2)	MSB of the carrier phase relative to the pseudorange. The full carrier phase can be computed by: L[cycles] = PR_{type1}[m]/λ +(CarrierMSB*65536+CarrierLSB)*0.001 where λ is the carrier wavelength corresponding to the frequency of the signal type in the Type field above: λ=299792458/f_L m, with f_L the carrier frequency as listed in section 4.1.10.
CN0	u1	0.25 dB-Hz	255	The C/N0 in dB-Hz is computed as follows, depending on the signal type in the Type field: C/N_0[dB-Hz] = CN0*0.25 if the signal number is 1 or 2 C/N_0[dB-Hz] = CN0*0.25+10 otherwise Users requiring a higher C/N0 resolution can use the MeasExtra SBF block. The Misc field of that block allows to extend the resolution to 0.03125dB-Hz.
LockTime	u2	1 s	65535	Duration of continuous carrier phase. The lock-time is reset at the initial lock of the phase-locked-loop, and whenever a loss of lock condition occurs. If the lock-time is longer than 65534s, it is clipped to 65534s. If the carrier phase measurement is not available, this field is set to its Do-Not-Use value.
ObsInfo	u1			Bit field: Bit 0: if set, the pseudorange measurement is smoothed Bit 1: Reserved Bit 2: this bit is set when the carrier phase (L) has a half-cycle ambiguity Bits 3-7: The interpretation of these bits depends on the value of SigIdxLo from the Type field. If SigIdxLo equals 31, these bits contain the signal number with an offset of 32 (see 4.1.10). For example, a value of 1 corresponds to signal number 33 (QZSS L1S). If SigIdxLo is 8, 9, 10 or 11, these bits contain the GLONASS frequency number with an offset of 8. For example, a value of 1 corresponds to frequency number -7. Otherwise, these bits are reserved.
N2	u1			Number of MeasEpochChannelType2 sub-blocks contained in this MeasEpochChannelType1 sub-block.

(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.

Padding	u1[..]			Padding bytes, see 4.1.5
Type2	...	...		*A succession of N2 MeasEpochChannelType2 sub-blocks, see definition below*

MeasEpochChannelType2 sub-block definition:

Parameter	Type	Units	Do-Not-Use	Description
Type	u1			Bit field indicating the signal type and antenna ID: Bits 0-4: SigIdxLo: if not 31, this is the signal number (see 4.1.10), otherwise the signal number can be found in the ObsInfo field below. Bits 5-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
LockTime	u1	1 s	255	See corresponding field in the MeasEpochChannelType1 sub-block above, except that the value is clipped to 254 instead of 65534.
CN0	u1	0.25 dB-Hz	255	See corresponding field in the MeasEpochChannelType1 sub-block above.
OffsetsMSB	u1	 65.536 m 6.5536 Hz	 −4 (3) −16 (4)	Bit field containing the MSB of the code and of the Doppler offsets with respect to the MeasEpochChannelType1 sub-block. Bits 0-2: CodeOffsetMSB: MSB of the code offset. Bits 3-7: DopplerOffsetMSB: MSB of the Doppler offset. CodeOffsetMSB and DopplerOffsetMSB are coded as two's complement. Refer to the CodeOffsetLSB and DopplerOffsetLSB fields to see how to use this field.
CarrierMSB	i1	65.536 cycles	−128 (5)	MSB of the carrier phase relative to the pseudorange.
ObsInfo	u1			Bit field: Bit 0: if set, the pseudorange measurement is smoothed Bit 1: Reserved Bit 2: this bit is set when the carrier phase (L) has a half-cycle ambiguity Bits 3-7: If SigIdxLo from the Type field of this sub-block equals 31, these bits contain the signal number with an offset of 32 (see 4.1.10), e.g. 1 corresponds to signal number 33 (QZSS L1S). Otherwise they are reserved and must be ignored by the decoding software.
CodeOffsetLSB	u2	0.001 m	0 (3)	LSB of the code offset with respect to pseudorange in the MeasEpochChannelType1 sub-block. To compute the pseudorange, use: PR_{type2} [m] = PR_{type1}[m] + (CodeOffsetMSB*65536+CodeOffsetLSB)*0.001
CarrierLSB	u2	0.001 cycles	0 (5)	LSB of the carrier phase relative to the pseudorange. The full carrier phase can be computed by: L[cycles]= PR_{type2}[m]/λ +(CarrierMSB*65536+CarrierLSB)*0.001 where λ is the carrier wavelength corresponding to the signal type in the Type field.

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

DopplerOffsetLSB	u2	0.0001 Hz	0 (4)	LSB of the Doppler offset relative to the Doppler in the MeasEpochChannelType1 sub-block. To compute the Doppler, use: D_{type2}[Hz] = D_{type1}[Hz]*α +(DopplerOffsetMSB*65536+DopplerOffsetLSB) *1e-4, where α is the ratio of the carrier frequency corresponding to the observable type in this MeasEpochChannelType2 sub-block, and that of the master observable type in the parent MeasEpochChannelType1 sub-block (see section 4.1.10 for a list of all carrier frequencies).
Padding	u1[..]			Padding bytes, see 4.1.5

MeasExtra	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	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
N	u1			Number of sub-blocks in this MeasExtra block.
SBLength	u1	1 byte		Length of a sub-block
DopplerVarFactor	f4	1 Hz^2 / $cycle^2$		Factor to be used to compute the Doppler variance from the carrier phase variance. More specifically, the Doppler variance in mHz^2 can be computed by: $\sigma^2_{\text{Doppler}}[\text{mHz}^2]$ = CarrierVariance * DopplerVarFactor, Where CarrierVariance can be found for each measurement type in the MeasExtraChannelSub sub-blocks.
ChannelSub	...	...		*A succession of N MeasExtraChannelSub sub-blocks, see definition below*
Padding	u1[..]			Padding bytes, see 4.1.5

`MeasExtraChannelSub` sub-block definition:

	Parameter	Type	Units	Do-Not-Use	Description
	`RxChannel`	u1			Receiver channel on which this satellite is currently tracked (see 4.1.11).
	`Type`	u1			Bit field indicating the signal type and antenna ID: Bits 0-4: `SigIdxLo`: if not 31, this is the signal number (see 4.1.10), otherwise the signal number can be found in the `Misc` field below. A value of 31 can only happen on block revision 3 or above. Bits 5-7: Antenna ID: 0 for main, 1 for *Aux1* and 2 for *Aux2*
	`MPCorrection`	i2	0.001 m		Multipath correction applied to the pseudorange. This number has to be added to the pseudorange to recover the raw pseudo-range as it would be if multipath mitigation was not used.
	`SmoothingCorr`	i2	0.001 m		Smoothing correction applied to the pseudorange. This number has to be added to the pseudorange to recover the raw pseudo-range as it would be if smoothing was disabled.
	`CodeVar`	u2	0.0001 m^2	65535	Estimated code tracking noise variance. If the variance is larger than 65534 cm^2, it is clipped to 65534 cm^2.
	`CarrierVar`	u2	1 $mcycle^2$	65535	Estimated carrier tracking noise variance. This value can be multiplied by `DopplerVarFactor` to compute the Doppler measurement variance. If the variance is larger than 65534 $mcycles^2$, it is clipped to 65534 $mcycles^2$.
	`LockTime`	u2	1 s	65535	Duration of continuous carrier phase. The lock-time is reset at the initial lock after a signal (re)acquisition. If the lock-time is longer than 65534s, it is clipped to 65534s. If the carrier phase measurement is not available, this field is set to its Do-Not-Use value.
Rev 1	`CumLossCont`	u1			Carrier phase cumulative loss-of-continuity counter (modulo 256) for the signal type, antenna and satellite this sub-block refers to. This counter starts at zero at receiver start-up, and is incremented at each initial lock after signal (re)acquisition, or when a cycle slip is detected.
Rev 1	`CarMPCorr`	i1	1.953125 mcycle		Multipath correction applied to the carrier phase, in units of 1/512 cycles. This number has to be added to the carrier phase to recover the raw phase as it would be if multipath mitigation was not used.
Rev 2	`Info`	u1			Bit field: Bits 0-3: Reserved. Bits 4-7: Reserved.
Rev 3	`Misc`	u1	0.03125 dB-Hz		Bit field: Bits 0-2: `CN0HighRes`: high-resolution extension of the C/N0 (unsigned value from 0 to 7). The C/N0 value in the `MeasEpoch` SBF block has a resolution of 0.25dB-Hz. `CN0HighRes` can be used to extend the resolution to 0.03125dB-Hz. The high-resolution C/N0, in dB-Hz, is computed as follows: $C/N_{0,\mathrm{HighRes}} = C/N_{0,\mathrm{MeasEpoch}} + \mathrm{CN0HighRes} * 0.03125$. where $C/N_{0,\mathrm{MeasEpoch}}$ is the C/N0 value coming from the `MeasEpoch` SBF block. Bits 3-7: If `SigIdxLo` from the `Type` field equals 31, these bits contain the signal number with an offset of 32 (see 4.1.10). Otherwise they are reserved.

Padding	u1[..]			Padding bytes, see 4.1.5

Meas3Ranges	Number: 4109 "OnChange" interval: internal measurement rate (receiver-type dependent)

This block contains all the code, carrier phase and C/N0 observables at a given measurement epoch. The resolution is 0.001m, 0.001cycles and 1dB-Hz for the code, carrier and C/N0 measurements respectively.

Applications requiring Doppler measurements can log the Meas3Doppler SBF block in addition to the Meas3Ranges block. Applications requiring extended C/N0 resolution (1/16dB-Hz) can log the Meas3CN0HiRes SBF block in addition to the Meas3Ranges block.

The advantage of this block compared to the MeasEpoch SBF block is its reduced size while offering the full resolution for the code and carrier measurements. One of the techniques used to reduce the size is to only encode full measurements (reference epochs) every N epochs. Between these reference epochs, Meas3Ranges contains delta epochs where the difference between the current measurements and the ones at the applicable reference epoch is encoded. The decoder must have received and stored the applicable reference epoch to be able to decode delta epochs. When streaming SBF over an unreliable communication link, if the reference epoch is lost, subsequent Meas3Ranges blocks cannot be decoded until the next reference epoch is received. The interval at which reference epochs are encoded can be controlled with the **setMeas3MaxRefInterval** command. A longer interval generally reduces the average block size, at the expense of a longer data gap in case a reference epoch is lost.

See also page 238 for additional information.

The format of this block and of the other Meas3 blocks is complex and is not provided here. Details can be obtained from Septentrio Support. The RxTools installation contains the complete source code of a decoder in C language, together with sbf2asc, a small application showing how to use it. All C files can be found under the sbf2asc folder in the RxTools installation. The main measurement decoding function is sbfread_MeasCollectAndDecode() in the sbfread_meas.c file. Users interested in decoding the Meas3 blocks are strongly advised to use the provided source code instead of writing their own decoder.

The detailed definition of this block is not available in this document.

Meas3CN0HiRes	Number: 4110 "OnChange" interval: internal measurement rate (receiver-type dependent)

The Meas3CN0HiRes block is an extension of the Meas3Ranges block containing the fractional part of the C/N0 values. The resolution of the C/N0 value in the Meas3Ranges SBF block is 1dB-Hz. Applications requiring a finer C/N0 resolution (0.0625dB-Hz) must log the Meas3CN0HiRes block together with the Meas3Ranges block.

The detailed definition of this block is not available in this document.

Meas3Doppler	Number: 4111 "OnChange" interval: internal measurement rate (receiver-type dependent)

The Meas3Doppler block is an extension of the Meas3Ranges block containing the range-rate (Doppler) values. Applications requiring range-rate or Doppler observables must log the Meas3Doppler block together with the Meas3Ranges block.

The detailed definition of this block is not available in this document.

Meas3PP	Number: 4112 "OnChange" interval: internal measurement rate (receiver-type dependent)

The Meas3PP block is an extension of the Meas3Ranges block containing various Septentrio-proprietary flags and values needed for accurate post-processing or re-processing of the PVT from the measurements in the Meas3Ranges SBF block. This block must be logged together with Meas3Ranges.

The detailed definition of this block is not available in this document.

Meas3MP	Number: 4113 "OnChange" interval: internal measurement rate (receiver-type dependent)

The Meas3MP block is an extension of the Meas3Ranges block containing the multipath correction applied by the receiver. It can be used for research purposes to undo the receiver multipath mitigation and revert to unmitigated data. This block must be logged together with Meas3Ranges.

The detailed definition of this block is not available in this document.

EndOfMeas	Number: 5922 "OnChange" interval: 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	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	