



Geo++[®]
State Space Representation
Format (SSRZ)

Geo++[®] SSRZ

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Abbreviations

GNSS	Global Navigation Satellite System
LR	Low Rate Message
HR	High Rate Message
GRI	Gridded Ionosphere Correction Message
GRT	Gridded Troposphere Correction Message
RSI	Satellite-dependent Regional Ionosphere Correction Message
GVI	Global VTEC Ionosphere Correction Message
RT	Regional Troposphere Correction Message
QIX	QIX Bias Message
RINEX	Receiver Independent Exchange Format
RTCM	Radio Technical Commission for Maritime Services
SSM	State Space Monitoring
SSR	State Space Representation
SSRM	SSR Model
SSRZ	SSR Compressed Format
TEC	Total Electron Content
VTEC	vertical TEC
STEC	slant TEC
QIX	Intra Frequency Inter Signal Biases (e.g. between GPS L5 Q, I and X signals)
ID	Identifier
ICD	Interface Control Document
IOD	Issue Of Data
PC	Phase Center
PCV	Phase Center Variation
SRP	Satellite Reference Point
IODE	Issue Of Ephemeris Data
LSB	Least Significant Bit
PC()	Prefix Code
CS	Cycle Slip
OF	Overflow

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1 State Space – General

The principle of the state space concept is to provide information on individual error sources acting on Global Navigation Satellite Systems (GNSS) signals. These error states can then be used to enable improved positioning for a rover. This approach to generate and represent GNSS corrections is called “State Space Representation” (SSR).

The SSR state vector consists of the following parameters:

- satellite orbit errors
- satellite clock errors
- satellite signal biases
- ionospheric parameters
- tropospheric parameters

Satellite orbit and clock errors are improvements to the broadcast information provided by a GNSS. Satellite signal biases are delays of the code and carrier phase components of GNSS signals, originating within satellite hardware and software. The ionospheric and tropospheric parameters describe the effect of the atmosphere on the propagation of GNSS signals.

SSR consists of state space parameters that consistently describe the corresponding error budget for GNSS positioning purposes. Additional corrections may be applicable.

2 State Space Representation - Compressed Format (SSRZ)

The SSR parameters typically have temporal and/or spatial variations. These variations are modeled by the SSR generating server application with a State Space Model (SSM). Different servers may use different models and the models can change, for example due to progress in state of the art GNSS techniques.

The idea of SSRZ is to describe the variations of the SSR parameters in a compressed and compact format. SSRZ gives the flexibility to adopt to the used SSM and parameters whenever it is appropriate or required but leaves the external representation (SSRZ) unchanged.

Some parameters of the SSR do have spatial variations. Spatially changing SSR parameters are defined for a grid of ground points. The grid size must be designed in such a way that simple interpolation algorithms can be used to predict the parameters for any position within the service area.

3 SSRZ Compressed Format Concepts

The SSRZ format is designed to generate a data stream with a constant and low bandwidth (bits/second). The compression and bandwidth optimization concepts are:

1. **Separation between SSR correction and metadata messages** – almost all constant parameters are avoided in the actual correction streaming format and transmitted in metadata messages.
2. **Scaling SSR in time domain** – bundling different SSR parameters according to their update rate.
3. **Distributing SSR to Satellite Groups** – satellite-dependent parameters are generated for different predefined sets of satellites.
4. **QIX biases** describe the systematic difference of satellite-specific signal delays between different signals at the same frequency. In SSRZ the QIX biases avoid the transmission of absolute values per supported signal.
5. **One Reference Code Bias per GNSS**
6. **Multi-Stage Atmospheric Corrections** – atmospheric corrections are divided into functional and residual parts with different spatial scales.
7. **Rice Encoded Data Blocks** – the Rice encoder in combination with additional SSR parameter specific grouping attributes are used for compression.

They are described in more detail in the remainder of this section.

3.1 Separation between SSR correction and metadata messages

Certain definitions and constant parameters relevant to a specific GNSS SSR correction service are located in the SSRZ Metadata. The SSRZ Metadata can be offline information (published by the Service provider) or provided by an SSRZ Metadata message online or distributed within the correction stream at a low transmission rate using the SSRZ Metadata message. The SSRZ Metadata consists of essential parameters that are needed to decode SSRZ data and offers flexibility for service providers to decide on correction model size and correction data resolution.

3.2 Scaling SSR in time domain

The individual SSR parameters change with different rates. In general, the satellite clock errors vary faster than other components. The adjustment of individual update rates of the different SSR components can drastically reduce the bandwidth requirement while keeping the same quality. For this purpose, the SSRZ format consists of low rate and high rate messages.

There are five relevant parameters in SSRZ:

- the length of SSR update interval T_{update} ,
- the offset of SSR update interval T_{offset} ,
- the transmission interval T_{trans} ,
- the transmission rate R_{trans}
- and the transmission date(s) t_{trans} .

The first two parameters are closely related to the SSR generating side (Figure 1). The length of an SSR update interval corresponds to the nominal validity of the SSR parameters. The offset of SSR update interval corresponds to a time difference between the beginning of an SSR update interval and a reference time. The generating process has to generate the SSR parameters according to T_{update} and T_{offset} continuously.

The three timing parameters are related to the data stream settings. The transmission interval T_{trans} indicates the maximum duration to transmit SSRZ corrections. The length of the transmission interval must be shorter than the length of the high rate clock update interval to guarantee the availability SSRZ corrections to ensure a consistent SSR data set.

The transmission rate R_{trans} indicates how often an SSRZ message is sent. The minimum transmission rate is identical to inverse of the length of SSR update interval. Higher transmission rates are allowed and provide the possibility to increase integrity by repeating the transmission of identical SSR parameters, reducing the risk of loss data. The transmission date t_{trans} of a new (updated) SSR correction message is in accordance with the offset of SSR update interval of the SSR parameters within the message (Figure 2).

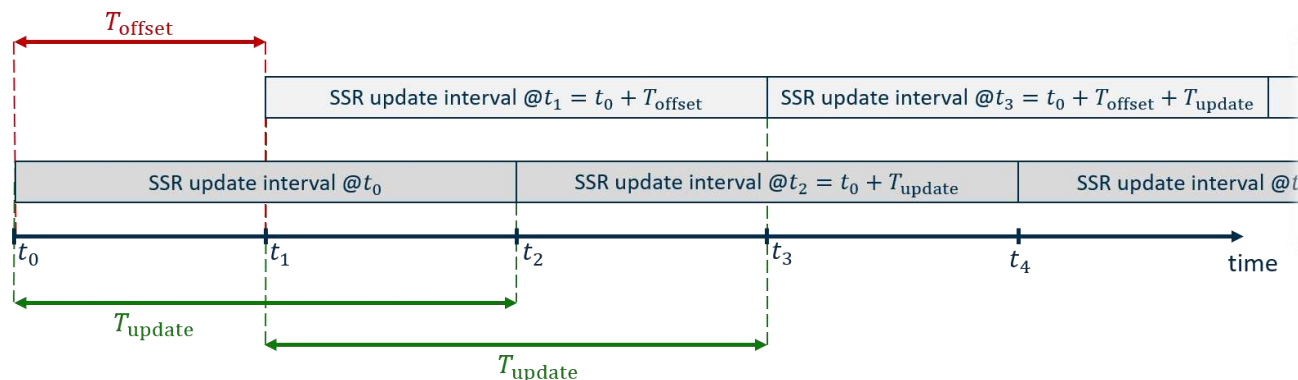


Figure 1 Scheme of length and offset of SSR update interval, T_{update} and T_{offset} , respectively.

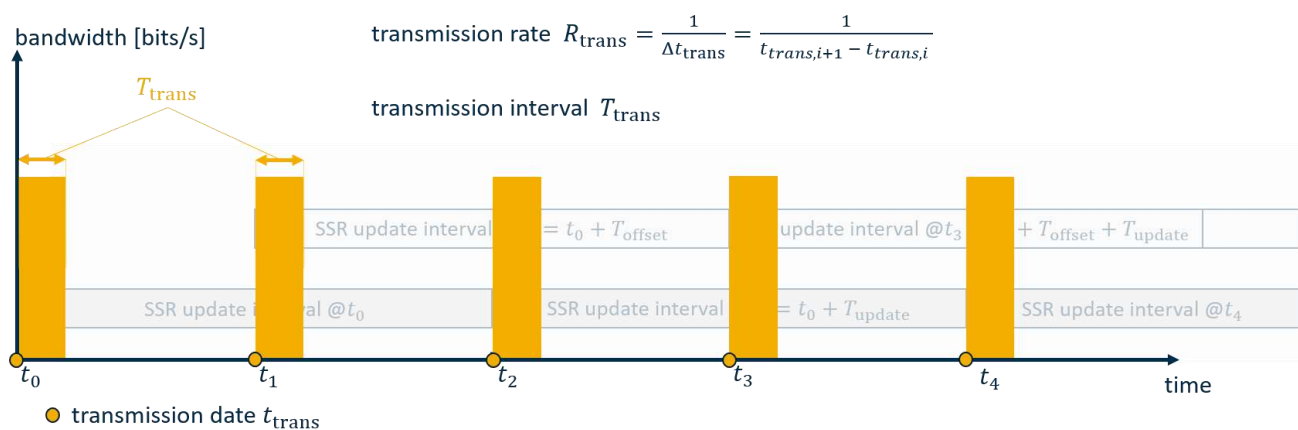


Figure 2 Sketch of transmission timing parameters. The first transmission date of an (updated) SSRZ message has to be aligned with the beginning of the corresponding SSR update interval. Thus, the minimum transmission rate R_{trans} of one (specific) SSRZ message is one message per length of SSR update interval. The transmission interval T_{trans} is the message transfer duration between transmission and reception time and depends on the total number of bits per message and the available bandwidth.

3.3 Distributing SSR to Satellite Groups

Some of the SSR parameters are satellite dependent. As an additional bandwidth optimization concept these SSR parameters can be transmitted for subsets of satellites with identical or different update and offset intervals. This strategy avoids data bursts at the beginning of an update interval.

A subset of satellites is called Satellite Group and can be defined as a list of Satellite IDs or by a predefined formation/grouping rule. A Satellite Group can contain satellites from one or more GNSS. The maximum number of satellites considered per group is defined by the service settings. Each Satellite Group has its own ID.

Satellite Groups are defined for high rate and low rate messages separately to allow flexible and optimized combinations of different Satellite Groups. The combination of Satellite Groups is controlled by the **Satellite Group List** that represents a list of Satellite Group IDs that will be considered in the SSRZ message. Thus, besides the timing parameters (introduced in 3.2) the **Satellite Group List** is an additional mechanism to control satellite-dependent SSRZ messages. In the context of Satellite Groups, the term high rate refers to the SSRZ High Rate message and low rate to all other satellite-related messages.

3.4 QIX Biases

In general, the SSRZ supports all accessible GNSS signals. QIX biases describe the systematic difference between satellite-specific signal delays for different signals at the same frequency. Thus, if the SSR (signal) biases from one signal per GNSS and frequency are known (this signal is named reference signal) the signal biases of the remaining signals for the same frequency can be computed using QIX bias information. While the signal biases of the reference signals are transmitted in an SSRZ Low Rate message (containing the RTK corrections) the QIX biases are transmitted in a separate message.

3.5 Clock compensation of one Code Bias per GNSS

The number of transmitted code bias values can be reduced by compensation of one code bias by the clock correction. One zero-code signal per GNSS can be flagged in the metadata and the corresponding correction will not be transmitted.

3.6 Multi-Stage Atmospheric Corrections

SSRZ supports multi-stage ionospheric and tropospheric corrections. Multi-Stage models utilize different messages for the same GNSS error component. The constituents from different messages are added. The different stages are required to represent the spatial variations on different scales and thus to enable different service applications/accuracies. SSRZ supports up to four ionosphere stages and up to three troposphere stages for the wet, dry, and their combined part.

3.6.1 Ionospheric Multi-Stage Model

The four possible ionospheric correction stages are

- Global VTEC Ionosphere Correction (Global VTEC (vertical TEC))
- Satellite-dependent Global Ionosphere Correction STEC (Global STEC (slant TEC))
- Satellite-dependent Regional Ionosphere Correction (Regional STEC)
- Gridded Ionosphere Correction (gridded STEC).

The abbreviation STEC always implies the satellite-dependent character of the corrections – However, for the sake of bandwidth optimization, all ionosphere correction values are transmitted as vertical-mapped values. The first three stages model functional parts of the ionosphere while the last stage describes the residuals between those functional parts and the observations. Different combinations of these stages are possible. For instance, the total ionospheric influence within in the network can be represented by the gridded STEC only.

3.6.2 Tropospheric Multi-Stage Model

A three-stage model of the troposphere is supported in SSRZ:

- Global Troposphere
- Regional Troposphere
- Gridded/residual/ site Troposphere

Each troposphere stage can be associated with the either the wet, dry, or dry-wet-combination part of the troposphere model in order to take the different spatial scales of these components into account. In general, troposphere corrections are represented as scale factors with respect to the troposphere reference model.

3.7 SSRZ Rice Encoded Data Blocks

3.7.1 Rice Encoder

The SSRZ format uses the Rice encoding algorithm (Rice (1972)) for data compression. It is a realization of an entropy encoder that allows lossless data compression.

The implementation of a Rice encoding algorithm relies on the so-called bin size parameter p , known to both encoder and decoder. A positive integer n is then encoded as the tuple (q, r) where:

$$n = 2^p q + r \quad (3.1)$$

$$q = \lfloor n/2^p \rfloor \quad (3.2)$$

$$r = n - 2^p q \quad (3.3)$$

The value of q is unary coded (i.e. q times '1' bits followed by one '0' bit) and r is binary coded with p bits (truncated binary coding).

In the SSRZ format an additional sign bit is used to cover negative integer ranges. The resulting *negative zero* (-0) is used as a general **invalid value indicator**.

3.7.2 SSRZ Rice Block

The SSR parameters are usually float values x and are transformed into integers based on a predefined scale factor resolution dx

$$x = n \cdot dx \quad (3.4)$$

To reduce static and redundant information while maintaining flexibility in the SSRZ correction messages, both, the scale factor dx and the bin size parameter p are substituted by the parameters dx_0 , a and p_0 , b , respectively:

$$dx = 2^a dx_0 \quad (3.5)$$

$$p = p_0 + b \quad (3.6)$$

The **Default Resolution** dx_0 and the **Default Bin Size Parameter** p_0 are static (Default Rice) parameters and will be part of the SSRZ metadata. The **Scale Factor Indicator** a is an unsigned integer value and gives the possibility to reduce the scaling factor and therefore the numerical resolution. This feature can be used, e.g., to respond to (apparently) decreasing bandwidth or increasing amount of data while providing full service with diminished accuracy.

The value of the bin size parameter strongly depends on the variation of the data to be compressed. In the SSRZ format the bin size parameter is a dynamic parameter and determined by the minimum number of bits needed for the compression of the data. The **Bin Size Indicator** b is an unsigned integer value and indicates the difference between the used and default bin size parameter.

Both the SSRZ Resolution Indicator a and the SSRZ Bin Size Indicator b are dynamical/adaptive parameters. Together with the N_{data} encoded data, they compose a so-called SSRZ *Rice-Block* (Table 3.1). The **Number of data values to be compressed** (N_{data}) must be known. This parameter is dynamically derived from metadata settings and the number of supported satellites, respectively.

Table 3.1 SSRZ Rice Block and corresponding Metadata

SSRZ Metadata (static parameters)			SSRZ Rice Block		
Default Rice Parameters			Adaptive Rice Parameters		
Default Resolution	Default Bin Size Parameter		Scale Factor Indicator	Bin Size Indicator	N_{data} data
dx_0	p_0		a	b	0101101 ...

3.7.3 SSRZ Rice encoded SSR Parameter Blocks

In general, an entropy encoder is most efficient when encoding data with similar/comparable statistical properties. If two subsets of data with two distinct statistics are encoded together, the Bin Size Parameter p is dominated by the subset with the larger variation. Thus, the subset with the lower variation is inefficiently encoded.




In SSR context, the statistical properties of the SSR parameters are closely related to the GNSS, mathematical representations (orders) and grid properties. To optimize the data compression of SSR parameters, the SSRZ format defines different **Rice encoded SSR Parameter Blocks** taking these specific influences as **attributes** into account.

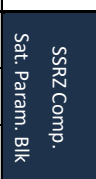
3.7.3.1 SSRZ Compressed Satellite Parameter Block

Satellite-dependent correction parameters (e.g. clock and orbit corrections) of satellites from different GNSS may possess different statistical properties. To optimize the data compression of these parameters independently from the transmitted satellites the *SSRZ Compressed Satellite Parameter Block* includes SSRZ Rice Blocks that include Rice-encoded data from all, a group or individual GNSS. The number of SSRZ Rice Blocks is denoted as N_{RB} . Table 3.2 illustrates the concept of the SSRZ Compressed Satellite Parameter Block and required metadata.

Table 3.2 SSRZ Compressed Satellite Parameter Block

The attribute of an SSRZ Compressed Satellite Parameter Block indicates which GNSS are bundled in the corresponding SSRZ Rice Block. The last three rows show an example of three SSRZ Rice Block definitions based on complementary GNSS attribute settings. A “1” (“0”) indicates that a system is (not) considered in the corresponding SSRZ Rice block. The first block includes data from GPS and Galileo, the second and third, respectively from GLONASS and BDS only. The white arrows illustrate the transmission sequence of Scale Factor Indicator a , Bin Size Indicator b , and Rice encoded data.

SSRZ Metadata (static parameters)								SSRZ Rice Block(s)				
	Attribute							Default Rice Parameters		Adaptive Rice parameters		
	GNSS							Default Resolution	Default Bin Size Parameter	Scale Factor Indicator	Bin Size Indicator	Rice encoded data
	G	R	S	E	C	J	...	dx_0	p_0	a	b	0101110
N_{RB} Rice Blocks	1	0	0	1	0	0						
	0	1	0	0	0	0						
	0	0	0	0	1	0						



3.7.3.2 SSRZ Compressed Signal Bias Block

The SSRZ Compressed Signal Bias Block allows the combination of different signals from different GNSS in one Rice Block. Table 3.3 SSRZ Compressed Signal Bias Block illustrates the concept of the *SSRZ Compressed Signal Bias Block* and required metadata.

Table 3.3 SSRZ Compressed Signal Bias Block

The attribute of the SSRZ Compressed Signal Bias Block indicates which signals are bundled in the corresponding SSRZ Rice Block. The last four rows illustrate the attribute setting to transmit the signals (G:1P, E:8Q), (R:1P), (R:2C, E:7Q) and (G:2C, G:2P, and E:5X) in one SSRZ Rice Block. The white arrows illustrate the transmission sequence of Scale Factor Indicator **a**, Bin Size Indicator **b**, and Rice-encoded data.

SSRZ Metadata (static parameters)					SSRZ Rice Block(s)				
Attribute					Default Rice Parameters		Adaptive Rice-Parameters		
Signals per frequency and GNSS					Default Resolution	Default Bin Size Parameter	Scale-Factor Indicator	Bin-Size Indicator	N_{data} data
G	R	E	...	dx_0	p_0	a	b	0101110	
1P	-	8Q							
-	1P	-							
-	2C	7Q							
2C, 2P	-	5X							

3.7.3.3 SSRZ Compressed Chain Data Block

SSRZ inherently supports so-called native grids representing the GNSS network to avoid interpolation errors. The total grid may consist of one or more chains. A chain describes a path through the grid (see section 12 for more details). The gridded atmospheric SSR corrections are transmitted according to the point order per chain. In a multi-stage approach the gridded atmospheric correction messages are able to transmit the residuals with respect to other stages while in a single model approach they are able to transmit all atmospheric corrections. Thus, gridded correction parameters probably show local correlations. In this case a gridded data predictor can be applied in SSRZ (section 12.1.3) to compensate these correlations. However, at least the first value has to be transmitted as an absolute value. SSRZ enables the bundling of gridded correction parameters per chain in one SSRZ Rice Block or in two, whereby the first one includes the first value and the second SSRZ Rice Block the remaining parameters. The number of SSRZ Rice Blocks (per chain) is indicated by the attribute “predictor application flag”. As the efficiency of the predictor application depends on the data itself, SSRZ allows the adaptive application and the attribute of the *SSRZ Compressed Chain Data Block* is part of correction message. Table 3.4 illustrates the combination of attribute, Rice-parameters and SSRZ Rice Blocks for two chains.

Table 3.4 SSRZ Compressed Chain Data Block

The SSRZ metadata required for the SSRZ Compressed Chain Data Block are the Default Rice-Parameters as well as the grid definition including the number of grid points per chain. A correction message includes SSRZ Rice Blocks and the (adaptive) attribute predictor flag. The last three lines of the table show the two possible cases of SSRZ Rice Block transmission: In the first case the predictor is not applied and all $N_{pts/chain}$ values (per chain) are part of one SSRZ Rice Block. In the second case the predictor is applied. Thus, the first value and the $N_{pts/chain} - 1$ values of the chain are transmitted in separated SSRZ Rice Blocks.

SSRZ Metadata (static parameters)				SSRZ Rice Block(s)			
	Default Rice Parameters		Grid Definition	Adaptive Rice-Parameters			
	Default Resolution	Default Bin Size Parameter	Number of Pts. per Chain	Attribute	Scale-Factor Indicator	Bin-Size Indicator	N_{data} data
	dx_0	ρ_0	N_{pts}	Predictor Flag	a	b	0101110
N _{SSRZ} Rice Blocks				do not apply	→		$N_{pts/chain}$
				apply	→		1
					→		$N_{pts/chain} - 1$

SSRZ Compressed Chain Data Block

3.7.3.4 SSRZ Compressed Coefficients Block

In SSRZ a few functional atmospheric models are represented by Chebyshev polynomials in two dimensions X and Y (the meaning of X and Y is specific for each functional SSR parameter and described in the corresponding model). Let l and m denote the order of the coefficients a_{lm} in X and Y direction, respectively. The value of the functional model parameter at a point (x, y) is then given by

$$f(x, y) = \sum_{l=0}^{M_l} \sum_{m=0}^{M_m} a_{lm} p(x, l) p(y, m), \forall \text{ model-supported } a_{lm}. \tag{3.7}$$

Whereby $p(x, l)$ and $p(y, m)$ are the polynomials in X and Y direction of order l and m with M_l and M_m being the maximum orders of l and m .

To account for different ranges of coefficients for orders $m + l$ the *SSRZ Compressed Coefficients Block* offers the order $l + m$ as attribute to define SSRZ Rice Blocks. This attribute information is represented by bit mask whose length L_{m+l} is obtained from

$$L_{l+m} = \max(l + m) + 1. \tag{3.8}$$

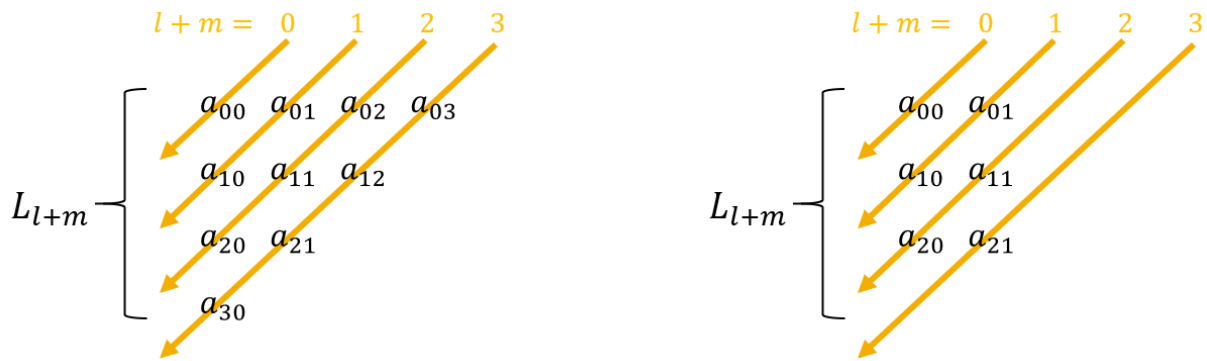
Table 3.5 SSRZ Compressed Coefficients Block

The attributes of the SSRZ Rice Blocks within a Compressed Coefficients Block are the polynomial orders. The example in the last three rows shows the definition of three SSRZ Rice Blocks bundling the 0th, the 1st and 2nd, and 3rd order coefficients. A “1”(“0”) indicates that order $m + l$ is (not) considered in the corresponding SSRZ Rice Block.

SSRZ Metadata (static parameters)				SSRZ Rice Block(s)				
Rice Block Attribute				Default Rice Parameters		Adaptive Rice-Parameters		
$m + l$				Default Resolution	Default Bin Size Parameter	Scale Factor Indicator	Bin Size Indicator	N_{data} data
0	1	2	3	dx_0	ρ_0	a	b	0101110

M _{RB}	1	0	0	0						SSRZ Comp. Coeff. Data Block
	0	1	1	0						
	0	0	0	1						

In general polynomial coefficients can be organized within an upper left triangle fashion. The transmitted sequence of coefficients of order $l + m$ corresponds to sequence of the anti-diagonal elements supported by the model. Figure 3 Sequence of polynomial Coefficients with respect to order $l + m$ and different model configuration examples ("triangle" and "box"). shows the sequences of coefficients with respect for different model configurations.



Order $l + m$	Sequence of Coefficients a_{lm} ("triangle")	Order $l + m$	Sequence of Coefficients a_{lm} ("box")
0	a_{00}	0	a_{00}
1	a_{01}, a_{10}	1	a_{01}, a_{10}
2	a_{02}, a_{11}, a_{20}	2	a_{11}, a_{20}
3	$a_{03}, a_{12}, a_{21}, a_{30}$	3	a_{21}

Figure 3 Sequence of polynomial Coefficients with respect to order $l + m$ and different model configuration examples ("triangle" and "box").

3.7.3.5 SSRZ Compressed Satellite-dependent Coefficients Block

The global satellite-dependent global and regional stages provide a set of (Chebyshev) polynomial coefficients per satellite. These coefficients are transmitted within SSRZ Rice Blocks in a *SSRZ Compressed Satellite-dependent Coefficients Block*. The SSRZ Rice Blocks are defined by order $m + l$. The sequence of coefficients within an SSRZ Rice Block is in increasing order of the satellite and GNSS. Table 3.6 clarifies the sequence order of coefficients in a *SSRZ Compressed Coefficients Block* (Table 3.5) and a *SSRZ Compressed Satellite dependent Coefficients Block*.

Table 3.6 Order of transmitted coefficients in SSRZ Compressed Coefficient Data Block

Order $l + m$	Sequence of Coefficients a_{lm} in Compressed Coefficient Data Block	Sequence of Coefficients a_{lm} in Satellite-dependent Compressed Coefficient Data Block
0	a_{00}	$a_{00}(G_1), a_{00}(G_2), \dots, a_{00}(R_1), a_{00}(R_1), \dots$
1	a_{01}, a_{10}	$a_{01}(G_1), \dots, a_{01}(R_1), \dots, a_{10}(G_1), \dots, a_{10}(R_1), \dots$
2	a_{02}, a_{11}, a_{20}	$a_{02}(G_1), \dots, a_{02}(R_1), \dots, a_{11}(G_1), \dots, a_{11}(R_1), \dots, a_{20}(G_1), \dots, a_{20}(R_1) \dots$

4 General Transport Layer/Framing

The SSRZ binary format is not designed for any special transport layer. Any suitable transport layer or framing can be added to the SSRZ format.

One feasible option is to use RTCM3 framing (RTCM 2016). Within the RTCM Standard proprietary messages are assigned to a specific company for the broadcast of proprietary data. The format is similar to other RTCM messages, in that the transport layer is defined in the same way, and the first data field is the 12-bit message type number. The message type number "4090" is reserved for Geo++ proprietary messages (see Table 4.1). Geo++ proprietary messages are also referred to as RTCM3++ messages.

For information on the general RTCM transport layer refer to the RTCM Standard document.

Table 4.1 RTCM Proprietary Message Type

Message Type	Organization	Contact
4090	Geo++	http://www.geopp.de

Within the RTCM Geo++ Proprietary Messages several sub-types of messages are defined, but they all utilize the assigned RTCM3 message type 4090.

The sub-types support different Geo++ Proprietary Messages. For Geo++ SSRZ data the **Sub-Type 7** is reserved.

To reduce the size of SSRZ messages in the transport layer the RTCM3 framing (consisting of 3 byte header including the message length and a 3 bytes checksum) and even the SSRZ header (consisting of RTCM3 message type DF002 and SSRZ sub-type ZDF000) can be omitted or substituted, if the transport layer ensures a checksum and length information.

5 SSRZ Message Type Summary

The SSRZ data are organized in different messages according to the update and service aspects. Table 5.1 describes the SSRZ message types. The message type is prefixed with “ZM” to indicate the SSRZ format content. The message types ZM001 – ZM007 are SSR correction messages (mostly updated in seconds) while the subsequent message types contain the SSRZ Metadata. SSRZ Metadata will be available via text file, internet, or they are broadcast as separate messages or split and piggybacked on the correction message stream. The different background gray-scales indicate the length of needed bits per SSRZ Message Type Indicator (2,5,9 bits).

Table 5.1 SSRZ Message Types

SSRZ Message Type	Message Name	No. of Bits per Message indicator	Notes	Chapter
ZM001	SSRZ High Rate Correction	2	Update interval ~5s	8.1
ZM002	SSRZ Low Rate Correction	2	Update interval ~30s	8.2
ZM003	SSRZ Gridded Ionosphere Correction	2	Update interval ~30s	8.3
ZM004	SSRZ Gridded Troposphere Correction	5	Update interval ~30s	8.4
ZM005	SSRZ Satellite dependent Regional Ionosphere Correction	5	Update interval ~30s	8.5
ZM006	SSRZ Global VTEC Ionosphere Correction	5	Update interval ~30s	8.6
ZM007	SSRZ Regional Troposphere Correction	5	Update interval ~30s	8.7
ZM008	SSRZ QIX Bias Correction	5	Update interval ~days	8.8
ZM009	SSRZ Time Tag	5	Update interval ~hours	8.9
ZM010	SSRZ Stream Identification Message	5	Update interval ~5s	
ZM011	SSRZ Satellite Group Definitions	9	offline/ online/ broadcast/ piggybacked	9.3
ZM012	SSRZ Metadata Definition	9	offline/ online/ broadcast/ piggybacked	9.4
ZM013	SSRZ Grid Definition	9	offline/ online/ broadcast/ piggybacked	9.5
...	Reserved	9		
ZM024	SSRZ Leap Second Message	9	Offline/ online/ broadcast	9.6
ZM025	Expected SSRZ Messages	14	Will be part of the metadata message ZM012 only	

6 SSRZ Data Type Summary

Table 6.1 shows the used data types in SSRZ. In addition to the signed and unsigned integer types, Table 6.1 includes the types Prefix Codes PC() and float data types. The Prefix Codes PC() are described in section Prefix Coding 6.1 and the float32 represents a float value according to IEEE Standard for Floating Point Arithmetic (IEEE-754).

Table 6.1 SSRZ Data Type Summary

Data Type	Description	Range	Data Type Notes
bit(n)	bit field 0 or 1, each bit	-	Reserved bits set to "0"
int8	8 bit 2's complement integer	± 127	-128 indicates data not available
int12	12 bit 2's complement integer	± 2047	-2048 indicates data not available
int14	14 bit 2's complement integer	± 8191	-8192 indicates data not available
int16	16 bit 2's complement integer	± 32,767	-32,768 indicates data not available
int17	17 bit 2's complement integer	± 65,535	-65,536 indicates data not available
int20	20 bit 2's complement integer	± 524,287	-524,288 indicates data not available
int21	21 bit 2's complement integer	± 1,048,575	-1,048,576 indicates data not available
int22	22 bit 2's complement integer	± 2,097,151	-2,097,152 indicates data not available
int24	24 bit 2's complement integer	± 8,388,607	-8,388,608 indicates data not available
int27	27 bit 2's complement integer	± 67,108,814	-67,108,815 indicates data not available
int28	28 bit 2's complement integer	± 134,217,727	-134,217,727 indicates data not available
int29	29 bit 2's complement integer	± 268,435,455	-268,435,455 indicates data not available
int30	30 bit 2's complement integer	± 536,870,911	-536,870,911 indicates data not available
int32	32 bit 2's complement integer	± 2,147,483,647	-2,147,483,648 indicates data not available
sint2	2 bit signed integer	± 1	
sint3	3 bit signed integer	± 3	
sint4	4 bit signed integer	± 7	
sint5	5 bit signed integer	± 15	
sint6	6 bit signed integer	± 31	
sint8	8 bit signed integer	± 63	
sint10	10 bit signed integer	± 511	
sint11	11 bit signed integer	± 1023	
sint12	12 bit signed integer	± 2047	
sint16	16 bit signed integer	± 4095	
PC(1,0)	Prefix Coding	≥0	Flexible length (Table 6.2)
PC(2,0)	Prefix Coding	≥0	Flexible length (Table 6.2)
PC(2,1,5)	Prefix Coding	≥0	Flexible length (Table 6.2)
float32			Float value representation according to IEEE-754

6.1 Prefix Coding

Besides the Rice encoding the SSRZ format uses different prefix encoder settings for different purposes (e.g. SSRZ message ID, Continuity Counters, adaptive Rice parameters). Prefix Codes PC() are sequences of bit blocks. The SSRZ uses different prefix encoder settings to describe the length of these bit blocks. The setting is described by two

mandatory and one optional parameter: the number of bits of the first block N_0 , the increment of bits db and the maximum number of bits per (additional) bit block N_{max} , respectively, $PC(N_0, db, N_{max})$. In general, a new bit block is added to the sequence if the previous one includes only "1" bits.

Three examples of the prefix coding are given in Table 6.2. The $PC(1,0)$ coding is similar to unitary representation of an integer value. $PC(2,0)$ and $PC(2,1,5)$ start with two bits for values from 0 to 2. A value of 3 is encoded by an additional bit block with 2 and 3 bits in length, respectively. If a new bit block is required for increasing values, $PC(2,0)$ always adds a two-bits block. In contrast, $PC(2,1,5)$ firstly increases the bit block length by one bit up to five bits and adds five-bits blocks afterwards (c.f. integer value 56 in Table 6.2).

Table 6.2 SSRZ Prefix Codes PC()

Integer value	PC(1,0)	PC(2,0)	PC(2,1,5)
0	0	00	00
1	10	01	01
2	110	10	10
3	1110	11 00	11 000
4	11110	11 01	11 001
5	111110	11 10	11 010
6	1111110	11 11 00	11 011
7	11111110	11 11 01	11 100
8	111111110	11 11 10	11 101
9	1111111110	11 11 11 00	11 110
10	11111111110	11 11 11 01	11 111 0000
11	111111111110	11 11 11 10	11 111 0001
12	1111111111110	11 11 11 11 00	11 111 0010
13	11111111111110	11 11 11 11 01	11 111 0011
...
23	111111...11111110	11 11 11 11 11 11 11 10	11 111 1110
24	111111...111111110	11 11 11 11 11 11 11 11 00	11 111 1111 00000
...
55	111...10	11 11 11 11 11 ... 01	11 111 1111 11110
56	111...110	11 11 11 11 11 ... 10	11 111 1111 11111 00000
...

7 SSRZ Data Field and Data Block Summaries

7.1 SSRZ Data Field Summary

Table 7.1 describes the SSRZ Data Fields required to support the compressed SSRZ messages. The data fields are prefixed with “ZDF” to indicate the SSRZ relevant content. The decoded data fields are documented together with the model representation in chapters 8 and 9. The bold capital letters **U** and **M** emphasize the association with an SSRZ Update and/or Metadata message. Gray numbered data fields without a name are reserved.

Table 7.1 SSRZ Data Fields

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF001	Reserved	-	-	bit(n)	All reserved bits should be set to “0”. However, since the value is subject to change in future versions, decoding should not rely on a zero value. U+M
ZDF002	SSRZ Message Type Number Indicator	0-X	-	PC(2,1,5)	SSRZ message type number: 0-2: SSRZ message number 1-3 3-9: SSRZ message number 4-10 10-24: SSRZ message number 11-25 U
ZDF003	SSRZ Metadata Type Number	0-X	-	PC(8,0)	This field identifies the metadata content and is individually for each message. The meaning of this data field is described in chapter 9 for each metadata message. 0: reserved M
ZDF004	SSRZ Message ID Bit Mask			bit(n)	This bit mask indicates the SSRZ messages of the data stream. The length of this bit mask depends on the SSRZ Metadata Tag (ZDF020) in ZMB025 (Table 9.26). M
ZDF005	SSRZ Metadata IOD	0-X		PC(2,2,0)	This field represents the issue of metadata IODM and is required for the correct association of SSRZ update messages and their corresponding metadata. M+U
ZDF006	SSRZ Metadata Announcement Bit			bit(1)	This field announces the availability of new metadata (with new SSRZ Metadata IOD ZDF005) that will be required after a metadata update. U
ZDF007	Satellite Antenna PCV Mode	0-X	.	PC(2,0)	This field indicates how to handle Satellite PCV data

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
					0: Rover must apply Satellite PCV (defined by service provider) 1: Server applied Satellite PCV 2: Rover must apply Satellite PCV from stream
SSRZ System and Satellite related Data Fields					
ZDF010	Number of SSRZ Low Rate Satellite Groups	1-32		uint5	Total number of defined SSRZ Low rate Satellite Groups $N_{G(LR)}$. $N_{G(LR)} = ZDF010 + 1$ In ZMB011 $N_{G(LR)} = ZDF010$ if the corresponding Metadata Tag ZDF020 is 1. M
ZDF011	Number of SSRZ High Rate Satellite Groups	1-32		uint5	Total number of defined SSRZ High Rate Satellite Groups $N_{G(HR)}$. $N_{G(HR)} = ZDF011 + 1$ In ZMB011 $N_{G(HR)} = ZDF011$ if the corresponding Metadata Tag ZDF020 is 1. M
ZDF012	SSRZ GNSS ID Bit Mask	16	-	bit(16)	SSRZ GNSS ID Bit Mask indicates the GNSS supported by the format/service provider. The order of bits is in ascending order of SSRZ GNSS IDs in Table 10.1. A bit is set to '1' if the maximum Satellite ID (ZDF013) is greater 0. M
ZDF013	SSRZ Maximum Satellite ID per GNSS and Group	0 to 127	-	uint7	The maximum Satellite ID (Table 10.2) per GNSS and Group $M_{GNSS,G}$. The maximum Satellite ID is not necessarily the maximum number of supported satellites. M
ZDF014	Satellite Group Definition Mode	-	-	uint4	The Satellite Group Definition Mode indicates formation rules. 0: list mode - groups are defined according to Satellite Group Bit Mask per GNSS (ZDF015). 1-5: reserved 6: GNSS mode – set all satellites from the lowest to the maximum satellite number indicated by ZDF013. 7-15: reserved M

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF015	Satellite Group Bit Mask per GNSS	$N_{G,GNSS}$			<p>This bit mask indicates the satellite IDs per GNSS associated with the satellite Group G. The length of this field is defined by maximum Satellite ID per GNSS for this group (ZDF013).</p> <p>'0': satellite is not part of this Satellite Group. '1': satellite is part of this Satellite Group.</p> <p>This field is not necessarily be transmitted but is able to represent all group definitions derived from ZDF013 and ZDF014.</p> <p>M</p>
ZDF016	SSRZ Satellite Group List Bit Mask			bit($N_{G(LR)}$) or bit($N_{G(HR)}$)	<p>This bit mask indicates the combination of different Satellite Groups per (satellite-dependent) update message. The length of this bit mask is given by the Number of SSRZ Low Rate (ZDF010) or High Rate Satellite Groups (ZDF011), respectively.</p> <p>U</p>
ZDF017	Satellite Bit Mask per GNSS			bit(n)	<p>This bit mask indicates the satellites of one system with valid SSR correction parameters in a satellite-dependent SSR correction message.</p> <p>The order and total number of satellites per GNSS represented by this bit mask is given by the total number of satellites per GNSS set in the satellite groups which are combined in the SSRZ satellite group list, indicated by ZDF016.</p> <p>'0': satellite not available '1': satellite available</p> <p>U</p>
ZDF018	Satellite Bit Mask			bit(n)	<p>The Satellite Bit Mask is the sequence of the Satellite Bit Masks per GNSS (ZDF017) according to ascending GNSS ID order given in Table 10.1.</p> <p>U</p>
ZDF019	SSRZ Signal Bit Mask per GNSS	32		bit(32)	<p>SSRZ Signal Bit Mask per GNSS indicates the signals according to Table 10.3 per GNSS.</p> <p>M</p>
SSRZ Metadata Message Block Data Fields					
ZDF020	SSRZ Metadata Tag	0-X	-	PC(8,0)	<p>This field indicates if and how metadata has to be read.</p> <p>M</p>
ZDF021	Size of specific SSRZ Metadata Message Block	0-8191		uint13	<p>Number of bits of the SSRZ Message Blocks.</p>

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
					M
SSRZ General Grid and Region ID Data Fields					
ZDF024	SSRZ Number of Satellite Groups	1-X		PC(5,0)	This field indicates the number of satellite groups.
ZDF025	SSRZ Grid ID	1-X		PC(8,0)	This field indicates the SSRZ Grid ID SSRZ Grid ID= ZDF025+1
ZDF026	SSRZ Grid ID Bit Mask			bit(M _{Grid ID})	The SSRZ Grid ID Bit Mask indicates in ascending order if a grid with SSRZ Grid ID is present. '0': grid with SSRZ Grid ID is not present '1': grid with SSRZ Grid ID is present bit0 → Grid ID=1 bit1 → Grid ID=2 ... The length of this bit mask is given by the maximum SSRZ Grid ID M _{Grid ID} .
ZDF027	SSRZ Region ID	1-X		PC(8,0)	This field indicates the SSRZ Region ID SSRZ Region ID=ZDF027+1
ZDF028	SSRZ Region ID Bit Mask			bit(M _{Region ID})	The SSRZ Region ID Bit Mask indicates in ascending order if a region with SSRZ Region ID is present. '0': region with SSRZ Region ID is not present '1': region with SSRZ Region ID is present bit0 → Region ID=1 bit1 → Region ID=2 ... The length of this bit mask is given by the maximum SSRZ Region ID M _{Region ID} .
ZDF029	SSRZ Multi-Grid flag			bit(1)	
ZDF030	SSRZ Multi-Region flag			bit(1)	
ZDF031	Regional Troposphere Residual Mean Value	-127 – 127	0.0016	int(8)	
ZDF032	Region Residual Value	XXX	XXX	uint	

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
<i>Metadata Main Data Fields</i>					
ZDF042	Number of SSRZ Rice Blocks			PC(2,1,5)	This field indicates the number of Rice Blocks defined for an SSR parameter by specific attributes. M
ZDF043	Default Bin Size Parameter			PC(2,1,5)	This field indicates the Default Bin Size Parameter p_0 . M
ZDF044	Number of components per SSR parameter type	0-3		uint2	Number of components related to a specific SSR parameter. M
ZDF045	Number of SSRZ Signal Rice Blocks			PC(2,0)	Number of SSRZ Signal Rice Blocks M
ZDF046	Default Bin Size Parameter of encoded Signal Bias			PC(2,0)	This field indicates the Default Bin Size Parameter p_0 of Signal Bias Block. M
ZDF047	SSRZ Parameter List Bit Mask			bit(N_{para})	This (general) bit mask indicates the presence of (general) parameters in a list. The sequence of 0 parameters and the length of this bit mask N_{para} is context-sensitive.
<i>SSRZ Timing Data Fields</i>					
ZDF050	SSRZ 15 minutes Time Tag	0-899	1s	uint10	Full seconds since the beginning of a 15min interval. M+U
ZDF051	GPS week number	0-4095	1week	uint12	GPS week number. Starting on the night of January 5/morning January 6, 1980. M+U
ZDF052	GPS epoch time 1s	0-604799	1s	uint20	Full seconds since the beginning of the GPS week. M+U
ZDF053	Length of SSR Update Interval	0-63	1s	uint6	This field indicates the length of an SSR update interval that is identical to its nominal validity time of an SSR parameter w.r.t. to SSRZ message and satellite group(s), respectively. M
ZDF054	SSR Offset Interval	0-63	1s	uint6	Interval offset of an SSR parameter w.r.t. to SSRZ message and satellite group(s), respectively. M

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF055	Number of Satellite dependent Timing Blocks	1-32		uint5	This field indicates the number of satellite dependent Timing Blocks N_{Timing} . $N_{Timing} = ZDF055 + 1$ M
ZDF056	SSR Length of SSR Update Interval	0-X	1s	PC(6,0)	This field indicates the length of an SSR update interval T_{update} that is identical to its nominal validity time of an SSR parameter. $T_{update} = ZDF056 + 1$ M
ZDF057	SSR Update Interval Offset	0-X	1s	PC(6,0)	This field indicates the temporal offset T_{offset} of an SSR update interval. $T_{offset} = ZDF057$ M
ZDF058	Number of Update and Offset Blocks	0-X	1	PC(3,0)	This field indicates the number N_{TB} of Update and Offset Blocks (ZDB040) within an SSRZ Timing Parameter Block (ZDB041). $N_{TB} = ZDF058 + 1$ M
SSRZ Default Resolutions (The final resolution settings are TBD)					
ZDF060	SSRZ High Rate Clock Default Resolution	0.0001m - X	0.0001m	PC(10,0)	This field represents the Default Resolution dx_0 of the SSRZ High Rate Clock parameter used in the corresponding SSRZ Rice Block. $dx_0 = ZDF060 \cdot 0.0001m$ M
ZDF061	SSRZ High Rate Radial Orbit Default Resolution	0.0001m - X	0.0001m	PC(10,0)	This field represents the Default Resolution dx_0 of the SSRZ High Rate Orbit Radial component used in the corresponding SSRZ Rice Block. $dx_0 = ZDF061 \cdot 0.0001m$ M
ZDF062	SSRZ Low Rate Clock C_0 Default Resolution	0.0001m - X	0.0001m	PC(10,0)	This field represents the Default Resolution dx_0 of the SSRZ low Rate Clock C_0 parameter used in the corresponding SSRZ Rice Block. $dx_0 = ZDF062 \cdot 0.0001m$ M
ZDF063	SSRZ Low Rate Clock C_1 Default Resolution	0.01mm/s - X	0.01mm/s	PC(10,0)	This field represents the Default Resolution dx_0 of the SSRZ low Rate Clock C_1 parameter used in the corresponding SSRZ Rice Block. $dx_0 = ZDF063 \cdot 0.01mm/s$ M

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF064	SSRZ Low Rate Radial Orbit Default Resolution	0.0001m - X	0.0001m	PC(10,0)	This field represents the Default Resolution dx_0 of the SSRZ Low Rate Radial Orbit component used in the corresponding SSRZ Rice Block. $dx_0 = \text{ZDF064} \cdot 0.0001\text{m}$ M
ZDF065	SSRZ Low Rate Along-Track Orbit Default Resolution	0.0001m - X	0.0001m	PC(8,0)	This field represents the Default Resolution dx_0 of the SSRZ Low Rate Along-Track Orbit component used in the corresponding SSRZ Rice Block. $dx_0 = \text{ZDF065} \cdot 0.0001\text{m}$ M
ZDF066	SSRZ Low Rate Cross-Track Orbit Default Resolution	0.0001m - X	0.0001m	PC(8,0)	This field represents the Default Resolution dx_0 of the SSRZ Low Rate Cross-Track Orbit component used in the corresponding SSRZ Rice Block. $dx_0 = \text{ZDF066} \cdot 0.0001\text{m}$ M
ZDF067	SSRZ Low Rate Radial Velocity Default Resolution	0.001mm/s - X	0.001mm/s	PC(10,0)	This field represents the Default Resolution dx_0 of the SSRZ Low Rate Radial Velocity component used in the corresponding SSRZ Rice Block. $dx_0 = \text{ZDF067} \cdot 0.001\text{mm/s}$ M
ZDF068	SSRZ Low Rate Along-Track Velocity Default Resolution	0.001mm/s - X	0.001mm/s	PC(10,0)	This field represents the Default Resolution dx_0 of the SSRZ Low Rate Along-Track Velocity component used in the corresponding SSRZ Rice Block. $dx_0 = \text{ZDF068} \cdot 0.001\text{mm/s}$ M
ZDF069	SSRZ Low Rate Cross-Track Velocity Default Resolution	0.001mm/s - X	0.001mm/s	PC(10,0)	This field represents the Default Resolution dx_0 of the SSRZ Low Rate Cross-Track Velocity component used in the corresponding SSRZ Rice Block. $dx_0 = \text{ZDF069} \cdot 0.001\text{mm/s}$ M
ZDF070	SSRZ Low Rate Code Bias Default Resolution	0.0001m - X	0.0001m	PC(11,0)	This field represents the Default Resolution dx_0 of the SSRZ Low Rate Code Bias corrections used in the corresponding SSRZ Rice Block. $dx_0 = \text{ZDF070} \cdot 0.0001\text{m}$ M

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF071	SSRZ Low Rate Phase Bias Cycle Range	1 - 255	1	PC(5,0)	This field indicates the cycle range of the phase bias values $N_{PB,cyc}$. M
ZDF072	SSRZ Low Rate Phase Bias Bitfield Length	1 - X	1	PC(5,0)	This field represents the number of bits $N_{PB,bits}$ used to transmit the SSRZ Phase Bias corrections. M
ZDF073	SSRZ Maximum Number of Continuity/Overflow bits	1 - X	1	PC(5,0)	This field indicates the maximum length of the Continuity/Overflow indicator. M
ZDF074	SSRZ Default Resolution of the Satellite-dependent Global Ionosphere corrections	0.001 TECU - X	0.001 TECU	PC(4,0)	This field indicates the Default Resolution dx_0 of the Chebyshev Coefficients used to describe the Global Satellite Ionospheric corrections. $dx_0 = ZDF074 \cdot 0.001 \text{ TECU}$ M
ZDF075	SSRZ Gridded Ionosphere Correction Default Resolution	0.001 TECU - X	0.001 TECU	PC(4,0)	This field indicates the Default Resolution dx_0 of the gridded Ionosphere corrections. $dx_0 = ZDF075 \cdot 0.001 \text{ TECU}$ M
ZDF076	SSRZ Gridded Troposphere Scale Factor Default Resolution	0.00001	0.00001	PC(8,0)	This field indicates the Default Resolution dx_0 of the gridded troposphere corrections. $dx_0 = ZDF076 \cdot 0.00001$ M
ZDF077	SSRZ Gridded Troposphere Gradient Default Resolution	TBD	TBD	TBD	TBD M
ZDF080	SSRZ Default Resolution of the Satellite-dependent Regional Ionosphere Coefficients	0.001 TECU - X	0.001 TECU	PC(4,0)	This field indicates the Default Resolution dx_0 of the Chebyshev Coefficients representing the RSI corrections. $dx_0 = ZDF080 \cdot 0.001 \text{ TECU}$ M
ZDF081	SSRZ Default Resolution of Global VTEC Ionosphere Coefficients	0.001 TECU - X	0.001 TECU	PC(4,0)	This field indicates the Default Resolution dx_0 of the Global VTEC coefficients. $dx_0 = ZDF081 \cdot 0.001 \text{ TECU}$ This field is used if the corresponding metadata tag ZDF020 is 2. M
ZDF082	SSRZ Default Resolution of Global VTEC	$10^{-5} \text{ TECU} - X$	-	PC(8,0)	This field indicates the Default Resolution dx_0 of the Global VTEC coefficients.

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
	Ionosphere Coefficients				$dx_0 = \text{ZDF082} \cdot 10^{-5} \text{ TECU}$ This field is used if the corresponding metadata tag ZDF020 is larger than 2. M
ZDF085	SSRZ Default Resolution of the Regional Troposphere Scale factor	0.00001 - X	0.00001	PC(8,0)	This field indicates the Default Resolution dx_0 of the Chebyshev Coefficients used to describe the Regional Troposphere corrections. $dx_0 = \text{ZDF085} \cdot 0.00001$ M
ZDF086	SSRZ Default Resolution of Regional Troposphere Mapping Improvements	0.000001 - X	0.000001	PC(8,0)	This field indicates the Default Resolution dx_0 of the mapping improvement parameters used to describe the regional troposphere corrections. $dx_0 = \text{ZDF086} \cdot 0.000001$ M
ZDF087					
ZDF088					
ZDF089	SSRZ QIX Code Bias Default Resolution	0.01 mm - X	0.01 mm	PC(7,0)	This field represents the Default Resolution dx_0 of the SSRZ QIX Code Bias corrections used in the corresponding SSRZ Rice Block. $dx_0 = \text{ZDF089} \cdot 0.01\text{mm}$ M
ZDF090	SSRZ QIX Phase Bias Default Resolution	0.01 mm -X	0.01 mm	PC(7,0)	This field represents the Default Resolution dx_0 of the SSRZ QIX Phase Bias corrections used in the corresponding SSRZ Rice Block. $dx_0 = \text{ZDF090} \cdot 0.01\text{mm}$ M
SSRZ Grid Definition Data Fields					
ZDF091	Number of Grids	0-X	1	PC(4,0)	This field indicates the number of grids N_{grid} . $N_{grid} = \text{ZDF091}$ M
ZDF092	Order indicator of the grid point coordinate resolution	0-X	1	PC(2,1,0)	This field indicates the order m of the resolution. The final resolution in units of rad is given by $dx = n \cdot 10^{-(2+m)}$ M
ZDF093	Integer part of the coordinate resolution	0-255	1	uint8	This field describes the integer part n of the coordinate resolution M
ZDF094	Number of Chains	0-X	1	PC(4,0)	This field indicates the number of chains N_{chain} in the corresponding grid.

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
					$N_{chain}=ZDF094+1$ M
ZDF095	Number of Grid Points per Chain	0-X	1	PC(5,0)	This field indicates the number of grid points per chain $N_{pts/chain}$. $N_{pts/chain}=ZDF095+1$ M
ZDF096	Grid Bin Size Parameter	0-X	1	PC(4,0)	This field indicates the bin size parameter p (see 3.7.1) used for the Rice encoder M
ZDF097	Use Baseline Flag	0-1	1	bit(1)	This parameter indicates if the baseline of the previous (last) triangle is identical with the baseline of the current triangle (1) or if the next baseline has to be used to reconstruct the current triangle. M
ZDF098	Point Position Flag	0-1	1	bit(1)	This parameter describes if the third point of the triangle is located left(1) or right(0) with respect to the baseline pointing from base point 1 to base point 2. M
ZDF099	Add Baseline Left Flag	0-1	1	bit(1)	If this flag is set (1) the baseline point located <i>left</i> from a line pointing from the midpoint of the baseline to third point of the triangle and the third point of the triangle form an additional baseline. This new baseline vector points from the current baseline point to the third point. M
ZDF100	Add Baseline Right Flag	0-1	1	bit(1)	If this flag is set (1) the third point of the triangle and the baseline point located <i>right</i> from a line pointing from the midpoint of the baseline to third point of the triangle form an additional baseline. This new baseline vector points from the third point to current baseline point. M
ZDF101	Height Flag	0-1	1	bit(1)	This flag indicates if grid point height data are provided (1) or not (0). M
ZDF102	Grid Point Height Resolution	0-X	1	PC(5,0)	This field indicates if grid point height data transmitted and if so with which resolution. 0: no height information

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
					>0: height information available with resolution ZDF102 in units of meters M
ZDF103	Gridded Data Predictor Points Flag	0-1	1	bit(1)	This flag indicates if the grid point indices for the gridded data predictor are provided (1) or not (0). M
ZDF104	Predictor Point Indicator			PC(2,0)	This field enables the computation of a point index required for the gridded-data predictor. M
ZDF105	Grid ID	0-X		PC(4,0)	The field indicates a grid. Grid ID= 1+ ZDF105 M+U
ZDF106	Grid IOD	0-7	3	bit(3)	This field represents the Issue of Data of a grid with a certain Grid ID (ZDF105). The identification of a valid grid is done by the two values Grid ID (ZDF105) and Grid IOD (ZDF106) M+U
SSRZ Specific Troposphere Component Data Fields					
ZDF107	Troposphere Basic Component Bit Mask			bit(16)	This field indicates the tropospheric components. Reserved bits are used in the future to allow for more complex troposphere models. According to LSB: bit 0: dry bit 1: wet bit 2: total bit 3: mapping improvements bits 4-15: reserved M+U
ZDF108	Separated Compressed Coefficient Blocks per Height Order Flag			bit(1)	Some models include coefficients related to different orders in height. This flag indicates if 0: coefficients related to different orders in height are transmitted within one Compressed Coefficient Rice Block 1: coefficients related to different orders in height are transmitted in separated Compressed Coefficient Rice Blocks. M
SSRZ Model Parameter Data Fields					
ZDF110	Model ID			uint8	M

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF111	Model Version			uint8	M
ZDF112	Number of Integer Model Parameters			uint8	M
ZDF113	Number of Float Model Parameters			uint8	M
ZDF114	Integer Model Parameter			Int32	M
ZDF115	Float Model Parameter			Float32	M
ZDF116	Coefficient Order Bit Mask			bit(n)	This bit mask is used as the attribute in a coefficient related Rice Block definition. The length of this bit mask is derived from SSR Model Parameters M
SSRZ Global VTEC Metadata Data Fields					
ZDF129	SSRZ Encoder Type	0-X		PC(2,1)	This value indicates the encoder type 0: no encoding 1: Rice encoding M
ZDF130	Number of Ionospheric Layers			PC(2,0)	Number of Ionospheric Layers L The VTEC spherical harmonics model consists of one or more infinitesimal thin ionospheric layers. $L = ZDF130 + 1$ M
ZDF131	Height of Ionospheric Layer			PC(10,0)	Height of the ionospheric layer l in units of km. M
ZDF132	Spherical Harmonics Degree			PC(6,0)	Degree N_l of spherical harmonic expansion of global ionosphere in latitude in layer l . M
ZDF133	Spherical Harmonics Order			PC(6,0)	Order M_l of spherical harmonic expansion of global ionosphere in longitude in layer l . M
SSRZ Satellite-dependent Global Ionosphere Metadata Data Fields					
ZDF134	Satellite-dependent Global Ionosphere Correction Flag			bit(1)	This flag indicates if satellite-dependent Global Ionosphere Corrections are part of the SSRZ Low Rate message (ZM002) and if metadata for this SSR parameter are provided in ZMB002. M

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF135	GSI polynomial type	TBD		TBD	This field indicates, which coefficients are transmitted. 0: a_{00} 1: a_{00}, a_{01}, a_{10} 3: $a_{00}, a_{01}, a_{10}, a_{02}, a_{11}, a_{20}$ M
ZDF140	Height of GSI Ionospheric Layer	TBD		TBD	M
SSRZ Satellite-dependent Regional Ionosphere Metadata Data Fields					
ZDF143	Number of Regions	1-X		PC(4,0)	Number of Regions N_{Region} $N_{Region} = ZDF143 + 1$
ZDF144	Region ID	1-X		PC(4,0)	Region ID = ZDF144 + 1 M
ZDF145	RSI polynomial Type	TBD		PC(4,0)	This field indicates, which coefficients are transmitted. 0: a_{00} 1: a_{00}, a_{01}, a_{10} 2: $a_{00}, a_{01}, a_{01}, a_{11}$ 3: $a_{00}, a_{01}, a_{10}, a_{02}, a_{02}$ 4: $a_{00}, a_{01}, a_{10}, a_{02}, a_{11}, a_{20}$ >4: reserved. M
ZDF146	RSI scale distance	0-X	100km	PC(6,0,0)	Scale_dist = ZDF146 * 100.0 km * $6.37 \cdot 10^{-3}$
ZDF147	Height of RSI Ionospheric Layer	10km – X	10km	uint7	Height of the iono layer $H = ZDF147 * 10\text{km}$ M
ZDF148	Latitude of RSI Ground Point Origin	-90,...,0,...,+90	0.1 deg	sint11	Lat = ZDF148 * 0.1deg M
ZDF149	Longitude of RSI Ground Point Origin	180,...,0,...,180	0.1 deg	sint12	Lon = ZDF149 * 0.1 deg M
ZDF150	Height of RSI Ground Point Origin	TBD	10m	sint11	GPO height = ZDF150 * 10m M
ZDF151	Update Rate of PPO	0-X	1s	PC(8,0)	T_Update_PPO = ZDF151 + 1
ZDF152	Offset of Update Rate of PPO	0-X	1s	PC(5,0)	T_offset_PPO = ZDF152 + 1
SSRZ Regional Troposphere Correction Metadata Data Fields					

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF165					
ZDF166	Maximum Horizontal Order	0-X		PC(2,0)	Maximum horizontal order of regional troposphere coefficients M_{hor} . M
ZDF167	Maximum Vertical Order	0-X		PC(2,0)	Maximum vertical order of regional troposphere coefficients M_{hgt} . M
ZDF168	Latitude of regional troposphere Ground Point Origin	$\pm 90.0^\circ$	0.1°	sint11	Latitude of the regional troposphere Ground Point Origin (GPO) Lat = ZDF168 * 0.1deg M
ZDF169	Longitude of regional troposphere Ground Point Origin	$\pm 180.0^\circ$	0.1°	sint12	Longitude of the regional troposphere Ground Point Origin (GPO) Lon = ZDF168 * 0.1deg M
ZDF170	Height of regional troposphere Ground Point Origin	$\pm 8191\text{m}$	1.0m	sint14	Height of the regional troposphere Ground Point Origin (GPO) H = ZDF170 * 1.0m M
ZDF171	Maximum Elevation for Mapping Improvement	$0^\circ - 63^\circ$	1°	uint6	This field indicates the maximum elevation for which the mapping improvements should be applied. M
ZDF172	Coverage Dependent Factor	100 km - X	10km	PC(8,0)	This field represents a coverage dependent factor D_{RT} that is used to normalize the arguments of the Chebyshev polynomials. $D_{RT} = 100\text{km} + \text{ZDF172} \cdot 10\text{ km}$. M
ZDF173	Vertical Scale Factor	100 m -X	10m	PC(8,0)	This field represents the vertical scale factor $H_{RT} = 100\text{ m} + \text{ZDF173} \cdot 10\text{ m}$. M
SSRZ QIX Bias metadata fields					
ZDF190	QIX Code Bias flag			bit(1)	This flag indicates the presence of the SSRZ QIX Code Bias Rice Block in ZM008 and the corresponding metadata in ZMB008. M

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF191	QIX Phase Bias flag			bit(1)	This flag indicates the presence of the SSRZ QIX Phase Bias Rice Block in ZM008 and the corresponding metadata in ZMB008. M
SSRZ BE IOD Metadata fields					
ZDF199	Length of the SSRZ BE IOD bit field	0-15	1bit	uint4	This field represents the number of bits $N_{\text{IOD,GNSS}}$ used to represent IOD values in ZDF303. M
ZDF200	SSRZ IOD Tag			PC(2,0)	This field indicates if and how the SSRZ IOD have to be used. 0: reserved 1: use IODs without modification M
ZDF201	SSRZ BE IOD Tag GPS	0-X		PC(2,0)	This field indicates the length and computation rule of the BE IODs of GPS satellites. 0: reserved 1: length of SSRZ BE IOD of GPS is TBD M
ZDF202	SSRZ BE IOD Tag GLONASS	0-X		PC(2,0)	This field indicates the length and computation rule of the BE IODs of GLONASS satellites. 0: reserved 1: length of SSRZ BE IOD of GLONASS is TBD M
ZDF203	SSRZ BE IOD Tag Galileo	0-X		PC(2,0)	This field indicates the length and computation rule of the BE IODs of Galileo satellites. 0: reserved 1: length of SSRZ BE IOD of Galileo is TBD M
ZDF204	SSRZ BE IOD Tag QZSS	0-X		PC(2,0)	This field indicates the length and computation rule of the BE IODs of QZSS satellites. 0: reserved 1: length of SSRZ BE IOD of QZSS is TBD M
ZDF205	SSRZ BE IOD Tag SBAS	0-X		PC(2,0)	This field indicates the length and computation rule of the BE IODs of SBAS satellites 0: reserved M
ZDF206	SSRZ BE IOD Tag BDS	0-X		PC(2,0)	This field indicates the length and computation rule of the BE IODs of BDS satellites. 0: reserved

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
					1: length of SSRZ BE IOD of BDS is TBD M
ZDF207	SSRZ BE IOD Tag IRNSS	0-X		PC(2,0)	This field indicates the length and computation rule of the BE IODs of IRNSS satellites. 0: reserved 1: length of SSRZ BE IOD of IRNSS is TBD M
ZDF208	SSRZ BE IOD Tag	0-X		PC(2,0)	0: reserved M
ZDF209	SSRZ BE IOD Tag	0-X		PC(2,0)	0: reserved M
ZDF210	SSRZ BE IOD Tag	0-X		PC(2,0)	0: reserved M
ZDF211	SSRZ BE IOD Tag	0-X		PC(2,0)	0: reserved M
ZDF212	SSRZ BE IOD Tag	0-X		PC(2,0)	0: reserved M
ZDF213	SSRZ BE IOD Tag	0-X		PC(2,0)	0: reserved M
ZDF214	SSRZ BE IOD Tag	0-X		PC(2,0)	0: reserved M
ZDF215	SSRZ BE IOD Tag	0-X		PC(2,0)	0: reserved M
ZDF216	SSRZ BE IOD Tag	0-X		PC(2,0)	0: reserved M
SSRZ Time Tag Message specific Data Fields					
ZDF230	SSRZ Time Tag Definition	-		PC(2,1)	
ZDF231	SSRZ 1hour- 30seconds Time Tag	0-3570s	30s	uint7	
ZDF232	SSRZ 1hour- 5seconds Time Tag	0-3595s	5s	uint10	
ZDF233	SSRZ 1hour- 1second Time Tag	0-3599s	1s	uint12	
ZDF234	SSRZ 1day-1second Time Tag	0-86399s	1s	uint17	
SSRZ Leap Second specific Data Fields					

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF250	SSRZ Leap Second Year	2023-X years	1 year	PC(5,0)	This field represents the year of the introduced leap second. YEAR = 2023 + ZDF250
ZDF251	SSRZ Leap Second Month	1-12 month	1 month	uint(4)	This field represents the month of the introduced leap second. MONTH = ZDF251 +1
ZDF252	SSRZ Leap Second	-7s,...,+7s	1s	sint4	Current Leap Second = 18 + ZDF252
ZDF254	SSRZ Delta Leap Seconds		1s	sint2	Leap second change ZDF254 = -1,0,1: new leap second is Current Leap Second + ZDF254 ZDF254 = -0: clear stored leap second

SSRZ Update Message Data fields

ZDF301	Scale Factor indicator	0-X		PC(2,0)	This field represents the scale factor indicator a . Together with Default Resolution values dx_0 (ZDF060-ZDF90) the actual resolution dx of the transmitted parameter value is computed by $dx = 2^a dx_0$ U+M
ZDF302	Bin Size Indicator	0-X		PC(2,0)	This field represents the bin size indicator b . Together with Default Bin Size Parameter p_0 (ZDF043) the actual used bin size parameter p is computed by $p = p_0 + b$ U+M
ZD303	Sign Bit	0-1		bit(1)	This bit indicates the sign of a numerical value. 0: positive $s = +1$ 1: negative sign $s = -1$ U+M
ZDF304	Rice Quotient			PC(1,0)	This data field represents the quotient part q of the Rice encoded (unsigned integer) value n . U+M
ZDF305	Rice Remainder			bit(p)	This data field represents the quotient part r of the Rice encoded (unsigned integer) value n . The length of this field is given by the bin size parameter p . U+M

SSRZ Low Rate Correction Message Data Fields

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF309	SSRZ BE IOD		-	bit(n)	This field indicates the Issue of Data of the Broadcast Ephemeris. The length of this field depends on GNSS and is given by ZDF199 or the corresponding SSRZ BE IOD Tag fields (ZDF201-ZDF216). U
ZDF310	Phase Bias Flag			bit(1)	This field indicates if the phase bias value is valid. U
ZDF311	Phase Bias Indicator			bit($N_{PB, bits}$)	This field represents a phase bias value. The phase bias correction δPB in units of cycles is derived from the ZDF071 and ZDF072: $\delta PB = N_{PB, cyc} / 2^{N_{PB, bits}}$
ZDF312	Overflow/Discontinuity Indicator		-	PC(1,0)	The SSRZ Overflow/Discontinuity Indicator indicates the time since the last cycle slip (CS) or cycle overflow (OF) occurred. This field should be read as "No cycle slip or overflow since the last t seconds". The time is normalized to the update interval of SSRZ Low Rate Corrections. Nbits: no CS since the last 0 Nbits-1: no CS since the last 30s Nbits-2: no CS since the last 60s ... 0: no CS/OF since the last $2^{N_{bits}} t_{update}$ Nbits is given by ZDF073. U
ZDF315	SSRZ predictor flag			bit(1)	This flag indicates if the gridded data are encoded with the gridded-data predictor and how the resulting SSRZ Rice Blocks have to read. U
ZDF320	SSRZ QIX Bias Metadata flag			bit(1)	This field indicates the presence of metadata in the QIX Bias Message (ZM008). U
SSRZ Satellite Dependend Regional Ionosphere Correction Data Fields					

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
SSRZ Global VTEC Ionosphere Correction Data Fields					
ZDF330	SSRZ VTEC flag			bit(1)	This bit flag indicates if the message contains valid VTEC parameters. U
ZDF330	SSRZ VTEC flag			bit(1)	This bit flag indicates if the message contains valid VTEC parameters. U
ZDF331	SSRZ Global VTEC bin size indicator	0-X		PC(3,1,0)	This field represents the bin size indicator p for the Global VTEC Rice Block encoding. $p = 10 + ZDF331$ This field is only used if the corresponding metadata tag ZDF020 is 2,3. U
SSRZ Stream Identification Data Fields					
ZDF340	SSRZ Stream Identification Message Version	1-7		bit(3)	Version of SSRZ Stream Identification Message Version = ZDF340 + 1
ZDF341	SSRZ Stream Identification Message Block Size	0...		PC(8,0)	Size of SSRZ Stream Identification Message Block in bytes
ZDF342	SSRZ Stream Identification Message Block Tag	0		PC(8,0)	This tag indicates if and what type of SSRZ Stream Identification Message Block (ZM010-X) will follow. ZDF342 = 0: no data will follow ZDF342 > 0: X = ZDF342
ZDF343	SSRZ Provider ID	0-X		PC(8,0)	Unique ID identifying an SSRZ service provider Note: 0: Default Provider and assumed if ZM010 is not part of the SSRZ stream.

ZDF #	ZDF Name	ZDF Range	ZDF Resolution	Data Type	Data Field Notes
ZDF344	SSRZ Stream ID	0-X		PC(8,0)	Unique ID identifying an SSRZ stream of an SSRZ service provider. Note: Stream ID is assumed to be 0 if ZM010 is not part of the SSRZ stream.

7.2 SSRZ Data Block Summary

Table 7.2 SSZ Data Blocks summarizes the SSRZ Data Blocks as they are essential parts of the SSRZ messages. The data blocks are prefixed with “ZDB” to indicate the SSRZ relevant content. The definition together with a more detailed explanation of each data block follows below.

Table 7.2 SSZ Data Blocks

ZDB	ZDB Name	Notes
ZDB001	Rice encoded integer value (block)	Table 7.3
ZDB002	SSRZ Rice Block	Table 7.4
Compressed SSR Parameter Blocks		
ZDB003	SSRZ Compressed Satellite Parameter Block	Table 7.5
ZDB004	SSRZ Compressed Signal Bias Block	Table 7.6
ZDB005	SSRZ Compressed Chain Data Block	Table 7.7
ZDB006	SSRZ Compressed Gridded Data Block	Table 7.8
ZDB007	SSRZ Compressed Coefficients Block	Table 7.9
ZDB008	SSRZ Compressed Satellite-dependent Coefficients Block	Table 7.10
Grid Definition Blocks		
ZDB010	SSRZ Compressed Chain Block	Table 7.12
ZDB011	SSRZ Predictor Point Indicator Block	Table 7.13
ZDB012	SSRZ Grid Definition Block	Table 7.14
Timing Blocks		
ZDB018	SSRZ Timing Block	Table 7.16
ZDB019	SSRZ Satellite dependent Timing Block	Table 7.17
Rice Block Definition Blocks		
ZDB020	SSRZ Signal Bit Mask Block	Table 7.18
ZDB021	SSRZ Satellite Parameter Rice Block Definition	Table 7.19
ZDB022	SSRZ Signal Rice Block Definitions	Table 7.20
ZDB023	SSRZ Compressed Coefficients Block Definition	Table 7.21
ZDB024	SSRZ Compressed Coefficients Block	Table 7.22
SSRZ message-specific Blocks		
ZDB030	SSRZ BE IOD Definition Block	Table 7.27

ZDB	ZDB Name	Notes
ZDB031	SSRZ Phase Bias Signal Block	Table 7.28
ZDB032	SSRZ Phase Bias Block	Table 7.29
ZDB060	SSRZ Model Parameters Block	Table 7.39

7.2.1 Rice-encoded integer value (ZDB001)

The *Rice-encoded integer value* (block) allows the decoding of the integer value $m = s(2^p q + r)$

Table 7.3 SSR Rice-encoded integer value ZDB001

Name	Definition	Number of Bits	Notes
Sign Bit	ZDF303	1	Symbol s
Rice Quotient	ZDF304	variable	Symbol q
Rice Remainder	ZDF305	p	Symbol r ; p is the bin size parameter which can be derived from ZDF302.

7.2.2 SSRZ Rice Block (ZDB002)

The *SSRZ Rice Block* combines the adaptive Rice parameters and the sequence of Rice-encoded integer values. The definition is given in Table 7.4.

Table 7.4 SSRZ Rice Block ZDB002

Name	Definition	Number of Bits	Notes
Scale Factor Indicator	ZDF301	variable	PC(2,0)
Bin size Indicator	ZDF302	variable	PC(2,0)
Rice-encoded integer value	ZDB001	variable	This block repeats for the number of parameters considered in this Rice Block.

7.2.3 SSRZ Compressed Satellite Parameter Block (ZDB003)

The *SSRZ Compressed Satellite Parameter Block* is a sequence of SSRZ Rice Blocks (ZDB002) containing encoded values of one satellite-dependent parameter (Table 3.2). The number and order of the parameter values per SSRZ Rice Block are determined by the attribute settings in the corresponding metadata as well as SSRZ Satellite Group and Satellite Group List settings. The order of the values per SSRZ Rice Block is in accordance to the ascending order of Satellite IDs per GNSS and to the ascending order of the set GNSS according to Table 10.1. The definition of the SSRZ Compressed Satellite Parameter Block is given in Table 7.5.

Table 7.5 SSRZ Compressed Satellite Parameter Block (ZDB003)

Name	Definition	Number of Bits	Notes
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is greater than 0 and if the number of transmitted satellites (indicated by ZDF018) for this Rice Block is larger than 0. Satellite systems that have to be considered in this SSRZ Rice Block are determined by the corresponding

Name	Definition	Number of Bits	Notes
			GNSS IDs set in the metadata of the 1 st SSRZ Rice Block for this SSR parameter.
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is greater than 1 and if the number of transmitted satellites (indicated by ZDF018) for this Rice Block is larger than 0. Satellite systems that have to be considered in this SSRZ Rice Block are determined by the corresponding GNSS IDs set in the metadata of the 2 nd SSRZ Rice Block for this SSR parameter.
...			
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is N and if the number of transmitted satellites (indicated by ZDF018) for this Rice Block is larger than 0. Satellite systems that have to be considered in this SSRZ Rice Block are determined by the corresponding GNSS IDs set in the metadata of the N th SSRZ Rice Block for this SSR parameter.

7.2.4 SSRZ Compressed Signal Bias Block (ZDB004)

The *SSRZ Compressed Signal Bias Block* is a sequence of SSRZ Rice Blocks containing encoded values of Signal Biases. The number and order of the signal bias values per SSRZ Rice Block is given by the SSRZ Satellite Group and Satellite Group List settings as well as the signal indicators (the attributes of these SSRZ Rice Blocks) in the corresponding metadata. The order of the values per SSRZ Rice Block is first in accordance to the ascending order of the set signals according to Table 10.3 per satellite, second in the ascending order of Satellite IDs per GNSS and third to the ascending order of set GNSS IDs according to Table 10.1. The definition of the SSRZ Compressed Signal Block is given in Table 7.6.

Table 7.6 SSRZ Compressed Signal Bias Block ZDB004

Name	Definition	Number of Bits	Notes
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR signal bias (code or phase bias) is greater than 0 and if the number of transmitted satellites (indicated by ZDF018) for this Rice Block is larger than 0. Signals that have to be considered in this SSRZ Rice Block are determined by the corresponding signal settings in the metadata of the 1 st SSRZ Rice Block for this SSR signal bias.
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR signal bias (code or phase bias) is greater than 1 and if the number of transmitted

Name	Definition	Number of Bits	Notes
			satellites (indicated by ZDF018) for this Rice Block is larger than 0. Signals that have to be considered in this SSRZ Rice Block are determined by the corresponding signal settings in the metadata of the 2 nd SSRZ Rice Block for this SSR signal bias.
...			
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR signal bias (code or phase bias) is N. Signals that have to be considered in this SSRZ Rice Block are determined by the corresponding signal settings in the metadata of the N th SSRZ Rice Block for this SSR signal bias.

7.2.5 SSRZ Compressed Chain Data Block (ZDB005)

The *SSRZ Compressed Chain Data Block* is a sequence of encoded gridded SSR parameter values related to the grid points per chain.

Table 7.7 SSRZ Compressed Chain Data Block ZDB005

Name	Definition	Number of Bits	Notes
SSRZ Predictor Flag	ZDF315	1	This flag indicates which subsequent SSRZ Rice Block is present. 0: one SSRZ Rice Block containing $N_{pts/chain}$ encoded values follow. 1: two SSRZ Rice Block with 1 and $N_{pts/chain} - 1$ encoded values, respectively, follow. This flag is only allowed to 1 if the ZDF103 in the corresponding Compressed Chain Block (ZDB010) is 1 and the Predictor Point Indicator Block ZDB011 is present.
SSRZ Rice Block	ZDB002	variable	This Block contains the gridded data of all grid chain points $N_{pts/chain}$. The gridded-data predictor has not to be applied. This Block is only present if ZDF315 is 0.
SSRZ Rice Block	ZDB002	variable	This Block contains the absolute grid value (not encoded with the gridded-data predictor) of the first grid point per chain. The subsequent SSRZ Rice Block with $N_{pts/chain} - 1$ is required to decode the gridded data per chain properly. This Block is only present if ZDF315 is 1.
SSRZ Rice Block	ZDB002	variable	This Block contains and $N_{pts/chain} - 1$ values encoded with the gridded-data predictor algorithm.

Name	Definition	Number of Bits	Notes
			The previous SSRZ Rice Block of the first point is required to decode the gridded data per chain properly. This Block is only present if ZDF315 is 1.

7.2.6 SSRZ Compressed Gridded Data Block (ZDB006)

The *SSRZ Compressed Gridded Data Block* is a sequence of SSRZ Compressed Chain Data Blocks (ZDB005) including all gridded SSR parameter correction values per grid. The number of SSRZ Compressed Chain Data Blocks is determined by the number of chains per grid (corresponding ZDF094 in ZMB003 and ZMB004).

Table 7.8 SSRZ Compressed Gridded Data Block ZDB006

Name	Definition	Number of Bits	Notes
SSRZ Compressed Chain Data Block	ZDB005	variable	This SSRZ Compressed Chain Block is only present if the number of chains is greater than 0 for this grid. The number and order of data values is related to the grid points associated with the 1 st chain.
SSRZ Compressed Chain Data Block	ZDB005	variable	This SSRZ Compressed Chain Block is only present if the number of chains is greater than 1 for this grid. The number and order of data values is related to the grid points associated with the 2 nd chain.
...			
SSRZ Compressed Chain Data Block	ZDB005	variable	This SSRZ Compressed Chain Block is only present if the number of chains is N for this grid. The number and order of data values is related to the grid points associated with the N th chain.

7.2.7 SSRZ Compressed Coefficients Block (ZDB007)

The *SSRZ Compressed Coefficients Block* (see also Table 3.6) is a sequence of SSRZ Rice Blocks including encoded coefficients of polynomials or spherical harmonics. The number and order of these coefficients per SSRZ Rice Block are determined by and in ascending order of the order $l + m$ set as attributes in the corresponding SSRZ Compressed Coefficients Block Definition.

Table 7.9 SSRZ Compressed Coefficients Block ZDB007

Name	Definition	Number of Bits	Notes
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is greater 0. The number and order of coefficients are determined by the corresponding polynomial order settings in the metadata of the 1 st SSRZ Rice Block for this SSR parameter.
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is greater 1.

Name	Definition	Number of Bits	Notes
			The number and order of coefficients are determined by the corresponding polynomial order settings in the metadata of the 2 nd SSRZ Rice Block for this SSR parameter.
...			
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is N. The number and order of coefficients are determined by the corresponding polynomial order settings in the metadata of the N th SSRZ Rice Block for this SSR parameter.

7.2.8 SSRZ Compressed Satellite-dependent Coefficients Block (ZDB008)

The *SSRZ Compressed Satellite-dependent Coefficients Block* is a sequence of SSRZ Rice Blocks containing encoded satellite-dependent Chebyshev coefficients. The number and order of these coefficients per SSRZ Rice Block are determined by the polynomial order indicators (the attributes of these SSRZ Rice Blocks) and satellites set by the SSRZ Satellite Group and SSRZ Satellite Group List definitions, respectively.

The order of the coefficients per SSRZ Rice Block is as follows: The first coefficient per SSRZ Rice Block is in the corresponding SSRZ Rice Block metadata setting. The relation between order and coefficients is written in Table 3.6.

Table 7.10 SSRZ Compressed Satellite-dependent Coefficient Block ZDB008

Name	Definition	Number of Bits	Notes
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is greater 0. The number and order of coefficients are determined by the corresponding polynomial order settings in the metadata of the 1 st SSRZ Rice Block for this SSR parameter and the number of valid satellites.
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is greater 1. The number and order of coefficients are determined by the corresponding polynomial order settings in the metadata of the 2 nd SSRZ Rice Block for this SSR parameter and the number of valid satellites.
...			
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is N. The number and order of coefficients are determined by the corresponding polynomial order settings in the metadata of the N th SSRZ Rice Block for this SSR parameter and the number of valid satellites.

7.2.9 SSRZ Compressed Parameter Block (ZDB009)

The *SSRZ Compressed Parameter Block* is a sequence of SSRZ Rice Blocks including encoded parameters. The included parameters are per SSRZ Rice Block are determined in ascending order of SSRZ Parameter List Bit Mask (ZDF047) – the attribute in the corresponding SSRZ Compressed Parameter Data Block Definition (ZDF027).

Table 7.11 SSRZ Compressed Parameter Block ZDB009

Name	Definition	Number of Bits	Notes
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is greater 0. The transmitted parameters are indicated by the SSRZ Parameter List Bit Mask (ZDF047) in the metadata of the 1 st SSRZ Parameter Rice Block Definition (ZDB028) in the corresponding Compressed Parameter Data Block Definition (ZDFB027).
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is greater 1. The transmitted parameters are indicated by the SSRZ Parameter List Bit Mask (ZDF047) in the metadata of the 2 nd SSRZ Parameter Rice Block Definition (ZDB028) in the corresponding Compressed Parameter Data Block Definition (ZDFB027).
...			
SSRZ Rice Block	ZDB002	variable	This Block is only present if the number of SSRZ Rice Blocks for this SSR parameter is N. The transmitted parameters are indicated by the SSRZ Parameter List Bit Mask (ZDF047) in the metadata of the n th SSRZ Parameter Rice Block Definition (ZDB028) in the corresponding Compressed Parameter Data Block Definition (ZDFB027).

7.2.10 SSRZ Compressed Chain Block (ZDB010)

The *SSRZ Compressed Chain Block* includes all parameters to reconstruct the $N_{pts/chain}$ grid points per chain.

Table 7.12 SSRZ Compressed Chain Block ZDB010

Name	Definition	Number of Bits	Notes
Number of grid points per chain	ZDF095	variable	$N_{pts/chain}$ This field is only present if ZDF020 is 3, 4.
Grid Bin Size Parameter	ZDF096	variable	Bin size parameter p to decode the latitude and longitude values of the first (chain) point. This field is only present if ZDF020 is 3, 4.
Rice encoded integer value	ZDB001	variable	This block repeats twice. It contains the latitude and longitude values of the first (chain) point (φ, λ). The resolution is given in ZDB012. This field is only present if ZDF020 is 3, 4.

Name	Definition	Number of Bits	Notes
Grid Bin Size Parameter	ZDF096	variable	Bin size parameter p to (Rice) decode the following $2*(N_{pts/chain}-1)$ chain point parameters. This field is only present if ZDF020 is 3, 4.
Rice encoded integer value	ZDB001	variable	This block repeats for $2*(N_{pts/chain}-1)$ times. The sequence contains pair-wisely two parameters per (chain) point: $(d\varphi, d\lambda)_2, (ds, ss)_3, (ds, ss)_4, \dots, (ds, ss)_{N_{pts/chain}}$ The resolution is given in ZDB012. This field is only present if ZDF020 is 3, 4.
Use Baseline Flag	ZDF097	$N_{pts/chain}-2$	This flag repeats from the third till the maximum grid point per chain. This field is only present if ZDF020 is 3, 4.
Point Position Flag	ZDF098	$N_{pts/chain}-2$	This flag repeats from the third till the maximum grid point per chain. This field is only present if ZDF020 is 3, 4.
Add Baseline Left Flag	ZDF099	$N_{pts/chain}-2$	This flag repeats from the third till the maximum grid point per chain. This field is only present if ZDF020 is 3, 4.
Add Baseline Right Flag	ZDF100	$N_{pts/chain}-2$	This flag repeats from the third till the maximum grid point per chain. This field is only present if ZDF020 is 3, 4.
Height Flag	ZDF101	1	This field indicates if height information of the chain points is provided. This field is only present if ZDF020 is 3.
Grid point height resolution	ZDF102	variable	This field is only present if ZDF020 is 3 and ZDF101 is '1'
Grid Bin Size Parameter	ZDF096	variable	Bin size parameter p to decode the height of the first (chain) point. This field is only present if <ul style="list-style-type: none"> ZDF020 is 3 and ZDF101 is set ZDF020 is 4 and ZDF102 in ZDB12 is >0
Rice encoded integer value	ZDB001	variable	Rice encoded absolute height of the first point (per chain). The resolution is given in the associated ZDF102. This field is only present if <ul style="list-style-type: none"> ZDF020 is 3 and ZDF101 is set ZDF020 is 4 and ZDF102 in ZDB12 is >0
Grid Bin Size Parameter	ZDF096	variable	Bin size parameter p to decode the following $(N_{pts/chain}-1)$ height differences $\Delta h_{01}, \Delta h_{12}, \dots$. This field is only present if <ul style="list-style-type: none"> ZDF020 is 3 and ZDF101 is set

Name	Definition	Number of Bits	Notes
			<ul style="list-style-type: none"> ZDF020 is 4 and ZDF102 in ZDB12 is >0 This field is only present if $N_{pts/chain} > 1$.
Rice encoded integer value	ZDB001	variable	This block repeats for $(N_{pts/chain}-1)$ times. The sequence contains the height differences $\Delta h_{01}, \Delta h_{12}, \dots$. The resolution is given in the associated ZDF102. This field is only present if <ul style="list-style-type: none"> ZDF020 is 3 and ZDF101 is set ZDF020 is 4 and ZDF102 in ZDB12 is >0 This field is only present if $N_{pts/chain} > 1$.
Gridded Data Predictor Points Flag	ZDF103	1	This flag indicates the presents of SSRZ Predictor Point Indicator Block. 0: ZDB011 is not present 1: ZDB011 is present This field is only present if ZDF020 is 3, 4.
SSRZ Predictor Point Indicator Block	ZDB011	variable	This block repeats for $N_{pts/chain} - 3$ times (from the forth till the maximum number of grid point per chain). This field is only present if ZDF103 is set and ZDF020 is 3, 4.

7.2.11 SSRZ Predictor Point Indicator Block (ZDB011)

The *SSRZ Predictor Point Indicator Block* provides the indices a, b, c of the three grid points (in a chain) that are used in the gridded data predictor algorithm. Due to the iterative representation/encoding of a chain these indices are mostly close to the index of the current point i . For this reason, the differences $\delta a, \delta b, \delta c$ between the indices a, b, c and i are transmitted.

Table 7.13 SSRZ Predictor Point Indicator Block ZDB011

Name	Definition	Number of Bits	Notes
Predictor Point Indicator for point δa	ZDF104	variable	The index of predictor grid point a (per chain) is computed with $a = i - (\delta a + 1)$, whereby i is the index of a grid point in a chain.
Predictor Point Indicator for point δb	ZDF104	variable	The index of predictor grid point b (per chain) is computed with $b = i - (\delta b + 1)$, whereby i is the index a grid point per chain.
Predictor Point Indicator for point δc	ZDF104	variable	The index of predictor grid point c (per chain) is computed with $c = i - (\delta c + 1)$, whereby i is the index a grid point per chain.

7.2.12 SSRZ Grid Definition Block (ZDB012)

The *SSRZ Grid Definition Block* contains the SSRZ Compressed Chain Blocks (ZDB010) and resolution parameters required to define a grid. The data field ZDF020 in the notes is identical to that one used in the SSRZ Grid Definition Metadata Message Block ZMB013 (Table 9.24).

Table 7.14 SSRZ Grid Definition Block ZDB012

Name	Definition	Number of Bits	Notes
Grid ID	ZDF105	variable	This field is only present if ZDF020 is 3, 4.
Grid IOD	ZDF106	3	This field is only present if ZDF020 is 3, 4.
Order of the grid point coordinate resolution	ZDF092	variable	This field is only present if ZDF020 is 3.
Integer part of the grid point coordinate resolution	ZDF093	8	The grid point coordinate resolution derived from ZDF092 and ZDF093 within this block (ZDB012) is only valid for the grid defined in this block. This field is only present if ZDF020 is 3.
Number of Chains per Grid	ZDF094	variable	N_{chain} This field is only present if ZDF020 is 3, 4.
SSRZ Compressed Chain Block	ZDB010	variable	This block is repeated for all chains per grid. This field is only present if ZDF020 is 3, 4.

7.2.13 SSRZ Satellite Group Definition Block (ZDB017)

The SSRZ Satellite Group Definition Block ZDB017 contains the data fields to describe an SSRZ Satellite Group Definition.

Table 7.15 SSRZ Satellite Group Definition Block ZDB017

Name	Definition	Number of Bits	Notes
SSRZ GNSS ID Bit Mask	ZDF012	16	
SSRZ Maximum Satellite ID per GNSS and Group	ZDF013	n	This fields repeats for every system present in SSRZ GNSS ID Bit Mask (ZDF012).
Satellite Group Definition Mode	ZDF014	4	
Satellite Group Bit Mask per GNSS	ZDF015	n	This field is only present if ZDF014 is 0 and repeats for every system present in the SSRZ GNSS ID Bit Mask (ZDF012). The length of the bitmask is per system is given by ZDF013.

7.2.14 SSRZ Timing Block (ZDB018)

The *SSRZ Timing Block* includes the length and the offset of an SSR update interval.

Table 7.16 SSRZ Timing Block ZDB018

Name	Definition	Number of Bits	Notes
Length of SSR Update Interval	ZDF053	6	

Offset of SSR Update Interval	ZDF054	6	
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7.2.15 SSRZ Satellite-dependent Timing Block (ZDB019)

The *SSRZ Satellite-dependent Timing Block* includes the update and offset intervals of a satellite-dependent SSR parameter sets and in addition indicators of the related satellite groups.

Table 7.17 SSRZ Satellite dependent Timing Block ZDB019

Name	Definition	Number of Bits	Notes
SSRZ Timing Block	ZDB018	12	
SSRZ Satellite Group List Bit Mask	ZDF016	variable	This bit mask indicates the satellite groups associated with the timing intervals.

7.2.16 SSRZ Signal Bit Mask Block (ZDB020)

The SSRZ Signal Bit Mask Block is used to indicate signals of all systems.

Table 7.18 SSRZ Signal Bit Mask Block ZDB020

Name	Definition	Number of Bits	Notes
SSRZ GNSS ID Bit Mask	ZDF012	16	This bit mask indicates which GNSS has as signal definition. '1': has signal definition '0': has not.
SSRZ Signal Bit Mask per GNSS	ZDF019	32	This fields repeats for every system present in the preceding SSRZ GNSS ID Bit Mask (ZDF012).

7.2.17 SSRZ Satellite Parameter Rice Block Definition (ZDB021)

The SSRZ Satellite Parameter Rice Block Definition includes the system bit mask as attribute and the Default Bin Size Parameter to define the Rice Block Metadata.

Table 7.19 SSRZ Satellite Parameter Rice Block Definition ZDB021

Name	Definition	Number of Bits	Notes
SSRZ GNSS ID Bit Mask	ZDF012	16	This bit mask indicates which GNSS has to be considered in this SSRZ Signal Rice Block. '1': has to be considered '0': has not to be considered
Default Bin Size Parameter	ZDF043	variable	This fields repeats for the number of components per SSR parameter type (corresponding data field ZDF044).

7.2.18 SSRZ Signal Rice Block Definition (ZDB022)

The SSRZ Satellite Parameter Rice Block Definition includes GNSS ID and signal ID bit masks as attributes and the Default Bin Size Parameter to define the Rice Block Metadata.

Table 7.20 SSRZ Signal Rice Block Definition ZDB022

Name	Definition	Number of Bits	Notes
SSRZ Signal Bit Mask Block	ZDB020	variable	This Block indicates which signals are set as attributes in this Rice SSRZ Signal Rice Block.
Default Bin Size Parameter of encoded Signal Biases	ZDF046	variable	

7.2.19 SSRZ Compressed Coefficient Data Block Definition (ZDB023)

The *SSRZ Compressed Coefficient Data Block Definition* includes the default bin size parameter value and attribute to define the Rice Blocks for the SSRZ Compressed Coefficient Block ZDB007 and Compressed Satellite-dependent Coefficient Block ZDB008.

The attribute of this rice block definition is an order bit mask. The length of this bit mask depends on the maximum order defined for the SSR parameter.

Table 7.21 SSRZ Compressed Coefficient Data Block Definition ZDB023

Name	Definition	Number of Bits	Notes
Number of Rice Blocks	ZDF042	variable	N_{RB}
SSRZ Coefficient Rice Block Definition	ZDB024	Variable	This Block repeats for N_{RB} times.

7.2.20 SSRZ Coefficient Rice Block Definition (ZDB024)**Table 7.22 SSRZ Coefficient Rice Block Definition ZDB024**

Name/ Block	Definition	NO. OF BITS	NOTES
Coefficient Order Bit Mask	ZDF116	variable	The length of this bit mask is derived from the corresponding Model Parameters.
Default Bin Size Parameter	ZDF043	Variable	

7.2.21 SSRZ Compressed Global VTEC Coefficient Data Block Definition (ZDB025)

The *SSRZ Compressed Global VTEC Coefficient Data Block Definition* includes the default bin size parameter value and the attribute to define the Rice Block for the SSRZ Compressed Global VTEC Data Block ZDB009. The attribute of this Rice block definition is parameter list bit mask.

Table 7.23 SSRZ Compressed Global VTEC Coefficient Data Block Definition ZDB025

Name	Definition	Number of Bits	Notes
Number of Rice Blocks	ZDF042	variable	N_{RB}
SSRZ Global VTEC Coefficient Rice Block Definition	ZDB027	Variable	This Block repeats for N_{RB} times.

7.2.22 SSRZ Global VTEC Coefficient Rice Block Definition (ZDB026)

Table 7.24 SSRZ Global VTEC Coefficient Rice Block Definition ZDB026

Name	Definition	Number of Bits	Notes
Default Bin Size Parameter	ZDF043	Variable	
Parameter List Bit Mask	ZDF116	variable	

7.2.23 SSRZ Compressed Parameter Data Block Definition (ZDB027)

The *SSRZ Compressed Parameter Data Block Definition* includes the attribute SSRZ parameter list bit mask and the default bin size parameter value of the Rice Block definitions.

Table 7.25 SSRZ Compressed Parameter Data Block Definition (ZDB027)

Name	Definition	Number of Bits	Notes
Number of Rice Blocks	ZDF042	variable	N_{RB}
SSRZ Parameter Rice Block Definition	ZDB028	variable	This Block repeats for N_{RB} times.

7.2.24 SSRZ Parameter Rice Block Definition (ZDB028)

Table 7.26 SSRZ Parameter Rice Block Definition ZDB028

Name/ Block	Definition	NO. OF BITS	NOTES
Parameter List Bit Mask	ZDF047	variable	Length of the bit mask and content as well as order of parameters are context-sensitive.
Default Bin Size Parameter	ZDF043	variable	

7.2.25 SSRZ BE IOD Definition Block (ZDB030)

The *SSRZ BE IOD Definition Block* includes information how to read and process the SSRZ BE IOD per GNSS.

Table 7.27 SSRZ BE IOD Definition Block ZDB030

Name	Definition	Number of Bits	Notes
SSRZ GNSS ID Bit Mask	ZDF012	16	This bit mask indicates which GNSS has to be considered. '1': has to be considered '0': has not to be considered This field is only present if ZDF020 is 1.
Length of the SSRZ BE IOD field	ZDF199	4	This fields repeats for every system present in the preceding SSRZ GNSS ID Bit Mask (ZDF012). This field is only present if ZDF020 is 1.
SSRZ BE IOD Tag	ZDF200	variable	This Tag indicates how to interpret the received IODs This field is only present if ZDF020 is 1.

Name	Definition	Number of Bits	Notes
SSRZ BE IOD Tag GPS	ZDF201	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag GLONASS	ZDF202	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag Galileo	ZDF203	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag QZSS	ZDF204	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag SBAS	ZDF205	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag BDS	ZDF206	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag IRNSS	ZDF207	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag	ZDF208	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag	ZDF209	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag	ZDF210	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag	ZDF211	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag	ZDF212	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag	ZDF213	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag	ZDF214	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag	ZDF215	variable	This field is only present if ZDF020 is 2.
SSRZ BE IOD Tag	ZDF216	variable	This field is only present if ZDF020 is 2.

7.2.26 SSRZ Phase Bias Signal Block (ZDB031)

The SSRZ Phase Bias Signal Block is the sequence of data fields related to the phase bias information per signal and satellite.

Table 7.28 SSRZ Phase Bias Signal Block ZDB031

Name	Definition	Number of Bits	Notes
Phase Bias Flag	ZDF310	1	
Phase Bias Value Indicator	ZDF311	$N_{PB, bits}$	This data field is only present if the Phase Bias Flag (ZDF310) is 1. The length of this bit field is given by ZDF071.
Combined Continuity / Overflow indicator	ZDF312	variable	This data field is only present if the Phase Bias Flag (ZDF310) is 1.

7.2.27 SSRZ Phase Bias Block (ZDB032)

The SSRZ Phase Bias Block is a sequence of SSRZ Phase Bias Signal Blocks for all transmitted satellites and defined signals per satellite. SSRZ Phase Bias Signal Blocks are arranged in ascending order of signals according to **Table 10.3** and in ascending order of Satellite IDs and GNSS (according to **Table 10.1**)

Table 7.29 SSRZ Phase Bias Block ZDB032

Name	Definition	Number of Bits	Notes
Phase Bias Signal Block	ZDB031	variable	This blocks repeats for all valid satellites and defined signals per satellite.

7.2.28 SSRZ Update and Offset Block (ZDB040)

The *SSRZ Update and Offset Block* includes the length and the offset of an SSR update interval and is an improvement of the SSRZ Timing Block (ZDB018).

Table 7.30 SSRZ Update and Offset Block ZDB040

Name	Definition	Number of Bits	Notes
SSR Length of SSR Update Interval	ZDF056	variable	
SSR Update Interval Offset	ZDF057	variable	

7.2.29 SSRZ Satellite-Group-related Update and Offset Block (ZDB041)

The *SSRZ Satellite-Group-related Update and Offset Block* represents the SSRZ satellite groups that are associated with timing parameters included in an Update and Offset Block (ZDB040).

Table 7.31 SSRZ Satellite-Group related Update and Offset Block ZDB041

Name	Definition	Number of Bits	Notes
SSRZ Update and Offset Block	ZDB040	variable	
SSRZ Satellite Group List Bit Mask	ZDF016	N_G	This bit mask indicates the satellite groups associated with the update and offset block parameters. The length of this bit mask N_G is given by ZDF024 in ZDB042.

7.2.30 SSRZ Satellite-Group-related Timing Parameters (ZDB042)

The *SSRZ Satellite-Group-related Timing Parameters* indicates the SSRZ Satellite Groups that are associated with specific Update and Offset Block (ZDB040).

Table 7.32 SSRZ Satellite-Group-related Timing Parameters ZDB042

Name	Definition	Number of Bits	Notes
Number of SSRZ Satellite Groups	ZDF024	variable	N_G
Number of SSRZ Satellite-Group-related Update and Offset Block	ZDF058	variable	$N_{Tmg,G}$
SSRZ Satellite-Group-related Update and Offset Block	ZDB041	variable	This block repeats $N_{Tmg,G}$ times. The length of SSRZ Satellite Group List Bit Mask ZDF016 is given by N_G (ZDF024).

7.2.31 SSRZ Grid-related Update and Offset Block (ZDB043)

The *SSRZ Grid-related Update and Offset Block* indicates those grids that are associated with an Update and Offset Block (ZDB040).

Table 7.33 SSRZ Grid-related Update and Offset Block ZDB043

Name	Definition	Number of Bits	Notes
SSRZ Update and Offset Block	ZDB040	variable	
SSRZ Grid ID Bit Mask	ZDF026	variable	This bit mask indicates which grid is associated with update and offset parameters included in ZDB041.

7.2.32 SSRZ Grid-related Timing Parameters (ZDB044)

The *SSRZ Grid-related Timing Parameters* indicates those SSRZ Grid IDs that are associated with specific Update and Offset Blocks (ZDB040).

Table 7.34 SSRZ Grid-related Timing Parameters ZDB044

Name	Definition	Number of Bits	Notes
Maximum SSRZ Grid ID	ZDF025	variable	$M_{\text{Grid ID}}$
Number of SSRZ Grid-related Update and Offset Block	ZDF058	variable	$N_{\text{Tmg,Grid}}$
SSRZ Grid-related Update and Offset Block	ZDB043	variable	This block repeats $N_{\text{Tmg,Grid}}$ times. The length of SSRZ Grid ID Bit Mask ZDF026 is given by $M_{\text{Grid ID}}$ (ZDF025).

7.2.33 SSRZ Region-related Update and Offset Block (ZDB045)

The *SSRZ Region-related Update and Offset Block* indicates those regions that are associated with an Update and Offset Block (ZDB040).

Table 7.35 SSRZ Region-related Update and Offset Block ZDB045

Name	Definition	Number of Bits	Notes
SSRZ Update and Offset Block	ZDB040	variable	
SSRZ Region ID Bit Mask	ZDF027	variable	This bit mask indicates which region with SSRZ region ID is associated with update and offset parameters included in ZDB041. bit0: regionID 1 bit1: regionID 2

7.2.34 SSRZ Region-related Timing Parameters (ZDB046)

The *SSRZ Region-related Timing Parameters* indicates those SSRZ Region IDs that are associated with specific Update and Offset Blocks (ZDB046).

Table 7.36 SSRZ Region-related Timing Parameters ZDB046

Name	Definition	Number of Bits	Notes
Maximum SSRZ Region ID	ZDF027	variable	$M_{\text{Region ID}}$
Number of SSRZ Region-related Update and Offset Block	ZDF058	variable	$N_{\text{Tmg,Region}}$

Name	Definition	Number of Bits	Notes
SSRZ Region-related Update and Offset Block	ZDB045	variable	This block repeats $N_{Tmg,Region}$ times. The length of SSRZ Region ID Bit Mask ZDF027 is given by $M_{Region ID}$ (ZDF027).

7.2.35 SSRZ Basic Troposphere Component Coefficient Data Block Definition (ZDB050)

Table 7.37 SSRZ Basic Troposphere Component Coefficient Data Block Definition ZDB050

Name	Definition	Number of Bits	Notes
Maximum horizontal Order of regional troposphere component c	ZDF166	variable	$M_{hor,c}$
Maximum vertical Order of regional troposphere component c	ZDF167	variable	$M_{hgt,c}$
Resolution of regional troposphere coefficients of component c	ZDF085	variable	
SSRZ Compressed Coefficients Block Definition of regional troposphere component c	ZDB023	variable	
SSRZ Separated Compressed Coefficient Blocks per Height Order Flag for regional troposphere component c	ZDF108	1	This flag is only present if bit 0 in ZDF107 is set. This flag indicates if different SSRZ Compressed Coefficient Blocks (all identically defined by the subsequent ZDB023) are used for coefficients, related to different height orders.

7.2.36 SSRZ Tropospheric Mapping Function Improvement Parameter Data Block Definition (ZDB051)

Table 7.38 SSRZ Tropospheric Mapping Function Improvement Parameter Data Block Definition ZDB051

Name	Definition	Number of Bits	Notes
Maximum horizontal Order of mapping function improvements	ZDF166	variable	$M_{hor,MFI}$
Maximum vertical Order of mapping function improvements	ZDF167	variable	$M_{hgt,MFI}$
Maximum Elevation for Mapping Improvement	ZDF171	6	E_0
Resolution of mapping function improvement parameters	ZDF086	variable	
SSRZ Compressed Parameter Data Block Definition of	ZDB027	variable	

Name	Definition	Number of Bits	Notes
mapping function improvements			

7.2.37 SSRZ Model Parameters Block (ZDB060)

The SSRZ Model Parameter Block is currently part of the metadata and includes the required model parameters of the atmospheric corrections. It includes integer and float model parameter values (not documented here) and will be replaced by specific model parameters (ZDF130 – ZDF173) in the next version. The meanings (if necessary) of the model parameters within the Model Parameter Block is mentioned in the Appendix for each relevant SSR parameter.

Table 7.39 SSRZ Model Parameters Block ZDB060

Name	Definition	Number of Bits	Notes
Model ID	ZDF110	8	Model ID
Model Version	ZDF111	8	Model Version
Number of Integer Model Parameters	ZDF112	8	N_{int}
Integer Model Parameter	ZDF114	32	This field repeats N_{int} times.
Number of Float Model Parameters	ZDF113	8	N_{float}
Float Model Parameters	ZDF115	32	This field repeats N_{float} times.

7.2.38 SSRZ Global VTEC Ionosphere Layer Block (ZDB061)

Table 7.40 SSRZ Global VTEC Ionosphere Layer Block ZDB061

Name	Definition	Number of Bits	Notes
Height of Ionospheric Layer	ZDF131	TBD	h_l
Spherical Harmonics Degree	ZDF132	TBD	N_l
Spherical Harmonics Order	ZDF133	TBD	M_l The total number of coefficients per layer l is calculated from $(N_l + 1)^2 - (N_l - M_l)(N_l - M_l + 1)$

7.2.39 SSRZ Global VTEC Rice-encoded integer value (ZDB062)

The SSRZ Global VTEC *Rice-encoded integer value* Block is necessary to decode integer values $m = s(2^p q + r)$ in the SSRZ Global VTEC message ZM006 if the corresponding metadata tag ZDF020 is 2 or 3.

Table 7.41 SSR Rice-encoded integer value ZDB062

Name	Definition	Number of Bits	Notes
Rice Quotient	ZDF304	variable	Symbol q
Sign Bit	ZDF303	1	Symbol s

Name	Definition	Number of Bits	Notes
Rice Remainder	ZDF305	p	Symbol r ; p is the bin size parameter which can be derived from ZDF302.

8 SSRZ Correction Messages

8.1 SSRZ High Rate Correction Message (ZM001)

Table 8.1 describes the SSRZ High Rate Correction message.

Table 8.1 SSRZ High Rate Correction Message ZM001

Name	Definition	Number of Bits	Notes
SSRZ High Rate Correction Message Header Block	ZMH001-1	variable	This block is present if the corresponding metadata tag is 1.
SSRZ High Rate Correction Message Data Block	ZMD001-1	variable	This block is present if the corresponding metadata tag is 1.

Table 8.2 SSRZ High Rate Correction Message Header Block ZMH001-1

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	2	Always "00" for SSRZ Message ZM001
SSRZ 15 minutes Time Tag	ZDF050	10	
Satellite Group List Bit Mask	ZDF016	$N_{G(HR)}$	Satellite Group List Bit Mask according to defined HR groups. HR correction data are transmitted for those satellites which are associated with the defined High Rate Satellite Groups set in this Group List Bit Mask and which were transmitted in the previously sent and still valid SSRZ Low Rate message(s).

Table 8.2 SSRZ High Rate Correction Message Data Block ZMD001-1

Name	Definition	Number of Bits	Notes
SSRZ Compressed Satellite Parameter Block for High Rate Clock corrections C_{HR}	ZDB003	variable	The corresponding metadata are provided in ZMB001 (Table 9.7).
SSRZ Compressed Satellite Parameter Block for High Rate (Radial) Orbit correction	ZDB003	variable	The corresponding metadata are provided in ZMB001 (Table 9.7).

8.2 SSRZ Low Rate Correction Message (ZM002)

This message (ZM002) describes the mandatory satellite correction terms clock, orbit as well as phase and code biases. Velocity and Satellite-dependent Global Ionosphere Corrections are optionally.

Table 8.3 SSRZ Low Rate Correction Message ZM002

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	2	Always "01" for SSRZ Message ZM002
SSRZ 15 minutes time tag	ZDF050	10	This Block is only present if ZDF020 in the corresponding ZMB012 is 2.

Name	Definition	Number of Bits	Notes
SSRZ Metadata IOD	ZDF005	2	Metadata with matching IOD is required to encode SSRZ messages.
SSRZ Metadata Announcement Bit	ZDF006	1	
SSRZ 15 minutes time tag	ZDF050	10	This Block is only present if ZDF020 in the corresponding ZMB012 is 1.
Satellite Group List Bit Mask	ZDF016	$N_{G(LR)}$	
Satellite Bit Mask	ZDF018	variable	
SSRZ BE IOD	ZDF309	variable	Sequence of SSRZ IODs (ZDF210) according to the ascending to the order of transmitted satellites indicated by the Satellite Bit Mask (ZDF018).
SSRZ Low Rate Clock Corrections			
SSRZ Compressed Satellite Parameter Block for Low Rate Clock correction C_0	ZDB003	variable	The corresponding resolution and Rice Block definitions are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8).
SSRZ Compressed Satellite Parameter Block for Low Rate Clock correction C_1	ZDB003	variable	The corresponding resolution and Rice Block definitions are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8). This block is only present if the number of Low Rate clock components in ZMB002 is 2.
SSRZ Low Rate Orbit Corrections			
SSRZ Compressed Satellite Parameter Block for Low Rate Radial Orbit Correction	ZDB003	variable	The corresponding resolution and Rice Block definitions are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8).
SSRZ Compressed Satellite Parameter Block for Low Rate Along-track Orbit Correction	ZDB003	variable	The corresponding resolution and Rice Block definitions are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the

Name	Definition	Number of Bits	Notes
			notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8).
SSRZ Compressed Satellite Parameter Block for Low Rate Cross-Track Orbit Correction	ZDB003	variable	The corresponding resolution and Rice Block definitions are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8).
SSRZ Low Rate Velocity Corrections			
SSRZ Compressed Satellite Parameter Block for Low Rate Radial Velocity Correction	ZDB003	variable	The corresponding resolution and Rice Block definitions are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8). This block is only present if the number of Low Rate velocity components ZMB002 is set to 3.
SSRZ Compressed Satellite Parameter Block for Low Rate Along-track Velocity Correction	ZDB003	variable	The corresponding resolution and Rice Block definitions are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8). This block is only present if the number of Low Rate velocity components ZMB002 is set to 3.
SSRZ Compressed Satellite Parameter Block for Low Rate Cross-Track Velocity Correction	ZDB003	variable	The corresponding resolution and Rice Block definitions are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8). This block is only present if the number of Low Rate velocity components ZMB002 is set to 3.
SSRZ Low Rate Code Bias Corrections			
SSRZ Compressed Signal Block for Low Rate Code Bias Corrections	ZDB004	variable	The corresponding resolution and Rice Block definitions are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata

Name	Definition	Number of Bits	Notes
			required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8).
SSRZ Low Rate Phase Bias Corrections			
SSRZ Phase Bias Block	ZDB032	variable	The corresponding metadata are given in ZMB002 (The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8).
SSRZ Low Rate Satellite dependent Global Ionosphere Corrections			
SSRZ Compressed Satellite-dependent Global Ionosphere Coefficients Block	ZDB008	variable	The metadata for this block is provided by ZMB002 (Fehler! Verweisquelle konnte nicht gefunden werden.). This Block is only present if the Satellite dependent Global Ionosphere Correction Flag (ZDF134) is set in ZMB002.

8.3 SSRZ Gridded Ionosphere Correction Message (ZM003)

This message (ZM003) describes the gridded ionosphere corrections.

Table 8.4 SSRZ Gridded Ionosphere Correction Message (ZM003)

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	2	Always "10" for SSRZ Message ZM003
SSRZ 15 minutes time tag	ZDF050	10	
SSRZ Grid ID	ZDF105	variable	Connects the gridded ionosphere corrections with a grid ID.
SSRZ Grid IOD	ZDF106	3	Connects the gridded ionosphere corrections with the valid grid with SSRZ Grid ID (ZDF105).
Satellite Group List Bit Mask	ZDF016	$N_{G(LR)}$	Satellite Group List Bit Mask according to defined LR groups. Gridded ionospheric correction data are transmitted for those satellites which are associated with the defined Low Rate Satellite Groups set in this Group List Bit Mask and which were transmitted in the previously sent and still valid SSRZ Low Rate message(s).
SSRZ Compressed Gridded Data Block for Gridded Ionosphere Corrections	ZDB006	variable	This block repeats for all satellites identified from the Satellite Group List Bit Mask and previously sent Low Rate message in ascending order Satellite IDs per system and ascending GNSS ID according to Table 10.1.

			The metadata for this block is provided by ZMB003 (Table 9.11).
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8.4 SSRZ Gridded Troposphere Correction Message (ZM004)

Table 8.5 describes the SSRZ Gridded Troposphere Correction Message. The required metadata are given in ZMB004.

Table 8.5 SSRZ Gridded Troposphere Correction Message (ZM004)

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	5	Always "11 000" for SSRZ Message ZM004
SSRZ 15 minutes time tag	ZDF050	10	
SSRZ Grid ID	ZDF105	variable	Connects the gridded troposphere corrections with a grid ID
SSRZ Grid IOD	ZDF106	3	Connects the gridded troposphere corrections with the valid grid with SSRZ Grid ID (ZDF105).
SSRZ Compressed Gridded Troposphere Corrections Block	ZDB006	variable	This block repeats for all Rice-encoded indicated parameters (ZDF107) per troposphere basic component and indicated troposphere basic components in ascending order.

8.5 SSRZ Satellite dependent Regional Ionosphere Correction Message (ZM005)

Table 8.6 describes the Satellite dependent Regional Ionosphere Correction message (RSI).

Table 8.6 SSRZ Satellite dependent Regional Ionosphere Correction Message (ZM005)

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	5	Always "11 001" for SSRZ Message ZM005
SSRZ 15 minutes time tag	ZDF050	10	
Satellite Group List Bit Mask	ZDF016	$N_{G(LR)}$	Satellite Group List Bit Mask according to defined LR groups. Regional ionospheric correction data are transmitted for those satellites which are associated with the defined Low Rate Satellite Groups set in this Group List Bit Mask and which were transmitted in the previously sent and still valid SSRZ Low Rate message(s).
SSRZ Satellite dependent Regional Ionosphere Correction Message	ZM005-1	variable	This block is only present if ZDF020 is 1

Table 8.7 SSRZ Satellite dependent Regional Ionosphere Correction Message (ZM005-1)

Name	Definition	Number of Bits	Notes
SSRZ Compressed Satellite dependent Regional Ionosphere Coefficients Block	ZDB008	variable	The metadata for this block is provided by ZMB005 (Fehler! Verweisquelle konnte nicht gefunden werden.).

8.6 SSRZ Global VTEC Ionosphere Correction Message (ZM006)

The content of this message (ZM006) are the coefficients of the spherical harmonics of the Global VTEC Ionosphere model. The data field ZDF020, which is mentioned in the notes, refers to ZDF020 in the corresponding SSRZ Metadata Message Block ZMB012 that includes ZMB006.

Table 8.8 SSRZ Global VTEC Ionosphere Correction Message ZM006

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	5	Always "11 010" for SSRZ Message ZM006
SSRZ 15 minutes time tag	ZDF050	10	
SSRZ VTEC flag	ZDF330	1	This flag indicates if the message contains valid values. 0: contains no valid values 1: contain valid values
SSRZ Global VTEC bin size indicator	ZDF331	variable	This field represents the binsize p that has to be used for decoding the subsequent rice-encoded integer values This block is only present if the ZDF330 is 1 and ZDF020 is 2,3.
SSRZ Global VTEC Rice-encoded integer value	ZDB062	variable	This block repeats for the number of coefficients N_{VTEC} which is obtained from model parameter block (Table 15.4). This block is only present if the ZDF330 is 1 and ZDF020 is 2,3.

8.7 SSRZ Regional Troposphere Correction Message (ZM007)

Table 8.9 describes the SSRZ Regional Troposphere Correction Message.

Table 8.9 Regional Troposphere Correction Message (ZM007)

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	5	Always "11 011" for SSRZ Message ZM007
SSRZ 15 minutes time tag	ZDF050	10	
Regional Troposphere Correction Message Block	ZM007-2	variable	This block is only present if ZDF020 is 2.
Regional Troposphere Correction Message Block	ZM007-3	variable	This block is only present if ZDF020 is 3 and repeats until the ZDF030 inside the block is 0.

8.7.1 SSRZ Regional Troposphere Correction Message Block for tag 2 (ZM007-2)

Table 8.10 Regional Troposphere Correction Message Block for tag 2 (ZM007-2)

Name	Definition	Number of Bits	Notes
SSRZ Compressed Coefficients Block for regional troposphere corrections of the total component.	ZDB007	variable	This block is only present if bit 0 is set in ZDF107 in ZMB007-2. Apply Eq. (11.79).

SSRZ Compressed Coefficients Block for regional troposphere corrections of the wet component.	ZDB007	variable	This block is only present if bit 1 is set in ZDF107 in ZMB007-2. Apply Eq. (11.79).
SSRZ Compressed Coefficients Block for regional troposphere corrections of the dry component.	ZDB007	variable	This block is only present if bit 2 is set in ZDF107 in ZMB007-2. Apply Eq. (11.79).
SSRZ Compressed Parameter Block for mapping function improvements.	ZDB009	variable	This block is only present if bit 3 is set in ZDF107 in ZMB007-2.

8.7.2 SSRZ Regional Troposphere Correction Message Block for tag 3 (ZM007-3)

Table 8.11 Regional Troposphere Correction Message Block for tag 3 (ZM007-3)

Name	Definition	Number of Bits	Notes
SSRZ Region ID	ZDF027	variable	Region Identifier
SSRZ Compressed Coefficients Block for regional troposphere corrections of the dry component.	ZDB007	variable	This block is only present if bit 0 is set in ZDF107 in ZMB007-3 for the corresponding Region ID (ZDF027) is set.
SSRZ Compressed Coefficients Block for regional troposphere corrections of the wet component.	ZDB007	variable	This block is only present if bit 1 is set in ZDB in ZMB007-3 for the corresponding Region ID (ZDF027) is set.
SSRZ Compressed Coefficients Block for regional troposphere corrections of the total component.	ZDB007	variable	This block is only present if bit 2 is set in ZDF107 in ZMB007-3 for the corresponding Region ID (ZDF027) is set.
SSRZ Compressed Parameter Block for mapping function improvements.	ZDB009	variable	This block is only present if bit 3 is set in ZDF107 in ZMB007-3 for the corresponding Region ID (ZDF027) is set.
SSR Multi-Region Flag	ZDF030	1	This field indicates if another block ZM007-3 follows.

8.8 SSRZ QIX Bias Message (ZM008)

The data field ZDF020 mentioned in the notes refers to ZDF020 in the corresponding metadata.

Table 8.12 describes the SSRZ QIX Bias correction message (ZM008). The message contains all estimated QIX code and phase biases of the defined signals for all satellites provided in the SSRZ stream. The metadata of the SSRZ QIX Bias Message can be either part of the SSRZ Metadata Message ZM012 or are included in the ZM008 for more flexibility. The data field ZDF020 mentioned in the notes refers to ZDF020 in the corresponding metadata.

Table 8.12 SSRZ QIX Bias Message ZM008

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	5	Always "11 100" for SSRZ Message ZM008
SSRZ QIX metadata flag	ZDF320	1	
SSRZ Metadata Tag	ZDF020	variable	This field is only present in ZDF320 is 1. Otherwise it is part of the metadata message ZM012

Name	Definition	Number of Bits	Notes
SSRZ QIX Bias Metadata Message Block	ZMB008	variable	This field is only present if ZDF320 is 1 and ZDF020 is 1,2.
SSRZ GNSS ID Bit Mask	ZDF012	16	This field is present if ZDF020 is 1,2.
SSRZ Maximum Satellite ID per GNSS and Group	ZDF013	variable	This fields repeats for every system present in SSRZ GNSS ID Bit Mask (ZDF012). This field is present if ZDF020 is 1,2.
Satellite Group Bit Mask per GNSS	ZDF015	variable	This field repeats for every system present in the SSRZ GNSS ID Bit Mask (ZDF012). The length of the bitmask is per system is given by ZDF013.
SSRZ Compressed Signal Bias Block for QIX code bias corrections	ZDB004	variable	This field is only present if <ul style="list-style-type: none"> ZDF020 is 1 ZDF020 is 2 and ZDF190 is 1 If ZDF020 is 2, ZDF190 is 0 and ZDF191 is 1: The QIX code biases are zero for all satellites and signals having valid values in the subsequent QIX phase bias corrections.
SSRZ Compressed Signal Bias Block for QIX phase bias corrections	ZDB004	variable	This field is only present if <ul style="list-style-type: none"> ZDF020 is 1 ZDF020 is 2 and ZDF191 is 1 If ZDF020 is 2, ZDF190 is 1 and ZDF191 is 0: The QIX phase biases are zero for all satellites and signals having valid values in the preceding QIX code bias corrections.

8.9 SSRZ Time Tag Message (ZM009)

This message transports information about the reference time for the SSRZ update messages.

In real-time applications a time tagging of the SSRZ messages is not required, as the continuously and sequential order of the messages (chronology) has to be maintained by the service provider. However, as the need for post-processing of SSRZ data is obvious, a time tag in the SSRZ stream is recommended. The actual time tag mechanism is open to be defined by the service provided together with the SSRZ metadata.

Table 8.13 SSRZ Time Tag Message ZM009

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	5	Always "11 101" for SSRZ Message ZM009
SSRZ Time Tag Definition	ZDF230	variable	
SSRZ 1hour - 30seconds Time Tag	ZDF231	7	This field is only present if ZDF230 is 0.
SSRZ 1hour - 5seconds Time Tag	ZDF232	10	This field is only present if ZDF230 is 1.
SSRZ 15 minutes Time Tag	ZDF050	10	This field is only present if ZDF230 is 2.
SSRZ 1hour - 1seconds Time Tag	ZDF233	12	This field is only present if ZDF230 is 3.
SSRZ 1day – 1second Time Tag	ZDF234	17	This field is only present if ZDF230 is 4.
GPS week number	ZDF051	12	This field is only present if ZDF230 is 6.

GPS epoch time	ZDF052	20	This field is only present if ZDF230 is 5,6.
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9 SSRZ Metadata Messages

9.1 SSRZ Stream Identification Message (ZM010)

The SSRZ stream identification message is needed to identify different SSRZ stream providers and/or different SSRZ data streams of a provider and can optionally contain additional stream-specific information. The size information of an additional message block allows skipping if the decoding is not up to date. SSRZ Provider IDs are listed in Table 15.6 and at www.geopp.de/ssrz.

Table 9.1 SSRZ Stream Identification Message ZM010

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	5	Always "11 110" for SSRZ Message ZM010
SSRZ Stream ID Message Version	ZDF340	3	
SSRZ Provider ID	ZDF343	variable	
SSRZ Stream ID	ZDF344	variable	
SSRZ Stream Identification Message Block Tag	ZDF342	variable	This field indicates if and what type of ZM010-X will follow. 0: end of message (no data fields will follow) 1: ZM010-1 will follow 2: ZM010-2 will follow ... X: ZM010-X will follow
SSRZ Stream Identification Message Block	ZM010-X	variable	This block is only present if the previous ZDF342 is > 0
SSRZ Stream Identification Message Block Tag	ZDF342	variable	This field indicates if and what type of ZM010-X will follow. 0: end of message (no data fields will follow) 1: ZM010-1 will follow 2: ZM010-2 will follow ... X: ZM010-X will follow
SSRZ Stream Identification Message Block	ZM010-X	variable	This block is only present if the previous ZDF342 is > 0
...			

9.2 SSRZ Stream Identification Message Block (ZM010-X)

The SSRZ Stream Identification Message Block is a *future feature* that provides additional information about the stream and its usage. These message blocks are designed to be skipped if the decoder cannot read the content.

Table 9.2 SSRZ Stream Identification Message Block ZM010-X

Name	Definition	Number of Bits	Notes
SSRZ Stream Identification Message Block size	ZDF341	variable	
...			

9.3 SSRZ Satellite Group Definition Message (ZM011)

SSRZ satellite groups are defined for the low rate and high rate messages (here, the term „low rate“ comprises all satellite-dependent SSRZ correction messages except the SSRZ high rate correction message ZM001).

Table 9.3 SSRZ Satellite Group Definition Message ZM011

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	9	Always “11 111 0000” for SSRZ Message ZM011
SSRZ Metadata Tag	ZDF020	variable	
SSRZ Satellite Group Definition Message for SSRZ Metadata Tag 1	ZM011-1	variable	This block is only present if ZDF020 is 1.
SSRZ Satellite Group Definition Message for SSRZ Metadata Tag 3	ZM011-3	variable	This block is only present if ZDF020 is 3.

Table 9.4 SSRZ Satellite Group Definition Message ZM011-1

Name	Definition	Number of Bits	Notes
SSRZ Satellite Group Definition Metadata Message Block	ZMB011	variable	

Table 9.5 SSRZ Satellite Group Definition Message ZM011-3

Name	Definition	Number of Bits	Notes
SSRZ Metadata IOD	ZDF005	variable	
SSRZ Satellite Group Definition Metadata Message Block	ZMB011	variable	

9.4 SSRZ Metadata Message (ZM012)

The SSRZ Metadata Message contains the metadata required to decode the compressed SSRZ correction messages defined in Chapter 8 and can transport Satellite Group and Grid definitions as well. The metadata is divided into message blocks. These message blocks are prefixed with “ZMB” to indicate the SSRZ relevant and message-specific content. This modularization allows for the use of separate metadata messages.

Table 9.6 SSRZ Metadata Message ZM012

Name	Definition	Number of Bits	Notes
SSRZ Message Type Indicator	ZDF002	9	Always “11 111 0001” for SSRZ Message ZM012
SSRZ Metadata IOD	ZDF005	2	
SSRZ Metadata Message Blocks			
SSRZ Metadata Message Block	ZMB012	variable	Table 9.23 This block repeats until ZDF020 in ZMB012 is 0.

9.4.1 SSRZ High Rate Metadata Message Block (ZMB001)

The SSRZ High Rate Metadata Message Block defines the metadata required for decoding the SSRZ High Rate message (ZM001). The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB001.

Table 9.7 SSRZ High Rate Metadata Message Block ZMB001

Name	Definition	Number of Bits	Notes
Number of SSRZ HR satellite groups	ZDF011	5	The value of this field has to be identical to $N_{G(HR)}$ obtained from ZDF011 in ZMB011. This field is only present if ZDF020 is 1.
Number of Satellite-dependent Timing Blocks	ZDF055	5	N_{Timing} This field is only present if ZDF020 is 1.
SSRZ High Rate Timing Block	ZDB019	$N_{Timing} * (N_{G(HR)} + 12)$	This block repeats for N_{Timing} times. The length of satellite group bit mask is given by ZDF011. This field is only present if ZDF020 is 1.
SSRZ High Rate Clock Metadata			
Number of SSRZ High Rate clock correction parameters	ZDF044	2	Number of (different) clock corrections transmitted in the SSRZ High Rate message (always 1). This field is only present if ZDF020 is 1.
SSRZ High Rate Clock Default Resolution	ZDF060	variable	This field is only present if ZDF020 is 1.
Number of SSRZ High Rate Clock Rice Blocks	ZDF042	variable	SSRZ Number of SSRZ High Rate Clock Rice Blocks $N_{RB,clock}$ This field is only present if ZDF020 is 1.
SSRZ Satellite Parameter Rice Block Definition for High Rate clock corrections	ZDB021	variable	This Block repeats for $N_{RB,clock}$ times This field is only present if ZDF020 is 1.
SSRZ High Rate Orbit Metadata			
Number of SSRZ High Rate orbit correction parameters	ZDF044	2	Number of SSR orbit corrections transmitted in the SSRZ High Rate message 0: No orbit corrections are transmitted 1: radial orbit corrections are transmitted This field is only present if ZDF020 is 1.
SSRZ High Rate Orbit Default Resolution	ZDF061	variable	This field is only present if the number of SSRZ High Rate corrections (ZDF044) is 1. This field is only present if ZDF020 is 1.
Number of SSRZ High Rate orbit Rice Blocks	ZDF042	variable	Number of SSRZ HR Orbit Rice Blocks $N_{RB,orbit}$. This block is only present if the number of SSRZ High Rate orbit corrections is 1. This block is only present if ZDF020 is 1.

Name	Definition	Number of Bits	Notes
SSRZ Satellite Parameter Rice Block definition for High Rate orbit corrections	ZDB021	variable	This Block repeats $N_{RB,orbit}$ times. This block is only present if the number of SSRZ High Rate orbit corrections is 1. This block is only present if ZDF020 is 1.

9.4.2 SSRZ Low Rate Metadata Message Block (ZMB002)

The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002). The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002.

Table 9.8 SSRZ Low Rate Metadata Message Block ZMB002

Name	Definition	Number of Bits	Notes
Number of SSRZ LR satellite groups	ZDF010	5	The value of this field has to be identical to $N_{G(LR)}$ obtained from ZDF010 in ZMB011.
Number of Satellite-dependent Timing Blocks	ZDF055	5	N_{Timing} This field is only present if ZDF020 is 1.
SSRZ Low Rate Timing Block	ZDB019	$N_{Timing} * (N_{G(LR)} + 12)$	This block repeats for N_{Timing} times. The length of satellite group bit mask is given by ZMB011. This field is only present if ZDF020 is 1.
SSRZ BE IOD Definition Block	ZDB030	variable	This field is only present if ZDF020 is 1.
SSRZ Low Rate Clock Correction Metadata			
Number of SSRZ Low Rate clock corrections	ZDF044	2	Number of clock corrections transmitted in the SSRZ Low Rate message (should always be 1 or 2) 1: constant C_0 term 2: constant C_0 and linear C_1 term This field is only present if ZDF020 is 1.
SSRZ Low Rate Clock C_0 Default Resolution	ZDF062	variable	This field is only present if ZDF020 is 1.
SSRZ Low Rate Clock C_1 Default Resolution	ZDF063	variable	This field is only present if the Number of SSRZ Low Rate clock corrections is 2. This field is only present if ZDF020 is 1.
Number of SSRZ Low Rate Clock Rice Blocks	ZDF042	variable	SSRZ Number of SSRZ Low Rate Rice Clock Blocks $N_{RB,clock}$ This field is only present if ZDF020 is 1.
SSRZ Satellite Parameter Rice Block Definition for SSRZ Low Rate Clock corrections	ZDB021	variable	This Block repeats for $N_{RB,clock}$ times. This field is only present if ZDF020 is 1.
SSRZ Low Rate Orbit Corrections Metadata			

Name	Definition	Number of Bits	Notes
Number of orbit components	ZDF044	2	Number of orbit corrections transmitted in the SSRZ Low Rate message (always 3) 3: radial, along-track, cross-track corrections This field is only present if ZDF020 is 1.
SSRZ Low Rate Radial Orbit Default Resolution	ZDF064	variable	This field is only present if ZDF020 is 1.
SSRZ Low Rate Along-track Orbit Default Resolution	ZDF065	variable	This field is only present if ZDF020 is 1.
SSRZ Low Rate Cross-track Orbit Default Resolution	ZDF066	variable	This field is only present if ZDF020 is 1.
Number of SSRZ Rice Blocks	ZDF042	variable	$N_{RB,orbit}$ This field is only present if ZDF020 is 1.
SSRZ Satellite Parameter Rice Block Definition for SSRZ Low Rate Orbit corrections	ZDB021	variable	This Block repeats for $N_{RB,orbit}$ times. This field is only present if ZDF020 is 1.
SSRZ Low Rate Velocity Corrections Metadata			
Number of velocity components	ZDF044	2	Number of velocity components transmitted in the SSRZ Low Rate message (should be 0 or 3) 0: no velocity components 3: radial, along-track, cross-track component This field is only present if ZDF020 is 1.
SSRZ Low Rate Radial Velocity Default Resolution	ZDF067	variable	This field is only present if the Number of velocity components (ZDF044) is 3. This field is only present if ZDF020 is 1.
SSRZ Low Rate Along-track Velocity Default Resolution	ZDF068	variable	This field is only present if the Number of velocity components (ZDF044) is 3. This field is only present if ZDF020 is 1.
SSRZ Low Rate Cross-track Velocity Default Resolution	ZDF069	variable	This field is only present if the Number of velocity components (ZDF044) is 3. This field is only present if ZDF020 is 1.
SSRZ Number of SSRZ Low Rate Velocity Rice Blocks	ZDF042	variable	Number of SSRZ Low Rate Velocity Rice Blocks $N_{RB,velocity}$. This field is only present if the Number of velocity components is larger than zero. This field is only present if ZDF020 is 1.
SSRZ METADATA Satellite Parameter Rice Block Definition for SSRZ Low Rate Velocity corrections	ZDB021	variable	This Block repeats for $N_{RB,velocity}$ times. It is only present if the Number velocity components is 3. This field is only present if ZDF020 is 1.
SSRZ Low Rate Code Bias Metadata			

Name	Definition	Number of Bits	Notes
SSRZ Code Bias Default Resolution	ZDF070	variable	This field is only present if ZDF020 is 1.
SSRZ Number of Code Bias Rice Blocks	ZDF045	variable	Number of SSRZ Low Rate Code Bias Rice Blocks $N_{RB,CB}$. This field is only present if ZDF020 is 1.
SSRZ Code Bias Signal Rice Block Definition	ZDB022	variable	This Block repeats for $N_{RB,CB}$ times. It is possible to define signals as rice block attributes for systems which are not considered in satellite groups. It allows for the system extension of a service by definition of a new satellite group only. Only signals from satellites that are defined in the satellite groups are considered. If the QIX bias message (ZM008 or ZMB012 with ZMB008) is part of the stream, only signals identical to those defined in the SSRZ Phase Bias Signal Bit Mask Block are allowed. This field is only present if ZDF020 is 1.
SSRZ Code Bias Reference Signal Bit Mask Block	ZDB020	variable	This signal bit mask block indicates at maximum one code bias reference signal per system whose correction values are inherently set to zero and not transmitted in the SSRZ Low Rate message. If the QIX bias message (ZM008 or ZMB012 with ZMB008) is part of the stream, only signals identical to those defined in the SSRZ Phase Bias Signal Bit Mask Block are allowed. This field is only present if ZDF020 is 1.
SSRZ Low Rate Phase Bias Metadata			
SSRZ Phase Bias Signal Bit Mask Block	ZDB020	variable	This signal bit mask block indicates the transmitted phase bias signals. If the QIX bias message (ZM008 or ZMB012 with ZMB008) is part of the stream, the phase bias signal bit mask have to contain one signal per frequency and GNSS at maximum. These signals are referred as (QIX bias) reference signals. This field is only present if ZDF020 is 1.
SSRZ Low Rate Phase Bias Cycle Range	ZDF071	variable	$N_{PB,cyc}$ This field is only present if ZDF020 is 1.
SSRZ Low Rate Phase Bias Bitfield Length	ZDF072	variable	$N_{PB,bits}$

Name	Definition	Number of Bits	Notes
			The phase bias resolution is derived from the ZDF071 and ZDF072: $\delta PB = N_{PB,cyc} / 2^{N_{PB,bits}}$ This field is only present if ZDF020 is 1.
SSRZ Maximum Number of Continuity/ Overflow bits	ZDF073	variable	This field is only present if ZDF020 is 1.
SSRZ Low Rate Satellite-dependent Global Ionosphere Correction Metadata			
Satellite dependent Global Ionosphere Correction Flag	ZDF134	1	This flag indicates if satellite-dependent Global Ionosphere Corrections are part of SSRZ Low Rate Correction message (ZM002) '1': Corrections are part of ZM002 and metadata follows. '0': Correction are not part of ZM002 and no metadata follows. This field is only present if ZDF020 is 1.
SSRZ Model Parameters Block	ZDB060	variable	This block is only present if ZDF134 is 1 and ZDF020 is 1.
SSRZ Satellite-dependent Global Ionosphere Correction Default Resolution	ZDF074	variable	This field is only present if ZDF134 is 1 and ZDF020 is 1.
SSRZ Compressed Coefficient Data Block Definition	ZDB023	variable	The Length of the attribute bit mask is obtained from ZDB060. This field is only present if ZDF134 is 1 and ZDF020 is 1.

9.4.3 SSRZ Gridded Ionosphere Correction Metadata Message Block (ZMB003)

The SSRZ Gridded Ionosphere Correction Metadata Message Block (ZMB003) defines the metadata required for decoding the SSRZ Gridded Ionosphere Correction Message (ZM003). The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB003.

Table 9.9 SSRZ Gridded Ionosphere Correction Metadata Message Block ZMB003

Name	Definition	Number of Bits	Notes
SSRZ Gridded Ionosphere Correction Metadata Message Block for tag 1	ZMB003-1	variable	This block is only present if ZDF020 is 1.
SSRZ Gridded Ionosphere Correction Metadata Message Block for tag 2	ZMB003-2	variable	This block is only present if ZDF020 is 2.

9.4.3.1 SSRZ Gridded Ionosphere Correction Metadata Message Block for tag 1 (ZMB003-1)

Table 9.10 SSRZ Gridded Ionosphere Correction Metadata Message Block for tag 1 ZMB003-1

Name	Definition	Number of Bits	Notes
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Number of SSRZ LR satellite groups	ZDF010	5	This field has to be identical to ZDF010 in ZMB011. (here, $N_{G(LR)}=ZDF010+1$). This field is only present if ZDF020 is 1.
Number of Satellite-dependent Timing Blocks	ZDF055	5	N_{Timing} This field is only present if ZDF020 is 1.
SSRZ GRI Timing Block	ZDB019	$N_{Timing} * (N_{G(LR)} + 12)$	This block repeats for N_{Timing} times. The length of satellite group bit mask is given by the number of Low Rate Satellite Groups $N_{G(LR)}$ (ZDF010). This field is only present if ZDF020 is 1.
SSRZ Default Resolution of the Gridded Ionosphere Corrections	ZDF075	variable	This field is only present if ZDF020 is 1.
Default Bin Size Parameter	ZDF043	variable	This default bin size parameter p_0 is used in all Rice Blocks of the corresponding SSRZ Correction messages ZM003. This field is only present if ZDF020 is 1.

9.4.3.2 SSRZ Gridded Ionosphere Correction Metadata Message Block for tag 2 (ZMB003-2)

Table 9.11 SSRZ Gridded Ionosphere Correction Metadata Message Block for tag 2 ZMB003-2

Name	Definition	Number of Bits	Notes
SSRZ Grid-related Timing Parameters	ZDB044	variable	
SSRZ Default Resolution of the Gridded Ionosphere Corrections	ZDF075	variable	
Default Bin Size Parameter	ZDF043	variable	This default bin size parameter p_0 is used in all Rice Blocks of the corresponding SSRZ Correction messages ZM003.

9.4.4 SSRZ Gridded Troposphere Correction Metadata Message Block (ZMB004)

The SSRZ Gridded Troposphere Correction Metadata Message Block (ZMB004) defines the metadata required for decoding the SSRZ Gridded Troposphere Correction Message (ZM004). The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata Message Block ZMB012 that includes ZMB004.

Table 9.12 SSRZ Gridded Troposphere Correction Metadata Message Block ZMB004

Name	Definition	Number of Bits	Notes
SSRZ Gridded Troposphere Correction Metadata Message Block for tag 2	ZMB004-2	variable	This block is only present if ZDF020 is 2.
SSRZ Gridded Troposphere Correction Metadata Message Block for tag 3	ZMB004-3	variable	This block is only present if ZDF020 is 3.

9.4.4.1 SSRZ Gridded Troposphere Correction Metadata Message Block for tag 2 (ZMB004-2)

Table 9.13 SSR Gridded Troposphere Correction Metadata Message Block for tag 2 ZMB004-2

Name	Definition	Number of Bits	Notes
SSRZ GRT Timing Block	ZDB018	12	
SSRZ GRT Model Parameters Block	ZDB060	variable	
Troposphere Component bit mask	ZDF107	16	This bit mask indicates which components are transmitted in the gridded Troposphere correction message.
SSRZ Gridded Troposphere Scale Factor Resolution of the dry component	ZDF076	variable	Resolution of the dry component. This field is only present if bit 0 is set in ZDF107.
SSRZ Default Bin Size Parameter	ZDF043	variable	Default bin size parameter p_0 to decode the dry component. This field is only present if bit 0 is set in ZDF107.
SSRZ Gridded Troposphere Scale Factor Resolution of the wet component	ZDF076	variable	Resolution of the wet component. This field is only present if bit 1 is set in ZDF107.
SSRZ Default Bin Size Parameter	ZDF043	variable	Default bin size parameter p_0 to decode the wet component. This field is only present if bit 1 is set in ZDF107.
SSRZ Gridded Troposphere Scale Factor Resolution of the total component	ZDF076	variable	Resolution of the total component. This field is only present if bit 2 is set in ZDF107.
SSRZ Default Bin Size Parameter	ZDF043	variable	Default bin size parameter p_0 to decode the total component. This field is only present if bit 2 is set in ZDF107.

9.4.4.2 SSRZ Gridded Troposphere Correction Metadata Message Block for tag 3 (ZMB004-3)

Table 9.14 SSR Gridded Troposphere Correction Metadata Message Block for tag 3 ZMB004-3

Name	Definition	Number of Bits	Notes
SSRZ Grid-related Timing Parameters	ZDB044	variable	
SSRZ GRT Model Parameters Block	ZDB060	variable	
Troposphere Component bit mask	ZDF107	16	This bit mask indicates which components are transmitted in the gridded Troposphere correction message.
SSRZ Gridded Troposphere Scale Factor Resolution of the dry component	ZDF076	variable	Resolution of the dry component. This field is only present if bit 0 is set in ZDF107.
SSRZ Default Bin Size Parameter	ZDF043	variable	Default bin size parameter p_0 to decode the dry component.

			This field is only present if bit 0 is set in ZDF107.
SSRZ Gridded Troposphere Scale Factor Resolution of the wet component	ZDF076	variable	Resolution of the wet component. This field is only present if bit 1 is set in ZDF107.
SSRZ Default Bin Size Parameter	ZDF043	variable	Default bin size parameter p_0 to decode the wet component. This field is only present if bit 1 is set in ZDF107.
SSRZ Gridded Troposphere Scale Factor Resolution of the total component	ZDF076	variable	Resolution of the total component. This field is only present if bit 2 is set in ZDF107.
SSRZ Default Bin Size Parameter	ZDF043	variable	Default bin size parameter p_0 to decode the total component. This field is only present if bit 2 is set in ZDF107.

9.4.5 SSRZ Satellite dependent Regional Ionosphere Correction Metadata Message Block (ZMB005)

The SSRZ Satellite dependent Regional Ionosphere Correction Metadata Message Block (ZMB005) defines the metadata required for decoding the SSRZ Satellite dependent Regional Ionosphere Correction Message (ZM005). The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata Message Block ZMB012 that includes ZMB005.

Table 9.15 SSRZ Satellite-dependent Regional Ionosphere Correction Metadata Message Block ZMB005

Name	Definition	Number of Bits	Notes
SSRZ Satellite-dependent Regional Ionosphere Correction Metadata Message Block for tag 1	ZMB005-1	variable	This block is only present if ZDF020 is 1.

Table 9.16 SSRZ Satellite-dependent Regional Ionosphere Correction Metadata Message Block for tag 1 ZMB005-1

Name	Definition	Number of Bits	Notes
Number of SSRZ LR satellite groups	ZDF010	5	This field has to identical to ZDF010 in ZMB011. (here, $N_{G(LR)}=ZDF010+1$). This field is only present if ZDF020 is 1.
Number of satellite-dependent Timing Blocks	ZDF055	5	N_{Timing} This field is only present if ZDF020 is 1.
SSRZ Timing Block of satellite-dependent ionosphere corrections	ZDB019	$N_{Timing} * (N_{G(LR)} + 12)$	This block repeats for N_{Timing} times. The length of satellite group bit mask is given by the number of Low Rate Satellite Groups $N_{G(LR)}$ (ZDF010). This field is only present if ZDF020 is 1.
SSRZ Model Parameters Block	ZDB060	variable	This field is only present if ZDF020 is 1.

Name	Definition	Number of Bits	Notes
SSRZ Default Resolution of the satellite-dependent regional ionosphere corrections	ZDF080	variable	This resolution is valid for all satellite dependent ionosphere correction values. This field is only present if ZDF020 is 1.
SSRZ Compressed Coefficient Data Block Definition	ZDB023	Variable	This block defines the SSRZ Rice Blocks in ZDB007 in ZM006. This block is only present if ZDF020 is 1.

9.4.6 SSRZ Global VTEC Ionosphere Correction Metadata Message Block (ZMB006)

The SSRZ Global VTEC Ionosphere Correction Metadata Message Block (ZMB006) defines the metadata required for decoding the SSRZ Global VTEC Ionosphere Correction Message (ZM006). The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata Message Block ZMB012 that includes ZMB006.

Table 9.17 SSRZ Global VTEC Ionosphere Correction Metadata Message Block ZMB006

Name	Definition	Number of Bits	Notes
SSRZ Global VTEC Timing Block	ZDB018	12	This block is only present if ZDF020 is 2, 3.
SSRZ Update and Offset Block	ZDB040	variable	This block is only present if ZDF020 is 4.
SSRZ Model Parameters Block	ZDB060	variable	This Block is only present if ZDF020 is 2, 3.
SSRZ Encoder Type	ZDF129	variable	0: No encoding 1: Rice Encoder This field is only present if ZDF020 is 2, 3.
Global VTEC Resolution	ZDF081	variable	This field is only present if ZDF020 is 2.
Global VTEC Resolution	ZDF082	variable	This field is only present if ZDF020 is 3, 4.
Number of Ionospheric Layers	ZDF130	variable	This field is only present if ZDF020 is 4
SSRZ Global VTEC Ionospheric Layer Block	ZDB061	variable	This block repeats for the number of layers indicated by ZDF130. The total number of Global VTEC corrections is computed from $N_{VTEC} = \sum_l^L (N_l + 1)^2 - (N_l - M_l)(N_l - M_l + 1)$ This block is only present if ZDF020 is 4.
SSRZ Compressed Coefficients Block Definition	ZDB023	variable	This block repeats for the number of layers indicated by ZDF130.

Name	Definition	Number of Bits	Notes
			The grouping/bundling of Global VTEC coefficients is not yet fully optimized and might change in upcoming SSRZ Format versions This block is only present if ZDF020 is 4.

9.4.7 SSRZ Regional Troposphere Correction Metadata Message Block (ZMB007)

The SSRZ Regional Troposphere Correction Metadata Message Block (ZMB007) defines the metadata required for decoding the SSRZ Regional Troposphere Correction Message (ZM007). The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata Message Block ZMB012 that includes ZMB007.

Table 9.18 SSRZ Regional Troposphere Correction Metadata Message Block ZMB007

Name	Definition	Number of Bits	Notes
SSRZ Regional Troposphere Correction Metadata Block for metadata tag 2	ZMB007-2	variable	This block is only present if ZDF020 is 2.
SSRZ Region-Related Timing Parameters	ZDB046	variable	This block is only present if ZDF020 is 3
SSRZ Regional Troposphere Correction Metadata Block for metadata tag 3	ZMB007-3	variable	This block repeats until the ZDF030 inside the block is 0. This block is only present if ZDF020 is 3.

9.4.7.1 SSRZ Regional Troposphere Correction Metadata Block for metadata tag 2 (ZMB007-2)

This Block ZMB007-2 includes the Regional Troposphere Correction Metadata valid for metadata tag 2.

Table 9.19 SSRZ Region Regional Troposphere Correction Metadata Block ZMB007-2

Name	Definition	Number of Bits	Notes
SSRZ Regional Troposphere Timing Block	ZDB018	12	
Troposphere Basic Component Bit Mask	ZDF107	bit(16)	This bit mask indicates which components are transmitted in the regional troposphere correction message (ZM007).
SSRZ Model Parameters Block	ZDB060	variable	Table 15.5 Model Parameter Block (ZDB060) in SSRZ Regional Troposphere Correction Metadata Message Block ZMB007.
SSRZ default resolution of the regional troposphere total component	ZDF085	variable	This field is only present if bit 0 in ZDF107 is set.
SSRZ Compressed Coefficients Block Definition of regional troposphere total component	ZDB023	variable	This block is only present if bit 0 in ZDF107 is set. The length of the Coefficient Order Bit Mask(s) ZDF116 is given by $N_{lat,RT} + N_{lon,RT}$ in ZDB060 (Table 15.5).
SSRZ Separated Compressed Coefficient Blocks per Height	ZDF108	1	This flag is only present if bit 0 in ZDF107 is set. This flag indicates if different SSRZ Compressed Coefficient Blocks (all identically defined by the

Name	Definition	Number of Bits	Notes
Order Flag for regional troposphere total component			subsequent ZDB023) are used for coefficients, related to different height orders.
SSRZ default resolution of the regional troposphere wet component	ZDF085	variable	This field is only present if bit 1 in ZDF107 is set.
SSRZ Compressed Coefficients Block Definition of regional troposphere wet component	ZDB023	variable	This block is only present if bit 1 in ZDF107 is set. The length of the Coefficient Order Bit Mask(s) ZDF116 is given by $N_{lat,RT}+N_{lon,RT}$ in ZDB060 (Table 15.5).
SSRZ Separated Compressed Coefficient Blocks per Height Order Flag for regional troposphere wet component	ZDF108	1	This flag is only present if bit 1 in ZDF107 is set. This flag indicates if different SSRZ Compressed Coefficient Blocks (all identically defined by the subsequent ZDB023) are used for coefficients, related to different height orders.
SSRZ default resolution of the regional troposphere dry component	ZDF085	variable	This field is only present if bit 2 in ZDF107 is set.
SSRZ Compressed Coefficients Block Definition of regional troposphere combined dry component	ZDB023	variable	This block is only present if bit 2 in ZDF107 is set. The length of the Coefficient Order Bit Mask(s) ZDF116 is given by $N_{lat,RT}+N_{lon,RT}$ in ZDB060 (Table 15.5).
SSRZ Separated Compressed Coefficient Blocks per Height Order Flag for regional troposphere dry component	ZDF108	1	This flag is only present if bit 2 in ZDF107 is set. This flag indicates if different SSRZ Compressed Coefficient Blocks (all identically defined by the subsequent ZDB023) are used for coefficients, related to different height orders.
SSRZ default resolution of the regional troposphere mapping improvements	ZDF086	variable	This field is only present if bit 3 in ZDF107 is set.
SSRZ Compressed Parameter Data Block Definition	ZDB027	variable	This block is only present if bit3 in ZDF107 is set.

9.4.7.2 SSRZ Regional Troposphere Correction Metadata Block for metadata tag 3 (ZMB007-3)

This Block ZMB007-3 includes the Regional Troposphere Correction Metadata valid for metadata tag 3.

Table 9.20 SSRZ Regional Troposphere Correction Metadata Block for metadata tag 3 ZMB007-3

Name	Definition	Number of Bits	Notes
SSRZ Regional Troposphere Region ID	ZDF027	variable	
Latitude of ground point origin	ZDF168	11	$\varphi_{GPO,RT}$
Longitude of ground point origin	ZDF169	12	$\lambda_{GPO,RT}$
Height of ground point origin	ZDF170	14	$H_{GPO,RT}$
Horizontal Scale Factor	ZDF172	variable	D_{RT}
Vertical Scale Factor	ZDF173	variable	H_{RT}
Troposphere Basic Component Bit Mask	ZDF107	bit(16)	This bit mask indicates which components are transmitted in the regional troposphere correction message (ZM007).
Basic Troposphere Component Coefficient Data Block Definition of the dry part	ZDB050	variable	This block is only present if bit 0 in ZDF107 is set.
Basic Troposphere Component Coefficient Data Block Definition of the wet part	ZDB050	variable	This block is only present if bit 1 in ZDF107 is set.
Basic Troposphere Component Coefficient Data Block Definition of the total part	ZDB050	variable	This block is only present if bit 2 in ZDF107 is set.
SSRZ Tropospheric Mapping Function Improvement Parameter Data Block Definition	ZDB051	variable	This block is only present if bit 3 in ZDF107 is set.
SSRZ Multi-Region Flag	ZDF030	1	

9.4.8 SSRZ QIX Bias Metadata Message Block (ZMB008)

Table 9.21 describes the SSRZ QIX Bias Metadata Message Block (ZMB008). This block can be part of the SSRZ Metadata Message (ZM012) or of the SSRZ QIX Bias Message ZM008 itself. The data field ZDF020 in the notes refers either to ZDF020 in the SSRZ Metadata Message Block ZM012 that includes ZMB008 or to ZDF020 in the ZM008.

Table 9.21 SSRZ QIX Bias Metadata Message Block ZMB008

Name	Definition	Number of Bits	Notes
SSRZ QIX Code Bias flag	ZDF190	1	This field is only present if ZDF020 is 2.
SSRZ QIX Phase Bias flag	ZDF191	1	This field is only present if ZDF020 is 2.
SSRZ QIX Code Bias Default Resolution	ZDF089	variable	This field is only present if <ul style="list-style-type: none"> ZDF020 is 1 ZDF020 is 2 and ZDF190 is 1.
SSRZ Number of QIX Code Bias Rice Blocks	ZDF045	variable	Number of SSRZ QIX Code Bias Rice Blocks $N_{RB,CB}$. This field is only present if

Name	Definition	Number of Bits	Notes
			<ul style="list-style-type: none"> ZDF020 is 1 ZDF020 is 2 and ZDF190 is 1.
SSRZ QIX Code Bias Signal Rice Block Definition	ZDB022	variable	This block repeats for $N_{RB,CB}$ times. This block is only present if <ul style="list-style-type: none"> ZDF020 is 1 ZDF020 is 2 and ZDF190 is 1.
SSRZ QIX Phase Bias Default Resolution	ZDF090	variable	This field is only present if <ul style="list-style-type: none"> ZDF020 is 1 ZDF020 is 2 and ZDF191 is 1.
SSRZ Number of QIX Phase Bias Rice Blocks	ZDF045	variable	Number of SSRZ QIX Phase Bias Rice Blocks $N_{RB,PB}$. This field is only present if <ul style="list-style-type: none"> ZDF020 is 1 ZDF020 is 2 and ZDF191 is 1.
SSRZ QIX Phase Bias Signal Rice Block Definition	ZDB022	variable	This block repeats for $N_{RB,PB}$ times. This block is only present if <ul style="list-style-type: none"> ZDF020 is 1 ZDF020 is 2 and ZDF191 is 1.

9.4.9 SSRZ Satellite Group Definition Metadata Message Block (ZMB011)

The SSRZ Satellite Group Definition Metadata Message Block (ZMB011) contains the satellite group definitions required in satellite dependent SSRZ correction messages and can be part of the SSRZ Metadata Message (ZM012) or SSRZ Satellite Group Definition Message (ZM011). In a service only one message type (ZM011 or ZM012) can be used. The data field ZDF020 in the notes refers either to ZDF020 in the SSRZ Metadata Message Block ZM012 that includes ZMB011 or to ZDF020 in the ZM011.

Table 9.22 SSRZ Satellite Group Definition Metadata Message Block ZMB011

Name	Definition	Number of Bits	Notes
Number of SSRZ Low Rate Satellite Groups	ZDF010	5	$N_{G(LR)}$ This field is only present if ZDF020 is 1, 2.
SSRZ Satellite Group Definition Block	ZDB017	variable	This block repeats for $N_{G(LR)}$ times. This block is only present if ZDF020 is 1, 2.
Number of SSRZ High Rate Satellite Groups	ZDF011	5	$N_{G(HR)}$ This field is only present if ZDF020 is 1, 2.
SSRZ Satellite Group Definition Block	ZDB017	variable	This block repeats for $N_{G(HR)}$ times. This block is only present if ZDF020 is 1, 2.

9.4.10 SSRZ Metadata Message Block (ZMB012)

The SSRZ Metadata Message Block describes the relation between the SSRZ Metadata Tag, Type Number and specific SSRZ metadata message blocks.

Table 9.23 SSRZ Metadata Message Block ZMB012

Name	Definition	Number of Bits	Notes
SSRZ Metadata Tag	ZDF020	variable	0: no data follow
SSRZ Metadata Type Number	ZDF003	8	This field is only present if ZDF020 is larger than 0.
Number of SSRZ Metadata bits	ZDF021	13	This field indicates the size of the subsequent SSRZ (SSR-specific) Metadata Message Block. If the user receives a valid (ZDF020, ZDF003) tuple but is not able to decode the subsequent block the number of bits given by ZDF014 have to be skipped to reach the next SSRZ Metadata Message Block (ZM012) This field is only present if ZDF020 is larger than 0.
SSRZ Metadata Message Blocks			
SSRZ High Rate Metadata Message Block	ZMB001	variable	Table 9.7 This block is only present if ZDF003 is 1 and ZDF020 is 1.
SSRZ Low Rate Metadata Message Block	ZMB002	Variable	The SSRZ Low Rate Metadata Message Block defines the metadata required for decoding the SSRZ Low Rate message (ZM002).The data field ZDF020 mentioned in the notes refers to ZDF020 in the SSRZ Metadata message Block ZMB012 that includes ZMB002. Table 9.8 This block is only present if ZDF003 is 2 and ZDF020 is 1.
SSRZ Gridded Ionosphere Correction Metadata Message Block	ZMB003	variable	Table 9.11 This block is only present if ZDF003 is 3 and ZDF020 is 1,2.
SSRZ Gridded Troposphere Correction Metadata Message Block	ZMB004	variable	Table 9.14 This block is only present if ZDF003 is 4 and ZDF020 is 2,3.
SSRZ Satellite-depending Regional Ionosphere Correction Metadata Message Block	ZMB005	variable	Fehler! Verweisquelle konnte nicht gefunden werden. This Block is only present if ZDF003 is 5 and ZDF020 is 1.
SSRZ Global VTEC Ionosphere Correction Metadata Message Block	ZMB006	variable	This block is only present if ZDF003 is 6 and ZDF020 is 2.
SSRZ Regional Troposphere Correction Metadata Message Block	ZMB007	variable	Table 9.18 This Block is only present if ZDF003 is 7 and ZDF020 is 2,3.
SSRZ QIX Bias Metadata	ZMB008	variable	Table 9.21 ZDF003 is 8 and ZDF020 is 1,2.
SSRZ Satellite Group Definition Metadata Message Block	ZMB011	variable	Table 9.22 This block is only present if ZDF003 is 11 and ZDF020 is 1, 2.

Name	Definition	Number of Bits	Notes
SSRZ Grid Definition Metadata Message Block	ZMB013	variable	This block is only present if ZDF003 is 13 and ZDF020 is 3, 4.
SSRZ Leap Second Metadata Message Block	ZMB024	variable	This block is only present if ZDF003 is 24 and ZDF020 is 1.
SSRZ Expected Messages Metadata Message Block	ZMB025	variable	Table 9.26 This block is only present if ZDF003 is 25 and ZDF020 is 1.

9.4.11 SSRZ Grid Definition Metadata Message Block (ZMB013)

The SSRZ Grid Definition Metadata Message Block (ZMB013) allows the transmission of grid definitions using SSRZ Metadata message ZM012 or as a separate message ZM013. The data field ZDF020 in the notes refers either to ZDF020 in the SSRZ Metadata Message Block ZM012 that includes ZMB013 or to ZDF020 in the SSRZ Grid Definition Message ZM013.

Table 9.24 SSRZ Grid Definition Metadata Message Block ZMB013

Name	Definition	Number of Bits	Notes
Number of grids	ZDF091	variable	Number of grids N_{grid} defined within this message block. This field is only present if ZDF020 is 3, 4.
Order part of the grid point coordinate resolution	ZDF092	variable	This field is only present if ZDF020 is 4.
Integer part of the grid point coordinate resolution	ZDF093	8	The grid point coordinate resolution derived from ZDF092 and the subsequent ZDF093 is identical for all grids transmitted with this message. This field is only present if ZDF020 is 4.
Grid point height resolution	ZDF102	variable	This field is valid for all transmitted grids with this message. This field is only present if ZDF020 is 4.
SSRZ Grid Definition Block	ZDB012	variable	This Block repeats for all Number of Grids N_{grid} This field is only present if ZDF020 is 3, 4.

9.4.12 SSRZ Leap Second Metadata Message Block for tag 1 (ZMB024-1)

The SSRZ Leap Second Metadata Message Block ZMB024-1 indicates the next application and value of a leap second. This information can be part of the metadata message ZM012 or transmitted using an individual message ZM024 (compare ZM011 and ZM013).

Table 9.25 SSRZ Leap Second Messages Metadata Message Block for tag 1 ZMB024-1

Name	Definition	Number of Bits	Notes
Years since 2023	ZDF250	variable	This field indicates the year of the application of the next leap second.
Month	ZDF251	4	This field indicates the month of the application of the next leap second.

Leap seconds until the announced change	ZDF252	variable	This field indicates the leap second used until announced changed date.
Leap seconds change	ZDF254	2	This field indicates the leap second change.

9.4.13 SSRZ Expected Correction Message Metadata Message Block (ZMB025)

The SSRZ Expected Correction Message Metadata Message Block holds information about the expected SSRZ messages of the data stream in order to verify completeness of SSRZ Metadata definitions and consequently SSR update data.

Table 9.26 SSRZ Expected Messages Metadata Message Block ZMB025

Name	Definition	Number of Bits	Notes
SSRZ Message ID Bit Mask	ZDF004	25	This field is only present if ZDF020 is 1.

9.5 SSRZ Grid Definition Message (ZM013)

This message (ZM013) describes the separated SSRZ Grid Definition Message.

Table 9.27 SSRZ Grid Definition Message ZM013

Name	Definition	Number of Bits	Notes
SSRZ Metadata Message Indicator	ZDF002	9	Always "11 111 0010" for SSRZ Message ZM013
SSRZ Grid Definition Tag	ZDF020	variable	
SSRZ Grid Definition Message Block	ZMB013	variable	This block is only present if ZDF020 is 3, 4.

9.6 SSRZ Leap Second Message (ZM024)

This message (ZM024) contains leap second information

Table 9.28 SSRZ Grid Definition Message ZM024

Name	Definition	Number of Bits	Notes
SSRZ Metadata Message Indicator	ZDF002	9	Always "11 111 1110" for SSRZ Message ZM024
SSRZ Leap Second Metadata Message Tag	ZDF020	variable	
Leap Second Messages Metadata Message Block	ZMB024-1	variable	This block is only present if ZDF020 is 1.

10 SSRZ System and Signal IDs

The RINEX3 Code follows the RINEX 3.4 observation code (RINEX 2018), i.e. observation band and attribute.

Table 10.1 SSRZ GNSS Identifier

GNSS	Field value	Bit in ZDF012	RINEX3 Code
GPS	1	bit 0 (LSB)	G
GLONASS	2	bit 1	R
Galileo	3	bit 2	E
QZSS	4	bit 3	J
SBAS	5	bit 4	S
BDS	6	bit 5	C
IRNSS	7	bit 6	I
reserved	8	bit 7	-
reserved	9	bit 8	-
reserved	10	bit 9	-
reserved	11	bit 10	-
reserved	12	bit 11	-
reserved	13	bit 12	-
reserved	14	bit 13	-
reserved	15	bit 14	-
reserved	16	bit 15 (MSb)	-

Table 10.2 SSRZ Satellite Identifier (Satellite ID)

GNSS	SSRZ Satellite ID
GPS	PRN
GLONASS	slot number in constellation
Galileo	satellite number
QZSS	PRN – 192
SBAS	PRN – 119
BDS	PRN
IRNSS	PRN

Table 10.3 Signal and Tracking Mode Identifier

GNSS	Bit in ZDF019	Signal Mapping	RINEX3 Code	Notes
GPS	bit 0	L1 C/A	1C	
	bit 1	L1 P (AS off)	1P	
	bit 2	L1 Z-tracking and similar (AS on)	1W	
	bit 3	reserved		
	bit 4	reserved		
	bit 5	L2 C/A	2C	
	bit 6	L2 L1(C/A)+(P2-P1) (semi-codeless)	2D	
	bit 7	L2 L2C (M)	2S	
	bit 8	L2 L2C (L)	2L	
	bit 9	L2 L2C (M+L)	2X	
	bit 10	L2 P (AS off)	2P	
	bit 11	L2 Z-tracking and similar (AS on)	2W	
	bit 12	reserved		
	bit 13	reserved		
	bit 14	L5 I	5I	
	bit 15	L5 Q	5Q	
	bit 16	L5 I+Q	5X	
	bit 17	L1 L1C (D)	1S	
	bit 18	L1 L1C (P)	1L	
	bit 19	L1 L1C (D+P)	1X	
bit 20-31	reserved			
GLONASS	bit 0	G1 C/A	1C	
	bit 1	G1 P	1P	
	bit 2	G2 P	2P	
	bit 3	G2 C/A (GLONASS M)	2C	
	bit 4	G1a L1OCd	4A	
	bit 5	G1a L1OCp	4B	
	bit 6	G1a L1OCd+ L1OCp	4X	
	bit 7	G2a L2CSI	6A	

GNSS	Bit in ZDF019	Signal Mapping	RINEX3 Code	Notes
	bit 8	G2a L2OCp	6B	
	bit 9	G2a L2CSI+L2OCp	6X	
	bit 10	G3 I	3I	
	bit 11	G3 Q	3Q	
	bit 12	G3 I+Q	3X	
	bit 13-31	reserved		
Galileo	bit 0	E1 A PRS	1A	
	bit 1	E1 B I/NAV OS/CS/SoL	1B	
	bit 2	E1 C no data	1C	
	bit 3	E1 B+C	1X	
	bit 4	E1 A+B+C	1Z	
	bit 5	E5a I F/NAV OS	5I	
	bit 6	E5a Q no data	5Q	
	bit 7	E5a I+Q	5X	
	bit 8	E5b I I/NAV OS/CS/SoL	7I	
	bit 9	E5b Q no data	7Q	
	bit 10	E5b I+Q	7X	
	bit 11	E5(E5a+E5b) I	8I	
	bit 12	E5(E5a+E5b) Q	8Q	
	bit 13	E5(E5a+E5b) I+Q	8X	
	bit 14	E6 A PRS	6A	
	bit 15	E6 B C/NAV CS	6B	
	bit 16	E6 C no data	6C	
	bit 17	E6 B+C	6X	
	bit 18	E6 A+B+C	6Z	
	bit 19-31	reserved		
QZSS	bit 0	L1 C/A	1C	
	bit 1	L1 L1C (D)	1S	
	bit 2	L1 L1C (P)	1L	
	bit 3	L2 L2C (M)	2S	

GNSS	Bit in ZDF019	Signal Mapping	RINEX3 Code	Notes
	bit 4	L2 L2C (L)	2L	
	bit 5	L2 L2C (M+L)	2X	
	bit 6	L5 I	5I	
	bit 7	L5 Q	5Q	
	bit 8	L5 I+Q	5X	
	bit 9	L6 L6D	6S	
	bit 10	L6 L6P	6L	
	bit 11	L6 L6(D+P)	6X	
	bit 12	L1 L1C (D+P)	1X	
	bit 13-31	reserved		
SBAS	bit 0	L1 C/A	1C	
	bit 1	L5 I	5I	
	bit 2	L5 Q	5Q	
	bit 3	L5 I+Q	5X	
	bit 4-31	reserved		
BDS	bit 0	B1-2 I	2I	
	bit 1	B1-2 Q	2Q	
	bit 2	B1-2 I+Q	2X	
	bit 3	B3 I	6I	
	bit 4	B3 Q	6Q	
	bit 5	B3 I+Q	6X	
	bit 6	B2b I	7I	
	bit 7	B2b Q	7Q	
	bit 8	B2b I+Q	7X	
	bit9	B1 Data	1D	
	bit10	B1 Pilot	1P	
	bit11	B1 Data+Pilot	1X	
	bit12	B1 B1A	1A	
	bit13	B1 Codeless	1N	
	bit14	B2a Data	5D	

GNSS	Bit in ZDF019	Signal Mapping	RINEX3 Code	Notes
	bit15	B2a Pilot	5P	
	bit16	B2a Data+Pilot	5X	
	bit17	B2b Data	7D	
	bit18	B2b Pilot	7P	
	bit19	B2b Data+Pilot	7Z	
	bit20	B2(B2a+B2b) Data	8D	
	bit21	B2(B2a+B2b) Pilot	8P	
	bit22	B2(B2a+B2b) Data+Pilot	8X	
	bit 23-31	reserved		

11 State Space Representation

The pseudo range $PR_{j,s}^i$ and carrier phase $\varphi_{j,s}^i \lambda_s$ between a satellite i and a receiver j for signal s based on code and phase measurements, respectively, are described by the observation equations (11.1) and (11.2). The main error components are clock, orbit, signal biases, ionosphere and troposphere:

$$PR_{j,s}^i = |\mathbf{R}_j^i| + \delta C_j^i + \delta CB_{j,s}^i + \delta I_{j,s}^i + \delta T_j^i + \delta S_{j,s}^i + \varepsilon_{j,s}^i \quad (11.1)$$

$$\varphi_{j,s}^i \lambda_s = |\mathbf{R}_j^i| + \delta C_j^i + \delta PB_{j,s}^i - \delta I_{j,s}^i + \delta T_j^i + \lambda_s N_{j,s}^i + \delta S_{j,s}^i + \varepsilon_{j,s}^i, \quad (11.2)$$

whereby

$ \mathbf{R}_j^i $	Range between satellite antenna phase center and receiver phase center. This range is obtained from the satellite's broadcast ephemeris and orbit corrections (eq. (11.14)).
δC_j^i	clock errors
$\delta CB_{j,s}^i$	code biases
$\delta PB_{j,s}^i$	phase biases
$\delta I_{j,s}^i$	ionospheric impacts
δT_j^i	tropospheric delays
λ_s	wavelength of carrier phase f_s of signal s
$N_{j,s}^i$	ambiguity in phase observation
$\delta S_{j,s}^i$	errors related to code observation
$\delta S_{j,s}^i$	errors related to phase observation
$\varepsilon_{j,s}^i$	noise

The clock errors are

$$\delta C_j^i = \delta C_j - \delta C^i \quad (11.3)$$

with

$$\delta C_j \quad \text{receiver clock error}$$

$$\delta C^i \quad \text{satellite clock error}$$

This signal biases can be separated into two biases

$$\delta CB_{j,s}^i = -\delta B_s^i + \delta B_{j,s} \quad (11.4)$$

$$\delta PB_{j,s}^i = -\delta b_s^i + \delta b_{j,s} \quad (11.5)$$

which are

$$\delta B_s^i \quad \text{satellite code bias for signal } s$$

$$\delta b_s^i \quad \text{satellite phase bias for signal } s$$

$$\delta B_{j,s} \quad \text{receiver code bias for signal } s$$

The errors $\delta S_{j,s}^i$ and $\delta s_{j,s}^i$ include terms to describe the impacts of variations at the receiver and satellite antenna as well as multipath at the rover site and at the satellite for signal s.

SSRZ provides parameters to compute individual

- orbit correction $\delta \mathbf{X}^i$ (section 11.1)
- clock correction δC^i (section 11.2)
- signal bias corrections δB_s^i and δb_s^i (section 11.3)
- ionosphere correction $\delta I_{j,s}^i$ (section 11.4)
- troposphere correction δT_j^i (section 11.5)

Using equations(11.3), (11.4), and (11.5) in equations (11.1) and (11.2) reveal the sign convention of the SSR parameters.

$$PR_{j,s}^i = |\mathbf{R}_j^i| + \delta C_j - \delta C^i - \delta B_s^i + \delta B_{j,s} + \delta B_{j,s}^i + \delta I_{j,s}^i + \delta T_j^i + \delta S_{j,s}^i + \varepsilon_{j,s}^i \quad (11.6)$$

$$\varphi_{j,s}^i \lambda_s = |\mathbf{R}_j^i| + \delta C_j - \delta C^i - \delta b_s^i + \delta b_{j,s} + \delta b_{j,s}^i - \delta I_{j,s}^i + \delta T_j^i + \lambda_s N_{j,s}^i + \delta S_{j,s}^i + \varepsilon_{j,s}^i, \quad (11.7)$$

11.1 SSR Orbit Correction

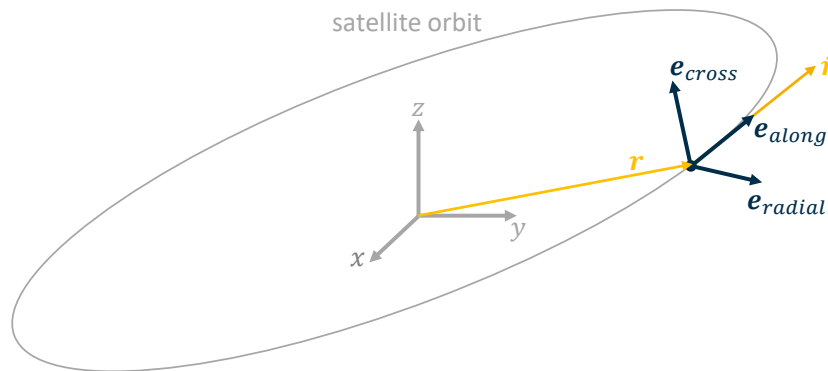


Figure 4 Radial, along-track, and cross-track orbit components

The SSRZ low rate message ZM002 contains the parameters $\delta \mathbf{O}$ for orbit corrections in radial, along-track and cross-track component (RTCM 2011). These orbit corrections are used to compute a satellite position correction $\delta \mathbf{X}$, to be combined with satellite position $\mathbf{X}_{broadcast}^i$ calculated from broadcast ephemeris. The SSR orbit corrections are then applied to it. The sign definition of the correction in SSRZ is

$$\mathbf{X}_{orbit}^i = \mathbf{X}_{broadcast}^i + \delta \mathbf{X}^i \quad (11.8)$$

with

\mathbf{X}_{orbit}^i

satellite position corrected by SSR Orbit Correction provided by SSRZ low rate message ZM002

$\mathbf{X}_{broadcast}^i$

satellite position computed according to corresponding GNSS ICD from broadcast ephemeris parameter set identified by IOD in SSR Orbit Correction message

δX^i

satellite position correction

The satellite position correction δX^i is computed via coordinate transformation from the (radial, along, cross) system according to

$$\mathbf{e}_{along} = \frac{\dot{\mathbf{r}}}{|\dot{\mathbf{r}}|} \quad (11.9)$$

$$\mathbf{e}_{cross} = \frac{\mathbf{r} \times \dot{\mathbf{r}}}{|\mathbf{r} \times \dot{\mathbf{r}}|} \quad (11.10)$$

$$\mathbf{e}_{radial} = \mathbf{e}_{along} \times \mathbf{e}_{cross} \quad (11.11)$$

$$\delta X^i = [\mathbf{e}_{radial} \quad \mathbf{e}_{along} \quad \mathbf{e}_{cross}] \delta \mathbf{O}^i \quad (11.12)$$

with

$\mathbf{r} = \mathbf{X}^i$ satellite broadcast position vector

$\dot{\mathbf{r}} = \dot{\mathbf{X}}^i$ satellite broadcast velocity vector

\mathbf{e}_k direction unit vector, $k = \{\text{radial, along, cross}\}$

$\delta \mathbf{O}^i$ orbit correction vector

The orbit correction vector $\delta \mathbf{O}$ reads:

$$\delta \mathbf{O} = \begin{bmatrix} \delta O_{radial} \\ \delta O_{along} \\ \delta O_{cross} \end{bmatrix} \quad (11.13)$$

The range finally results in

$$|\mathbf{R}_j^i| = |\mathbf{X}_{broadcast}^i + [\mathbf{e}_{radial} \quad \mathbf{e}_{along} \quad \mathbf{e}_{cross}] \delta \mathbf{O}^i - \mathbf{X}_j|. \quad (11.14)$$

The orbit representation requires the definition of a coordinate reference system. For global services the coordinate system should be related to the ITRF. For regional services a reference system related to the tectonic plate of the region is often used.

NOTE: On geostationary satellites (GEO)

The satellite broadcast velocity vector for Geostationary Earth Orbit satellites (GEO) can be null, which gives no SSR orbit corrections using equations (11.9) to (11.14). The velocity vector for GEO satellites is therefore defined in a non-rotating system parallel to the ITRF at GNSS epoch time. The GPS value of the angular velocity of the Earth around the Z-axis (IS-GPS-20000) is used in the computation for all GNSS.

The satellite broadcast velocity vector for geostationary satellites is computed

$$\dot{\mathbf{r}} = \dot{\mathbf{r}}_{broadcast} + \begin{bmatrix} -\dot{\Omega}_e \cdot Y_{broadcast} \\ \dot{\Omega}_e \cdot X_{broadcast} \\ 0 \end{bmatrix} \quad (11.15)$$

with the angular velocity

$$\dot{\Omega}_e = 7.2921151467 \cdot 10^{-5} \text{ rad/sec} \quad (11.16)$$

NOTE: On Broadcast Messages

The orbit and clock messages contain data to be combined with the corresponding values obtained from the satellites broadcast message. The supported broadcast messages are redundant in some GNSS. The SSR model definitions refer currently for the different GNSS to the following broadcast messages, i.e. GNSS ICDs:

- GPS (NAV data, D(t), IS-GPS-200D)
- GLONASS GLONASS M data
- Galileo (I/NAV data, Galileo OS SIS ICD, Issue 1.1, September 2010)
- BDS (BeiDou) D1 NAV/D2 NAV data
- QZSS NAV data, D(t)
- SBAS NAV data, D(t)
- IRNSS/NavIC

NOTE: On Satellite Reference Point

The satellite antenna reference point (SRP) for orbit corrections is the phase center (PC) of the reference frequency as listed in Table 11.1. The signal and tracking descriptions follow the RINEX 3.04 observation code (RINEX 2018), i.e. observation band and attribute.

Table 11.1 GNSS SRP Definition

GNSS	SRP Reference Frequency	RINEX3 Code
GPS	L1	1C
GLONASS	G1	1C
Galileo	E1	1C
QZSS	L1	1C
SBAS	L1	1C
BDS	B1-2	2I
IRNSS	L5	5C

In the past the PCs and PCV for GPS and GLONASS have been treated identical for L1 and L2 to be the PC and PCV of the L1/L2 ionospheric free linear combination. The change to a reference frequency SRP definition, e.g. L1 for GPS and GLONASS, will have no effect on dual-frequency services. With the availability of new frequencies and GNSS as well as individual ground calibrations of transmitting satellite antennae a rigorous definition is necessary. Selecting the PC for a certain linear combination of signals complicates computation. The PC of the most commonly used and generally available frequencies has been chosen for the SRP definition to minimize the corrections to be applied and to keep algorithms simple.

11.2 SSR Clock Correction

The SSRZ messages ZM001 and ZM002 contain the parameters to compute the clock correction δC applied to the broadcast satellite clock. The satellite clock is computed according to the corresponding GNSS ICD algorithm from the satellite broadcast parameters. The SSR corrections are not defined as corrections to any GNSS specific broadcast correction term itself (e.g. the corrections C_i are not directly related to the GPS clock correction terms a_i nor to the GLONASS clock bias (τ_n) or GLONASS frequency offset (γ_n) correction terms). The SSR satellite clock corrections are then applied to satellite clock.

The polynomial SSR representation describes the clock difference for a certain time period. The sign definition of the corrections is

$$t_{satellite} = t_{broadcast} - \frac{\delta C}{Speed\ of\ light} \quad (11.17)$$

with

$t_{broadcast}$	satellite time computed according to corresponding GNSS ICD from broadcast clock parameters, identified by IOD/IODE of corresponding SSR Orbit Correction message
$t_{satellite}$	satellite time corrected by SSR clock correction
δC	clock correction obtained from SSR clock correction provided by SSRZ Low Rate and High Rate Messages ZM002 and ZM001, respectively

The polynomial is computed according to

$$\delta C = C_0 + C_1(t - t_0) + C_{HR} \quad (11.18)$$

with

C_i	polynomial Clock Correction coefficients from SSR Low Rate Message, $i = 0,1$
C_{HR}	clock Correction from SSR High Rate Message
t	time
t_0	time obtained from SSR High Clock Correction message

The reference time for the polynomial terms is the beginning of the SSR Update Interval.

NOTE: On Relativistic Effects

The satellite clock is computed following the corresponding GNSS ICD algorithm, i.e. a relativistic is applied accordingly. The relativity correction has to be applied e.g. for GPS according to IS-GPS-200D (paragraph 20.3.3.3.3.1). The relativistic correction term Δt_T is

$$\Delta t_T = -\frac{2 \mathbf{r} \cdot \dot{\mathbf{r}}}{c^2} \quad (11.19)$$

For GLONASS the relativistic effects are already taken into account in the broadcast clock parameters.

Satellite clocks are determined from ionospheric free signals derived from observations used by the service provider. Such observations are affected by delays introduced in the satellite hardware (code signal biases). For example, GPS broadcast clocks are referenced to the ionospheric free linear combination of the P codes on L1 and L2, ignoring any code biases of these signals. For SSR, the selection of signals used to generate the satellite clock corrections and the treatment of code biases are left to the service provider. The service provider shall ensure a consistent transmission of clock and code bias parameters. A Client must then consistently apply the code biases and clock corrections.

NOTE: On Broadcast Messages

See also corresponding Note in 11.1.

According to the Galileo OS SIS ICD, Issue 1.1, September 2010, there are two different clock representations for Galileo satellite clock corrections, namely the F/NAV and the I/NAV clock. The clocks are transmitted for different services and signals. F/NAV is for Dual-frequency (E1, E5a) or Single-frequency E5a services. I/NAV is available for Dual-Frequency (E1, E5b), Single-frequency E5b and Single-frequency E1. The clocks will be derived from dual frequency ionosphere free linear combinations of observables on E1/E5A or E1/E5b respectively.

For both, F/NAV and I/NAV, clock polynomial coefficients and a reference time are provided by Galileo. However, there is no information on consistency of both clocks in conjunction with group delay parameters transmitted.

SSR clock corrections are related to a broadcast reference clock. The I/NAV clock has been chosen as the reference clock for Galileo SSR correction.

The computation of satellite positions and satellite clock offsets from broadcast data must be consistent. The GLONASS ICD refers to two different algorithms. For SSR, the GLONASS broadcast ephemeris computation “Simplify of algorithm for re-calculation of ephemeris to current time” must be used (see GLONASS ICD Version 5.1, A.3.1.2).

Note: On GLONASS ICD correction

Please consider two corrections in the GLONASS ICD Version 5.1. In appendix A.3.1.2, the sign of the 4th term in dV_y/dt correctly reads $-2\omega V_x$ instead of $+2\omega V_x$ and for dV_z/dt the term in parentheses correctly reads $(3-5z^2/r^2)$ instead of $(1-5z^2/r^2)$.

Note: On GNSS IOD definition

Table 11.2 GNSS IOD Definition

GNSS	IOD	Remarks
GPS	Issue of Data (IOD) GPS broadcast Satellite Ephemeris data	
GLONASS	Issue of Data (IOD) of GLONASS broadcast Satellite Ephemeris data If bit 7 is 0 (bit 7 is MSb): Bits 0-6 represent the 7 bits of the GLONASS tb	
Galileo	Issue of Data (IOD) Galileo I/NAV broadcast Satellite Ephemeris data, which uses the Galileo IODnav 8 LSbs of IODnav	
QZSS	Issue of Data (IOD) QZSS broadcast Satellite Ephemeris data	
SBAS	Issue of Data (IOD) for SBAS, which is IODN	IODN is called spare in the RTCA DO229, but SBAS broadcast ephemeris indicate support and increasing count of the IODN
BDS	Issue of Data (IOD) of BDS broadcast Satellite Ephemeris data, which uses the BDS toc IOD=mod(toc/720,240)	
IRNSS	TBD	

11.3 SSR Signal Bias Correction

SSRZ Low Rate Message ZM002 and SSRZ QIX Bias Message ZM008 provide parameters to compute SSR satellite code and phase bias corrections δB_s^i and δb_s^i in units of meters. They are computed in the following fashion

$$\delta B_s^i = B_s^i \tag{11.20}$$

with

B_s^i SSR satellite code bias correction provided by SSRZ Low Rate Message ZM002 (in units of meters)

and

$$\delta b_s^i = b_s^i \cdot \lambda_s \quad (11.21)$$

with

b_s^i SSR satellite phase bias correction provided by SSRZ Low Rate Message ZM002 (in units of cycles)
 λ_s wavelength of carrier phase f_s of signal s

NOTE: On GNSS phase biases

Phase Wind-Up. The satellite yaw angle if needed to apply the phase wind-up corrections for carrier phase observations. The server shall generate consistent satellite clock corrections and phase biases. In order to allow consistent corrections at the client side, the yaw angle used by the server is included in the phase bias message.

A rover must know the GLONASS channel numbers from an external resource to compute the GLONASS phase biases in units of meters.

NOTE: On GLONASS phase bias correction

A rover must know the GLONASS channel numbers from an external resource to compute the GLONASS phase biases in units of meters.

The SSRZ QIX Bias Message ZM008 includes parameters that enable the computation of code and signal bias corrections of signal s_n in combination with code and phase bias corrections of signal s_0 provided by the SSRZ Low Rate Message (equations (11.20) and (11.21)). The index s_0 indicates the so-called reference signal of a frequency per GNSS.

$$\delta B_{s_n} = \delta B_{s_0} - QIX_{s_n}, \quad \text{if } f_{s_n} = f_{s_0} \quad (11.22)$$

$$\delta b_{s_n} = \delta b_{s_0} - qix_{s_n}, \quad \text{if } f_{s_n} = f_{s_0} \quad (11.23)$$

whereby

QIX_{s_n} QIX code bias parameters of signal s_n provided by SSRZ QIX Bias Message ZM008 (in units meters)
 qix_{s_n} QIX phase bias parameter of signal s_n provided by SSRZ QIX Bias Message ZM008 (in units meters)
 f_{s_0} frequency of the reference signal s_0
 s_n signal with the same frequency as s_0

The SSRZ Low Rate and QIX Bias Messages contain the satellite biases for the GNSS observable. The signal and tracking descriptions follow the RINEX 3.4 observation code (RINEX 2018), i.e. observation band and attribute.

The signal biases reported in the SSRZ messages must be added to the pseudo range measurements of the corresponding signal to get corrected pseudo ranges. Biases have no reference to any satellite broadcast parameter. The biases are applied to the original observables without any prior correction of observables due to broadcast parameters (e.g. the GPS group delay differential, T_{GD} , IS-GPS 200D).

The provider shall support as many signals as possible and must report signal biases which are zero. A Client can consistently use signals for which a signal bias is transmitted. It is not reliable for a client to use a signal without retrieving a corresponding signal bias from the data stream.

11.4 SSR Ionosphere Corrections

SSRZ supports a multi-stage correction model for the ionosphere.

The total ionospheric impact on the range observation [m] for a specific frequency f_s [Hz] is given by the sum of STEC values from all stages:

$$\delta I_{j,s}^i = \frac{40.3 \cdot 10^{16}}{f_s^2} (STEC_{GVI} + STEC_{GSI} + STEC_{RSI} + STEC_{GRI}) \quad (11.24)$$

$STEC_{GVI}$	STEC of the global vertical ionosphere correction (GVI) provided by ZM006
$STEC_{GSI}$	STEC of the global satellite dependent ionosphere correction (GSI) provided by ZM002
$STEC_{RSI}$	STEC of the regional satellite dependent ionosphere correction (RSI) provided by ZM005
$STEC_{GRI}$	STEC of the gridded (satellite dependent) ionosphere correction (GRI) provided by ZM003

The notation $STEC$ (slant TEC) implies the dependency of rover and satellite position. For that reason, the indexes i and j are omitted.

The ionospheric impact results in a pseudo range delay for code observations and phase range advance for phase observations. This behavior is considered by the sign of $\delta I_{j,s}^i$ in equations (11.1) and (11.2).

It is up to the service provider which stages are supported.

11.4.1 Global VTEC Ionosphere Correction

The Global VTEC Ionosphere Correction is represented by a spherical harmonic expansion. A spherical harmonic expansion allows a global and continuous model of the ionosphere but can also be applied to a regional area. It is the (optional) first constituent of a multiple stage ionospheric correction.

The VTEC (vertical TEC) from the spherical harmonic expansion is defined for infinitesimal thin TEC layers. The values must be mapped to slant TEC (STEC) values using the elevation of the satellites at the height of the corresponding ionospheric layer transmitted in the SSR VTEC message (see below).

NOTE: On Unreasonable VTEC

A spherical harmonic expansion with high degree and order may suffer a weak representation of the true VTEC in areas with sparse observation coverage. It is the responsibility of the service provider to take counter measures to avoid unreasonable VTEC values.

To simplify the algorithm and to avoid heavy computational load, the spherical harmonics are defined for a spherical Earth model, with a mean radius of 6370 km. Latitude, longitude, height as well as azimuth and elevation of the satellites are defined with respect to this model instead of an ellipsoidal representation.

NOTE: On Sagnac Effect

For the computation of the ECEF satellite position's azimuth and elevation, the ECEF satellite coordinates computed at the time of signal transmission at the satellite shall be rotated to the epoch of signal reception at the receiver to account for the Sagnac effect caused by Earth rotation and signal propagation.

The cosine coefficients C and sine coefficients S are represented for a specific degree N and order $M \leq N$ of a series of spherical harmonic functions to describe the VTEC in total electron content units ($1 \text{ TECU} = 10^{16} \frac{\text{electrons}}{\text{m}^2}$).

The VTEC contribution for each layer is computed in TECU as:

$$VTEC(\varphi_{PP}, \lambda_{PP}) = \sum_{n=0}^N \sum_{m=0}^{\min(n,M)} (C_{nm} \cos m\lambda_S + S_{nm} \sin m\lambda_S) P_{nm}(\sin \varphi_{PP}) \quad (11.25)$$

with

N	degree of spherical expansion
M	order of spherical expansion
n, m	indices
C_{nm}	cosine coefficients for the layer [TECU]
S_{nm}	sine coefficients for the layer [TECU]
λ_S	mean sun-fixed and phase shifted longitude of ionospheric pierce point for the layer modulo 2π [radians]
λ_{PP}	longitude of ionospheric pierce point for the layer [radians]
t	GPS time of computation epoch modulo 86400 [s]
φ_{PP}	geocentric latitude of ionospheric pierce point for the layer [radians]
$P_{nm}(\cdot)$	fully normalized associated Legendre functions

The mean sun-fixed longitude phase is shifted by 2 h to the approximate TEC maximum at 14:00 local time (resp. 50400 s) according to:

$$\lambda_S = \lambda_{PP} + \left(\frac{(t - 50400)}{86400} 2\pi \right) \text{ modulo}(2\pi) \quad (11.26)$$

Longitude λ_{PP} and latitude φ_{PP} refer to the position of the ionospheric pierce point at the height of the ionospheric layer. The ionospheric pierce point is the intersection of a straight line from the Client position to the satellite and a sphere with the height of the ionospheric layer above the spherical Earth model.

The position of the pierce point in the spherical Earth model is computed in radians, for example, by

$$\varphi_{PP} = \arcsin(\sin \varphi_R \cos \psi_{PP} + \cos \varphi_R \sin \psi_{PP} \cos A) \quad (11.27)$$

with

φ_R	geocentric latitude of Client position [radians]
λ_R	longitude of Client position [radians]
ψ_{PP}	central angle of the pierce point [radians]
A	azimuth of satellite from Client position in the spherical Earth model [radians]

The angle ψ_{PP} is the spherical Earth's central angle between Client position and the projection of the pierce point to the spherical Earth's surface. It is computed in radians by:

$$\psi_{PP} = \pi/2 - E - \arcsin\left(\frac{R_e + h_R}{R_e + h_I} \cos E\right) \quad (11.28)$$

E	elevation angle of satellite at Client position in the spherical Earth model [radians]
R_e	spherical Earth's radius of 6370 km
h_I	height of ionospheric layer above the spherical Earth model [km]
h_R	height of Client position above the spherical Earth model [km]

Under the following conditions, which apply for Client position and satellites visible at Client position

$$\begin{aligned} \varphi_R \geq 0^\circ \text{ and } \quad \tan \psi_{PP} \cos A > \tan(\pi/2 - \varphi_R) \\ \text{or} \\ \varphi_R < 0^\circ \text{ and } \quad -\tan \psi_{PP} \cos A > \tan(\pi/2 + \varphi_R) \end{aligned} \quad (11.29)$$

the pierce point longitude is computed in radians according to

$$\lambda_{PP} = \lambda_R + \pi - \arcsin\left(\frac{\sin \psi_{PP} \sin A}{\cos \varphi_{PP}}\right) \quad (11.30)$$

In all other cases the pierce point longitude is computed in radians according to

$$\lambda_{PP} = \lambda_R + \arcsin\left(\frac{\sin \psi_{PP} \sin A}{\cos \varphi_{PP}}\right) . \quad (11.31)$$

The STEC contribution of the layer l is computed in TECU with

$$STEC_l = sf \cdot VTEC_l, \quad (11.32)$$

with mapping function

$$sf = \frac{1}{\sin(E + \psi_{PP})}. \quad (11.33)$$

The total $STEC_{GVI}$ is computed by the sum of the individual $STEC_l$ for each layer $l = 1, 2, \dots, L$.

$$STEC_{GVI} = \sum_{l=1}^L STEC_l. \quad (11.34)$$

11.4.2 Satellite-dependent Global and Regional Ionosphere Corrections

The Satellite-dependent Global (GSI) and Regional (RSI) Ionosphere corrections are the second and third stage of the SSRZ supported multi-stage ionosphere model.

Similar to the Global VTEC ionospheric model the corrections are defined for an infinitesimal thin layer and a sun-fixed spherical Earth model (mean radius 6370 km).

For both models the VTEC contribution of a layer is computed as a two-dimensional Chebyshev polynomial expansion

$$VTEC(\Delta N_{PP}, \Delta E_{PP}) = \sum_{i=0}^{M_i} \sum_{j=0}^{M_j} a_{ij} T_i(\Delta N_{PP}) T_j(\Delta E_{PP}) \quad (11.35)$$

with

$T_n(\cdot)$	Chebyshev polynomial of order n
$\Delta N_{PP}, \Delta E_{PP}$	Differences in the projected North and East direction [radians] between the satellite's pierce point and the pierce point origin PPO. The type of projection and the PPO (the origin of the Chebyshev expansion) are defined differently for GSI and RSI.
a_{ij}	STEC Polynomial Coefficients for the satellite provided by ZDB008 in ZM002 and ZM005, respectively. Coefficients not provided by the model have be assumed to be zero.
$VTEC$	vertical TEC for the satellite at Client location, in [TECU]
M_i, M_j	Maximum order of polynomials in North direction and East directions $M_i = M_j = \max(i + j)$ for i, j supported by the model.

Chebyshev polynomials $T_n(x)$ of order n with argument x are recursively defined:

$$\begin{aligned} T_0(x) &= 1 \\ T_1(x) &= x \\ T_2(x) &= 2x^2 - 1 \\ &\vdots \\ T_{n+1}(x) &= 2xT_n(x) - T_{n-1}(x) \end{aligned} \quad (11.36)$$

and vary in the range of $[-1, +1]$ for $-1 \leq x \leq 1$.

The origin of the polynomial expansion is given by the pierce point origin PPO that is, however, differently defined for each model. For the GSI model the PPO is the pierce point of the nadir direction of satellite with respect to the spherical ionospheric layer (Figure 5). For the RSI model the PPO is the pierce point of the satellite for the STEC Ground Point Origin STEC GPO (Figure 7). The ellipsoidal coordinates of GPO (with respect to a region) are given in the RSI metadata. The PPOs of both models are valid and fixed from the beginning and for the length of the corresponding update interval indicated by the time tag ZDF050 in the correction messages (Figure 6 and Figure 8).

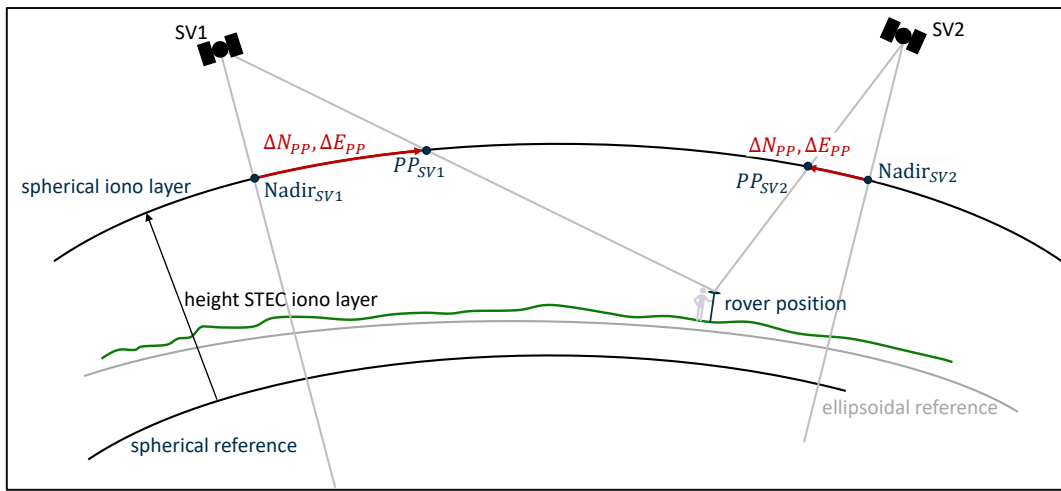


Figure 5 Pierce point origin of the GSI model. The PPO is defined by the nadir with respect to spherical layer.

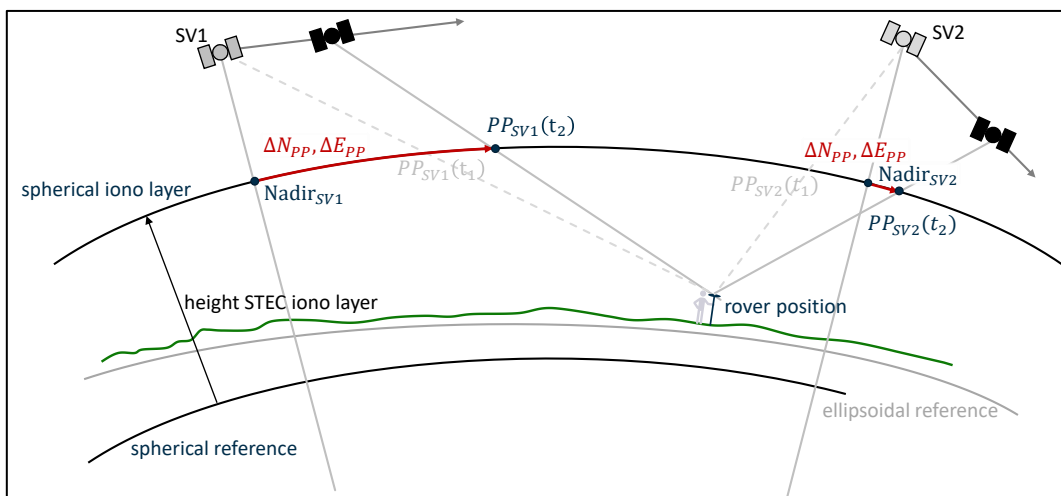


Figure 6 GSI Changing satellite geometry for reference time t_1 and time t_2 for a static rover position within an update interval. The PPO (nadir) of the satellites are identical for these two times.

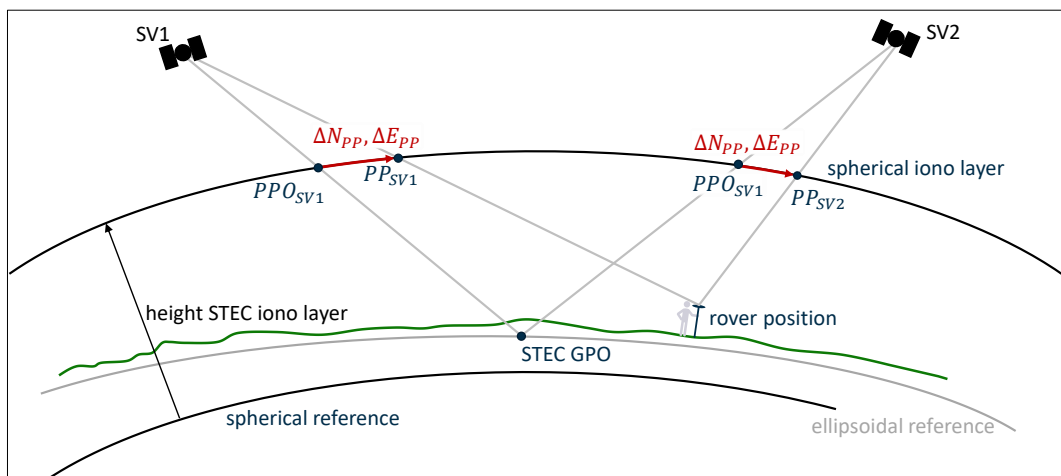


Figure 7 STEC model for two satellites with Pierce Points of spherical STEC Ground Point Origin (GPO) and Client position.

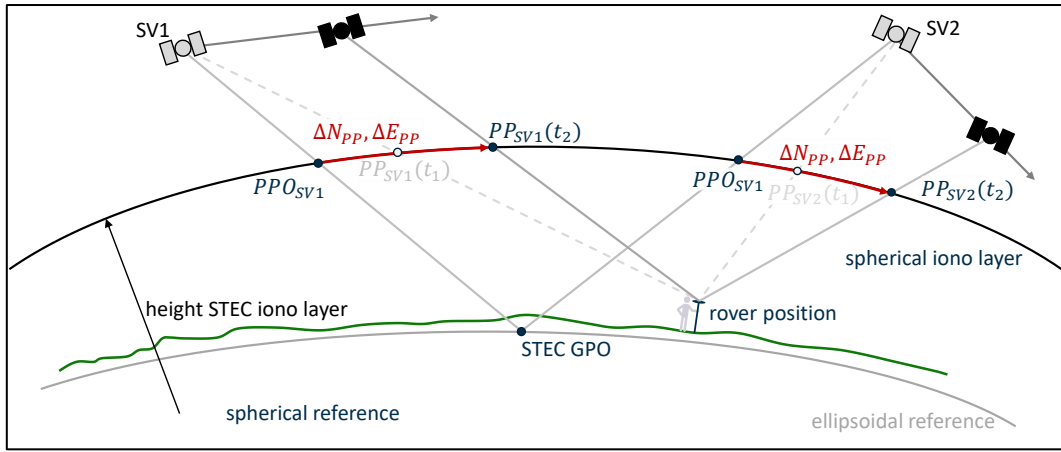


Figure 8 Changing satellite geometry for reference time t_1 and time t_2 for earth fixed STEC model and a static Client position.

GSI and RSI models include a sun-fixed polynomial expansion. Thus, the longitude of a pierce point must be shifted according to equation (11.26).

The PPO and the projection types are differently for GSI and RSI while the definition of the North and East directions is defined identically: The meridian plane through PPO is described by its normal unit vector \mathbf{n} in the spherical earth model:

$$\mathbf{n} = \frac{\mathbf{e}_{north\ pole} \times \mathbf{e}_{PPO}}{|\mathbf{e}_{north\ pole} \times \mathbf{e}_{PPO}|} \quad (11.37)$$

with the unit vector $\mathbf{e}_{north\ pole}$ from earth center to North pole

$$\mathbf{e}_{north\ pole} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad (11.38)$$

and the unit vector \mathbf{e}_{PPO} from earth center to pierce point origin PPO

$$\mathbf{e}_{PPO} = \frac{\mathbf{X}'_{PPO}}{|\mathbf{X}_{PPO}|} \quad (11.39)$$

With

$$\mathbf{X}'_{PPO} = \begin{pmatrix} \cos \theta & -\sin \theta & \mathbf{0} \\ \sin \theta & \cos \theta & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & 1 \end{pmatrix} \mathbf{X}_{PPO}$$

\mathbf{X}_{PPO}

$$\theta = \frac{\Delta t}{43200s} \pi$$

position vector of PPO in the spherical earth model rotated by the time difference Δt between current SSR epoch and last Pierce-point origin update

position vector of PPO in the spherical earth model.

Rotation angle between \mathbf{X}_{PPO} and \mathbf{X}'_{PPO} .

The origin of the transversal system is the PPO and the North and East directions are given by

$$\mathbf{e}_N = \frac{\mathbf{e}_{PPO} \times \mathbf{n}}{|\mathbf{e}_{PPO} \times \mathbf{n}|} \quad (11.40)$$

and

$$\mathbf{e}_E = \frac{\mathbf{e}_{PPO} \times \mathbf{e}_N}{|\mathbf{e}_{PPO} \times \mathbf{e}_N|}. \quad (11.41)$$

The distance n_{PP} of the Client pierce point PP to the meridian plane through PPO is computed from:

$$n_{PP} = \mathbf{n} \cdot \mathbf{e}_{PP} \quad (11.42)$$

with

$$\mathbf{e}_{PP} = \frac{\mathbf{X}_{PP}}{|\mathbf{X}_{PP}|} \quad (11.43)$$

and

\mathbf{X}_{PP} position vector of PP in the spherical earth model.

The coordinate difference ΔE_{PP}^t equals the latitude of PP in the transversal system (upper index t), i.e. the angular distance of the PP from the meridian plane through PPO:

$$\Delta E_{PP}^t = \arcsin(n_{PP}) \quad (11.44)$$

The coordinate difference ΔN_{PP}^t is the difference in longitude of PP in the transversal system and can be computed as follows.

$$\mathbf{e}_{z,PP} = \frac{\mathbf{e}_{PP} - n_{PP} \mathbf{n}}{|\mathbf{e}_{PP} - n_{PP} \mathbf{n}|} \quad (11.45)$$

and

$$\bar{\mathbf{n}} = \frac{\mathbf{e}_{z,PP} \times \mathbf{e}_{PPO}}{|\mathbf{e}_{z,PP} \times \mathbf{e}_{PPO}|} \quad (11.46)$$

Under the condition $\bar{\mathbf{n}} = \mathbf{n}$ the term ΔN_{PP}^t is computed as

$$\Delta N_{PP}^t = \arcsin(|\mathbf{e}_{z,PP} \times \mathbf{e}_{PPO}|) \quad (11.47)$$

Under the condition $\bar{\mathbf{n}} = -\mathbf{n}$ it is computed as

$$\Delta N_{PP}^t = -\arcsin(|\mathbf{e}_{z,PP} \times \mathbf{e}_{PPO}|). \quad (11.48)$$

The different conditions consider the sign change of the latitude at the equator.

The GSI and RSI corrections are based on two-dimensional polynomial expansions. Two different projections are chosen: The GSI model uses a stereographic projection of the transversal system. Thus, the coordinate differences in North and East scale with

$$\Delta N_{PP}^{GSI} = 2 \tan(\Delta N_{PP}^t / 2) \quad (11.49)$$

$$\Delta E_{PP}^{GSI} = 2 \tan(\Delta E_{PP}^t / 2). \quad (11.50)$$

The RSI model works with a transversal Mercator projection

$$\Delta N_{PP}^{RSI} = \Delta N_{PP}^t \cdot 6.37 \quad (11.51)$$

$$\Delta E_{PP}^{RSI} = \Delta E_{PP}^t \cdot 6.37 \quad (11.52)$$

In both models, the STEC contribution is TECU with

$$STEC(\Delta N_{PP}, \Delta E_{PP}) = sf \cdot VTEC(\Delta N_{PP}, \Delta E_{PP}) \quad (11.53)$$

and with mapping function sf from equation (11.33). The sum of all layers and model is inserted in equation (11.24).

11.4.3 SSR Gridded Ionosphere Correction

The Gridded Ionosphere correction (gridded STEC or GRI) is the fourth stage of the SSRZ supported multi-stage ionosphere model and includes the residuals between STEC contributions of the previously introduced ionospheric correction models and the total STEC values obtained from GNSS network processing.

The vertical-mapped corrections $VTEC_{GRI}(\varphi_i, \lambda_i, h_i)$ for each grid point i with ellipsoidal coordinates $(\varphi_i, \lambda_i, h_i)$ (obtained from ZMB013) are transmitted in ZM003. The resulting $STEC_{GRI}(\varphi_i, \lambda_i, h_i)$ is given by

$$STEC_{GRI}(\varphi_i, \lambda_i, h_i) = sf(h_i = 400km) \cdot VTEC_{GRI}(\varphi_i, \lambda_i, h_i), \quad (11.54)$$

with $sf(h_i = 400km)$ being the mapping function (Eq. (11.33)) for iono layer height 400km.

11.5 SSR Troposphere Correction

SSRZ provides a multi-stage correction model for each (basic) tropospheric component (dry, wet or total) including stage-specific extensions.

$$\delta T_j^i = STD_{total}^{Model} + \sum_s \left(\sum_c \delta T_c^s + \sum_e \delta T_e^s \right), \quad (11.55)$$

with

δT_j^i	tropospheric delay [m] between satellite position i and user position j .
δT_c^s	(slant) tropospheric delay correction [m] estimated for stage s and component c .
s	stage $s = GT, RT, GRT$
c	troposphere component $c = dry, wet, total$

Slant tropospheric model delay [m].

STD_c^{Model}

The notation STD (slant tropospheric delay) implies the dependency of rover and satellite position. For that reason, the indexes i and j are omitted.

δT_e^s

Tropospheric delay corrections [m] based on stage-specific model extensions

Introducing the tropospheric scale factor δt_c^s , Eq. (11.73) becomes

$$\delta T_j^i = STD_{total}^{Model} + \sum_s \left(\sum_c \delta t_c^s \cdot STD_c^{Model} + \sum_e \delta T_e^s \right) \quad (11.56)$$

with

δt_c^s

Tropospheric correction represented as tropospheric scale factor. The scale factor is the ratio of the estimated slant tropospheric delay correction over modelled delay

$$\delta t_c^s = \frac{\delta T_c^s}{STD_c^{Model}}$$

11.5.1 SSRZ Model Troposphere

11.5.1.1 Weather data from MOPS

The SSR troposphere model is based on a model troposphere [RTCA, 2001] based on five meteorological parameters computed for user latitude φ at DOY D at orthometric height $H = 0$. Each separated into an average (Table 11.3) and seasonal variation (Table 11.4) part.

Table 11.3 Meteorological parameters – average values [Schüler, 2001]

Latitude $ \varphi $	P_0 [hPa]	T_0 [K]	e_0 [hPa]	β_0 [K/m]	λ_0 [/]
$\leq 15^\circ$	1013.25	299.65	26.31	0.00630	2.77
30°	1017.25	294.15	21.79	0.00605	3.15
45°	1015.75	283.15	11.66	0.00558	2.57
60°	1011.75	272.15	6.78	0.00539	1.81
$\geq 75^\circ$	1013.00	263.65	4.11	0.00453	1.55

Table 11.4 Meteorological parameters – seasonal variations (adopted from [Schüler, 2001])

Latitude $ \varphi $	ΔP [hPa]	ΔT [K]	Δe [hPa]	$\Delta \beta$ [K/m]	$\Delta \lambda$
$\leq 15^\circ$	0.00	0.00	0.00	0.00000	0.00
30°	-3.75	7.00	8.85	0.00025	0.33
45°	-2.25	11.00	7.24	0.00032	0.46
60°	-1.75	15.00	5.36	0.00081	0.74

$\geq 75^\circ$	-0.50	14.50	3.39	0.00062	0.30
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The orthometric height H is calculated by

$$H(\varphi, \lambda) = h - N(\varphi, \lambda). \quad (11.57)$$

Here, $N(\varphi, \lambda)$ is the 10 x 10 Degrees WGS84 Geoidal Height Grid from [Stein, 1991].

The zero-height values

$$P(\varphi, D, H = 0) = P(\varphi, D) \quad (11.58)$$

$$T(\varphi, D, H = 0) = T(\varphi, D) \quad (11.59)$$

$$e(\varphi, D, H = 0) = e(\varphi, D) \quad (11.60)$$

$$\beta(\varphi, D, H = 0) = \beta(\varphi, D) = \beta \quad (11.61)$$

$$\lambda(\varphi, D, H = 0) = \lambda(\varphi, D) = \lambda \quad (11.62)$$

are computed according to [Schüler, 2001]:

$$\xi(\varphi, D) = \xi_0(\varphi) - \Delta\xi(\varphi) \cdot \cos\left[\frac{2\pi(D - D_0)}{365.25}\right] \quad (11.63)$$

$$\xi_0(\varphi) = \xi_0(\varphi_i) + [\xi_0(\varphi_{i+1}) - \xi_0(\varphi_i)] \cdot \left(\frac{\varphi - \varphi_i}{\varphi_{i+1} - \varphi_i}\right) \quad (11.64)$$

$$\Delta\xi(\varphi) = \Delta\xi(\varphi_i) + [\Delta\xi(\varphi_{i+1}) - \Delta\xi(\varphi_i)] \cdot \left(\frac{\varphi - \varphi_i}{\varphi_{i+1} - \varphi_i}\right) \quad (11.65)$$

11.5.1.2 Saastamoinen Troposphere Model

These zero-height meteorological parameters are used as input parameters for Saastamoinen's troposphere model.

The height-dependent parameters $P(\lambda, D, H(\varphi, \lambda))$, $T(\lambda, D, H(\varphi, \lambda))$ and $e(\lambda, D, H(\varphi, \lambda))$ are calculated using the orthometric height H (in units of meters) based on the WGS84 geoid.

$$T(\lambda, D, H(\varphi, \lambda)) = T(\varphi, D) - \beta H \quad (11.66)$$

$$\frac{T(\lambda, D, H(\varphi, \lambda))}{T(\varphi, D)} = 1 - \frac{\beta H}{T(\varphi, D)} = \theta \quad (11.67)$$

$$P(\lambda, D, H(\varphi, \lambda)) = P(\varphi, D)(\theta)^{\left(\frac{g_0}{R_d\beta}\right)} \quad (11.68)$$

$$e(\lambda, D, H(\varphi, \lambda)) = \begin{cases} e(\varphi, D)(\theta)^{\left(\frac{(\lambda+1)g_0}{R_d\beta}\right)} \\ 1 \text{ if } e(\varphi, D)(\theta)^{\left(\frac{(\lambda+1)g_0}{R_d\beta}\right)} > 1 \end{cases} \quad (11.69)$$

with

$$R_d = 287.0537625$$

$$g_0 = 9.80665 \frac{m}{s^2}$$

The gravity correction is given by

$$\frac{g_0}{g_\phi} = \frac{1}{1 - 0.000266 \cdot \cos(2\phi) - 0.00000028H} \quad (11.70)$$

The hydrostatic and wet model Zenith Tropospheric Delay (ZTD) in units of meters are computed with Saastamoinen 1972 Eq. 22

$$ZTD_{dry}^{Model}(\varphi, D, H(\varphi, \lambda)) = 0.0022768 \frac{g_0}{g_\phi} P(\varphi, D, H(\varphi, \lambda)) \quad (11.71)$$

$$ZTD_{wet}^{Model}(\varphi, D, H(\varphi, \lambda)) = \left(0.022768 \left(\frac{1255}{T(\varphi, D, H(\varphi, \lambda))} + 0.05 \right) \right) e(\varphi, D, H(\varphi, \lambda)) \quad (11.72)$$

The Slant Tropospheric Delays STD of the dry, wet and total component are given by

$$STD_{dry}^{Model} = ZTD_{dry}^{Model} \cdot GMF_{dry}(E) \quad (11.73)$$

$$STD_{wet}^{Model} = ZTD_{wet}^{Model} \cdot GMF_{wet}(E) \quad (11.74)$$

$$STD_{total}^{Model} = STD_{dry}^{Model} + STD_{wet}^{Model}, \quad (11.75)$$

with

$GMF_{dry}(E)$ global mapping function dry component
[Boehm et al., 2005]

$GMF_{wet}(E)$ global mapping function wet component
[Boehm et al., 2005]

E satellite elevation [deg]

11.5.2 SSR Global Troposphere Correction

A future SSRZ message will support the broadcast of global troposphere corrections. For that reason, the contribution of the global troposphere stage is zero.

$$\delta t_c^{GT} = 0. \quad (11.76)$$

$$\delta T_e^{GT} = 0. \quad (11.77)$$

11.5.3 SSR Regional Troposphere Correction

11.5.3.1 Tropospheric scale factor

The tropospheric scale factor of the regional troposphere $\delta t_c^{RT} = \delta t_c^{RT}(\varphi_j, \lambda_j, h_j)$ for a component c at position j with ellipsoidal coordinates $(\varphi_j, \lambda_j, h_j)$ is computed as a horizontal Chebyshev and vertical algebraic polynomial expansion.

$$\delta t_c^{RT}(\Delta\varphi, \Delta\lambda, \Delta h) = \sum_{k=0}^{M_{hgt,c}} \sum_{l=0}^{M_{hor,c}} \sum_{m=0}^{M_{hor,c}-l} a_{klm} (\Delta h)^k T_l(\Delta\varphi) T_m(\Delta\lambda), \quad (11.78)$$

whereby

$$\Delta\varphi = (\varphi_j - \varphi_{GPO}) \cdot R_E / D_{RT} \quad \text{Scale difference between rover and ground point latitude.}$$

$$\Delta\lambda = (\lambda_j - \lambda_{GPO}) \cos(\varphi_{GPO}) \cdot R_E / D_{RT} \quad \text{Scaled difference between rover and ground point longitude.}$$

$$\Delta h = (h_j - h_{GPO}) / H_{RT} \quad \text{Scaled difference between rover and ground point height.}$$

$$a_{klm} \quad \text{regional troposphere scale factor coefficient for component } c$$

$$T_n(\cdot) \quad \text{Chebyshev polynomial of order } n \text{ (Eq. (11.36))}$$

$$N_{hor,c} \quad \text{maximum horizontal order of component } c$$

$$N_{hgt,c} \quad \text{maximum vertical order of component } c$$

$$R_E \quad \text{Earth's radius of 6378135.0 m}$$

$$D_{RT} \quad \text{horizontal scale factor in [km]}$$

$$H_{RT} \quad \text{vertical scale factor in [m]}$$

Note: If the corresponding metadata tag ZDF020 is 2

In addition, the coefficients are provided as "box" pattern. Thus Eq. (11.78) changes to

$$\delta t_c^{RT}(\Delta\varphi, \Delta\lambda, \Delta h) = \sum_{k=0}^{N_{hgt,RT}-1} \sum_{l=0}^{N_{lat,RT}-1} \sum_{m=0}^{N_{lon,RT}-1} a_{klm} (\Delta h)^k T_l(\Delta\varphi) T_m(\Delta\lambda), \quad (11.79)$$

using $N_{lat,RT}$, $N_{lon,RT}$, $N_{hgt,RT}$ provided by Table 15.5.

11.5.3.2 Mapping Function Improvement

An extension of the regional troposphere correction is the mapping function improvement for low-elevation satellites.

$$\delta T_e^{RT}(E) = \begin{cases} STD_{total}^{Model} \sum_{p=0}^{M_{hgt,MFI}} \sum_{q=0}^{M_{hor,MFI}} m_{pq} \left(1 - \cos\left(\varepsilon \frac{\pi}{2}\right)\right) \cdot \varepsilon^q \cdot \Delta h^p, & \text{if } E \leq E_0 \\ 0, & \text{if } E > E_0 \end{cases} \quad (11.80)$$

whereby

$$E_0 \quad \text{Maximum elevation [deg] for mapping function improvements.}$$

$$\varepsilon = (E_0 - E)/E_0$$

normalized elevation

$$M_{hgt,MFI}$$

Maximum order of height-dependent mapping function improvements.

$$M_{hor,MFI}$$

Maximum horizontal polynomial order of mapping function improvements

$$\Delta h = (h_j - h_{GPO})/1000m$$

(MFI) Scaled difference between rover and ground point height.

11.5.4 SSR Gridded Troposphere Correction

The SSR Gridded Troposphere Correction (GRT) is a stage of the SSRZ supported multi-stage Troposphere correction model. The Gridded Troposphere correction for each grid point (defined in ZMB013) is transmitted in message ZM004.

The tropospheric scale factor of the gridded troposphere model $\delta t_c^{GRT}(\lambda_j, \varphi_j, h_j)$ for a component c at position j with ellipsoidal coordinates $(\lambda_j, \varphi_j, h_j)$ is obtained from interpolation of gridded troposphere corrections.

The user is free to choose his own preferred interpolation algorithm as the gridded troposphere corrections are associated with the network's stations (native grid) observations.

12 Grid Representation and Gridded Data Predictor

The SSRZ format is optimized for a two-dimensional native grid corresponding to the network stations to avoid double interpolation errors. The SSRZ grid encoding algorithm assumes that neighbored network stations form almost equilateral triangles.

The latitude and longitude of the i th point of such a triangle are represented by the coordinate vector

$$\vec{r}_i = (\varphi_i, \lambda_i). \tag{12.1}$$

Due to the assumption of equilateral triangles, the third point of a triangle can be represented by three parameters with respect to the baseline formed by the first and second point: two float value parameters, ds and ss , and a **Point Position Flag**. The *Point Position Flag* indicates the location of the third point with respect to the baseline pointing from \vec{r}_1 to \vec{r}_2 (1 means left, 0 means right). The parameter ds can be seen as the difference between the position of the real third point and the estimated one, parallel to the baseline. The parameter ss can be seen as the variation along the perpendicular direction with respect to the baseline.

$$ds = s_{23} - s_{13} \tag{12.2}$$

$$ss = \frac{s_{13} + s_{23}}{2} - s_{12}, \tag{12.3}$$

with

$$s_{ij} = |\vec{r}_j - \vec{r}_i|; i, j = \{1,2,3\} i \neq j \tag{12.4}$$

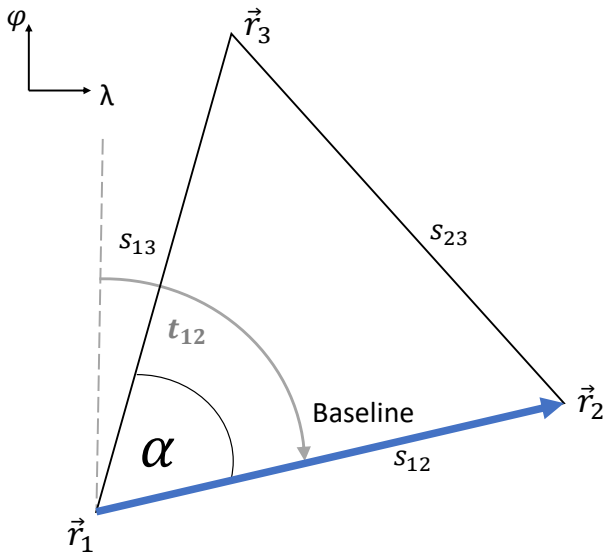


Figure 9 SSRZ triangle point and edge descriptions

The grid representation is iterative and based on the first triangle as well as three additional flags per grid point, respectively, starting with the third point of the chain. These flags indicate, if the current used baseline is also the baseline of the next triangle (*Use Baseline Flag*), or if the edges s_{13} (*Add Baseline Left Flag*) or s_{23} (*Add Baseline Right Flag*) are used as baselines for a further triangle. The sequence of (iteratively) connected triangles in a grid is called

chain. The triangles of a chain should have comparable sizes as the values of grid point related atmospheric SSR parameters of one triangle are used to predict the value at a point in a neighbored triangle (Paeth-Predictor). This predictor works the better, the similar the triangles of a chain. This close relation requires the consideration of clustered grid points in a service area (e.g. islands or differently separated regions). For this reason, more than one chain per grid is possible. A criterium for this separation could be the maximum distance between two closed neighbored grid points.

12.1.1 Grid reconstruction

The grid is chain-wise reconstructed. The required parameters per chain are gained from the SSRZ Compressed Chain Block (ZDB010). The first point of a chain is identical to the first point of the first triangle. Its latitude and longitude

$$\vec{r}_1 = (\varphi_1, \lambda_1) \quad (12.5)$$

are given by the decoded values from the first Rice-encoded data block. The second Rice-encoded data block contains pair-wisely the parameters per grid point: $(d\varphi, d\lambda)_2, (ds, ds)_3, (ds, ds)_4, \dots, (ds, ds)_{N_{pts}/chain}$. The coordinates of the second point are

$$\vec{r}_2 = (\varphi_1 + d\varphi_2, \lambda_1 + d\lambda_2). \quad (12.6)$$

These two points define the first baseline which points from \vec{r}_1 to \vec{r}_2 .

The SSRZ Compressed Chain Block provides six parameters for the third and each subsequent point: (ds, ds) , *Use Baseline Flag* (ZDF095), *Point Position Flag* (ZDF096), *Add Baseline Left Flag* (ZDF097), and *Add Baseline Right Flag* (ZDF098).

The *Use Baseline Flag* should be always 1 for the third point of a chain as only one baseline has been defined so far and this current baseline has to be used. For other points it could also be zero, indicating that the next baseline from a list has to be used. The *Add Baseline Left Flag* or *Add Baseline Right Flag* indicate if one or even two additional baselines (defined by one of the current baseline points and the third triangle point) have to be added to a list. The direction of the additional baseline vectors is described in the Flag Data Field Notes. If both flags are set first, the baseline derived from the *Add Baseline Left Flag* is added to the list.

The previously mentioned flags describe the iterative path along a chain. The third point of each reached triangle \vec{r}_3 is reconstructed together with corresponding *Point Position Flag* in the following fashion:

Step 1:

$$\begin{aligned} d\varphi &= \varphi_2 - \varphi_1 \\ d\lambda &= \lambda_2 - \lambda_1 \end{aligned} \quad (12.7)$$

$$t_{12} = \text{atan2}(d\lambda, d\varphi) \quad (12.8)$$

Step 2:

$$s_{13} = ss + s_{12} - \frac{ds}{2} \quad (12.9)$$

$$s_{23} = s_{13} + ds \quad (12.10)$$

$$\alpha = \arccos\left(\frac{s_{13}^2 + s_{12}^2 - s_{23}^2}{2s_{13}s_{12}}\right) \quad (12.11)$$

Step 3:

$$t_3 = \begin{cases} t_{12} - \alpha, & \text{Point Position Flag} = 1 \\ t_{12} + \alpha, & \text{Point Position Flag} = 0 \end{cases} \quad (12.12)$$

Step 4:

$$\vec{r}_3 = \vec{r}_1 + \begin{pmatrix} s_{13} \cos t_3 \\ s_{13} \sin t_3 \end{pmatrix} \quad (12.13)$$

12.1.2 Height Encoding

SSRZ allows the transmission of height information as well. The height values per chain are encoded on the following fashion:

- 1) Height of the first pointer per chain is transmitted absolutely h_1
- 2) The heights of all subsequent points per chain are transmitted as differences to the previous grid point $\Delta h_{i,i+1}$. Thus, the height of point $i + 1$ is given by:

$$h_{i+1} = h_i + \Delta h_{i,i+1} \quad (12.14)$$

12.1.3 Gridded Data Predictor

Ionospheric and tropospheric delays can be modeled with functional and gridded parts. In case of a total or partial representation of an atmospheric parameter as gridded data or after removing the functional part(s) from them, the remaining gridded data probably show local/spatial correlations. In order to compensate these correlations a simplified gridded-data predictor (Paeth 1991) can be applied in SSRZ.

Let $\delta x_0, \delta x_1, \delta x_2, \delta x_3, \delta x_4, \delta x_5, \dots, \delta x_{N_{\text{pts/chain}}-1}$ the series of Rice-decoded (gridded-data) values for $N_{\text{pts/chain}}$ points (per chain) received from an SSRZ Compressed Chain Block (ZDB103) including invalid values and f_i the generated parameter value at point $i = 0, 1, 2, \dots, N_{\text{pts/chain}} - 1$.

If the SSRZ Gridded-data Predictor Indicator is zero, these Rice-decoded values are identical to the gridded SSR data for the corresponding grid points (i.e. $f_i = \delta x_i$).

If the predictor indicator is set, the corresponding SSRZ gridded atmospheric metadata provide three predictor point indices a, b, c for all chain points with indices larger than 2 that are required to decode the gridded data.

The predictive algorithm is iterative. That is the predicted value of point depends on the values of previously decoded grid points (indexed with a, b, c). Table 12.1 shows the relation between the Rice-decoded values δx_i , the predicted value \hat{x}_i , the generated grid point value f_i and the value x_i that used in the prediction of a further point values for the first four values $i = i_0, i_0 + 1, i_0 + 2, i_0 + 3$, and the general description $i = i_0 + n$. The predictor algorithm starts with the first valid value of the series indicated by the index i_0 .

This first valid value is directly transmitted $f_{i_0} = \delta x_{i_0}$. The predicted value of the second and third point is the generated value of the first one. A grid point has an invalid value f_i if the Rice-decoded value is invalid ($\delta x_i = -0$). If the Rice-decoded value is invalid, the used value for further prediction is equal to the estimated one, and otherwise equal the generated value

$$x_i = \begin{cases} \hat{x}_i, & \text{if } \delta x_i = -0 \\ f_i, & \text{if } \delta x_i \neq -0 \end{cases} \quad (12.15)$$

Table 12.1 Gridded data predictor algorithm

Chain Point Index i	Rice-decoded value δx_i	Predicted value \hat{x}_i	Generated value f_i	Used value in the prediction of a further point x_i
i_0	δx_{i_0}	0	δx_{i_0}	$x_i = f_i$
$i_0 + 1$	δx_i	x_{i_0}	$\hat{x}_i + \delta x_i$ if $\delta x_i \neq -0$	$x_i = \begin{cases} \hat{x}_i, & \text{if } \delta x_i = -0 \\ f_i, & \text{if } \delta x_i \neq -0 \end{cases}$
$i_0 + 2$	δx_i	x_{i_0}	$\hat{x}_i + \delta x_i$ if $\delta x_i \neq -0$	$x_i = \begin{cases} \hat{x}_i, & \delta x_i = -0 \\ f_i, & \delta x_i \neq -0 \end{cases}$
$i_0 + 3$	δx_i	$x_{b=i_0+1} + x_{c=i_0} - x_{a=i_0+2}$	$\hat{x}_i + \delta x_i$ if $\delta x_i \neq -0$	$x_i = \begin{cases} \hat{x}_i, & \text{if } \delta x_i = -0 \\ f_i, & \text{if } \delta x_i \neq -0 \end{cases}$
$i_0 + n$	δx_i	$x_b + x_c - x_a$	$\hat{x}_i + \delta x_i$ if $\delta x_i \neq -0$	$x_i = \begin{cases} \hat{x}_i, & \text{if } \delta x_i = -0 \\ f_i, & \text{if } \delta x_i \neq -0 \end{cases}$

13 Applications

An SSR application may consider correction models e.g. for:

- coordinate frame transformation to account e.g. for tectonics (transformation from global to continental frames)
- solid Earth tides
- ocean loading
- atmospheric pressure loading
- rotational deformation due to polar motion (e.g. polar tide)
- relativistic effects
- satellite phase wind-up
- satellite phase variations

14 References

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15 Appendix

15.1 Model Parameter Blocks ZDB060

The Model Parameters Blocks ZDB060 within different SSRZ Metadata Message Blocks will be replaced in the next SSRZ Document version. In order interpret these model parameter blocks in the meantime, their values are listed in the following tables. If necessary, the meaning of the data fields are mentioned as well.

Table 15.1 Model Parameter Block (ZDB060) in SSRZ Satellite-dependent Global Ionosphere Corrections Metadata Message Block ZMB001.

Name	Definition	Number of Bits	Notes
Model ID	ZDF110	8	Always 5.
Model Version	ZDF111	8	Always 0.
Number of Integer Model Parameters	ZDF112	8	Always 5.
Integer Model Parameter	ZDF114	32	Number of GSI coefficients N_{GSI} $N_{GSI}=(M_{GSI} + 1) \cdot (M_{GSI} + 2)/2$.
Integer Model Parameter	ZDF114	32	Always 2.
Integer Model Parameter	ZDF114	32	Maximum order and degree of the GSI M_{GSI} . It represents the maximum order in North and East of a full upper left triangle. This field be replaced by ZDF135) 0: a_{00} 1: a_{00}, a_{01}, a_{10} 2: $a_{00}, a_{01}, a_{10}, a_{02}, a_{11}, a_{20}$... This field be replaced by ZDF135.
Integer Model Parameter	ZDF114	32	Always 1.
Integer Model Parameter	ZDF114	32	Always 60.
Number of Float Model Parameters	ZDF113	8	Always 1.
Float Model Parameters	ZDF115	32	Height of ionospheric layer L in kilometers. Will be replaced by ZDF140.

Table 15.2 Model Parameter Block (ZDB060) in SSRZ Gridded Troposphere Correction Metadata Message Block ZMB004

Name	Definition	Number of Bits	Notes
Model ID	ZDF110	8	Always 6.
Model Version	ZDF111	8	Always 0.
Number of Integer Model Parameters	ZDF112	8	Always 5.
Integer Model Parameter	ZDF114	32	Total number of corrections N_{GRT} per grid point.
Integer Model Parameter	ZDF114	32	Always 2.
Integer Model Parameter	ZDF114	32	0 or 1.

Name	Definition	Number of Bits	Notes
Integer Model Parameter	ZDF114	32	Always 0.
Integer Model Parameter	ZDF114	32	Always 0.
Number of Float Model Parameters	ZDF113	8	Always 0.

Table 15.3 Model Parameter Block (ZDB060) in SSRZ Regional Satellite-dependent Ionosphere Correction Metadata Message Block ZMB005.

Name	Definition	Number of Bits	Notes
Model ID	ZDF110	8	Always 8.
Model Version	ZDF111	8	Always 0.
Number of Integer Model Parameters	ZDF112	8	Always 3.
Integer Model Parameter	ZDF114	32	Total number of coefficients N_{RSI} indicating the sequence of coefficients 1: a_{00} 3: a_{00}, a_{01}, a_{10} 4: $a_{00}, a_{01}, a_{01}, a_{11}$ 5: $a_{00}, a_{01}, a_{10}, a_{02}, a_{02}$ 6: $a_{00}, a_{01}, a_{10}, a_{02}, a_{11}, a_{20}$ This field will be replaced by ZDF145.
Integer Model Parameter	ZDF114	32	Always 1.
Integer Model Parameter	ZDF114	32	Always 60.
Number of Float Model Parameters	ZDF113	8	Always 4.
Float Model Parameters	ZDF115	32	Height of ionospheric layer L in kilometers. Will be replaced by ZDF147.
Float Model Parameters	ZDF115	32	Latitude of the RSI Ground Point Origin in deg. This field will be replaced by ZDF148.
Float Model Parameters	ZDF115	32	Longitude of the RSI Ground Point Origin in deg. This field will be replaced by ZDF149.
Float Model Parameters	ZDF115	32	Height of the RSI Ground Point Origin in m. This field will be replaced by ZDF150.

Table 15.4 Model Parameter Block (ZDB060) in SSRZ Global VTEC Ionosphere Corrections Metadata Message Block ZMB006.

Name	Definition	Number of Bits	Notes
Model ID	ZDF110	8	Always 4.
Model Version	ZDF111	8	Always 0.
Number of Integer Model Parameters	ZDF112	8	Always 4.
Integer Model Parameter	ZDF114	32	Total number of corrections N_{VTEC} (see notes in ZMB006).

Integer Model Parameter	ZDF114	32	Number of ionospheric layers L . Will be replaced by ZDF130. Always 1.
Integer Model Parameter	ZDF114	32	Degree of Spherical Harmonics. Will be replaced by ZDF132.
Integer Model Parameter	ZDF114	32	Order of Spherical Harmonics. Will be replaced by ZDF132.
Number of Float Model Parameters	ZDF113	8	Always 2.
Float Model Parameters	ZDF115	32	Always 0.0.
Float Model Parameters	ZDF115	32	Height of ionospheric layer L in kilometers. Will be replaced by ZDF131.

Table 15.5 Model Parameter Block (ZDB060) in SSRZ Regional Troposphere Correction Metadata Message Block ZMB007.

Name	Definition	Number of Bits	Notes
Model ID	ZDF110	8	Always 2.
Model Version	ZDF111	8	Always 0.
Number of Integer Model Parameters	ZDF112	8	Always 10.
Integer Model Parameter	ZDF114	32	Total number of corrections N_{RT} .
Integer Model Parameter	ZDF114	32	Always 2.
Integer Model Parameter	ZDF114	32	Mapping Improvement flag. Will be replaced by bit 3 in ZDF107. 0: no mapping improvement 1: mapping improvement
Integer Model Parameter	ZDF114	32	Number of Orders in Latitude $N_{lat,RT}$.
Integer Model Parameter	ZDF114	32	Number of Orders in Longitude $N_{lon,RT}$.
Integer Model Parameter	ZDF114	32	Number of Orders in Height $N_{hgt,RT}$.
Integer Model Parameter	ZDF114	32	Total Number of Mapping Improvements.
Integer Model Parameter	ZDF114	32	Always 0.
Integer Model Parameter	ZDF114	32	Always 0.
Integer Model Parameter	ZDF114	32	Always 1.
Number of Float Model Parameters	ZDF113	8	Always 8.
Float Model Parameters	ZDF115	32	Mapping improvement elevation. Will be replaced by ZDF173.
Float Model Parameters	ZDF115	32	Latitude of the RT Ground Point Origin in deg. This field will be replaced by ZDF168.
Float Model Parameters	ZDF115	32	Longitude of the RT Ground Point Origin in deg. This field will be replaced by ZDF169.
Float Model Parameters	ZDF115	32	Height of the RT Ground Point Origin in m. This field will be replaced by ZDF170.
Float Model Parameters	ZDF115	32	Arbitrary value

Name	Definition	Number of Bits	Notes
Float Model Parameters	ZDF115	32	Arbitrary value
Float Model Parameters	ZDF115	32	This field represents a coverage dependent factor D_{RT} in units of meters that is used to normalize the arguments of the Chebyshev polynomials. Will be replaced by ZDF174.
Float Model Parameters	ZDF115	32	Arbitrary value

15.2 SSRZ Provider ID List

The Stream Identification Message ZM010 contains an SSRZ Provider ID and Stream ID to identify the SSRZ data stream. This message within the data stream serves as a mechanism that allows SSRZ users to uniquely distinguish SSRZ data streams. The SSRZ Provider ID is centrally managed by Geo++ (similar to the Provider ID in RTCM) and listed in the official SSRZ ICD (Table Table 15.6 SSRZ Provider ID List) and www.geopp.de/ssrz.

Table 15.6 SSRZ Provider ID List

SSRZ Provider ID	Organization / Assignment	Note
0	Default	It is used internally when the SSRZ Stream Identification Message (ZM010) is not included in the stream.
1-32	-	RESERVED
33	BKG	Federal Agency for Cartography and Geodesy (BKG) bkg.bund.de
34	ZSS	Satellitenpositionierungsdienst der deutschen Landesvermessung (SAPOS) www.zentrale-stelle-sapos.de
35	BEV	Bundesamt für Eich- und Vermessungswesen www.bev.gv.at
36	IGN	Instituto Geográfico Nacional de España www.ign.es/web/ign/portal
37	NLSC	National Land Surveying and Mapping Center www.nlsc.gov.tw
38	06-GPS	06-GPS www.06-gps.nl
39-127	-	RESERVED
128-138	-	FREE TO USE Provider IDs within this range are reserved and not assigned to organizations, making them available for testing purpose.
139 - ...	-	RESERVED