3GPP TSG-RAN WG2 Meeting #117-e***R2-22xxxxx***

Electronic, 21 Feb - 03 Mar, 2022

**Agenda item:** x.xx

**Source:** Swift Navigation

**Title:** GNSS Integrity – Remaining TPs (Stages 2 and 3)

**Document for:** Discussion, Agreement

# 1. Introduction

Text proposals are provided on the following topics from the Open issues on GNSS Integrity (R2-2203525):

* **Satellite Vehicle (SV) DNU**
* **Orbit and Clock bounds**
* **Satellite and Constellation Residual Risks**
* **Validity Period**
* **Mapping of Integrity Parameters**

Different options are presented based on the outcomes from the email discussion.

# 2. SV DNU

In R2-2203525 the following proposals are made:

**Proposal 1. For the purpose of GNSS integrity feature added in Release17, use GNSS-RealTimeIntegrity IE to signal to UE bad satellites (and GNSS constellations).**

**Proposal 2. Update description of GNSS-RealTimeIntegrity IE and Stage 2 to clarly state what condition can be interpreted as DNU = FALSE.**

Note: Annex A contain a modified version of the GNSS-RealTimeIntegrity IE which highlights the list of satellites monitored for integrity. This can be used as input for Stage 3 CR and subject to offline review.

**Proposal 3. For the purpose of GNSS integrity feature added in Release17, an additional DNU flag per constellation is not needed.**

## OPTION 1 – Update the GNSS-RealTimeIntegrity IE

### 2.1 Stage 2 Text Proposal (SV DNU)

<------------------------------------ Start of Text Proposal ------------------------------------>

##### 8.1.2.1.8 Real-Time Integrity

Real-Time Integrity assistance provides the GNSS receiver with information about the health status of a GNSS constellation (where the specific GNSS is indicated by a GNSS ID). For integrity purposes (as per Clause 8.1.1a), a list of monitored signals and satellites is included. Only the satellites and signals included within this list should be used for integrity purposes. A GNSS satellite and signal combination should be considered as being marked “Do Not Use” (DNU) unless the satellite ID and signal is present in the list of monitored signals and the satellite ID and signal are not present in the list of unhealthy (bad) signals.

<------------------------------------ End of Text Proposal ------------------------------------>

### 2.2 Stage 3 Text Proposal (SV DNU)

<------------------------------------ Start of Text Proposal ------------------------------------>

– *GNSS-RealTimeIntegrity*

The IE *GNSS-RealTimeIntegrity* is used by the location server to provide parameters that describe the real-time status of the GNSS constellations. *GNSS-RealTimeIntegrity* data communicates the health of the GNSS signals to the mobile in real‑time.

The location server shall always transmit the *GNSS-RealTimeIntegrity* with the current list of unhealthy signals (i.e., not only for signals/SVs currently visible at the reference location), for any GNSS positioning attempt and whenever GNSS assistance data are sent. If the number of bad signals is zero, then the *GNSS-RealTimeIntegrity* IE may be omitted except where integrity is supported in which case the GNSS-RealTimeIntegrity IE shall be transmitted indicating the monitored SV-IDs, with gnss-BadSignalList empty.

For integrity purposes, a GNSS satellite and signal combination should be considered as being marked “Do Not Use” (DNU) unless the SV-ID and signal is present in the GNSS-IntegrityMonitoredSignalList and the SV-ID and signal are not present in the gnss-BadSignalList.

-- ASN1START

GNSS-RealTimeIntegrity ::= SEQUENCE {

gnss-BadSignalList GNSS-BadSignalList,

...,

[[

gnss-IntegrityMonitoredSignalList-r17 GNSS-IntegrityMonitoredSignalList, OPTIONAL

]]

}

GNSS-BadSignalList ::= SEQUENCE (SIZE(1..64)) OF BadSignalElement

BadSignalElement ::= SEQUENCE {

badSVID SV-ID,

badSignalID GNSS-SignalIDs OPTIONAL, -- Need OP

...

}

GNSS-IntegrityMonitoredSignalList ::= SEQUENCE (SIZE(1..64)) OF MonitoredSignalElement

MonitoredSignalElement ::= SEQUENCE {

monitoredSVID SV-ID,

monitoredSignalID GNSS-SignalIDs,

...

}

-- ASN1STOP

| ***GNSS-RealTimeIntegrity* field descriptions** |
| --- |
| ***gnss-BadSignalList***  This field specifies a list of satellites with bad signal or signals. |
| ***badSVID***  This field specifies the GNSS *SV‑ID* of the satellite with bad signal or signals. |
| ***badSignalID***  This field identifies the bad signal or signals of a satellite. This is represented by a bit string in *GNSS-SignalIDs*, with a one‑value at a bit position means the particular GNSS signal type of the SV is unhealthy; a zero‑value means healthy. Absence of this field means that all signals on the specific SV are bad. |
| ***gnss-IntegrityMonitoredSignalList***  This field specifies a list of satellites and signals which are monitored to satisfy the requirements in the Integrity Principle of Operation (Clause 8.1.1a of TS 36.305/38/305). |
| ***monitoredSVID***  This field specifies the GNSS *SV‑ID* of the satellite monitored signals. |
| ***monitoredSignalID***  This field identifies the monitored signals of a satellite. This is represented by a bit string in *GNSS-SignalIDs*, with a one‑value at a bit position means the particular GNSS signal type of the SV is monitored; a zero‑value means not monitored. |

## OPTION 2 – Implicit Integrity Monitoring

Option 2 is based on the Qualcomm suggestion to make integrity monitoring implicit based on what other assistance data is provided. Qualcomm initially suggested basing this on iono/tropo assistance data presence, but we have generalized this approach to have integrity monitoring implicit whenever any bound is issued for a parameter relating to a certain satellite and signal.

### 2.3 Stage 2 Text Proposals (SV DNU)

The following text should be included to the existing descriptions in **Section 8.1.1a**:

<------------------------------------ Start of Text Proposal ------------------------------------>

The set of satellites and signals that are considered monitored for integrity purposes (and hence may be used in the integrity outputs) is the set of all the satellites and signals for which any integrity bound has been issued in any of the relevant assistance data listed in Table 8.1.2.1b-1 columns “Mean” and “Standard Deviation (StdDev)”.

<------------------------------------ End of Text Proposal ------------------------------------>

<------------------------------------ Start of Text Proposal ------------------------------------>

##### 8.1.2.1.8 Real-Time Integrity

Real-Time Integrity assistance provides the GNSS receiver with information about the health status of a GNSS constellation (where the specific GNSS is indicated by a GNSS ID). For integrity purposes (as per Clause 8.1.1a), a GNSS satellite and signal combination should be considered as being marked “Do Not Use” (DNU) unless a Real Time Integrity message is issued and the SV-ID and signal are not present in the list of unhealthy (bad) signals.

<------------------------------------ End of Text Proposal ------------------------------------>

### 2.4 Stage 3 Text Proposals (SV DNU)

<------------------------------------ Start of Text Proposal ------------------------------------>

– *GNSS-RealTimeIntegrity*

The IE *GNSS-RealTimeIntegrity* is used by the location server to provide parameters that describe the real-time status of the GNSS constellations. *GNSS-RealTimeIntegrity* data communicates the health of the GNSS signals to the mobile in real‑time.

The location server shall always transmit the *GNSS-RealTimeIntegrity* with the current list of unhealthy signals (i.e., not only for signals/SVs currently visible at the reference location), for any GNSS positioning attempt and whenever GNSS assistance data are sent. If the number of bad signals is zero, then the *GNSS-RealTimeIntegrity* IE may be omitted, except where integrity is supported in which case the GNSS-RealTimeIntegrity IE shall be transmitted with gnss-BadSignalList empty.

<------------------------------------ End of Text Proposal ------------------------------------>

## OTHER

For either option we should be more explicit in **Section 8.1.1a** regarding which IEs the Alerts correspond to, i.e.

<------------------------------------ Start of Text Proposal ------------------------------------>

Equation 8.1.1a-1 holds only at the epoch time of the DNU flag(s). The condition is not required to be met at any other times or when no DNU flags are available, i.e. DNU flags are affirmative and non-presence of the Integrity Service Alert IE and Real Time Integrity IEs should not be interpreted as a usable condition. It is up to the implementation how to handle epochs for which integrity results are desired but there are no DNU flag(s) available, e.g. the Time To Alert (TTA) may be set such that there is a “grace period” to receive the next set of DNU flags.

<------------------------------------ End of Text Proposal ------------------------------------>

# 3. Orbit and Clock Bounds

In R2-2203525 the following proposals are made:

**Proposal 5. For Release 17, besides the 3 required variance parameters for Orbit, the covariance parameters, in along-track/cross-track/radial frame, can be provided optionally.**

**Proposal 6. Agree to include integrity bounds for Clock in the GNSS-SSR-ClockCorrections IE and bounds for Orbit in the existing GNSS-SSR-OrbitCorrections IEs rather than combining them in a new joint IE.**

### 3.1 Stage 2 Text Proposals (Orbit and Clock Bounds)

<------------------------------------ Start of Text Proposal ------------------------------------>

##### 8.1.2.1.21 SSR Orbit Corrections

SSR Orbit Corrections provides the GNSS receiver with parameters for orbit corrections in radial, along – track and cross – track components. These orbit corrections are used to compute a satellite position correction, to be combined with satellite position ­calculated from broadcast ephemeris (see clause 8.1.2.1.7). For integrity purposes, SSR Orbit Corrections also provides the mean and covariance that bounds the residual Orbit Error.

When applying the integrity bounds as per 8.1.1a, the mean and stdDev must be calculated by projecting the Orbit error mean vector and covariance matrix along the line-of-sight vector between the satellite and the user, according to the following formula:

*stdDevorbit =* **(Equation 8.1.2.1.21-1)**

*meanorbit =*

*C’ =*

where: *I*: 3-D line of sight vector from the user to the satellite in the WGS-84 ECEF coordinate frame.

R: the rotation matrix from satellite along-track, cross-track and radial coordinates into the WGS-84 ECEF coordinate frame.

*C’*: the 3x3 Orbit error covariance matrix expressed in the WGS-84 ECEF coordinate frame.

*C*: the 3x3 Orbit error covariance matrix expressed in satellite along-track, cross-track and radial coordinates.

*μ*: the Mean Orbit Error vector expressed in satellite along-track, cross-track and radial coordinates.

The matrix C is expressed in the SSR Orbit Corrections as the three diagonal elements in the Variance Orbit Residual Error Vector. Optionally the off-diagonal elements can also be included as three additional parameters from the Covariance Orbit Residual Error Matrix, noting that the matrix C is symmetric. If the off-diagonal components are not included then they should be assumed to be zero.

<------------------------------------ End of Text Proposal ------------------------------------>

### 3.2 Stage 3 Text Proposals (Orbit and Clock Bounds)

<------------------------------------ Start of Text Proposal ------------------------------------>

*– GNSS-SSR-OrbitCorrections*

The IE *GNSS-SSR-OrbitCorrections* is used by the location server to provide radial, along-track and cross-track orbit corrections together with integrity information. The target device may use the parameters to compute a satellite position correction to be combined with the satellite position calculated from broadcast ephemeris.

The parameters provided in IE *GNSS-SSR-OrbitCorrections* are used as specified for SSR Clock Messages (e.g., message type 1057 and 1063) in [30] and apply to all GNSSs.

-- ASN1START

GNSS-SSR-OrbitCorrections-r15 ::= SEQUENCE {

epochTime-r15 GNSS-SystemTime,

ssrUpdateInterval-r15 INTEGER (0..15),

satelliteReferenceDatum-r15 ENUMERATED { itrf, regional, ... },

iod-ssr-r15 INTEGER (0..15),

ssr-OrbitCorrectionList-r15 SSR-OrbitCorrectionList-r15,

...,

[[

orbit-IntegrityParameters-r17 ORBIT-IntegrityParameters-r17 OPTIONAL -- Need ON

]]

}

SSR-OrbitCorrectionList-r15 ::= SEQUENCE (SIZE(1..64)) OF SSR-OrbitCorrectionSatelliteElement-r15

SSR-OrbitCorrectionSatelliteElement-r15 ::= SEQUENCE {

svID-r15 SV-ID,

iod-r15 BIT STRING (SIZE(11)),

delta-radial-r15 INTEGER (-2097152..2097151),

delta-AlongTrack-r15 INTEGER (-524288..524287),

delta-CrossTrack-r15 INTEGER (-524288..524287),

dot-delta-radial-r15 INTEGER (-1048576..1048575) OPTIONAL, -- Need ON

dot-delta-AlongTrack-r15 INTEGER (-262144..262143) OPTIONAL, -- Need ON

dot-delta-CrossTrack-r15 INTEGER (-262144..262143) OPTIONAL, -- Need ON

...,

[[

ssr-IntegrityOrbitBounds-r17 SSR-IntegrityOrbitBounds-r17 OPTIONAL -- Cond Integrity 1

]]

}

ORBIT-IntegrityParameters- r17 ::= SEQUENCE {

orbitRangeErrorCorrelationTime-r17 INTEGER (0..255) OPTIONAL, -- Need ON

orbitRangeRateErrorCorrelationTime-r17 INTEGER (0..255) OPTIONAL, -- Cond Integrity 2

...

}

SSR-IntegrityOrbitBounds-r17 ::= SEQUENCE {

orbitErrorMeanVector Integrity-MeanVector-r17,

orbitErrorVarianceVector Integrity-VarianceVector-r17,

orbitErrorCovarianceMatrix-r17 Integrity-CovarianceMatrix-r17 OPTIONAL, -- Need ON

orbitRateErrorMeanVector Integrity-MeanVector-r17,

orbitRateErrorVarianceVector Integrity-VarianceVector-r17,

orbitRateErrorCovarianceMatrix-r17 Integrity-CovarianceMatrix-r17 OPTIONAL, -- Need ON

...

}

Integrity-MeanVector-r17 ::= SEQUENCE (SIZE(3)) OF INTEGER (0..255)

Integrity-VarianceVector-r17 ::= SEQUENCE (SIZE(3)) OF INTEGER (0..255)

Integrity-CovarianceMatrix-r17 ::= SEQUENCE (SIZE(3)) OF INTEGER (0..255)

}

-- ASN1STOP

| Conditional presence | Explanation |
| --- | --- |
| *Integrity1* | The field is mandatory present if *ORBIT-IntegrityParameters* is present*;* otherwise it is not present. |
| *Integrity2* | The field is mandatory present if *orbitRangeErrorCorrelationTime* is present*;* otherwise it is not present. |

| ***GNSS-SSR-OrbitCorrections* field descriptions** |
| --- |
| ***epochTime***  This field specifies the epoch time of the orbit corrections. The *gnss-TimeID* in *GNSS-SystemTime* shall be the same as the *GNSS-ID* in IE *GNSS-GenericAssistDataElement*. |
| ***ssrUpdateInterval***  This field specifies the SSR Update Interval. The SSR Update Intervals for all SSR parameters start at time 00:00:00 of the GPS time scale. A change of the SSR Update Interval during the transmission of SSR data should ensure consistent data for a target device. See table Value of *ssrUpdateInterval* to SSR Update Interval relation below. NOTE 1. |
| ***satelliteReferenceDatum***  This field specifies the satellite refence datum for the orbit corrections. |
| ***iod-ssr***  This field specifies the Issue of Data number for the SSR data. A change of *iod-ssr* is used to indicate a change in the SSR generating configuration. |
| ***svID***  This field specifies the satellite for which the orbit corrections are provided. |
| ***iod***  This field specifies the IOD value of the broadcast ephemeris for which the orbit corrections are valid (see IE *GNSS‑NavigationModel*). NOTE 2. |
| ***delta-radial***  This field specifies the radial orbit correction for broadcast ephemeris. NOTE 3.  Scale factor 0.1 mm; range ±209.7151 m. |
| ***delta-AlongTrack***  This field specifies the along-track orbit correction for broadcast ephemeris. NOTE 3.  Scale factor 0.4 mm; range ±209.7148 m. |
| ***delta-CrossTrack***  This field specifies the cross-track orbit correction for broadcast ephemeris. NOTE 3.  Scale factor 0.4 mm; range ±209.7148 m. |
| ***dot-delta-radial***  This field specifies the velocity of radial orbit correction for broadcast ephemeris. NOTE 3.  Scale factor 0.001 mm/s; range ±1.048575 m/s. |
| ***dot-delta-AlongTrack***  This field specifies the velocity of along-track orbit correction for broadcast ephemeris. NOTE 3.  Scale factor 0.004 mm/s; range ±1.048572 m/s. |
| ***dot-delta-CrossTrack***  This field specifies the velocity of cross-track orbit correction for broadcast ephemeris. NOTE 3.  Scale factor 0.004 mm/s; range ±1.048572 m/s. |
| ***orbitRangeErrorCorrelationTime***  This field specifies the Orbit Range Error Correlation Time which is the upper bound of the correlation time of the satellite residual range error due to orbit.  The time is calculated using:  Range is 1-28,200 s. |
| ***orbitRangeRateErrorCorrelationTime***  This field specifies the Orbit Range Rate Error Correlation Time which is the upper bound of the correlation time of the satellite residual range rate error due to orbit.  The time is calculated using:  Range is 1-28,200 s. |
| ***orbitErrorMeanVector***  This field specifies the Mean Orbit Residual Error Vector which defines the mean parameter for a set of three paired overbounding models that bound the residual satellite orbit error.  The 3 random variables are defined as:   * *A* – along track orbit error * *X* – across track orbit error * *R* – radial orbit error   The normalised values are transmitted in the following order:   * *orbitErrorMeanVector*[0] = *mean*(*A*) * *orbitErrorMeanVector*[1] = *mean*(*X*) * *orbitErrorMeanVector*[2] = *mean*(*R*)   The scale factor is calculated using:  Range is 0-55 m. |
| ***orbitErrorVarianceVector***  This field specifies the Variance Orbit Residual Error Vector which defines the Variance parameters for a set of three paired overbounding models that bound the residual satellite orbit error.  The 3 random variables are defined the same as *orbitMeanVector.*  The normalised values are transmitted in the following order:   * *orbitErrorCovarianceMatrix*[0] = *var*(*A*) * *orbitErrorCovarianceMatrix*[1] = *var*(*X*) * *orbitErrorCovarianceMatrix*[2] = *var*(*R*)   The scale factor is calculated using:  Range is 0-55 m. |
| ***orbitErrorCovarianceMatrix***  This field specifies the Covariance Orbit Residual Error Matrix which defines the covariance parameters for a set of three paired overbounding models that bound the residual satellite orbit error. Only the 3 upper right values are transmitted.  The 3 random variables are defined the same as *orbitMeanVector.*  The normalised values are transmitted in the following order:   * *orbitErrorCovarianceMatrix*[0] = *cov*(*A*, *X*) * *orbitErrorCovarianceMatrix*[1] = *cov*(*A*, *R*) * *orbitErrorCovarianceMatrix*[2] = *cov*(*X*, *R*)   The scale factor is calculated using:  Range is 0-55 m. |
| ***orbitRateErrorMeanVector***  This field specifies the Mean Orbit Residual Rate Error Vector which defines the mean parameter for a set of three paired overbounding models that bound the residual satellite orbit rate error.  The 3 random variables are defined as:   * *A’* – along track orbit error * *X’* – across track orbit error * *R’* – radial orbit error   The normalised values are transmitted in the following order:   * *orbitRateErrorMeanVector*[0] = *mean*(*A*) * *orbitRateErrorMeanVector*[1] = *mean*(*X*) * *orbitRateErrorMeanVector*[2] = *mean*(*R*)   Scale factor 0.001 m/s; range 0-0.255 m/s. |
| ***orbitRateErrorVarianceVector***  This field specifies the Variance Orbit Residual Rate Error Vector which defines the Variance parameters for a set of three paired overbounding models that bound the residual satellite orbit rate error.  The 3 random variables are defined the same as *orbitRateMeanVector.*  The normalised values are transmitted in the following order:   * *orbitRateErrorCovarianceShapeMatrix*[0] = *var*(*A’*) * *orbitRateErrorCovarianceShapeMatrix*[4] = *var*(*X’*) * *orbitRateErrorCovarianceShapeMatrix*[7] = *var*(*R’*)   Scale factor 0.001 m/s; range 0-0.255 m/s. |
| ***orbitRateErrorCovarianceMatrix***  This field specifies the Covariance Orbit Residual Rate Error Matrix which defines the covariance parameters for a set of three paired overbounding models that bound the residual satellite orbit rate error. Only the 3 upper right values are transmitted.  The 3 random variables are defined the same as *orbitRateMeanVector.*  The normalised values are transmitted in the following order:   * *orbitRateErrorCovarianceShapeMatrix*[0] = *cov*(*A’*, *X’*) * *orbitRateErrorCovarianceShapeMatrix*[1] = *cov*(*A’*, *R’*) * *orbitRateErrorCovarianceShapeMatrix*[2] = *cov*(*X’*, *R’*)   Scale factor 0.001 m/s; range 0-0.255 m/s. |

NOTE 1: The update intervals are aligned to the GPS time scale for all GNSSs in order to allow synchronous operation for multiple GNSS services. This means that the update intervals may not be aligned to the beginning of the day for another GNSS. Due to the leap seconds, this is generally the case for GLONASS.

NOTE 2: In the cases that *gnss-ID* indicates 'gps' or 'qzss', the *iod* refers to the NAV broadcast ephemeris (GPS L1 C/A or QZSS QZS-L1, respectively, in table GNSS to iod Bit String(11) relation in IE *GNSS‑NavigationModel).*

NOTE 3: The reference time *t0* is *epochTime* + ½ × *ssrUpdateInterval*. The reference time *t0* for *ssrUpdateInterval* '0' is *epochTime*.

**Value of *ssrUpdateInterval* to SSR Update Interval relation**

|  |  |
| --- | --- |
| **Value of *ssrUpdateInterval*** | **SSR Update Interval** |
| 0 | 1 second |
| 1 | 2 seconds |
| 2 | 5 seconds |
| 3 | 10 seconds |
| 4 | 15 seconds |
| 5 | 30 seconds |
| 6 | 60 seconds |
| 7 | 120 seconds |
| 8 | 240 seconds |
| 9 | 300 seconds |
| 10 | 600 seconds |
| 11 | 900 seconds |
| 12 | 1800 seconds |
| 13 | 3600 seconds |
| 14 | 7200 seconds |
| 15 | 10800 seconds |

*– GNSS-SSR-ClockCorrections*

The IE *GNSS-SSR-ClockCorrections* is used by the location server to provide clock correction parameters together with integrity information. The target device may use the parameters to compute a clock correction to be applied to the broadcast satellite clock parameters, identified by *iod* of corresponding *GNSS-SSR-OrbitCorrections*.

The parameters provided in IE *GNSS-SSR-ClockCorrections* are used as specified for SSR Clock Messages (e.g., message type 1058 and 1064) in [30] and apply to all GNSSs.

-- ASN1START

GNSS-SSR-ClockCorrections-r15 ::= SEQUENCE {

epochTime-r15 GNSS-SystemTime,

ssrUpdateInterval-r15 INTEGER (0..15),

iod-ssr-r15 INTEGER (0..15),

ssr-ClockCorrectionList-r15 SSR-ClockCorrectionList-r15,

... ,

[[

clock-IntegrityParameters-r17 CLOCK-IntegrityParameters-r17 OPTIONAL -- Need ON

]]

}

SSR-ClockCorrectionList-r15 ::= SEQUENCE (SIZE(1..64)) OF SSR-ClockCorrectionSatelliteElement-r15

SSR-ClockCorrectionSatelliteElement-r15 ::= SEQUENCE {

svID-r15 SV-ID,

delta-Clock-C0-r15 INTEGER (-2097152..2097151),

delta-Clock-C1-r15 INTEGER (-1048576..1048575) OPTIONAL, -- Need ON

delta-Clock-C2-r15 INTEGER (-67108864..67108863) OPTIONAL, -- Need ON

...,

[[

ssr-IntegrityClockBounds-r17 SSR-IntegrityClockBounds-r17 OPTIONAL -- Cond Integrity 1

]]

}

CLOCK-IntegrityParameters- r17 ::= SEQUENCE {

clockRangeErrorCorrelationTime-r17 INTEGER (0..255) OPTIONAL, -- Need ON

clockRangeRateErrorCorrelationTime-r17 INTEGER (0..255) OPTIONAL, -- Cond Integrity 2

...

}

SSR-IntegrityClockBounds-r17 ::= SEQUENCE {

meanClock-r17 INTEGER (0..255),

stdDevClock-r17 INTEGER (0..255),

meanClockRate-r17 INTEGER (0..255),

stdDevClockRate-r17 INTEGER (0..255),

...

}

-- ASN1STOP

| Conditional presence | Explanation |
| --- | --- |
| *Integrity1* | The field is mandatory present if *CLOCK-IntegrityParameters* is present*;* otherwise it is not present. |
| *Integrity2* | The field is mandatory present if *clockRangeErrorCorrelationTime* is present*;* otherwise it is not present. |

| ***GNSS-SSR-ClockCorrections* field descriptions** |
| --- |
| ***epochTime***  This field specifies the epoch time of the clock corrections. The gnss-TimeID in *GNSS-SystemTime* shall be the same as the *GNSS-ID* in IE *GNSS-GenericAssistDataElement.* |
| ***ssrUpdateInterval***  This field specifies the SSR Update Interval. The SSR Update Intervals for all SSR parameters start at time 00:00:00 of the GPS time scale. A change of the SSR Update Interval during the transmission of SSR data should ensure consistent data for a target device. See table Value of *ssrUpdateInterval* to SSR Update Interval relation in IE *GNSS‑SSR‑OrbitCorrections*. |
| ***iod-ssr***  This field specifies the Issue of Data number for the SSR data. A change of iod-ssr is used to indicate a change in the SSR generating configuration. |
| ***svID***  This field specifies the satellite for which the clock corrections are provided. |
| ***delta-Clock-C0***  This field specifies the C0 polynomial coefficient for correction of broadcast satellite clock. NOTE 1.  Scale factor 0.1 mm; range ±209.7151 m. |
| ***delta-Clock-C1***  This field specifies the C1 polynomial coefficient for correction of broadcast satellite clock. NOTE 1.  Scale factor 0.001 mm/s; range ±1.048575 m/s. |
| ***delta-Clock-C2***  This field specifies the C2 polynomial coefficient for correction of broadcast satellite clock. NOTE 1.  Scale factor 0.00002 mm/s2; range ±1.34217726 m/s2. |
| ***clockRangeErrorCorrelationTime***  This field specifies the Clock Range Error Correlation Time which is the upper bound of the correlation time of the satellite residual range error due to clock.  The time is calculated using:  Range is 1-28,200 s. |
| ***clockRangeRateErrorCorrelationTime***  This field specifies the Clock Range Rate Error Correlation Time which is the upper bound of the correlation time of the satellite residual range rate error due to clock.  The time is calculated using:  Range is 1-28,200 s. |
| ***meanClock***  This field specifies the Mean Clock Error bound which is the mean value for an overbounding model that bounds the residual clock error.  The bound is *meanClock* + K \* *stdDevClock* and shall be so that the probability of it to be exceeded shall be lower than IRallocation for *irMinimum* < IRallocation < *irMaximum*, where K = normInv(IRallocation / 2) and *irMinimum*, *irMaximum* as provided in IE *GNSS-Integrity-ServiceParameters*.  This IRallocation is a fraction of the Target Integrity Risk that represents the integrity risk budget available.  The scale factor is calculated using:  Range is 0-55 m. |
| ***stdDevClock***  This field specifies the Standard Deviation Clock Error bound which is the standard deviation for an overbounding model that bounds the residual clock error.  The scale factor is calculated using:  Range is 0-55 m. |
| ***meanClockRate***  This field specifies the Mean Clock Rate Error bound which is the mean value for an overbounding model that bounds the residual clock rate error.  The bound is *meanClockRate* + K \* *stdDevClockRate* and shall be so that the probability of it to be exceeded shall be lower than IRallocation for *irMinimum* < IRallocation < *irMaximum*, where K = normInv(IRallocation / 2) and *irMinimum*, *irMaximum* as provided in IE *GNSS-Integrity-ServiceParameters*.  This IRallocation is a fraction of the Target Integrity Risk that represents the integrity risk budget available.  Scale factor 0.001 m/s; range 0.000-0.255 m/s. |
| ***stdDevClockRate***  This field specifies the Standard Deviation Clock Rate Error bound which is the standard deviation for an overbounding model that bounds the residual clock rate error.  Scale factor 0.001 m/s; range 0.000-0.255 m/s. |

NOTE 1: The reference time *t0* is *epochTime* + ½ × *ssrUpdateInterval*. The reference time *t0* for *ssrUpdateInterval* '0' is *epochTime*.

# 4. Satellite and Constellation Residual Risks

In R2-2203525 the following proposals are made:

**Proposal 7. If possible, reuse existing IEs the following Integrity Residual Risk parameters: Probability of Onset of Constellation Fault, Mean Constellation Fault Duration, Proability of Onset of Satellite Fault, and Mean Satellite Fault Duration.**

Note: candidate IEs in order of preference: GNSS-SSR-OrbitCorrections, GNSS-RealTimeIntegrity IE. This can be dealth offline as part of update to stage 3 CR – input from Rapporteur.

## OPTION 1 – Create a new IE

### 4.1 Stage 2 Text Proposal (Satellite/Constellation Residual Risks)

Already covered by the description under 8.1.2.1.31 in the draft CR (R2-2202862).

### 4.2 Stage 3 Text Proposal (Satellite/Constellation Residual Risks)

<------------------------------------ Start of Text Proposal ------------------------------------>

#### *– GNSS-Integrity-ConstellationParameters*

The IE *GNSS-Integrity-ConstellationParameters* is used by the location server to provide low update rate integrity parameters related to the probability of onset of satellite and constellation faults.

-- ASN1START

GNSS-Integrity-ConstellationParameters-r17 ::= SEQUENCE {

epochTime-r17 GNSS-SystemTime,

iod-ssr-r17 INTEGER (0..15),

},

probOnsetConstFault-r17 INTEGER (0..255),

meanConstFaultDuration-r17 INTEGER (1..3600),

probOnsetSatFault-r17 INTEGER (0..255),

meanSatFaultDuration-r17 INTEGER (1..3600),

...

}

-- ASN1STOP

|  |
| --- |
| ***GNSS-Integrity-ConstellationParameters* field descriptions** |
| ***epochTime***  This field specifies the epoch time of the constellation integrity values. The *gnss-TimeID* in *GNSS-SystemTime* shall be the same as the *GNSS-ID* in IE *GNSS-GenericAssistDataElement*. |
| ***iod-ssr***  This field specifies the Issue of Data number for the SSR data that the integrity values are applicable to. |
| ***probOnsetConstFault***  This field specifies the Probability of Onset of Constellation Fault per Time Unit where a constellation fault is at least two satellites being faulty simultaneously due to the same event. This field specifies the onset probability that the residual range or range rate error exceeds a bound created using the minimum allowed inflation factor *Kmin*, and bounding parameters as *mean* + *Kmin* \* *stdDev* where *Kmin* = *normInv*(*irMaximum*/2).  The probability is calculated by where *n* is the value of *pConstellation* and the range is 10-10.2 to 1 per hour. |
| ***meanConstFaultDuration***  This field specifies the Mean Constellation Fault Duration which is the mean duration between when a constellation fault occurs, and the user is alerted by the service through the DNU flags (or the integrity violation is over).  Scale factor 1 s; range 1-3,600 s. |
| ***probOnsetSatFault***  This field specifies the Probability of Onset of Satellite Fault per Time Unit which is the probability of occurrence of satellite error to exceed the residual error bound for more than the Time to Alert (TTA).  This field specifies the onset probability that the residual range or range rate error exceeds a bound created using the minimum allowed inflation factor *Kmin*, and bounding parameters as *mean* + *Kmin* \* *stdDev* where *Kmin* = *normInv*(*irMaximum* / 2).  The probability is calculated by where *n* is the value of *pSatellite* and the range is 10-10.2 to 1 per hour. |
| ***meanSatFaultDuration***  This field specifies the Mean Satellite Fault Duration which is the mean duration between when a satellite fault occurs, and the user is alerted by the service through the DNU flags (or the integrity violation is over).  Scale factor 1 s; range 1-3,600 s. |

## OPTION 2 – Reuse existing IE

### 4.3 Stage 3 Text Proposal (Satellite/Constellation Residual Risks)

FFS whether GNSS-SSR-OrbitCorrections or GNSS-RealTimeIntegrity IE is more suitable.

# 5. Validity Period

In R2-2203525 the following proposals is flagged as potentially agreeable:

**Open Issue #4:**

**Proposal 9. Agree not to include additional validaity time parameters together with the bounds parameters.**

## OPTION 1 – Validity Period is included explicitly in the assistance data

### 3.1 Stage 2 Text Proposal (Validity Period)

The following text should be included to the existing descriptions in **Section 8.1.1a**:

<------------------------------------ Start of Text Proposal ------------------------------------>

The validity period of the integrity bounds is determined by the corresponding validity period parameters accompanying each integrity bound. The bounds must not be used for integrity purposes beyond their corresponding validity periods.

<------------------------------------ End of Text Proposal ------------------------------------>

### 3.2 Stage 3 Text Proposal (Validity Period)

The followingValidity Period field would be included in each of the bounds *GNSS-SSR-OrbitCorrections, GNSS-SSR-ClockCorrections, GNSS-SSR-CodeBias, GNSS-SSR-PhaseBias, GNSS-SSR-STEC-Correction, GNSS-SSR-GriddedCorrection.*

|  |
| --- |
| ***validityPeriodSeconds***  This field specifies the Validity Duration in seconds. The integrity values are only valid for the time interval from *epochTime* to *epochTime* + *validityPeriod*.  Scale factor 1 s; range 1-86,400 s. |

## OPTION 2 – Validity Period is equal to the SSR assistance data validity period

### 3.3 Stage 2 Text Proposal (Validity Period)

The following text should be included to the existing descriptions in **Section 8.1.1a**:

<------------------------------------ Start of Text Proposal ------------------------------------>

The validity period of the integrity bounds assistance data is determined as follows:

-- FFS, based on how the SSR assistance data validity period is defined

<------------------------------------ End of Text Proposal ------------------------------------>

# 6. Mapping of Integrity Parameters

Table 8.1.2.1b-1 also needs to be updated in the draft CRs for TS 36.305/38.305

### 3.1 Stage 2 Text Proposal (Validity Period)

<------------------------------------ Start of Text Proposal ------------------------------------>

Table 8.1.2.1b-1: Mapping of Integrity Parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Error** | **GNSS Assistance Data** | **Integrity Fields** | | | | |
| **Integrity Alerts** | **Integrity Bounds (Mean)** | **Integrity Bounds (StdDev)** | **Residual Risks** | **Integrity Correlation Times** |
| Orbit | SSR Orbit Corrections | Real-Time Integrity  (see Section 8.1.2.1.8) | Calculated according to Equation 8.1.2.1.21-1 | Calculated according to Equation 8.1.2.1.21-1 | Probability of Onset of Constellation Fault  Probability of Onset of Satellite Fault  Mean Constellation Fault Duration  Mean Satellite Fault Duration | Orbit Range Error Correlation Time  Orbit Range Rate Error Correlation Time |
| Clock | SSR Clock Corrections | Mean Clock Residual Error Vector | Standard Deviation Clock Error | Clock Range Error Correlation Time  Clock Range Rate Error Correlation Time |
| Code Bias | SSR Code Bias | Mean Code Bias Error  Mean Code Bias Rate Error | Standard Deviation Code Bias Error  Standard Deviation Code Bias Rate Error |  |
| Phase Bias | SSR Phase Bias | Mean Phase Bias Error  Mean Phase Bias Rate Error | Standard Deviation Phase Bias Error  Standard Deviation Phase Bias Rate Error |
| Ionosphere | SSR STEC Correction  SSR Gridded Correction | Ionosphere DNU | Mean Ionospherre Error  Mean Ionospherre Rate Error | Standard Deviation Ionosphere Error  Standard Deviation Ionosphere Rate Error | Probability of Onset of Ionosphere Fault  Mean Ionosphere Fault Duration | Ionosphere Range Error Correlation Time  Ionosphere Range Rate Error Correlation Time |
| Troposphere Vertical Hydro Static Delay | SSR Gridded Corrections | Troposphere DNU | Mean Troposphere Vertical Hydro Static Delay Error  Mean Troposphere Vertical Hydro Static Delay Rate Error | Standard Deviation Troposphere Vertical Hydro Static Delay Error  Standard Deviation Troposphere Vertical Hydro Static Delay Rate Error | Probability of Onset of Troposphere Fault  Mean Troposphere Fault Duration | Troposphere Range Error Correlation Time  Troposphere Range Rate Error Correlation Time |
| TroposphereVertical WetDelay | Mean Troposphere Vertical Wet Delay Error  Mean Troposphere Vertical Wet Delay Rate Error | Standard Deviation Troposphere Vertical Wet Delay Error  Standard Deviation Troposphere Vertical Wet Delay Rate Error |