3GPP TSG-RAN WG2 Meeting #117 ***R2-220xxxx***

Electronic Meeting, February 21 – March 3, 2022

**Agenda item:** 8.11.1

**Source:** ESA

**Title:** [Pre117-e][610][POS] Open issues on GNSS positioning integrity (ESA)

**Document for:**  Discussion

# 1. Introduction

The following email discussion has been triggered after RAN2#116bis-e:

**[Pre117-e][610][POS] Open issues on GNSS positioning integrity (ESA)**

The discussion below is mainly based on the open issues provided by the following contributions:

* R2-2201722 Summary of [Post116bis-e][628][POS] 37.355 running CR (Qualcomm)
* R2-2202005 Report of email discussion [Post116bis-e][634][POS] Positioning open issues list (Intel)
* R2-2201765 GNSS integrity – Extended Discussion (Stage 3) (Swift Navigation)

# 2. Contact Information

|  |  |
| --- | --- |
| Company | Contact: Name (E-mail) |
| ESA | Florin-catalin.grec@esa.int |
| Swift Navigation | grant@swiftnav.com |
| Huawei, HiSIlicon | yinghaoguo@huawei.com |
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# 3. Open issues

## 3.1 Summary Open Issues

- The below issues have been extracted from the R2-2202005 after cross-checking their status with R2-2201722 and R2-2201765.

- As a reminder, an open issue is an issue critical to the completion of the WI as marked in the R2-2202005.

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| **Topic** | **Open issues****Note:** Open Issues should be defined for aspects that need to be closed, important to make already agreed functionality work in a reasonable way. Not yet agreed optimizations that may not be needed shall not be listed as Open Issues. | **Related to the completion of WI?** **The topic has to be removed from Rel-17 scope if the corresponding open issues cannot be resolved.**  | **Remark** |
| **Stage 3 details** | #1. RAN2 to discuss whether to modify the existing GNSS-RealTimeIntegrity IE or create a new IE to accommodate the Alerts for the satellite/constellation specific DNUs under GNSS-GenericAssistData. Discuss whether a Constellation DNU and per-signal DNU should be included in addition to the SV DNU. | Yes | **Status:** Discussion in R2-2201765. check the status of LPP email discussion 116bis-628 |
| #2. RAN2 to discuss whether or not the cross-covariance should be included for the Orbit and Clock integrity bounds and whether these bounds should be included as a new IE or within the existing SSR Orbit and Clock IEs. | Yes | **Status:** Discussion in R2-2201765. check the status of LPP email discussion 116bis-628 |
| #3. RAN2 to discuss whether the Residual Risk parameters proposed in Table 3.2-2 (R2-2201765) should be integrated into their corresponding SSR correction IEs or within a separate standalone IE. | Yes | **Status:** Discussion in R2-2201765. check the status of LPP email discussion 116bis-628 |
| #4: RAN2 to discuss whether a validity period needs to be defined for each of the bounds and what value ranges are appropriate if so. | Yes | **Status:** Discussion in R2-2201765. check the status of LPP email discussion 116bis-628 |
| #5: RAN2 to discuss which of the assistance data should be sent as periodic assistance data. | Yes | **Status:** Discussion in R2-2201765. check the status of LPP email discussion 116bis-628 |
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Added on the 10/02 at the recommendation of the group

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| (added on the 10/02)#6: Stage 3 details on the support of broadcast assistance data.FFS: the detailed IE should depend on stage 3 details | Yes | **Status:** check the status of LPP email discussion 116bis-628 check the status of RRC email discussion 116bis-631RAN2#116bisIntroduce a new posSIB for the new assistance data added for integrity. |
| #7: Integrity requirements information to be included in the LPP signaling |  | **Status:** endorsed in stage 2, no details in stage 3. |

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| # | Item | Description | Affected IEs | Source |
| #8 (R2-D1) | Integrity Request Information | The information required for an integrity request | CommonIEsRequestLocationInformation🡪 IntegrityInformationRequest-r17 | Rapporteur |
| #9 (R2-D2) | Integrity Information Result | The information required for an integrity report,Encoding of protection level | CommonIEsProvideLocationInformation🡪IntegrityInfo-r17 | Rapporteur |
| #5 (R2-D3) | Periodic Assistance Data | Which integrity information need to be provided periodically | GNSS-PeriodicAssistData-r15 | Rapporteur |
| #10 (R2-D4) | Integrity Service Parameters | Confirm the proposed encoding | GNSS-Integrity-ServiceParameters-r17 | Rapporteur |
| #11 (R2-D5) | Code Bias Bounds | Confirm the proposed encoding | GNSS-SSR-CodeBias-r15🡪SSR-IntegrityCodeBiasBounds-r17 | Rapporteur |
| #12 (R2-D6) | Phase Bias Bounds | Confirm the proposed encoding | GNSS-SSR-PhaseBias-r16🡪 SSR-IntegrityPhaseBiasBounds-r17 | Rapporteur |
| #13 (R2-D7) | STEC Integrity | Confirm the proposed encoding | GNSS-SSR-STEC-Correction-r16🡪 STEC-IntegrityParameters-r17STEC-IntegrityErrorBounds-r17 | Rapporteur |
| #14 (R2-D8) | Gridded Correction Integrity | Confirm the proposed encoding | GNSS-SSR-GriddedCorrection-r16🡪 SSR-GriddedCorrectionIntegrityParameters-r17TropoDelayIntegrityErrorBounds-r17 | Rapporteur |

# 4. Open issues discussion

## 4.1 Open Issue 1: Update *GNSS-RealTimeIntegrity* or a new IE for DNU flag

R2-2201765 (ED 116bis-611) includes a first discussion on the need to add a new IE to accommodate the alerts for the satellite/constellation specific DNUs under GNSS-GenericAssistData. The possibility to reuse the existing *GNSS-RealTimeIntegrity* IE has been touched on as well in the past.

We also note that RAN2 already agreed that assistance data in GNSS-RealTimeIntegrity can be reused for GNSS integrity in R17.

Agreement captured in R2-2201722 116bis-628

Proposal2-11: The assistance data in GNSS-RealTimeIntegrity can be reused for GNSS integrity in R17

For completion, the GNSS-RealTimeIntegrity is copied below:

#### *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 shall be omitted.

-- ASN1START

GNSS-RealTimeIntegrity ::= SEQUENCE {

 gnss-BadSignalList GNSS-BadSignalList,

 ...

}

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

BadSignalElement ::= SEQUENCE {

 badSVID SV-ID,

 badSignalID GNSS-SignalIDs OPTIONAL, -- Need OP

 ...

}

-- 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.  |

**Q1: Do you agree that GNSS-RealTimeIntegrity can be used as it already mentions the unhealthy satellites (therefore, implicitly, also the constellation) and the bad signals? If not, please clarify what the new IE would achieve that GNSS-RealTimeIntegrity cannot.**

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| **Company** | **Yes** | **No** | **Comments** |
| ESA | Y |  | We think this IE represents a good structure for achieving the signalling of unhealthy satellites and even signals. Extension of this IE, if needed, seems more appropriate than duplication. |
| Swift Navigation |  | N | For Integrity, the DNU concept has a specific meaning and RAN2 already supports the DNU concept in Stage 2 and Stage 3 (e.g. *GNSS-Integrity-ServiceAlert*).If we reuse *GNSS-RealTimeIntegrity* IE we may need to rename the fields with the DNU terminology, which can lead to issues of backward compatibility for existing implementations which do not support R17 integrity functionality. This is why in R2-2201214 we propose to include the *GNSS-Integrity-ConstellationAlert* IE as a standalone message (copied below for reference) to specifically address the functionality of R17:*– GNSS-Integrity-ConstellationAlert*The IE *GNSS-Integrity-ConstellationAlert* is used by the location server to indicate whether the GNSS constellation can be used for integrity related applications.-- ASN1STARTGNSS-Integrity-ConstellationAlert-r17 ::= SEQUENCE { constellationDoNotUse-r17 BOOLEAN, integrity-svAlertList-r17 Integrity-SVAlertList-r17, ...}Integrity-SVAlertList-r17 ::= SEQUENCE (SIZE(1..64)) OF Integrity-SVAlertElement-r17Integrity-SVAlertElement-r17 ::= SEQUENCE { svID-r17 SV-ID,  svDoNotUse-r17 BOOLEAN, ...}-- ASN1STOP

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| ***GNSS-Integrity-ConstellationAlert* field descriptions** |
| ***constellationDoNotUse***This field specifies the Constellation DNU Flag which indicates whether the GNSS constellation can be used for integrity related applications (FALSE) or not (TRUE). |
| ***svID***This field specifies the satellite for which *svDoNotUse* applies to. |
| ***svDoNotUse***This field specifies the SV DNU Flag which indicates whether the satellite can be used for integrity related applications (FALSE) or not (TRUE). |

Alternatively we could supplement the documentation/description of the *GNSS-RealTimeIntegrity* to clarify that this content can be interpreted as DNU flags for the purpose of integrity. But we think this adds unnecessary complexity and it’s preferable to add a self-contained Alert IE (as above) rather than conflating it with *GNSS-RealTimeIntegrity* (which is a more generic form of integrity compared to the Principle of Operation described in Stage 2). Furthermore, if existing implementations already implement the *GNSS-RealTimeIntegrity* IE, they may not guarantee to satisfy the Principle of Operation summarised by Equation 8.1.1a-1 in Stage 2. |
| Huawei, HiSilicon |  |  | No strong view. Both solutions by swift and ESA can work. But if a self-contained alert as shown by swift is introduced, it should be clarified that the indication of DNU should be aligned with that in GNSS-RealTimeIntegrity. |
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**Q2: Do you agree that a Constellation DNU needs included, in addition to SV DNU?**

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| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| ESA |  | N | In *GNSS-RealTimeIntegrity* constellation is not needed as badSVID can achieve that feature. |
| Swift Navigation | Y |  | The reason we include the Satellite Vehicle (SV) and Constellation DNUs is to simplify the Alert if the entire constellation is impacted (rather than needing to Alert on each satellite individually). If we only flag the satellite, how do we ensure that all satellites have been accounted for as part of the constellation, i.e. how do we ensure that no satellites are omitted from the list (e.g. if a new satellite is added to the system and the Network software has not yet been updated with this information, but the user software is using the satellite).  |
| Huawei, HiSilicon |  |  | Constellation DNU can save signalling overhead than signalling DNU individually |
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**Q3: Do you agree that a signal DNU needs to be included, in addition to SV DNU?**

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| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| ESA |  | N | In *GNSS-RealTimeIntegrity* constellation already includes this field. Of course, if RAN2 decides to define a new IE instead of using GNSS-RealTimeIntegrity than signal DNU should also be included. |
| Swift Navigation |  |  | We are fine to add a signal DNU within the proposed *GNSS-Integrity-ConstellationAlert* but we don’t think the additional granularity is needed (e.g. we are not aware of a case where there is an issue with one signal but you would want to continue using other signals from the same satellite). |

## 4.2 Open Issue 2: Cross-covariance and inclusion of integrity bounds for Clock and Orbit in a new or existing IEs.

From pervious discussion it was not clear why these parameters, for the Orbit and Clock integrity bounds, lead to improved performance in accordance with the principle of operation. There was no strong preference expressed for including these parameters therefore more discussions were recommended.

**Q4: Do you agree that the cross-covariance terms should be included for the Orbit and Clock integrity bounds? Please clarify the reason for your choice.**

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| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| ESA |  | Not yet | We think mean and variance are enough. Sending also the cross-covariance is increasing the size of the information to be signalled and its need/criticality is not stated until now. |
| Swift Navigation | Y |  | Based on the questions raised in prior discussions we think this topic warrants an extended explanation to highlight why this message is directly equivalent to the MT28 message already standardised for SBAS (which was added to achieve necessary performance and is considered state-of-the-art).**Background*** For paired overbounding we derive a mean and standard deviation to bound the error distribution. For the SSR Orbit Corrections, these are further decomposed into their radial, along-track and cross-track components/axes, and for integrity the error covariances between each axis must be considered. This is why, for example, the MT28 message (described below) was developed to model these covariances as they occur for SBAS services.
* By sending the full covariance a user has more information available to model all error sources with greater precision, thereby reducing the magnitude of these errors when the errors are projected along the satellite line-of-sight using SSR methods. If only the mean and standard deviation are used, we must be conservative and overinflate the distribution to protect against errors which have not been modelled explicitly (i.e. the covariances), which in turn will inflate the Protection Level.

**Comparison to SBAS Message Type 28 (MT28)*** The cross-covariance message in R2-2201214 is based on SBAS Message Type 28 (Clock-Ephemeris Covariance Matrix) from the GPS MOPS (A.4.4.16) [1]. The matrix shape and parametrisation are equivalent to MT28, including only sending 10 values given the matrix is symmetrical. For further context, a brief introduction to MT28 is available on the [ESA Navipedia](https://gssc.esa.int/navipedia/index.php/The_EGNOS_SBAS_Message_Format_Explained#Message_type_28) website.
* The main differences to MT28 are that in 3GPP we need higher resolution in the message contents because we are bounding the precise SSR orbit corrections rather than the satellite’s native ephemeris, which is much lower in accuracy, i.e. we need to satisfy Alert Limits down to 1m in 3GPP (using SSR) rather than 40m (at best) using SBAS. These requirements are why we also use a smaller scale factor (0.004) as part of the value range, to mitigate potential quantization errors that would otherwise impact the size of the bound (e.g. as described in [2]).
* Also, a recent [performance analysis](https://satellite-navigation.springeropen.com/articles/10.1186/s43020-021-00045-z) from using MT28 with GPS + BDS corrections across China provides a useful demonstration of applying this message in a dual-frequency, multi-constellation SBAS context.
* We suggest [2][3][4] for further technical background and performance assessments relating to MT28 and for deriving covariances [5]:
1. DO-229D, RTCA, "RTCA DO-229D Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment," 2013.
2. Walter, T., Hansen, A., Enge, P. (2001) “**Message Type 28**,” Proceedings of the 2001 National Technical Meeting of The Institute of Navigation, Long Beach, CA, January 2001, pp. 522-532, < <https://www.researchgate.net/publication/242405363_Message_Type_28>>.
3. Blanch, J., Walter, T., Enge, P., Stern, A., Altshuler, E. (2014) "**Evaluation of a Covariance-based Clock and Ephemeris Error Bounding Algorithm for SBAS**," Proceedings of the 27th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2014), Tampa, Florida, September 2014, pp. 3270-3276, <<https://web.stanford.edu/group/scpnt/gpslab/pubs/papers/Blanch_IONGNSS_2014_covUDRE_paper.pdf>>.
4. Authié, T., Trilles, S., Fort, J-C, Azaïs, J-M. (2017) "**Integrity Based on MT28 for EGNOS: New Algorithm Formulation & Results**," Proceedings of the 30th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2017), Portland, Oregon, September 2017, pp. 1077-1088, < <https://hal.archives-ouvertes.fr/hal-01646740/document>>.
5. Yu, S., Kim, D., Song, J., Kee, C. (2021), “**Covariance Analysis of Real-Time Precise GPS Orbit Estimated from Double-Differenced Carrier Phase Observations**,” Remote Sensing. 2019; 11(19):2271, <<https://doi.org/10.3390/rs11192271>>.

To summarise, although there is some additional bandwidth required (and possibly a new IE), it is already demonstrated by existing standards that the covariance parameters are needed to improve user integrity performance. |
| Huawei, HiSilicon |  | N | According to the backgrounds provided by Swift, the covariance parameters can be considered as an optimization for improving user integrity performance. We think the agreed mean and variance parameters already work well for Rel-17. |
| Swift Navigation |  |  | In response to Huawei, we are highlighting above that the covariance parameters are core functionality rather than an optimisation. The cross-covariance parameters are needed to meet the KPIs identified in the SI. |
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**Q5: Do you agree that the integrity bounds should be included as a new IE or within the existing SSR Orbit and Clock IEs? Please clarify the reason for your choice.**

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| **Company** | **~~Yes~~** | **~~No~~** | **Comments** |
| ESA | ~~Y~~ |  | We would like to include these parameters in existing IEs in order to minimize the number of new IEs. |
| Swift Navigation |  |  | We’re unclear which option corresponds to Y or N, but regardless our preference is for a new IE because we think it is the most efficient method when including the full covariance. If, however, we decide to combine with the existing IEs, we agree with the option suggested by Qualcomm in R2-2201761 which is to duplicate the content but let the Network decide which IE to send it in. |
| Huawei, HiSilicon |  | ~~Y~~ | Even if the co-variance is needed, it still can be included by extending the existing SSR orbit and clock IEs |
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## 4.3 Open Issue 3: Residual Risk parameters

RAN2 to discuss whether the Residual Risk parameters proposed in R2-2201765 should be integrated into their corresponding SSR correction IEs or within a separate standalone IE. These parameters are used to provide the residual risk parameters related to the satellite, constellation, ionosphere, and troposphere residual risk probabilities.

We first recall past agreements relevant to this point:

Proposal 5: RAN2 agrees to include the Integrity Residual Risk Parameters into their existing corresponding GNSS IEs (as per Appendix A (R2-2201761). This discussion is also subject to the Stage 3 outcomes regarding which Ies and associated fields to define for integrity.

The corresponding mapping between the Stage 2 and Stage 3 fields is shown in Table 3.2-2 extracted from R2-2201765. RAN2 has all agreed to add Mean Fault Duration parameters (in green).

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|  | **Stage 2 Fields (Table 8.1.2.1b-1)** | **Stage 3 Parameters (R2-2201214)** |
| **Integrity Residual Risk Parameters** | ***GNSS-Integrity-OrbitClockErrorBounds*** |
| Block 1 | Probably of Onset of Constellation Fault | *pConstellation* |
| Mean Constellation Fault Duration | *tConstellation* |
| Probability of Onset of Satellite Fault | *pSatellite* |
| Mean Satellite Fault Duration | *tSatellite* |
|  |  | ***GNSS-SSR-STEC-Correction*** |
| Block 2 | Probability of Onset of Ionosphere Fault | *pIonosphere* |
| Mean Ionosphere Fault Duration | *tIonosphere* |
|  | ***GNSS-SSR-GriddedCorrection*** |
| Probability of Onset of Troposphere Fault | *pTroposphere* |
| Mean Troposphere Fault Duration | *tTroposphere* |

 **Table 3.2-2: Mapping between the Stage 2 and Stage 3 field descriptions for the Residual Risks.**

In previous discussions several companies have expressed their preference to keep satellite parameters in *GNSS-SSR-OrbitCorrections* IE and clock parameters in *GNSS-SSR-ClockCorrections* IE which raises objection to creation of the a new *GNSS-Integrity-OrbitClockErrorBounds* IE.

To make things simpler, we believe it would be easier to advance by splitting the table from above in two distinct blocks.

**Q6: Do you agree with the mapping from Stage 2 to Stage 3 in Table 3.2-2 for Block 1 parameters, and that these new parameters should be included in the corresponding IEs? Please detail your understanding.**

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| **Company** | **Yes** | **No** | **Comments** |
| ESA |  | Not yet | We think the new parameters in Block 1 should be included in the corresponding IEs as suggested by an old agreement we have (recalled in the beginning of this section). Furthermore, we think the resolution of this point depends on Open Issue 2.We understand the static nature of these parameters but we do not see any fundamental problem in repeating (unchanged) values at the rate of the GNSS-SSR-OrbitCorrections and GNSS-SSR-ClockCorrections. |
| Swift Navigation | Y |  | Consistent with Q5, our preference is for a new IE, but we are also ok to include in the existing IEs if the group thinks this is better. |
| Huawei, HiSilicon |  |  | See reply to Q5 |
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**Q7: Do you agree with the mapping from Stage 2 to Stage 3 in Table 3.2-2 for Block 2 parameters, and that these new parameters should be included in the corresponding IEs? Please detail your understanding.**

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| **Company** | **Yes** | **No** | **Comments** |
| ESA | Y |  | We think the new parameters in Block 2 should be included in the proposed IEs. |
| Swift Navigation | Y |  | As proposed already (R2-2201723). |
| Huawei, HiSIlicon | Y |  | This has already been captured in the current LPP CR, isn’t it? |
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## 4.4 Open Issue 4: Validity period for each error bound and value ranges

In R2-2201214 there are certain common parameters proposed to accompany the bounds parameters to indicate validity and applicability of the bound.

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| ***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. |
| ***validityPeriodDays***This field specifies the Validity Duration in days. The integrity values are only valid for the time interval from *epochTime* to *epochTime* + *validityPeriod*. A day is defined to be 86,400 seconds.Scale factor 1 day; range 1-365 days.  |

From past discussions two main options emerged:

* Option 1 – add two new parameters to denote the validity of the new integrity assistance data: ValidityPeriodSeconds and validityPeriodDays
* Option 2 – no need for an validity time as bounds are now included directly in the SSR assistance data

The bounds are valid until new data are received. If something happens between updates, we have the DNU flags. Therefore, the need for a validity time is unclear.

**Q8: Please express your preference for one of the two opinions and motivate your choice.**

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| **Company** | **OP1** | **OP2** | **Comments** |
| ESA |  | X | We think option 2 is enough and validity of bounds lasts until new data is received. |
| Swift Navigation | Y |  | Several conditions for integrity validity and applicability were summarised in the last email discussion (R2-2201765). The most important requirement is to ensure that at future times (i.e. after the bounds are issued) the user is able to determine whether the bounds are still valid. To elaborate:* The Alerts are used to indicate that the bounds are still valid. If there is no Alert (i.e. all corresponding DNU flags are false) then the bound is still valid.
* However, the network does not know necessarily which users have received which bounds, therefore when it issues an Alert message it must verify that all the bounds that were previously issued are still valid.
* To make this practical, the bounds should have a validity period such that they expire and the network only needs to check that all bounds that are still within their validity period are still valid.
* To meet these requirements, it is sufficient to have a validity period on each set of bounds (unless the equivalent functionality already exists in LPP?) to ensure that the integrity system can fail safely.

To be more explicit, as stated above the challenge is if “the bounds are valid until new data are received” and we do not know when the client has received the data (due to loss of connectivity), without a validity period it is never safe to clear the DNU flag, as any user regaining connectivity after an outage may be using stale data. The solution is to bound the maximum validity period and then keep the DNU asserted until the validity period expires. |
| Huawei, HiSilicon | Y |  |  |
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Another delegate raised the need for validityPeriodDays. Therefore,

**Q9: If you replied with OP1 at Q8, please clarify what validity parameters should we add.**

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| **Company** | **validityPeriodSeconds** | **validityPeriodDays** | **both** | **Comments** |
| Swift Navigation | Y |  | optional | The days field gives some flexibility but practically speaking we don’t see a need for a validity period greater than 24 hours |
| Huawei, HiSilicon |  |  | Optional  | We are ok with both granularities if there are applicable use cases. |
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## 4.5 Open Issue 5 (R2-D3): Periodic Assistance data for GNSS integrity

It was acknowledged the need to discuss which of the assistance data should be sent as periodic assistance data. This procedure enables a target to request a server to send assistance data periodically. In Rel-16 37.355 specifications, periodic assistance data transfer is supported for HA GNSS (e.g., RTK) positioning only.

#### *GNSS-PeriodicAssistData*

The IE *GNSS-PeriodicAssistData* is used by the location server to provide control parameters for a periodic assistance data delivery session (e.g., interval and duration) to the target device.

NOTE: Omission of a particular assistance data type field in IE *GNSS-PeriodicAssistData* means that the location server does not provide this assistance data type in a data transaction of a periodic assistance data delivery session, as described in clauses 5.2.1a and 5.2.2a. Inclusion of no assistance data type fields in IE *GNSS-PeriodicAssistData* means that a periodic assistance data delivery session is terminated.

-- ASN1START

GNSS-PeriodicAssistData-r15 ::= SEQUENCE {

 gnss-RTK-PeriodicObservations-r15 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 glo-RTK-PeriodicBiasInformation-r15 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 gnss-RTK-MAC-PeriodicCorrectionDifferences-r15

 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 gnss-RTK-PeriodicResiduals-r15 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 gnss-RTK-FKP-PeriodicGradients-r15 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 gnss-SSR-PeriodicOrbitCorrections-r15

 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 gnss-SSR-PeriodicClockCorrections-r15

 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 gnss-SSR-PeriodicCodeBias-r15 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

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 gnss-SSR-PeriodicURA-r16 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 gnss-SSR-PeriodicPhaseBias-r16 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 gnss-SSR-PeriodicSTEC-Correction-r16 GNSS-PeriodicControlParam-r15 OPTIONAL, -- Need ON

 gnss-SSR-PeriodicGriddedCorrection-r16 GNSS-PeriodicControlParam-r15 OPTIONAL -- Need ON

 ]],

 [[

 gnss-Integrity-PeriodicServiceAlert-r17 GNSS-PeriodicControlParam-r15 OPTIONAL -- Need ON

 ]]

}

-- ASN1STOP

Editor's Note: FFS whether the *GNSS-Integrity-ServiceParameters* need to be provided periodically..

**Q10: Do you agree that periodic assistance data for GNSS integrity is needed?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| ESA | Y |  | Essentially, GNSS integrity feature is an extension of the SSR feature and therefore we find naturally to include GNSS integrity assistance data in the list with Periodic Assistance Data |
| Swift Navigation | Y |  | This is a natural extension of the SSR periodic assistance data.  |
| Huawei, HiSilicon | Y |  | Aligned with the existing GNSS assistance data. |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**Q11: Which assistance data should be sent as periodic assistance data?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ESA | We think new IEs for GNSS integrity need to be provided also periodic, same as it was the case for RTK and SSR features. However, we think that a more clear picture will emerge once we clarify the points from above as they impact Stage 3 and final list of new IEs needed in support of GNSS integrity.  |
| Swift Navigation | The integrity AD included in existing IEs will already be sent periodically within the periodic IEs, e.g.:gnss-SSR-PeriodicCodeBias-r15 gnss-SSR-PeriodicPhaseBias-r16gnss-SSR-PeriodicSTEC-Correction-r16gnss-SSR-PeriodicGriddedCorrection-r16For the Common Alerts, we support the new periodic IE proposed in R2-2201723:gnss-Integrity-PeriodicServiceAlert-r17Subject to Q1 and Q5, a new periodic IE would also be needed for the Constellation Alerts (Q1) and orbit/clock bounds (Q5), e.g. (R2-2201214):gnss-Integrity-PeriodicConstellationAlert-r17gnss-Integrity-PeriodicOrbitClockErrorBounds-r17Regarding the *GNSS-Integrity-ServiceParameters* (R2-2201723), these are typically static and there’s no need to send periodically. |
| Huawei, HiSilicon | All the new IEs introduced for integrity |
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|  |  |

## 4.6 Open Issue 6: Stage 3 details on the support of broadcast assistance data.

FFS: the detailed IE should depend on stage 3 details

Broadcast of positioning assistance data is supported via Positioning System Information Blocks (posSIBs) as specified in TS 36.331 or TS 38.331. The posSIBs are carried in RRC System Information (SI) messages.

GNSS integrity in Rel-17 is an extension of GNSS SSR, therefore several posSIBs are already defined is Stage 3. Stage 3 running CR already includes several new posSIBs for GNSS integrity.

**Q12: Do you agree with the mapping of GNSS Integrity IEs to posSIB proposed in section 7.2 of R2-2201723 Stage 3 Running CR?**

|  |  |  |
| --- | --- | --- |
|  | *posSibType* | *assistanceDataElement* |
| GNSS Common Assistance Data (clause 6.5.2.2) | *posSibType1-9* | *GNSS-Integrity-ServiceParameters* |
| *posSibType1-10* | *GNSS-Integrity-ServiceAlert* |

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | Y |  |  |
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**Q13: What other posSIB are needed? Please note, additional posSIBType will be needed to enable broadcast of GNSS integrity data (is highly correlated to other open items discussed above).**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | Y |  | If new IEs are added for the Constellation Alerts (Q1) and Orbit/Clock bounds (Q5) then new posSIBs will also be required for each. |
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## 4.7 Open Issue 7: Integrity requirements information to be included in the LPP signalling.

Nokia made the following remark in a previous discussion:

“We think the “integrity requirements” (i.e. KPIs) to be transferred from LMF to UE for integrity result calculation is still missing.

Currently in Stage-2 we already have endorsed the following text:

*- allow the UE to determine and report the integrity results of the calculated location; the UE can use the integrity requirements and assistance data obtained via NG-RAN, together with its own measurements, to determine the integrity results of the calculated location.*

However, it seems RAN2 has never discussed what integrity requirements information should be included in the LPP signaling.”

**The coordinator of this discussion believes that this issue overlaps with Open Issue 8 and Open Issue 9. ESA is proposing to close this item. Nokia is asked to confirm that the scope of 4.8 and 4.9 matches its observation.**

## 4.8 Open Issue 8 (R2-D1): Integrity Request information

#### *CommonIEsRequestLocationInformation*

The *CommonIEsRequestLocationInformation* carries common IEs for a Request Location Information LPP message Type.

…

IntegrityInformationRequest-r17 ::= SEQUENCE {

 -- FFS

}

…

**Q14: Companies are requested to provide their view on what should be the information included in the IntegrityInformationRequest-r17**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | The integrity KPI information, specifically: **TIR, AL, TTA** (as per TR 38.857).In R2-2107989 (Question 10, Phase 2) we agreed that Integrity Availability does not need to be included given it is an outcome of integrity rather than an input KPI. The AL KPI can be further represented as a horizontal and vertical component (HAL and VAL). |
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## 4.9 Open Issue 9 (R2-D2): Integrity Information Result

The goal is to agree on the information needed in the integrity result and how to best encode protection level. We observe that protectionLevel field is added and the range is FFS. Another remark from our side is that fact that usually protection level has two components – horizontal and vertical.

#### *CommonIEsProvideLocationInformation*

The *CommonIEsProvideLocationInformation* carries common IEs for a Provide Location Information LPP message Type.

IntegrityInfo-r17 ::= SEQUENCE {

 protectionLevel-r17 INTEGER (0..FFS),

 ...

}

**Q15: Do you agree to express protection level as two parameters – horizontal and vertical protection level? What should be the range of the protection level parameter(s)?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | Optional |  | We support the decomposition of the PL into HPL and VPL but if we do so we must also decompose the AL into HAL and VAL (see also Q14). Regarding the value range we propose that a range of **0 – 500m** would be more than sufficient for all foreseeable applications. The resolution should be sufficient to represent low PLs in high accuracy applications, we propose **1cm** would be adequate. |
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**Q16: Are there any fields missing?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | As we have discussed previously, in practice the user client should optionally report the TIR, AL and TTA that were used to calculate the Protection Level. For example, if the client can still compute a Protection Level but only for a TIR that is worse than the TIR that was initially requested. This is not an issue for UE-based MO-LR where the positioning client and KPIs are both internal, but it may be an issue for UE-based MT-LR if the KPIs are requested by the Network. If we omit this functionality then note that integrity outputs must be disabled if the KPIs cannot be fully satisfied, significantly impacting interoperability. |
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## 4.10 Open Issue 10 (R2-D4): Integrity Service Parameters

The objective is to confirm the proposed encoding for GNSS-Integrity-ServiceParameters-r17 in running CR for Stage 3.

#### *GNSS-Integrity-ServiceParameters*

The IE *GNSS-Integrity-ServiceParameters* is used by the location server to provide the range of Integrity Risk (IR) for which the GNSS integrity assistance data are valid.

-- ASN1START

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

 irMinimum-r17 INTEGER (0..255),

 irMaximum-r17 INTEGER (0..255),

 ...

}

-- ASN1STOP

|  |
| --- |
| *GNSS-Integrity-ServiceParameters* field descriptions |
| ***irMinimum***This field specifies the Minimum Integrity Risk (IR) which is the minimum IR for which the error bounds provided in the IEs TBD are valid.The IR is calculated by where n is the value of *irMinimum* and the range is 10-10.2 to 1. |
| ***irMaximum***This field specifies the Maximum Integrity Risk (IR) which is the maximum IR for which the error bounds provided in the IEs TBD are valid.The IR is calculated by where n is the value of *irMaximum* and the range is 10-10.2 to 1. |

Editor's Note: FFS on encoding details/value ranges.

#### – *GNSS-Integrity-ServiceAlert*

The IE *GNSS-Integrity-ServiceAlert* is used by the location server to indicate whether the corresponding assistance data can be used for integrity related applications.

-- ASN1START

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

 ionosphereDoNotUse-r17 BOOLEAN,

 troposphereDoNotUse-r17 BOOLEAN,

 ...

}

-- ASN1STOP

|  |
| --- |
| *GNSS-Integrity-ServiceAlert* field descriptions |
| ***ionosphereDoNotUse***This field indicates whether the ionospheric corrections in IEs FFS can be used for integrity related applications (FALSE) or not (TRUE). |
| ***troposphereDoNotUse***This field indicates whether the tropospheric corrections in IEs FFS can be used for integrity related applications (FALSE) or not (TRUE). |

Editor's Note: FFS on whether to also include a "Service DNU".

**Q17: Do you agree with the proposed encoding?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | With Comments |  | Service DNU should also be included as a simplified way to indicate that the entire service is no longer valid for the purpose of integrity (rather than needing to issue each of the DNUs individually). |
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**Q18: Do you think the FFS value can be replaced by clear information already?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | In *GNSS-Integrity-ServiceParameters*, we are fine with the encoding/value ranges. The field descriptions labelled ‘TBD’ can be listed once the Stage 3 IEs are finalised.For GNSS-Integrity-ServiceAlert, the *GNSS-SSR-STEC-Correction* IE can be listed for the ionosphereDNU and the *GNSS-SSR-GriddedCorrection* IE can be listed for the troposphereDNU. In Q17 we also propose including the Service DNU. |
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## 4.11 Open Issue 11 (R2-D5): Code Bias Bounds

The objective is to confirm the proposed encoding for SSR-IntegrityCodeBiasBounds-r17 in the running CR for Stage 3.

#### *GNSS-SSR-CodeBias*

The IE *GNSS-SSR-CodeBias* is used by the location server to provide GNSS signal code bias together with integrity information. The target device may add the code bias to the pseudo-range measurement of the corresponding code signal to get corrected pseudo-ranges.

NOTE: Any code biases transmitted in the broadcast messages (e.g., the GPS group delay differential TGD [4] (*NAV‑ClockModel*)) are not applied at all by the target device.

The parameters provided in IE *GNSS-SSR-CodeBias –* except for *SSR-IntegrityCodeBiasBounds –* are used as specified for SSR Code Bias Messages (e.g., message type 1059 and 1065) in [30] and apply to all GNSSs.

-- ASN1START

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

 epochTime-r15 GNSS-SystemTime,

 ssrUpdateInterval-r15 INTEGER (0..15),

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

 ssr-CodeBiasSatList-r15 SSR-CodeBiasSatList-r15,

 ...

}

SSR-CodeBiasSatList-r15 ::= SEQUENCE (SIZE(1..64)) OF SSR-CodeBiasSatElement-r15

SSR-CodeBiasSatElement-r15 ::= SEQUENCE {

 svID-r15 SV-ID,

 ssr-CodeBiasSignalList-r15 SSR-CodeBiasSignalList-r15,

 ...

}

SSR-CodeBiasSignalList-r15 ::= SEQUENCE (SIZE(1..16)) OF SSR-CodeBiasSignalElement-r15

SSR-CodeBiasSignalElement-r15 ::= SEQUENCE {

 signal-and-tracking-mode-ID-r15 GNSS-SignalID,

 codeBias-r15 INTEGER (-8192..8191),

 ...,

 [[

 ssr-IntegrityCodeBiasBounds-r17 SSR-IntegrityCodeBiasBounds-r17 OPTIONAL -- Need ON

 ]]

}

SSR-IntegrityCodeBiasBounds-r17 ::= SEQUENCE {

 meanCodeBias-r17 INTEGER (0..255),

 stdDevCodeBias-r17 INTEGER (0..255),

 meanCodeBiasRate-r17 INTEGER (0..255),

 stdDevCodeBiasRate-r17 INTEGER (0..255),

 ...

}

-- ASN1STOP

| *GNSS-SSR-CodeBias* field descriptions |
| --- |
| ***epochTime***This field specifies the epoch time of the code bias data. 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 GNSS satellite for which the code biases are provided. |
| ***signal-and-tracking-mode-ID***This field specifies the GNSS signal for which the code biases are provided.  |
| ***codeBias***This field provides the code bias for the GNSS signal indicated by *signal-and-tracking-mode-ID*.Scale factor 0.01 m; range ±81.91 m. |
| ***meanCodeBias***This field specifies the Mean Code Bias Error bound which is the mean value for an overbounding model that bounds the residual code bias error.The bound is *meanCodeBias* + K \* *stdDevCodeBias* 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 0.005 m; range 0-1.275 m. |
| ***stdDevCodeBias***This field specifies the Standard Deviation Code Bias Error bound which is the standard deviation for an overbounding model that bounds the residual code bias error.Scale factor 0.005 m; range 0-1.275 m. |
| ***meanCodeBiasRate***This field specifies the Mean Code Bias Rate Error bound which is the mean value for an overbounding model that bounds the residual code bias rate error.The bound is *meanCodeBiasRate* + K \* *stdDevCodeBiasRate* 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 0.00005 m/s; range 0-0.01275 m/s. |
| ***stdDevCodeBiasRate***This field specifies the Standard Deviation Code Bias Rate Error bound which is the standard deviation for an overbounding model that bounds the residual code bias rate error.Scale factor 0.00005 m/s; range 0-0.01275 m/s. |

Editor's Note: FFS on encoding details/value ranges.

**Q19: Do you agree with the proposed encoding?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | Y |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**Q20: What should be the value ranges for the new fields ?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | Agree with the proposed value ranges. |
|  |  |
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|  |  |
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|  |  |

## 4.12 Open Issue 12 (R2-D6): Phase Bias Bounds

The objective is to confirm the proposed encoding SSR-IntegrityPhaseBiasBounds-r17 in running CR for Stage 3.

#### *GNSS-SSR-PhaseBias*

The IE *GNSS-SSR-PhaseBias* is used by the location server to provide GNSS signal phase bias together with integrity information. The target device may add the phase bias to the phase-range measurement of the corresponding phase signal to get corrected phase-ranges.

The parameters provided in IE *GNSS-SSR-PhaseBias –* except for *SSR-IntegrityPhaseBiasBounds –* are used as specified for Compact SSR GNSS Satellite Phase Bias Messages (e.g., message type 4073,5) in [43] and apply to all GNSSs.

-- ASN1START

GNSS-SSR-PhaseBias-r16 ::= SEQUENCE {

 epochTime-r16 GNSS-SystemTime,

 ssrUpdateInterval-r16 INTEGER (0..15),

 iod-ssr-r16 INTEGER (0..15),

 ssr-PhaseBiasSatList-r16 SSR-PhaseBiasSatList-r16,

 ...

}

SSR-PhaseBiasSatList-r16 ::= SEQUENCE (SIZE(1..64)) OF SSR-PhaseBiasSatElement-r16

SSR-PhaseBiasSatElement-r16 ::= SEQUENCE {

 svID-r16 SV-ID,

 ssr-PhaseBiasSignalList-r16 SSR-PhaseBiasSignalList-r16,

 ...

}

SSR-PhaseBiasSignalList-r16 ::= SEQUENCE (SIZE(1..16)) OF SSR-PhaseBiasSignalElement-r16

SSR-PhaseBiasSignalElement-r16 ::= SEQUENCE {

 signal-and-tracking-mode-ID-r16 GNSS-SignalID,

 phaseBias-r16 INTEGER (-16384..16383),

 phaseDiscontinuityIndicator-r16 INTEGER (0..3),

 phaseBiasIntegerIndicator-r16 INTEGER (0..3) OPTIONAL, -- Need OP

 ...,

 [[

 ssr-IntegrityPhaseBiasBounds-r17 SSR-IntegrityPhaseBiasBounds-r17 OPTIONAL -- Need ON

 ]]

}

SSR-IntegrityPhaseBiasBounds-r17 ::= SEQUENCE {

 meanPhaseBias-r17 INTEGER (0..255),

 stdDevPhaseBias-r17 INTEGER (0..255),

 meanPhaseBiasRate-r17 INTEGER (0..255),

 stdDevPhaseBiasRate-r17 INTEGER (0..255),

 ...

}

-- ASN1STOP

| *GNSS-SSR-PhaseBias* field descriptions |
| --- |
| ***epochTime***This field specifies the epoch time of the phase bias data. 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 GNSS satellite for which the phase biases are provided. |
| ***signal-and-tracking-mode-ID***This field specifies the GNSS signal for which the phase biases are provided.  |
| ***phaseBias***This field provides the phase bias for the GNSS signal indicated by *signal-and-tracking-mode-ID*.Scale factor 0.001 m; range ±16.383 m. |
| ***phaseDiscontinuityIndicator***This field provides the phase discontinuity counter for the GNSS signal indicated by *signal-and-tracking-mode-ID*. This counter is increased for every discontinuity in phase (roll-over from 3 to 0). |
| ***phaseBiasIntegerIndicator***This field informs whether the phase bias is Undifferenced Integer (Value 0), Widelane Integer (Value 1) or Non-Integer (Value 2):Value 0: The Undifferenced Integer Phase Bias supports PPP-RTK fixed, widelane or float mode.Value 1: The Widelane Integer Phase Bias indicates that after application of the Phase Bias value, this signal can be differenced with any other signal from the same satellite that also has Widelane Integer Phase Bias indicated to form a new combined carrier phase measurement of integer quality, supporting PPP-RTK widelane fixed mode.Value 2: The Non-Integer Phase Bias supports PPP-RTK float mode.Value 3: Reserved.If the *phaseBiasIntegerIndicator* field is not present then it is interpreted as having Value 0 (Undifferenced Integer). |
| ***meanPhaseBias***This field specifies the Mean Phase Bias Error bound which is the mean value for an overbounding model that bounds the residual phase bias error.The bound is *meanPhaseBias* + K \* *stdDevPhaseBias* 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 0.005 m; range 0-1.275 m. |
| ***stdDevPhaseBias***This field specifies the Standard Deviation Phase Bias Error bound which is the standard deviation for an overbounding model that bounds the residual phase bias error.Scale factor 0.005 m; range 0-1.275 m. |
| ***meanPhaseBiasRate***This field specifies the Mean Phase Bias Rate Error bound which is the mean value for an overbounding model that bounds the residual phase bias rate error.The bound is *meanPhaseBiasRate* + K \* *stdDevPhaseBiasRate* 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 0.00005 m/s; range 0-0.01275 m/s. |
| ***stdDevPhaseBiasRate***This field specifies the Standard Deviation Phase Bias Rate Error bound which is the standard deviation for an overbounding model that bounds the residual phase bias rate error.Scale factor 0.00005 m/s; range 0-0.01275 m/s. |

Editor's Note: FFS on encoding details/value ranges.

**Q21: Do you agree with the proposed encoding?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | Y |  |  |
|  |  |  |  |
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|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**Q22: What should be the value ranges for the new fields ?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | Agree with the proposed value ranges. |
|  |  |
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## 4.13 Open Issue 13 (R2-D7): STEC integrity

The objective is to confirm the proposed encoding for STEC-IntegrityParameters-r17 and STEC-IntegrityErrorBounds-r17.

#### *GNSS-SSR-STEC-Correction*

The IE *GNSS-SSR-STEC-Correction* is used by the location server to provide ionosphere slant delay correction together with integrity information. The ionosphere slant delay (STEC) consists of the polynomial part provided in *GNSS-SSR-STEC-Correction* and the residual part provided in *GNSS-SSR-GriddedCorrection*.

The parameters provided in IE *GNSS-SSR-STEC-Correction –* except for *STEC-IntegrityParameters* and *STEC-IntegrityErrorBounds –* are used as specified for Compact SSR STEC Correction Messages (e.g., message type 4073,8) in [43] and apply to all GNSSs.

-- ASN1START

GNSS-SSR-STEC-Correction-r16 ::= SEQUENCE {

 epochTime-r16 GNSS-SystemTime,

 ssrUpdateInterval-r16 INTEGER (0..15),

 iod-ssr-r16 INTEGER (0..15),

 correctionPointSetID-r16 INTEGER (0..16383),

 stec-SatList-r16 STEC-SatList-r16,

 ...,

 [[

 stec-IntegrityParameters-r17 STEC-IntegrityParameters-r17 OPTIONAL -- Need ON

 ]]

}

STEC-SatList-r16 ::= SEQUENCE (SIZE(1..64)) OF STEC-SatElement-r16

STEC-SatElement-r16 ::= SEQUENCE {

 svID-r16 SV-ID,

 stecQualityIndicator-r16 BIT STRING (SIZE(6)),

 stec-C00-r16 INTEGER (-8192..8191),

 stec-C01-r16 INTEGER (-2048..2047) OPTIONAL, -- Need ON

 stec-C10-r16 INTEGER (-2048..2047) OPTIONAL, -- Need ON

 stec-C11-r16 INTEGER (-512..511) OPTIONAL, -- Need ON

 ...,

 [[

 stec-IntegrityErrorBounds-r17 STEC-IntegrityErrorBounds-r17 OPTIONAL -- Cond Integrity1

 ]]

}

STEC-IntegrityParameters-r17 ::= SEQUENCE {

 probOnsetIonoFault-r17 INTEGER (0..255),

 meanIonoFaultDuration-r17 INTEGER (1..256),

 ionoRangeErrorCorrelationTime-r17 INTEGER (1..255) OPTIONAL, -- Need ON

 ionoRangeRateErrorCorrelationTime-r17 INTEGER (1..255) OPTIONAL, -- Cond Integrity2

 ...

}

STEC-IntegrityErrorBounds-r17 ::= SEQUENCE {

 meanIonosphere-r17 INTEGER (0..255),

 stdDevIonosphere-r17 INTEGER (0..255),

 meanIonosphereRate-r17 INTEGER (0..255),

 stdDevIonosphereRate-r17 INTEGER (0..255),

 ...

}

-- ASN1STOP

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

| *GNSS-SSR-STEC-Correction* field descriptions |
| --- |
| ***epochTime***This field specifies the epoch time of the STEC correction data. 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*. |
| ***correctionPointSetID***This field provides the ID of the *GNSS-SSR-CorrectionPoints* set. The reference point used for the STEC calculations (see NOTE below) is the reference pointprovided in IE *GNSS-SSR-CorrectionPoints* with the same *correctionPointSetID.* |
| ***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 GNSS satellite for which the STEC corrections are provided. |
| ***stecQualityIndicator***This field specifies SSR STEC quality indicator. The STEC quality indicator is represented by a combination of CLASS and VALUE. The 3 MSB define the CLASS with a range of 0-7 and the 3 LSB define the VALUE with a range of 0-7. See Table 'Relationship between SSR STEC quality indicator and physical quantity' below. |
| ***stec-C00***This field provides the polynomial coefficient *C00* used to define the STEC. as defined in [43]. NOTEScale factor 0.05 TECU; range ±409.55 TECU. |
| ***stec-C01***This field provides the polynomial coefficient *C01* used to define the STEC as defined in [43]. NOTEScale factor 0.02 TECU/deg; range ±40.94 TECU/deg. |
| ***stec-C10***This field provides the polynomial coefficient *C10* used to define the STEC as defined in [43]. NOTEScale factor 0.02 TECU/deg; range ±40.94 TECU/deg. |
| ***stec-C11***This field provides the polynomial coefficient *C11* used to define the STEC as defined in [43]. NOTEScale factor 0.02 TECU/deg2; range ±10.22 TECU/deg2. |
| ***probOnsetIonoFault*** This field specifies the Probability of Onset of Ionosphere Fault per Time Unit which is the probability of occurrence of ionosphere 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), with *irMaximum* as provided in IE *GNSS-Integrity-ServiceParameters*.The probability is calculated by *P*=10-0.04*n* [hour-1] where *n* is the value of *probOnsetIonoFault* and the range is 10-10.2 to 1 per hour. |
| ***meanIonoFaultDuration***This field specifies the Mean Ionosphere Fault Duration which is the mean duration between when an ionosphere integrity violation occurs, and the user is alerted through *GNSS-Integrity-ServiceAlert* (or the integrity violation is over).Scale factor 1 s; range 1-256 s. |
| ***ionoRangeErrorCorrelationTime***This field specifies the Ionosphere Range Error Correlation Time which is the upper bound of the correlation time of the ionosphere residual range error.The time is calculated using:Range is 1-28,200 s. |
| ***ionoRangeRateErrorCorrelationTime***This field specifies the Ionosphere Range Rate Error Correlation Time which is the upper bound of the correlation time of the ionosphere residual range rate error.The time is calculated using:Range is 1-28,200 s. |
| ***meanIonosphere***This field specifies the Mean Ionospherre Error bound which is the mean value for an overbounding model that bounds the residual ionosphere error.The bound is *meanIonosphere* + *K* \* *stdDevIonosphere* 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 mean is calculated using:Range is 0-17.5 m. |
| ***stdDevIonosphere***This field specifies the Standard Deviation Ionosphere Error bound which is the standard deviation for an overbounding model that bounds the residual ionosphere error.The standard deviation is calculated using:Range is 0-17.5 m. |
| ***meanIonosphereRate***This field specifies the Mean Ionosphere Rate Error which is the mean value for an overbounding model that bounds the residual ionosphere rate error.The bound is *meanIonosphereRate* + *K* \* *stdDevIonosphereRate* 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 0.00005 m/s; range 0-0.01275 m/s. |
| ***stdDevIonosphereRate***This field specifies the Standard Deviation Ionosphere Rate Error which is the standard deviation for an overbounding model that bounds the residual ionosphere rate error.Scale factor 0.00005 m/s; range 0-0.01275 m/s. |

Editor's Note: FFS on encoding details/value ranges.

**Q23: Do you agree with the proposed encoding?**

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| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | Y |  |  |
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**Q24: What should be the value ranges for the new fields ?**

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| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | Agree with the proposed value ranges. |
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## 4.14 Open Issue 14 (R2-D8): Gridded Correction Integrity

The objective is to confirm the proposed encoding for SSR-GriddedCorrectionIntegrityParameters-r17 and

TropoDelayIntegrityErrorBounds-r17

#### *GNSS-SSR-GriddedCorrection*

The IE *GNSS-SSR-GriddedCorrection* is used by the location server to provide troposphere delay correction, together with the residual part of the STEC corrections and integrity information.

The parameters provided in IE *GNSS-SSR-GriddedCorrection* *–* except for *SSR-GriddedCorrectionIntegrityParameters* and *TropoDelayIntegrityErrorBounds-r17 –* are used as specified for Compact SSR Gridded Correction Message (e.g., message type 4073,9) in [43] and apply to all GNSSs.

-- ASN1START

GNSS-SSR-GriddedCorrection-r16 ::= SEQUENCE {

 epochTime-r16 GNSS-SystemTime,

 ssrUpdateInterval-r16 INTEGER (0..15),

 iod-ssr-r16 INTEGER (0..15),

 troposphericDelayQualityIndicator-r16 BIT STRING (SIZE(6)) OPTIONAL, -- Cond Tropo

 correctionPointSetID-r16 INTEGER (0..16383),

 gridList-r16 GridList-r16,

 ...,

 [[

 ssr-GriddedCorrectionIntegrityParameters-r17

 SSR-GriddedCorrectionIntegrityParameters-r17

 OPTIONAL -- Need ON

 ]]

}

GridList-r16 ::= SEQUENCE (SIZE(1..64)) OF GridElement-r16

GridElement-r16 ::= SEQUENCE {

 tropospericDelayCorrection-r16 TropospericDelayCorrection-r16 OPTIONAL, -- Need ON

 stec-ResidualSatList-r16 STEC-ResidualSatList-r16 OPTIONAL, -- Need ON

 ...

}

TropospericDelayCorrection-r16 ::= SEQUENCE {

 tropoHydroStaticVerticalDelay-r16 INTEGER (-256..255),

 tropoWetVerticalDelay-r16 INTEGER (-128..127),

 ...,

 [[

 tropoDelayIntegrityErrorBounds-r17 TropoDelayIntegrityErrorBounds-r17

 OPTIONAL -- Cond Integrity1

 ]]

}

STEC-ResidualSatList-r16 ::= SEQUENCE (SIZE(1..64)) OF STEC-ResidualSatElement-r16

STEC-ResidualSatElement-r16 ::= SEQUENCE {

 svID-r16 SV-ID,

 stecResidualCorrection-r16 CHOICE {

 b7-r16 INTEGER (-64..63),

 b16-r16 INTEGER (-32768..32767)

 },

 ...

}

SSR-GriddedCorrectionIntegrityParameters-r17 ::= SEQUENCE {

 probOnsetTroposphereFault-r17 INTEGER (0..255),

 meanTroposphereFaultDuration-r17 INTEGER (1..256),

 troposphereRangeErrorCorrelationTime-r17 INTEGER (1..255) OPTIONAL, -- Need ON

 troposphereRangeRateErrorCorrelationTime-r17 INTEGER (1..255) OPTIONAL, -- Cond Integrity2

 ...

}

TropoDelayIntegrityErrorBounds-r17 ::= SEQUENCE {

 meanTroposphereVerticalHydroStaticDelay-r17 INTEGER (0..255),

 stdDevTroposphereVerticalHydroStaticDelay-r17 INTEGER (0..255),

 meanTroposphereVerticalWetDelay-r17 INTEGER (0..255),

 stdDevTroposphereVerticalWetDelay-r17 INTEGER (0..255),

 meanTroposphereVerticalHydroStaticDelayRate-r17 INTEGER (0..255),

 stdDevTroposphereVerticalHydroStaticDelayRate-r17 INTEGER (0..255),

 meanTroposphereVerticalWetDelayRate-r17 INTEGER (0..255),

 stdDevTroposphereVerticalWetDelayRate-r17 INTEGER (0..255),

 ...

}

-- ASN1STOP

| Conditional presence | Explanation |
| --- | --- |
| *Tropo* | The field is mandatory present if *tropospericDelayCorrection* is included in *gridList*. Otherwise it is not present. |
| *Integrity1* | The field is mandatory present if *SSR-GriddedCorrectionIntegrityParameters* is present; otherwise it is not present. |
| *Integrity2* | The field is mandatory present if *troposphereRangeErrorCorrelationTime* is present*;* otherwise it is not present. |

| *GNSS-SSR-GriddedCorrection* field descriptions |
| --- |
| ***epochTime***This field specifies the epoch time of the gridded correction data. 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.  |
| ***troposphericDelayQualityIndicator***This field specifies the quality indicator of the tropospheric delay. The troposphere quality indicator is represented by a combination of CLASS and VALUE. The 3 MSB define the CLASS with a range of 0-7 and the 3 LSB define the VALUE with a range of 0-7. The troposphere quality indicator is computed by:See Table 'Relationship between SSR troposphere quality and URA indicator and physical quantity' below. |
| ***correctionPointSetID***This field provides the ID of the *GNSS-SSR-CorrectionPoints* set. The *GNSS-SSR-GriddedCorrection* are valid for the correction points provided in IE *GNSS-SSR-CorrectionPoints* with the same *correctionPointSetID.* |
| ***gridList***This field provides the troposphere delay correction together with the residual part of the STEC corrections for up to 64 correction points defined in IE *GNSS-SSR-CorrectionPoints*.If the IE *GNSS-SSR-CorrectionPoints,* which belongs to the *correctionPointSetID*, includes the *listOfCorrectionPoints*, the *gridList* includes the same number of entries, and listed in the same order, as in the *listOfCorrectionPoints.*If the IE *GNSS-SSR-CorrectionPoints,* which belongs to this *correctionPointSetID*, includes the *arrayOfCorrectionPoints* the *gridList* includes the same number of entries, and listed in the same order, as defined by the enabled bits in the *bitmaskOfGrids*. |
| ***tropoHydroStaticVerticalDelay***This field specifies the variation in the hydro static troposphere vertical delay relative to nominal value. The target device should add the constant nominal value of 2.3 m to calculate the tropospheric hydro-static vertical delay.Scale factor 0.004 m; range ±1.02 m. |
| ***tropoWetVerticalDelay***This field specifies the variation in the wet troposphere vertical delay relative to nominal value. The target device should add the constant value of 0.252 m to calculate the tropospheric wet (non hydro-static) vertical delay.Scale factor 0.004 m; range ±0.508 m. |
| ***svID***This field specifies the GNSS satellite for which the STEC residual corrections are provided. |
| ***stecResidualCorrection***This field specifies the STEC residual correction.Scale factor 0.04 TECU; range ±2.52 TECU (b7) or ±1310.68 TECU (b16). |
| ***probOnsetTroposphereFault***This field specifies the Probability of Onset of Troposphere Fault per Time Unit which is the probability of occurrence of troposphere 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) and *irMaximum* as provided in IE *GNSS-Integrity-ServiceParameters*.The probability is calculated by P=10-0.04n [hour-1] where *n* is the value of *probOnsetTroposphereFault* and the range is 10-10.2 to 1 per hour. |
| ***meanTroposphereFaultDuration*** This field specifies the Mean Troposphere Fault Duration which is the mean duration between when a troposphere integrity violation occurs, and the user is alerted through *GNSS-Integrity-ServiceAlert* (or the integrity violation is over).Scale factor 1 s; range 1-256 s. |
| ***troposphereRangeErrorCorrelationTime***This field specifies the Troposphere Range Error Correlation Time which is the upper bound of the correlation time of the troposphere residual range error.The time is calculated using:Range is 1-28,200 s. |
| ***troposphereRangeRateErrorCorrelationTime***This field specifies the Troposphere Range Rate Error Correlation Time which is the upper bound of the correlation time of the troposphere residual range rate error.The time is calculated using:Range is 1-28,200 s. |
| ***meanTroposphereVerticalHydroStaticDelay***This field specifies the Mean Troposphere Vertical Hydro Static Delay Error bound which is the mean value for an overbounding model that bounds the residual troposphere error in the vertical hydro static delay component.The bound is *meanTroposphereVerticalHydroStaticDelay* + K \* *stdDevTroposphereVerticalHydroStaticDelay* 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 0.005 m; range 0-1.275 m. |
| ***stdDevTroposphereVerticalHydroStaticDelay***This field specifies the Standard Deviation Troposphere Vertical Hydro Static Delay Error bound which is the standard deviation for an overbounding model that bounds the residual troposphere error in the vertical hydro static delay component.Scale factor 0.005 m; range 0-1.275 m. |
| ***meanTroposphereVerticalWetDelay*** This field specifies the Mean Troposphere Vertical Wet Static Delay Error bound which is the mean value for an overbounding model that bounds the residual troposphere error in the vertical wet delay component.The bound is *meanTroposphereVerticalWetDelay* + K \* *stdDevTroposphereVerticalWetDelay* 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 0.005 m; range 0-1.275 m. |
| ***stdDevTroposphereVerticalWetDelay*** This field specifies the Standard Deviation Troposphere Vertical Wet Static Delay Error bound which is the standard deviation for an overbounding model that bounds the residual troposphere error in the vertical wet delay component.Scale factor 0.005 m; range 0-1.275 m. |
| ***meanTroposphereVerticalHydroStaticDelayRate***This field specifies the Mean Troposphere Vertical Hydro Static Delay Rate Error bound which is the mean value for an overbounding model that bounds the residual troposphere rate error in the vertical hydro static delay component.The bound is *meanTroposphereVerticalHydroStaticDelayRate* + K \* *stdDevTroposphereVerticalHydroStaticDelayRate* 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 0.00005 m/s; range 0-0.01275 m/s. |
| ***stdDevTroposphereVerticalHydroStaticDelayRate***This field specifies the Standard Deviation Troposphere Vertical Hydro Static Delay Rate Error bound which is the standard deviation for an overbounding model that bounds the residual troposphere rate error in the vertical hydro static delay component.Scale factor 0.00005 m/s; range 0-0.01275 m/s. |
| ***meanTroposphereVerticalWetDelayRate***This field specifies the Mean Troposphere Vertical Wet Static Delay Rate Error bound which is the mean value for an overbounding model that bounds the residual troposphere rate error in the vertical wet delay component.The bound is *meanTroposphereVerticalWetDelayRate* + K \* *stdDevTroposphereVerticalWetDelayRate* 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 0.00005 m/s; range 0-0.01275 m/s. |
| ***stdDevTroposphereVerticalWetDelayRate*** This field specifies the Standard Deviation Troposphere Vertical Wet Static Delay Rate Error bound which is the standard deviation for an overbounding model that bounds the residual troposphere rate error in the vertical wet delay component.Scale factor 0.00005 m/s; range 0-0.01275 m/s. |

Editor's Note: FFS on encoding details/value ranges.

**Q25: Do you agree with the proposed encoding?**

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| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | Y |  |  |
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**Q26: What should be the value ranges for the new fields ?**

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| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | Agree with the proposed value ranges. |
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