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

|  |  |
| --- | --- |
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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-631  RAN2#116bis  Introduce 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-r17  STEC-IntegrityErrorBounds-r17 | Rapporteur |
| #14 (R2-D8) | Gridded Correction Integrity | Confirm the proposed encoding | GNSS-SSR-GriddedCorrection-r16🡪 SSR-GriddedCorrectionIntegrityParameters-r17  TropoDelayIntegrityErrorBounds-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.**

|  |  |  |  |
| --- | --- | --- | --- |
| **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.  -- ASN1START  GNSS-Integrity-ConstellationAlert-r17 ::= SEQUENCE {  constellationDoNotUse-r17 BOOLEAN,  integrity-svAlertList-r17 Integrity-SVAlertList-r17,  ...  }  Integrity-SVAlertList-r17 ::= SEQUENCE (SIZE(1..64)) OF Integrity-SVAlertElement-r17  Integrity-SVAlertElement-r17 ::= SEQUENCE {  svID-r17 SV-ID,  svDoNotUse-r17 BOOLEAN,  ...  }  -- ASN1STOP   |  | | --- | | ***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. |
| Qualcomm | Seems possible |  | I can only see one difference between the existing *GNSS-RealTimeIntegrity* IE and the proposed "DNU version" by Swift above:  If the *GNSS-RealTimeIntegrity* IE is absent, it indicates "everything is O.K.". The "DNU version" on the other hand is also present in case "everything is O.K.". I.e., the "DNU version" must always be present with value TRUE or FALSE. This is a consequence of the used "integrity principle of operation".  However, transmitting the "DNU Version" always for all supported GNSSs and all SVs per GNSS seems quite inefficient. In nominal cases, we would transmit a long list with just FALSE values.  Given that we already have the DNU for Iono/Tropo, which – according to the principle of operation – must always be transmitted, the presence of the Iono/Tropo DNU and absence of *GNSS-RealTimeIntegrity* IE can mean SV DNU=FALSE. If the *GNSS-RealTimeIntegrity* IE is present, it indicates DNU=TRUE.  So it seems we don't need to introduce a new IE. The indication of GNSS/SV DNU = FALSE is implicit, and the DNU is TRUE when the *GNSS-RealTimeIntegrity* IE is present (together with *GNSS-Integrity-ServiceAlert-r17*). |
| CATT |  | N | Better to have independent indication for constellation alerts. |
| Apple | Y |  | Slight preference for the ESA version, but no strong view |
| OPPO | Y |  | Enhancement on the current IE may make the newly introduced DNU indications more aligned |
| Xiaomi | Y |  | Both solutions can work, we slightly prefer to reuse the existing IE. |
| vivo | Y |  | We think the current GNSS-RealTimeIntegrity can already work well. |
| ZYE | Y |  | Agree with ESA’s version |
| InterDigital |  | N | Share similar understanding with Swift |
| Nokia | Y |  | We prefer to reuse the existing IE |
| Ericsson | Possible but need discussion |  | We share the view of QC that we need to make sure that all combinations are represented well and efficiently, but DNU not present should also have a well-defined meaning to ensure efficient signaling and backwards compatibility.  The problem with IE combination is backwards compatibility. For example, adding just the DNU flag as an extension like the following:  BadSignalElement ::= SEQUENCE {  badSVID SV-ID,  badSignalID GNSS-SignalIDs OPTIONAL, -- Need OP  ...,  [[  svDoNotUse-r17 null OPTIONAL,  ]]  }  with the meaning that if a SV is indicated as bad, that can be further specified the mean that it should not be used for integrity assessment, while it still would be fine to use for positioning etc. A legacy device would instead interpret this as an indication of a bad SV not to be used for positioning. |
| u-blox | Possible |  | There is potentially a benefit in using GNSS-RealTimeIntegrity, but it may need to be extended to cover High Integrity applications. |
| Swift |  |  | 15/02/2022:  We are ok to reuse the existing GNSS-RealTimeIntegrity IE but we must be able to distinguish which satellites have been monitored for the purpose of integrity or not.  16/02/2022:  Knowing which satellites/signals have been monitored for integrity (DNU = TRUE or FALSE) is necessary for Equation 8.1.1a-1 to hold. DNU flags are affirmative and non-presence of the DNU cannot be interpreted as a usable condition, meaning the DNU must be set either way. The existing *GNSS-RealTimeIntegrity* IE only has a way to indicate DNU=TRUE but no way to indicate DNU=FALSE. This could be a serious issue if the user was tracking a satellite that was not known to the network, and that satellite had a fault condition],  we can accept reusing the *GNSS-RealTimeIntegrity* IE if the proposed fields are added (or an equivalent set of fields if other companies have suggestions for meeting this requirement). Unfortunately without a way to indicate DNU=FALSE, the *GNSS-RealTimeIntegrity* IE cannot be reused as-is] |

**Moderator´s summary**

**There is a majority in favour of using the existing *GNSS-RealTimeIntegrity* IE to signal when and what satellites should not be used. Several companies are still not sure that *GNSS-RealTimeIntegrity* IE should be used.**

**Opposed to the other option discussed, the GNSS-RealTimeIntegrity IE would allow a more efficient signalling as it is used only when satellites/constellations/signals are unhealthy (i.e., not nominal operations). As per suggestions from Swift, QC, and Ericsson, the description of the GNSS-RealTimeIntegrity could be updated to highlight that this content can be interpreted as DNU flag for the purpose of integrity. Furthermore, Swift argues that it is important for the Integrity principle of operation capture in the Stage 2 to be able to signal also the DNU = FALSE at all time (ie. During nominal conditions) not only when there is a fault and satellites should not be used. From the answers collected until now this can be achieved either implicitly (by clarifying that absence of GNSS-RealTimeIntegry means DNU=FALSE i.e. everything ok) or explicitly by means of new fields in the IE (similar to annex A).**

**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 to make clear that its content (e.g. badSVID, etc.) can be interpreted as DNU flag for the purpose of integrity.**

**Note: Addition of new fields (as per Annex A) are input from Stage 3 rapporteur and subject to offline review of stage 3 CR.**

**Q2: Do you agree that a Constellation DNU needs included, in addition to SV DNU?**

|  |  |  |  |
| --- | --- | --- | --- |
| **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 |
| Qualcomm |  | N | With the current proposal, it would not save any signalling, since the DNU is present for each SV per GNSS anyhow. |
| CATT | Y |  | Agree with Swift. |
| Apple |  | N |  |
| OPPO |  | N |  |
| Xiaomi |  | N |  |
| vivo |  | N |  |
| ZTE |  | N | Agree with ESA’s view |
| InterDigital | Y |  |  |
| Nokia |  | N | Agree with ESA |
| Ericsson |  |  | See Q1 – need to be discussed a bit. What is the typical scenario? |
| u-blox |  | N |  |

**Moderator´s summary**

**There is a majority in favour of not using a DNU for constellation as DNU indication is present for each SV per GNSS. One company suggests that this needs more discussions, in particular, the typical scenario.**

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

**Q3: Do you agree that a signal DNU needs to be included, in addition to SV DNU?**

|  |  |  |  |
| --- | --- | --- | --- |
| **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). |
| Qualcomm |  |  | Would already be the case if we use *GNSS-RealTimeIntegrity.* |
| CATT |  | N | If as Swift stated there are no use cases for this situation, there is no need to add the signal DNU. |
| Apple |  | N |  |
| OPPO |  | N |  |
| Xiaomi |  | N |  |
| vivo |  |  | Agree with QC. |
| ZTE |  | N |  |
| InterDigital |  | N |  |
| Nokia |  | N |  |
| Ericsson |  |  | No strong view. What is the typical scenario? |
| u-blox |  |  | We don’t see a strong use case for this and therefore are ambivalent |

**Moderator´s summary**

**All participants agree that there is no need for updates regarding sginal DNU (either is already present, or is not needed in general for the purpose of integrity).**

## 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.**

|  |  |  |  |
| --- | --- | --- | --- |
| **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. |
| Qualcomm |  | N | The "Integrity Principle of Operation" requires only the mean and std of the error. It is unclear what a UE should do with the cross-correlation terms. |
| CATT |  | N | We think the mean and the variance are enough for the Rel-17 A-GNSS integrity |
| Apple |  | N | No need for overoptimization |
| OPPO |  | N | The mean and the variance are sufficient. |
| Xiaomi |  | N | We think mean and the variance are sufficient in Rl-17. |
| vivo |  | N | We think the mean and the variance are enough for the Rel-17 A-GNSS integrity. |
| ZTE |  | N | No strong view but we prefer to keep the feature simple |
| Nokia |  | N | We prefer to keep it simple in Rel-17 |
| Ericsson | Y |  | Cross-correlation is important to represent, especially since these errors can be compensating each other, meaning that a simple standard deviation would be not representing the errors accurately enough as it would provide a pessimistic view. This is well use of bandwidth.  Reading the comments, there is one strong technical argument in favor of including the full covariance matrix, and no technical argument against.   Question to Qualcomm – what is the “integrity principle of operation”? Why is it unclear what the UE shall do with the cross-correlation terms? The sufficiency of mean and std dev relies on an assumption of statistical independence between orbit and clock errors, which does not seem to be the case from experience. |
| u-blox |  | N | The case put forward by Swift follows the arguments behind the SBAS MT28 message for aviation. We are not convinced that the same approaches are optimum for High Accuracy multi-constellation multi-band terrestrial navigation, especially with much larger more distributed correction networks being available today.  Many existing PPP services use only a single error variance estimate for lumped OCB (Orbits, Clocks, Biases) errors. Research indicates that there are good arguments for including the covariance error terms for the three orbital parameters (Along Track, Cross Track, Radial), but we don’t believe that there is sufficient data or research today (for HA terrestrial applications) to include cross-correlation terms between orbits and clocks. We think this may be an issue that needs to be and will be solved in the correction service in due course.  Furthermore, we must not forget that these error estimate terms are included for the purpose of PL computation. In terrestrial applications there are many other factors outside the corrections service affecting the PL calculation: receiver/antenna biases and errors; environmental factors such as multipath etc. These latter errors are often the dominant ones for terrestrial applications.  We acknowledge that there is a significant body of research for aviation behind the correction services used in SBAS, and much of it also relevant in terrestrial applications. Nevertheless we’d like to propose two alternative compromise options for consideration:  *Alternative a) Separate error estimates in the individual messages: biases correction message includes the bias variance estimate; clocks correction message includes the clock error variance estimate; orbits correction message includes the three orbit variances and as an option the three covariances for the orbital parameters (or the Cholesky decomposition of the covariance matrix, or one of the newer more compact methods for representing the covariance matrix, see note).*  *Alternative b) Add a separate message for integrity OCB error estimates containing a single lumped error estimate for the UDRE based on orbits, clocks and bias errors and don’t put these parameters into the correction messages.*  We prefer a simple implementation in this WI with time for further study to better understand whether the extra complexity is needed.  NOTE: Current researchers have proposed alternative ways of representing the orbital covariances: instead of 3 extra parameters it has been shown that good results can be achieved using just 2 or even 1 extra parameter to represent the covariance terms. See for example: <https://www.researchgate.net/publication/336140262_Covariance_Analysis_of_Real-Time_Precise_GPS_Orbit_Estimated_from_Double-Differenced_Carrier_Phase_Observations> |
| Swift |  |  | 15/02/2022:   1. Further to the comments from Ericsson and Swift, we cannot see a technical justification from other companies explaining why the cross-covariance parameters *should not* be included in this release. To elaborate:  * At the prior meeting RAN2 agreed to discuss this topic in detail via email. Swift brought forward a technical justification and supporting reference list detailing how and why the cross-covariances are needed, including comparable examples in other GNSS standards. Other companies have in turn suggested this feature is an optimisation and can be handled at a later stage of the GNSS integrity work, but we have not seen an accompanying technical justification on why? We see that some of the concerns raised by Swift and Ericsson have been flagged in the Moderator Summary, but not yet addressed overall. * We also want to clarify that if a GNSS corrections provider does not wish to provide cross-covariance information, the corresponding off-diagonal parameters of the matrix can simply be set to zero so that only the mean and sigma are sent, i.e. the proposed OrbitClockErrorBound in R2-2201214 is directly compatible with what companies are suggesting in their comments (if they choose to only send the mean and standard deviation). * In light of the above we think more feedback is first needed from other companies on the following: * **What is the technical justification for not including the cross-covariances for the orbit and clock parameters? How will this impact the objective to support integrity determination in R17?** * Qualcomm also raises the point that an explanation on how to interpret the cross-covariance parameters is not yet provided in Stage 2. To address this we can bring forward some Stage 2 text to clarify how to compute the bound (i.e. extending Equation 8.1.1a-2) based on the covariance matrix. |
|  |  |  |  |

**Moderator´s summary**

**Swift has provided more details on the need for the cross-covariance parameters. Still, the majority believes there is no need for any other terms beside mean and standard deviation for he purpose of GNSS integrity in Rel-17. Furthermore, Ericsson and Swift point out to technical reasons for which the cross-correlation term is important e.g. representation of errors based on mean and std alone is not sufficient as the assumption of statistical independence between orbit and clock errors is not the case in practice.**

**After initial deadline has passed, more feedback has been provided by Swift, u-blox and ESA. Swift invited companies to clarify technical arguments based on which the need for full covariance Orbit-Clock matrix is considered an optimisation rather than a need. u-blox argues that existing PPP services use only a single error variance estimate for lumped Orbit, Clock, and Biases errors. The approach taken by RAN2 is already superior to that as decomposition of errors is more granular.**

**According to u-blox we can separate error estimates in the individual messages (what is used until now – i.e. uses existing IEs) or a one separate message for all OCB error containing a single lumped error estimate. There is a preference for the first opion which actually corresponds to the approach we have agreed until now.**

**Annex B contains more exchanges between ESA – Swift on technical merits of providing covariance matrix. ESA agrees with u-blox remarks that there are better ways to represent the orbital covarinces instead of the full matrix.**

**Proposal 4. For Release 17, the bounding of GNSS errors is based on paired overbounding principle characterized by mean and standard deviation. In future releases provision of full covariance matrix for the orbital covariance can be considered.**

**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.**

|  |  |  |  |
| --- | --- | --- | --- |
| **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 |
| Qualcomm |  |  | Existing IEs.  Orbit error bounds should be included in the *GNSS-SSR-OrbitCorrections* and clock error bounds in *GNSS-SSR-ClockCorrections*. |
| CATT |  | N | Including the integrity bounds in the existing corresponding GNSS IEs can avoid additional complex |
| Apple |  | ~~N~~ | Existing IEs |
| OPPO |  |  | Existing IE is preferred |
| Xiaomi |  |  | Existing IEs. |
| vivo |  |  | Existing IEs. |
| ZTE |  |  | Existing IEs since they already present the similar function |
| InterDigital |  | ~~N~~ | Existing IEs |
| Nokia |  | N | Existing IEs is preferred |
| Ericsson |  |  | Either is fine, as long as full covariance matrix can be represented well |
| u-blox |  |  | We prefer to see the error estimates in the existing IEs, but would not oppose a new IE if it is agreed to provide combined error estimates for OCB or even just Orbits and Clocks. |

**Moderator´s summary**

**Except one participant, everyone is in favour that integrity bounds for Orbit and Clock should be included in existing IEs rather than a new IE joining Clock nd Orbit. Swift and Ericcson, who is in favour for the latter, can accept working with existing IEs as long as the full covraince matrix can be represented including the cross-correlation terms (addressed in previous question).**

u-blox agrees to with majority and prefers to have the bounds included in existing IEs. All other solutions discussed are acceptable as well.

**Proposal 5. Agree to include integrity bounds for Clock and Orbit in the existing *GNSS-SSR-ClockCorrections* and *GNSS-SSR-OrbitCorrections* IEs rather in a new joint IE.**

## 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).

|  |  |  |
| --- | --- | --- |
|  | **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.**

|  |  |  |  |
| --- | --- | --- | --- |
| **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 |
| Qualcomm |  | No | Same as Q5. |
| CATT | Y |  | Including the integrity residual risk parameters in the existing corresponding GNSS IEs can avoid additional complex |
| Apple |  | N |  |
| OPPO |  | N | Existing IEs are preferred |
| Xiaomi |  | N | We prefer existing IEs. |
| vivo |  | N | Existing IEs are ok. |
| ZTE |  | N |  |
| InterDigital |  | N |  |
| Nokia |  | N | Existing IEs is preferred |
| Ericsson | Y |  | Given the different update rates from the clock corrections themselves, it seems more appropriate with a separate IE |
| u-blox |  |  | We have a preference for the same IE, see previous question |
| Swift |  |  | 15/02/2022:  Further to above, Proposal 6 needs to be more specific on which existing IE the *pConstellation*, *tConstellation*, *pSatellite*, *tSatellite* fields are being included into. We don’t think it makes sense to include them in either the Orbit or the Clock messages individually as these terms correspond to the satellite and constellation itself, not to the orbit/clock error components. If we do not have a combined OrbitClock message then this may require a new IE under GenericAssistData. |

**Moderator´s summary**

**There is a significant majority in favour of including the parameters related to satellite and constellation in existing IEs instead of a new GNSS-Integrity-OrbitClockErrorBounds. Swift clarified that in absence of the new GNSS-Integrity-OrbitClockErrorBouds IE it is not clear what “existing IE” are we referring to since GNSS-SSR-OrbitCorrections is not the best fit for parameters realted to constellation and satellite faults. ESA suggested that GNSS-RealTimeIntegrity IE can be used and this can be better judged as part of review of Stage 3 CR.**

**Proposal 6. 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: FFS if GNSS-RealTimeIntegrity IE can accommodate these parameters otherwise a new IE may be needed (input from Stage 3 CR rapporteur).**

**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.**

|  |  |  |  |
| --- | --- | --- | --- |
| **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? |
| Qualcomm | Y |  |  |
| CATT | Y |  | Including the integrity residual risk parameters in the existing corresponding GNSS IEs can avoid additional complex |
| Apple | Y |  |  |
| OPPO | Y |  |  |
| Xiaomi | Y |  |  |
| vivo | Y |  |  |
| ZTE | Y |  |  |
| InterDigital | Y |  |  |
| Nokia | Y |  |  |
| Ericsson | Y |  |  |
| u-blox | Y |  |  |

**Moderator´s summary**

**All participants support the mapping of Ionosphere and Troposhere parameters to GNSS-SSR-STEC-Correction and GNSS-SSR-GriddedCorrection respectively.**

**Proposal 7. Probability of Onset of Ionosphere Fault and Mean Ionosphere Fault Duration parameters are included in the GNSS-SSR-STEC-Correction. Probability of Onset of Troposphere Fault and Mean Troposphere Fault Duration parameters are included in the GNSS-SSR-GriddedCorrection.**

## 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.

|  |
| --- |
| ***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.**

|  |  |  |  |
| --- | --- | --- | --- |
| **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 |  |  |
| Qualcomm |  | X | It is unclear how a validy period works if it is not the same validity as the SSR assistance data. E.g., if SSR Assistance is updated every 10 seconds, but included integrity is only valid for 5 seconds, what would the gap of 5 seconds mean? If something happens during SSR validity, we have the DNU flags. |
| CATT |  | N | Agree with ESA. |
| Apple |  | X |  |
| OPPO |  | X |  |
| Xiaomi |  | X |  |
| vivo |  | X |  |
| ZTE |  | X | No new features should be included as this is the last meeting, and we haven’t discussed the validity time yet |
| Nokia |  | X | We do not see the need to further complicate |
| Ericsson | Y |  | If the device fails to receive a message or a posSIB that would bring new information, the device could use integnrity information beyond its intended validity. Therefore, validity seems to be motivated. However, not sure about the suggested value range |
| u-blox |  | X | It seems to us that the validity period of the integrity data (error bound estimates) is at least as long as the validity period of the corrections provided. Since corrections are associated with a validity period there is no need for an additional validity period when error estimates are included in the same IE. An additional validity period is only required if the integrity data is supplied in separate IE(s). We think this is another argument in favour of keeping the integrity data in the same IE as the corrections. |
| Swift |  |  | 15/02/2022:   1. We still have not addressed the case of when a bound is issued and the service loses its connection (i.e. no DNU or SSR correction update is sent). This requirement has been consistently raised since the SI phase. No technical argument has been presented as to why these concerns can safely be ignored. If the service cannot guarantee that integrity will not be violated after a loss of connectivity, then it is simply not fit for purpose as an integrity system, and could lead to a hazardous condition occurring in a safety critical system.  * To address the comment from Qualcomm, if one makes the validity period equal to the SSR update rate, then any lost or delayed message would require integrity outputs to be disabled until the message can be received which would impact availability. We agree there is no reason to have a shorter validity period than the SSR update rate, however setting the validity period longer than the SSR update rate is beneficial to give some margin for latency in the communications. Either way, the validity period must be explicitly described. Even if you were to set it equal to the SSR update rate (an arbitrary choice, and detrimental to availability), then it must be called out in Stage 2 that the integrity bounds are valid for one SSR update interval. |

**Moderator´s summary**

**A significant majority thinks there is no need for a validity time. Swift and Ericsson believe that validity time can be used in some specific occasions e.g. when UE fails to receive a message with new information, etc. u-blox feedback supports the majority and thinsk there is no need for an additional validity period when the bounds are included in the same IE as the error estimates. This is actually a reason for which integrity data and corrections should be kept in same IE.**

**Furthermore, ESA has raised the question to RAN2 level on what happens when connection is lost during a positioning session. This can help clarify the use case brough up by Swift – service loses connection.**

**Proposal 8. Agree not to include additional validaity time parameters together with the bounds parameters.**

Another delegate raised the need for validityPeriodDays. Therefore,

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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. |
| Ericsson | Y |  | Optional/to be discussed | Need to understand the value range and representation better – a choice representation would be more appropriate with lower resolution for longer valididty periods etc |
|  |  |  |  |  |

**Moderator´s summary**

**Among those that answered with Op1 at Q8, there is a preference for adding validityPeriodSeconds alone. Nevertheless, if Option 2 is finally agreed on, this items needs no futher discussions.**

## 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

...,

[[

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. |
| Qualcomm | Y |  |  |
| CATT | Y |  | Agree |
| Apple | Y |  |  |
| OPPO | Y |  |  |
| Xiaomi | Y |  |  |
| vivo | Y |  |  |
| ZTE | Y |  |  |
| InterDigital | Y |  |  |
| Nokia | Y |  |  |
| Ericsson | Y |  |  |
| u-blox | Y |  |  |

**Moderator´s summary**

**All participants agree that periodic assistance data for GNSS integrity is needed.**

**Proposal 9. Agree to enable periodic transmission of assistance data for GNSS integrity.**

**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-r16  gnss-SSR-PeriodicSTEC-Correction-r16  gnss-SSR-PeriodicGriddedCorrection-r16  For the Common Alerts, we support the new periodic IE proposed in R2-2201723:  gnss-Integrity-PeriodicServiceAlert-r17  Subject 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-r17  gnss-Integrity-PeriodicOrbitClockErrorBounds-r17  Regarding 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 |
| Qualcomm | With Q5, the *GNSS-Integrity-ServiceAlert* seems the only new periodic assistance data required.  The *GNSS-Integrity-ServiceParameters* seems only needed "once in a session". Therefore, they only need to be present in the control transaction of a periodic assistance data delivery. |
| CATT | The new IEs defined for GNSS integrity should be periodic assistance data |
| OPPO | At least *GNSS-Integrity-ServiceAlert* is needed for periodic transmission |
| Xiaomi | The *GNSS-Integrity-ServiceAlert* should be sent as periodic assistance data. |
| vivo | The new IEs defined for GNSS integrity should be periodic assistance data. |
| ZTE | If the other features are configured in existing IE*s, GNSS-Integrity-ServiceAlert* along with those features should be sent as periodic AD |
| Ericsson | The service alerts and new IEs introduced, such as representing orbit-clock cross-correlation. Furthermore, it would be relevant to add information about the local environment of the UE given that such information is available. Can be average number of satellites expected, Expected GNSS ambiguity fix status categories, typical CNo, multipath etc |
| Swift | 15/02/2022:  When was it discussed / agreed by the group to include information about the local environment? |

**Moderator´s summary**

**A number of new periodic IEs are proposed by the participants to the discussion. Based on the outcome of the open issue 1 and open issue 5 we may find each other into one of the two situations:**

* **Group 1: gnss-Integrity-PeriodicServiceAlert-r17 (if decision is to use existing IE as solutions for OI #1 and OI #5). Note, we may need to add a gnss-Periodic-RealTimeIntegrity-r17.**
* **Group 2: gnss-Integrity-PeriodicServiceAlert-r17; gnss-Integrity-PeriodicConstellationAlert-r17; gnss-Integrity-PeriodicOrbitClockErrorBounds-r17 (assuming new IEs are agreed on as solution for OI #1 and OI #3).**

**Ericsson also suggests the need for an IE that includes information about the local environment of the UE (e.g., number of satellites expected, typical CN0, multipath, etc.). This item has not been discussed until now and the view of the companies is not known.**

**Proposal 10. Add gnss-Integrity-PeriodicServiceAlert-r17 to the list of periodic GNSS assistance data.**

**Optional proposal 11: Add gnss-Periodic-RealTimeIntegrity-r17 to the list of periodic GNSS assistance data. (assuming RealTimeIntegrity is selected as solution for OP #1).**

**Optional proposal 12: Add gnss-Integrity-PeriodicConstellationAlert-r17 to the list of periodic GNSS assistance data (assuming a new IE is proposed as solution for OP #1).**

**Optional proposal 13: Add gnss-Integrity-PeriodicOrbitClockErrorBounds-r17 to the list of periodic GNSS assistance data. (assuming a new IE is proposed as solution for OP #3).**

**Proposal 14: Add information about the local environement of the UE.**

## 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 |  |  |
| ESA | Y |  |  |
| Qualcomm | Y |  |  |
| CATT | Partly agree. |  | We agree that GNSS-Integrity-ServiceAlert could be included in the GNSS Common Assistance Data and add a new posSIB for this IE.  For GNSS-Integrity-ServiceParameters, we think this IE should be included in the LPP Request Location Inforation message as the intrgrity requirements. As the TS 38.305 below, the integrity requirement should be included in the LPP request Location information.    Figure 8.1.3.3.1-1: LMF-initiated Location Information Transfer Procedure  (1) The LMF sends a LPP Request Location Information message to the UE for invocation of A-GNSS positioning. This request includes positioning instructions such as the GNSS mode (UE-assisted, UE-based, UE-based preferred but UE-assisted allowed, UE-assisted preferred, but UE-based allowed, standalone), positioning methods (GPS, Galileo, GLONASS, BDS, etc. and possibly non-GNSS methods, such as OTDOA positioning or E-CID positioning), specific UE measurements requested if any, such as fine time assistance measurements, velocity, carrier phase, multi-frequency measurements, quality of service parameters (accuracy, response time), and possibly integrity requirements.  (2) The UE performs the requested measurements and possibly calculates its own location. The UE may also determine the integrity results of the calculated location. The UE sends an LPP Provide Location Information message to the LMF before the Response Time provided in step (1) elapsed. If the UE is unable to perform the requested measurements, or if the Response Time provided in step 1 elapsed before any of the requested measurements have been obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information. |
| Apple | Y |  |  |
| OPPO | Y |  |  |
| Xiaomi | Y |  |  |
| vivo | Y |  |  |
| ZTE | Y |  | For broadcasting we agree with these two posSIB types |
| InterDigital | Y |  |  |
| Nokia | Y |  |  |
| Ericsson | Y |  | And any new IEs potentially introduced needs to be represented as well |

**Moderator´s summary**

**A significant majority agrees with the mapping of GNSS-Integrity-ServiceParameters to posSibType1-9 and GNSS-Integrity-ServiceAlert to posSibType1-10.**

**Proposal 15: Adopt the mapping of GNSS Integrity IEs to posSIB as propoed in the table from below:**

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

**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. |
| ESA | Y |  | Same as Swift. We may have new posSIBs based on the outcome of other open issues we discuss in this document. |
| Qualcomm |  |  | With the response to Q5, these two posSIBs would be all what is needed. |
| CATT |  | N | If no new IEs are introduced, we do not need to define new posSIBType. |
| Ericsson | Y |  | In particular the orbit-clock cross-correlation |
|  |  |  |  |

**Moderator´s summary**

**The addition of new posSIBs depends on the resolution for Open Item 1 and Open Item 5.**

## 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.”

**10/09/2022: 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.**

**11/02/2022: Nokia suggest to keep this point open and collect views from delegates.**

**TR 38.857 includes a section on integrity KPIs:**

|  |
| --- |
| **Target Integrity Risk (TIR):** The probability that the positioning error exceeds the Alert Limit (AL) without warning the user within the required Time-to-Alert (TTA).  NOTE: The TIR is usually defined as a probability rate per some time unit (e.g., per hour, per second or per independent sample).  **Alert Limit (AL):** The maximum allowable positioning error such that the positioning system is available for the intended application. If the positioning error is beyond the AL, the positioning system should be declared unavailable for the intended application to prevent loss of positioning integrity.  NOTE: When the AL bounds the positioning error in the horizontal plane or on the vertical axis then it is called Horizontal Alert Limit (HAL) or Vertical Alert Limit (VAL), respectively.  **Time-to-Alert (TTA):** The maximum allowable elapsed time from when the positioning error exceeds the Alert Limit (AL) until the function providing positioning integrity annunciates a corresponding alert.  **Integrity Availability:** The integrity availability is the percentage of time that the PL is below the required AL.  The relationship between the KPIs and the Protection Level (PL), and their impacts on the positioning solution are further examined below. |

**Q13a: What integrity requirements need to signalled to UE? What should be their value ranges?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ESA | TIR, AL, and TTA. IA can be computed, is not an input. Regarding values, we have no strong views for now but recommend to take the value ranges based on Table 9.2.4 in TR 38.857. |
| Qualcomm | TIR seems sufficient. The PL can be compared with the AL at the LMF. |
| Apple | TIR is sufficient |
| OPPO | At least TIR, TTA and AL are also needed for the mode wherein the UE needs to send the flag of the integrity result towards the LMF. |
| Xiaomi | TIR is sufficient. |
| ZTE | AL TIR. For integrity result flag reporting, AL is needed to compare |
| Nokia | TIR, AL and TTA.  We also agree to take the value ranges from Table 9.2.4 in TS 38.857 |
| Ericsson | Same view as ESA |
| u-blox | TIR is sufficient. The LCS client needs AL and TTA. When Mode 2 is supported the UE will need AL in addition to TIR. |
|  |  |

**Moderator´s summary**

**The following integrity requirements are needed:**

* **TIR ( 9 votes)**
* **AL in addition to TIR ( 6 votes )**
* **TTA + TIR + AL (4 votes)**

**TIR is seen as necessary by all participants; AL has a small majority and seems to be needed in Mode 2 only, and views are split regarding TTA.**

## 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). |
| ESA | Same as Swift. We think this open issues is overlapping with 4.7. |
| Qualcomm | TIR seems sufficient. The PL can be compared with the AL at the LMF. |
| CATT | Agree with Swift |
| Apple | TIR is sufficient |
| OPPO | At least TIR, TTA and AL are also needed for the mode wherein the UE needs to send the flag of the integrity result towards the LMF. |
| Xiaomi | TIR is sufficient. |
| ZTE | AL TIR. For integrity result flag reporting, AL is needed to compare |
| InterDigital | Same view as Swift |
| Nokia | The information to be included should be integrity requirements – TIR, AL, and TTA.  On the other hand, if it is agreed to support Integrity Flagging as one of the reporting mode (i.e. Reporting Mode 2 in TR 38.857), then **IntegrityInformationRequest-r17** should further include an indicator to tell the UE either Reporting Mode 1 or Mode 2 should be conducted. |
| Ericsson | For the common message, we agree with ESA and Swift. In addition, there can be additional requests to be part of A-GNSS-RequestLocationInformation, for example to be able to request local environment information such as number of detected/used satellites, ambiguity fix status category, CNo, multipath etc |
| u-blox | TIR is sufficient, LCS client needs AL and TTA. For Mode 2 support UE also needs AL |
| Swift | When was it discussed / agreed by the group to include information about the local environment?   1. As per the definition in TR 38.857, the TIR, AL and TTA are all a function of the PL meaning all three KPIs need to be sent:  * **Protection Level:** The PL is a statistical upper-bound of the Positioning Error (PE) that ensures that, the probability per unit of time of the true error being greater than the AL and the PL being less than or equal to the AL, for longer than the TTA, is less than the required TIR, i.e., the PL satisfies the following inequality:   **Prob per unit of time [((PE> AL) & (PL<=AL)) for longer than TTA] < required TIR**  NOTE: When the PL bounds the positioning error in the horizontal plane or on the vertical axis then it is called Horizontal Protection Level (HPL) or Vertical Protection Level (VPL) respectively.  NOTE: A specific equation for the PL is not specified as this is implementation-defined. For the PL to be considered valid, it must simply satisfy the inequality above. |

**Moderator´s summary**

**The answers to this question overlap partly with answers to Q13. In addition, Nokia is proposing to include an indicator for Reporting Mode 1 or Reporting Mode 2 if it is agreed to support Integrity Flagging as one of the reporting modes. Ericsson suggests to request more information in A-GNSS-RequestLocationInformation: number of detect/used satellites, ambiguity fix status, CN0, etc.**

**u-blox clarify that TIR is sufficient. AL is needed in Reporting Mode 2.**

**Proposal 16. Add TIR and AL to the IntegrityInformationRequest-r17 IE. TTA is FFS. Their value ranges shall be based on table 9.2.4 in TR 38.857.**

**Proposal 17. Indicate wehter Reporting Mode 1 or Reporting Mode 2.**

**Proposal 18. A-GNSS RequestLocationInformation includes additional requests about the local environment of the UE: number of detected/used satellites, ambiguity fix status category, CN0, multipath.**

## 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 the 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. |
| ESA | Y |  | We think it would be more complete to decompose in HPL and VPL; some of the cases we have discussed during the study may need only HPL (IIOT – factory floor).  We share Swift view – HPL and VPL is selected, then we need also VAL and HAL assuming AL will be endorsed as one of the KPIs needed to be signalled to UE by LMF.  No strong views on value range but 0 – 500m proposed by Swift is more than enough. |
| Qualcomm | Y |  |  |
| CATT |  |  | No strong view. We are okay for both these two options. |
| Apple | Y |  |  |
| OPPO | Y |  | In some use cases such as vehicle navigation, only HPL is needed. |
| vivo | Y |  |  |
| ZTE | Y |  |  |
| InterDigital | Y |  |  |
| Nokia | Y |  |  |
| Ericsson | Y |  | Yes, but separate into HPL and VPL. |
| u-blox | Y |  | This seems to be a common requirement.  The horizontal PL could also be expressed as a 2D ellipse or two parameters: Along Track; and Cross Track. Different applications need different ways of expressing the PL(s).  The PL is expressed in component parts to match the AL. Typically the application would specify the required horizontal AL (circular, ellipse or along/cross track) and for optimum results the PL is computed using the same representation. |

**Moderator´s summary**

**There is a strong preference for expressing PL as two terms, one for horizontal domain and one for vertical domain. Since PL needs to be compared to AL, this implies the need of separating AL in two terms as well: a horizontal and vertical one. According to u-blox the horizontal PL can also be expressed as a 2D ellipse or two parameters: along track and cross track. PL needs to match the AL and typically the application would specify the required horizontal AL (circular, ellipse, etc.)**

**Proposal 19. Add HPL and VPL to the IntegrityInfo IE. The value range of these two parameters covers 0 – 500m interval. Resolution is 1cm.**

**Note: HPL representation e.g., 2D ellipse or Alon-Cross track pair is based on input from Stage 3 rapporteur.**

**Proposal 20. Add HAL and VAL to the IntegrityInfo IE. The value range of these two parameters covers 0 – 500m interval. Resolution is 1cm.**

**Note: HAL representation e.g. cicular, 2D ellipse is based on input from Stage 3 rapporteur.**

**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. |
| Nokia | We think Reporting Mode 2 in TR 38.857should be supported as well, which allows the UE to raise the flag indicating whether there is an integrity risk. |
| Ericsson | Not in the common, but it would be beneficial to include richer information from the device about the GNSS performance than just position and uncertainty. Information about the local environment becomes important in order to aggregate information on the network side for the statistical spatial situation by allowing devices to report number of detected/used satellites, ambiguity fix status, typical CNo, multipath etc |
|  |  |
|  |  |
|  |  |

**Moderator´s summary**

**Swift suggests as optional the reporting of TIR, AL, and TTA. Nokia thinks Reporting Mode 2 in TR 38.857 needs be supported as well. Ericsson, reiterates the benefits of having additional information about the local environment of the UE reported (already covered by past proposals).**

**Proposal 21. Add TIR, AL, and TTA to the IntegrityInfo IE.**

**Proposal 22. Support Reporting Mode 2.**

## 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). |
| ESA | Yes |  |  |
| Qualcomm | Yes |  |  |
| CATT |  |  | Should GNSS-Integrity-ServiceParameters only be provided to UE in the UE-based? |
| Apple | Y |  |  |
| OPPO | Y |  |  |
| Xiaomi | Y |  |  |
| vivo | Y |  |  |
| ZTE | Y |  |  |
| InterDigital | Y |  |  |
| Nokia | Y |  |  |
| Ericsson | Y |  |  |

**Moderator´s summary**

**All participants agree with the proposed encoding for GNSS-Integrity-ServiceParameters. Swift suggests to include Service DNU to indicate that the entire service is no longer valid for the purpose of integrity.**

**Proposal 23. Adopt the proposed encoding for GNSS-Integrity-ServiceParameter in Stage 3.**

**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. |
| CATT | Agree with Swift. The *GNSS-SSR-STEC-Correction* IE and the *GNSS-SSR-GriddedCorrection* IE can be listed. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

**Moderator´s summary**

**Swift and CATT recommend replace FFS fields in the description of GNSS-Integrity-ServiceAlert by GNSS-SSR-STEC-Correction IE and GNSS-SSR-GriddedCorrection IE.**

**Proposal 24a . Adopt the following description for the GNSS-Integrity-ServiceAlert in Stage 3. Service DNU is FFS.**

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

## 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 |  |  |
| ESA | Y |  |  |
| Qualcomm | Y |  |  |
| CATT | Y |  |  |
| Apple | Y |  |  |
| OPPO | Y |  |  |
| Xiaomi | Y |  |  |
| vivo | Y |  |  |
| ZTE | Y |  |  |
| InterDigital | Y |  |  |
| Nokia | Y |  |  |
| Ericsson | Y |  |  |

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

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | Agree with the proposed value ranges. |
| ESA | We think the proposed value ranges are acceptable. |
| CATT | Agree |
|  |  |
|  |  |
|  |  |
|  |  |

**Moderator´s summary**

**All participants agree with the proposed encoding, including the value ranges.**

**Proposal 25. Adopt the proposed encoding of the SSR-IntegrityCodeBiasBounds.**

## 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 |  |  |
| ESA | Y |  |  |
| Qualcomm | Y |  |  |
| CATT | Y |  |  |
| Apple | Y |  |  |
| OPPO | Y |  |  |
| Xiaomi | Y |  |  |
| vivo | Y |  |  |
| ZTE | Y |  |  |
| InterDigital | Y |  |  |
| Nokia | Y |  |  |
| Ericsson | Y |  |  |

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

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | Agree with the proposed value ranges. |
| ESA | We think the proposed value ranges are acceptable |
| CATT | Agree |
|  |  |
|  |  |
|  |  |
|  |  |

**Moderator´s summary**

**All participants agree with the proposed encoding, including the value ranges.**

**Proposal 26. Adopt the proposed encoding of the SSR-IntegrityPhaseBiasBounds.**

## 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]. NOTE  Scale 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]. NOTE  Scale 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]. NOTE  Scale 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]. NOTE  Scale 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?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | Y |  |  |
| ESA | Y |  |  |
| Qualcomm | Y |  |  |
| CATT | Y |  |  |
| Apple | Y |  |  |
| OPPO | Y |  |  |
| Xiaomi | Y |  |  |
| vivo | Y |  |  |
| ZTE | Y |  |  |
| InterDigital | Y |  |  |
| Nokia | Y |  |  |
| Ericsson | Y |  |  |

**Q24: What should be the value ranges for the new fields ?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | Agree with the proposed value ranges. |
| ESA | We think the proposed value ranges are acceptable |
| CATT | Agree |
|  |  |
|  |  |
|  |  |

**Moderator´s summary**

**All participants agree with the proposed encoding, including the value ranges.**

**Proposal 27. Adopt the proposed encoding for the STEC-IntegrityParameters-r17 and STEC-IntegrityErrorBounds-r17.**

## 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?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes** | **No** | **Comments** |
| Swift Navigation | Y |  |  |
| ESA | Y |  |  |
| Qualcomm | Y |  |  |
| CATT | Y |  |  |
| Apple | Y |  |  |
| OPPO | Y |  |  |
| Xiaomi | Y |  |  |
| vivo | Y |  |  |
| ZTE | Y |  |  |
| InterDigital | Y |  |  |
| Nokia | Y |  |  |

**Q26: What should be the value ranges for the new fields ?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Swift Navigation | Agree with the proposed value ranges. |
| ESA | We think the proposed value ranges are acceptable |
| CATT | Agree |
|  |  |
|  |  |
|  |  |

**Moderator´s summary**

**All participants agree with the proposed encoding, including the value ranges.**

**Proposal 28. Adopt the proposed encoding for the SSR-GriddedCorrectionIntegrityParameters-r17 and TropoDelayIntegrityErrorBounds-r17.**

# 5. Summary

The proposals collected based on views from companies are allocated to three groups: Agreed in Principle (i.e. no objections during the discussion), Easily Agreeable, Open Issues.

## 5.1 Agreed in Principle

**Proposal 7. Probability of Onset of Ionosphere Fault and Mean Ionosphere Fault Duration parameters are included in the GNSS-SSR-STEC-Correction. Probability of Onset of Troposphere Fault and Mean Troposphere Fault Duration parameters are included in the GNSS-SSR-GriddedCorrection.**

**Proposal 9. Agree to enable periodic transmission of assistance data for GNSS integrity.**

**Proposal 10. Add gnss-Integrity-PeriodicServiceAlert-r17 to the list of periodic GNSS assistance data.**

**Proposal 15: Adopt the mapping of GNSS Integrity IEs to posSIB as propoed in the table from below:**

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

**Proposal 16. Add TIR and AL to the IntegrityInformationRequest-r17 IE. TTA is FFS. Their value ranges shall be based on table 9.2.4 in TR 38.857.**

**Proposal 19. Add HPL and VPL to the IntegrityInfo IE. The value range of these two parameters covers 0 – 500m interval. Resolution is 1cm.**

**Proposal 23. Adopt the proposed encoding for GNSS-Integrity-ServiceParameter in Stage 3.**

**Proposal 24. Adopt the following description for the GNSS-Integrity-ServiceAlert in Stage 3. Service DNU is FFS.**

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

**Proposal 25. Adopt the proposed encoding of the SSR-IntegrityCodeBiasBounds.**

**Proposal 26. Adopt the proposed encoding of the SSR-IntegrityPhaseBiasBounds.**

**Proposal 27. Adopt the proposed encoding for the STEC-IntegrityParameters-r17 and STEC-IntegrityErrorBounds-r17.**

**Proposal 28. Adopt the proposed encoding for the SSR-GriddedCorrectionIntegrityParameters-r17 and TropoDelayIntegrityErrorBounds-r17.**

## 5.2 Potentially Agreeable

Proposals realted to GNSS-RealTimeIntegrity:

**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 to make clear that its content (e.g. badSVID, etc.) can be interpreted as DNU flag for the purpose of integrity.**

**Note: Addition of new fields (as per Annex A) are input from Stage 3 rapporteur and subject to offline review of stage 3 CR.**

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

**Optional proposal 11: Add gnss-Periodic-RealTimeIntegrity-r17 to the list of periodic GNSS assistance data. (assuming RealTimeIntegrity is selected as solution for OP #1).**

Other proposals:

**Proposal 4. For Release 17, the bounding of GNSS errors is based on paired overbounding principle characterized by mean and standard deviation. In future releases provision of full covariance matrix for the orbital covariance can be considered.**

**.**

**Proposal 5. Agree to include integrity bounds for Clock and Orbit in the existing *GNSS-SSR-ClockCorrections* and *GNSS-SSR-OrbitCorrections* IEs rather in a new joint IE.**

**Proposal 6. 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: FFS if GNSS-RealTimeIntegrity IE can accommodate these parameters otherwise a new IE may be needed (input from Stage 3 CR rapporteur).**

**Proposal 8. Agree not to include additional validaity time parameters together with the bounds parameters.**

**Proposal 20. Add HAL and VAL to the IntegrityInfo IE. The value range of these two parameters covers 0 – 500m interval. Resolution is 1cm.**

**Proposal 21. Add TIR, AL, and TTA to the IntegrityInfo IE.**

## 5.3 Others & Non-critical items for Rel-17

Few other proposals exist but they may be discarded depending the outcome of the proposals treated in 5.2. in particular if P1 and Proposal 5 are adopted.

**Optional proposal 12: Add gnss-Integrity-PeriodicConstellationAlert-r17 to the list of periodic GNSS assistance data (assuming a new IE is proposed as solution for OP #1).**

**Optional proposal 13: Add gnss-Integrity-PeriodicOrbitClockErrorBounds-r17 to the list of periodic GNSS assistance data. (assuming a new IE is proposed as solution for OP #3).**

Non-critical items for completion of release 17. Could be revisited in future releases.

**Proposal 14: Add information about the local environement of the UE.**

**Proposal 18. A-GNSS RequestLocationInformation includes additional requests about the local environment of the UE: number of detected/used satellites, ambiguity fix status category, CN0, multipath.**

# Annex A. Proposed extensions to GNSS-RealTimeIntegrity IE

1. *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~~ may be omitted, except where integrity is supported in which case the *GNSS-RealTimeIntegrity* IE shall be transmitted to indicate 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 DNU 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*, where a one‑value at a bit position means the particular GNSS signal type of the SV is monitored; a zero‑value means not monitored. |

# Annex B. Email exchanges

Round 1: Swift

Generally speaking, the proposals are largely based on tallying the company inputs to determine the majority view. For some questions however, we think additional consideration is needed where detailed technical contributions and remaining questions have (or have not in some cases) been provided by companies. To be more specific:

* **Question 1 / Proposals 1 and 2 (SV/Constellation DNUs):** We are ok to reuse the existing GNSS-RealTimeIntegrity IE but we must be able to distinguish which satellites have been monitored for the purpose of integrity or not. We suggest the following additions to help address Proposals 1 and 2 in the summary (see Annex A)
* **Question 4 / Proposals 4 and 5 (orbit-clock cross-covariance):** Further to the comments from Ericsson and Swift, we cannot see a technical justification from other companies explaining why the cross-covariance parameters *should not* be included in this release. To elaborate:
* At the prior meeting RAN2 agreed to discuss this topic in detail via email. Swift brought forward a technical justification and supporting reference list detailing how and why the cross-covariances are needed, including comparable examples in other GNSS standards. Other companies have in turn suggested this feature is an optimisation and can be handled at a later stage of the GNSS integrity work, but we have not seen an accompanying technical justification on why? We see that some of the concerns raised by Swift and Ericsson have been flagged in the Moderator Summary, but not yet addressed overall.
* We also want to clarify that if a GNSS corrections provider does not wish to provide cross-covariance information, the corresponding off-diagonal parameters of the matrix can simply be set to zero so that only the mean and sigma are sent, i.e. the proposed OrbitClockErrorBound in R2-2201214 is directly compatible with what companies are suggesting in their comments (if they choose to only send the mean and standard deviation).
* In light of the above we think more feedback is first needed from other companies on the following:
* **What is the technical justification for not including the cross-covariances for the orbit and clock parameters? How will this impact the objective to support integrity determination in R17?**
* Qualcomm also raises the point that an explanation on how to interpret the cross-covariance parameters is not yet provided in Stage 2. To address this we can bring forward some Stage 2 text to clarify how to compute the bound (i.e. extending Equation 8.1.1a-2) based on the covariance matrix.
* **Question 6 / Proposal 6:**Further to above, Proposal 6 needs to be more specific on which existing IE the *pConstellation*, *tConstellation*, *pSatellite*, *tSatellite* fields are being included into. We don’t think it makes sense to include them in either the Orbit or the Clock messages individually as these terms correspond to the satellite and constellation itself, not to the orbit/clock error components. If we do not have a combined OrbitClock message then this may require a new IE under GenericAssistData.
* **Question 8 / Proposal 8 (Validity Periods):** We still have not addressed the case of when a bound is issued and the service loses its connection (i.e. no DNU or SSR correction update is sent). This requirement has been consistently raised since the SI phase. No technical argument has been presented as to why these concerns can safely be ignored. If the service cannot guarantee that integrity will not be violated after a loss of connectivity, then it is simply not fit for purpose as an integrity system, and could lead to a hazardous condition occurring in a safety critical system.
* To address the comment from Qualcomm, if one makes the validity period equal to the SSR update rate, then any lost or delayed message would require integrity outputs to be disabled until the message can be received which would impact availability. We agree there is no reason to have a shorter validity period than the SSR update rate, however setting the validity period longer than the SSR update rate is beneficial to give some margin for latency in the communications. Either way, the validity period must be explicitly described. Even if you were to set it equal to the SSR update rate (an arbitrary choice, and detrimental to availability), then it must be called out in Stage 2 that the integrity bounds are valid for one SSR update interval.
* **Proposals 14 and 18 (local environment FEs):** When was it discussed / agreed by the group to include this information?
* **Proposal 16 (KPI information):** As per the definition in TR 38.857, the TIR, AL and TTA are all a function of the PL meaning all three KPIs need to be sent:
* **Protection Level:** The PL is a statistical upper-bound of the Positioning Error (PE) that ensures that, the probability per unit of time of the true error being greater than the AL and the PL being less than or equal to the AL, for longer than the TTA, is less than the required TIR, i.e., the PL satisfies the following inequality:

**Prob per unit of time [((PE> AL) & (PL<=AL)) for longer than TTA] < required TIR**

NOTE: When the PL bounds the positioning error in the horizontal plane or on the vertical axis then it is called Horizontal Protection Level (HPL) or Vertical Protection Level (VPL) respectively.

NOTE: A specific equation for the PL is not specified as this is implementation-defined. For the PL to be considered valid, it must simply satisfy the inequality above.

Round 2: ESA-Swift

1). GNSS Integrity - I do not understand this part "we must be able to distinguish which satellites have been monitored for the purpose of integrity or not." What is the difference between a badSVID and a monitoredSVID? I tend to believe that you wish to send a DNU flag all the time, for each satellite, even when the flag is FALSE. Correct?

[Swift - that’s correct. Knowing which satellites/signals have been monitored for integrity (DNU = TRUE or FALSE) is necessary for Equation 8.1.1a-1 to hold. DNU flags are affirmative and non-presence of the DNU cannot be interpreted as a usable condition, meaning the DNU must be set either way. The existing *GNSS-RealTimeIntegrity* IE only has a way to indicate DNU=TRUE but no way to indicate DNU=FALSE. This could be a serious issue if the user was tracking a satellite that was not known to the network, and that satellite had a fault condition]

My understanding of the situation is that everyone can accept the use of GNSS-RealTimeIntegrity with the clarification that its description needs updating (Proposal 2). I believe this aspect does not require tdocs and can be done by the rapporteur for the running CR for Stage 3; some of the wording proposed by Swift for the new red fields can be added to existing fields to make the link clear with the Integrity Principle of Operation from Stage 2. Let me know what am I missing so I know how to update the summary in a way that captures Swift´s concerns.

[Swift - we can accept reusing the *GNSS-RealTimeIntegrity* IE if the proposed fields are added (or an equivalent set of fields if other companies have suggestions for meeting this requirement). Unfortunately without a way to indicate DNU=FALSE, the *GNSS-RealTimeIntegrity* IE cannot be reused as-is]

2). Cross-covariance

I believe several companies have brought forward some technical justifications for which they believe there is no need for it: the principle of operation seems to work with mean and std, several companies found it as overoptimization, increases bandwidth.

From ESA point of view, the need for cross-covariance parameters may come from the way the corrections are generated. I believe already today it is possible to estimate quite well independent errors so the need for cross-covariance is not obvious.

[Swift - there are some important clarifications to make here. Swift is not aware of any existing algorithms or implementations that are able to estimate these parameters independently such that there is no correlation between them. This is really a limitation of the observability of these errors, rather than a limitation of any particular implementation. If the correlation is ignored then the bounds must be inflated to compensate for this modeling error. The principle of operation does not preclude the use of covariance, and does not imply the performance will be sufficient to meet the WI objectives when treating clock and orbit independently. If the implementation does not want to make use of the cross-covariance terms then they can simply be set to zero (std. dev are the diagonal terms of the covariance matrix).

As a real-world example, the equivalent MT28 SBAS message includes the cross-covariances, but MT28 is not sent by ESA within its [EGNOS service](https://gssc.esa.int/navipedia/index.php/The_EGNOS_SBAS_Message_Format_Explained#Message_type_28) at present. So the mean and standard deviation alone may be suitable for satisfying the current SBAS requirements in this case (e.g. AL down to 40m), but the 3GPP use cases are far more demanding and require that all error correlations be considered for integrity (as is already the case for the SSR orbits which are decomposed into their along-track, across-track and radial components). In fact, even for SBAS, why would the industry include the cross-covariance parameters in the standard if these parameters were not a useful option for current and future SBAS performance requirements? Returning to 3GPP, we are already dealing with use cases that are 1 to 2 orders of magnitude more demanding than SBAS]

We have a 10-2 vote in favour of not introducing these additional parameters. Honestly, I don´t know what else we can do here. I can only encourage companies to take into account the input provided by Swift in the email and let me know if their position has changed.

[Swift - Would it be helpful to give some proposed Stage 2 text in preparation for the meeting? We are also unclear on what the alternative would be as currently no other concrete proposals have been brought forwards. For example, if the orbit/clock bounds are separated, how would the issue of the orbit decomposition into along-track, cross-track and radial components be addressed?].

3). Q6/P6. This is a good remark. I had in mind that this will go to SSR Orbit message but you are right, does not make much sense. What about extending the GNSS-RealTimeIntegrity IE with these fields?

[It is possible but will further increase bandwidth utilization as GNSS-RealTimeIntegrity would be sent at a high rate whereas these parameters are only updated very infrequently, if at all]

4). Q8/P8 Validity Period.

I remember we have discussed a lot loss/interruptions of service during the SI and for some of us it was an important potential error source that may compromise the integrity service. I also remember that we could not go far with this from the same reasons we did not advance on "UE-faults", and "LMF-faults" fronts. Your concerns are shared by ESA but don´t see what we can do about them in this current release as this scenario you mentioned has not been accepted in the past.

[The discussions on UE-Faults and LMF-Faults were a separate topic related to the positioning method, whereas the Validity Period is an implicit property of the integrity concept itself, as noted already in the Principle of Operation (8.1.1a). We can't see how to accept the current proposals without adding the Validity Period (or some other suitable way of defining the validity period of the bounds) as it will violate the safety concept which underpins the need for integrity assistance information to satisfy the target use cases (TR 38.857)].

5). Proposals 14 and 18. You are right. This reminds me that the objective of the discussion is to close as many of the open issues deemed critical for Rel17. These two do not fit in the critical group and the summary will make this clear. The proposal reflects ideas brought forward by companies and if the group does not agree with them they can be dissmissed on the spot.

6). P16. Agree, all 3 are needed. We should vote on all 3 together and remove TTA as FFS

Round 3: From ESA

**1). GNSS-RealTimeIntegrity.**

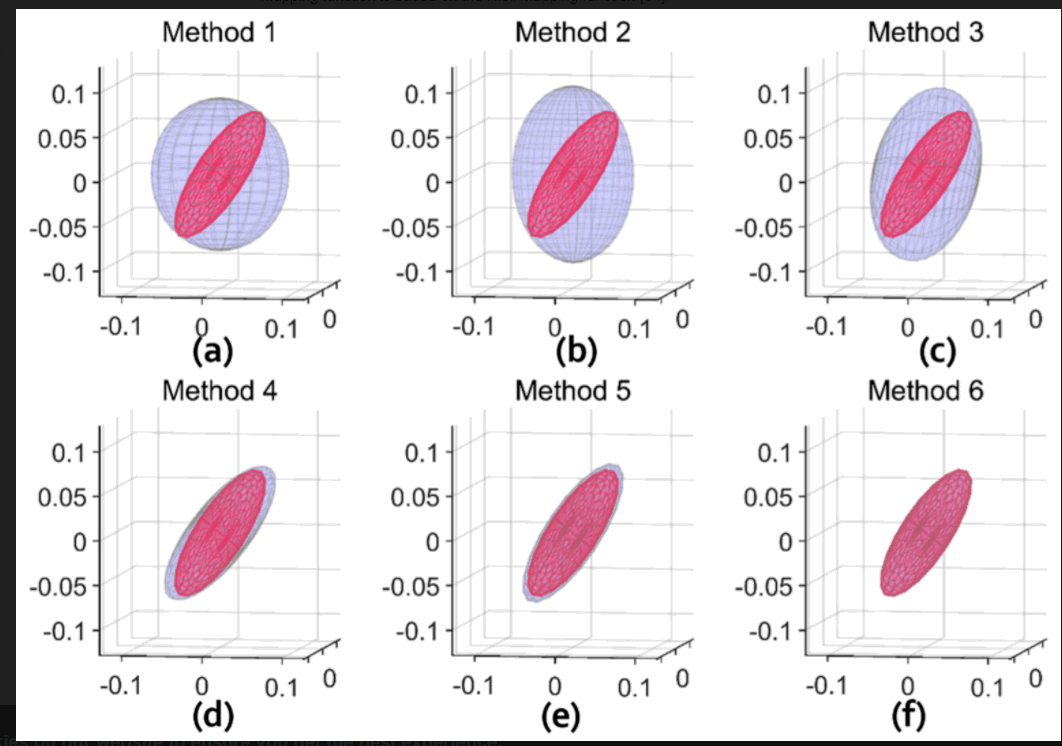
Majority agree to reuse this IE instead of a new one. As a minimum an update to the description of the IE is needed to clarify the meaning. Addition to the description update, Swift thinks new fields are also needed to indicate DNU=FALSE all the time, also during nominal operations. As part of the email discussion, Qualcomm has indicated that on option to achieve the DNU=TRUE and DNU=FALSE exist: if GNSS-RealTimeIntegrity is absent and Iono/Tropo is present, the UE should take this SV DNU = FALSE. When GNSS-RealTimeIntegrity is present, it indicates DNU = TRUE.

Decision point: do we agree that absence of GNSS-RealTimeIntegrity means SV-DNU=FALSE or do we need to introduce additional signalling/new fields in the IE that sends SV-DNU=FALSE values in nominal conditions. **To me this is something we can agree offline as part of the review of the running CR for Stage 3. For completion, will put the updated GNSS-RealTimeIntegrity IE in an Annex of the summary and invite all companies give this a look in anticipation to the revision of Stage 3 (input to come from Rapporteur of Stage 3).**

**2). Cross-covariance**

I have reviewed the paper on GPS Orbit (resource 5 in your answer - link below) and, based on Figure 10, Table 9, Figure 12, and Figure 13, it is becoming more obvious that we are now debating on an optimisation, not a need. The paper shows clearly that the diagonal of the covariance matrix alone gets us at a very good level (Method 4) and providing the full covariance brings marginal gains (Method 6 below). These marginal gains come with a cost though - in your 4x4 covariance matrix, instead of just 4 parameters (3 for orbit + 1 clock) we would need 10 (6 for correlations between pair of orbit axis, and orbit axis and clock combinations). These extra 6 parameters need to be multiplied by number of satellites (anywhere between 50 - 80 depending on the number of GNSS constellations) and we should quickly start thinking about the bandwidth. An intermediate approach is to send only diagonal + Radial-Across axis correlation (Method 5).

Based on all what has been exchanged, Huawei´s, Apple´s and few others´ remark still stand - we are talking about optimisation, not a need/missing piece. The paired overbouding of errors, based on mean and standard deviation, is already a great feature for Release 17.



<https://www.mdpi.com/2072-4292/11/19/2271/htm#>

Decision point: do we need full covariance matrix to enable the principle of operations for integrity or standard deviation and mean is enough to enable basic functionality in Release 17? **I invite all companies to take into account the latest inputs and let us know if their position has changed. For the time being we have 11 votes opposing full covariance and 2 votes in favour.**

**3). IE for Constellation parameters - pConstellation, tConstellation, pSatellite, tSatellite**

Majority of the companies have expressed interest in re-using existing IEs in this case as well. It seems that companies were thinking about reusing *GNSS-SSR-OrbitCorrections*IE for new fields to satellite/constellation. Technically speaking pConstellation, tConstellation, pSatellite, and tSatellite do not fit in GNSS-SSR-OrbitCorrections as this IE provides information about the precision of the satellites location on the orbit around the Earth and not constellation and satellites fault probability and duration. These 4 parameters are very slow changing, if at all. Therefore, a candidate existing IE for these 4 parameters is the GNSS-RealTimeIntegrity (?). Otherwise, a new IE must be included under the GNSS Generic Assistance data.

Decision point: is *GNSS-RealTimeIntegrity* IE more appropriate to include pConstellation, tConstellation, pSatellite, and tSatellite fields instead of *GNSS-SSR-OrbitCorrections* IE? Alternatively, if none of the two discussed IE work, a new IE is needed. **To me this is a detail for offline as part of reviewing the CR for Stage 3 (input from Rapporteur of Stage 3).**

**4). Validity Period**

Majority of the companies feel there is no explicit need for validity period fields as the error bounds are included directly in the SSR assistance data and they are valid until new data are received. Swift thinks that we have not addressed the case of when a bound is issued and the service loses its connection (i.e. no DNU or SSR correction update is sent). I would imagine that in such case there are already general mechanisms in place - maybe Swift can check the A-GNSS Error IE and look at the fields related to provision of periodic assistance data in the meantime. Based on all what was provided until now, our interpretation is that we are dealing with a niche case and therefore an optimisation rather than a basic functionality.

Question to LPP experts: what happens with a positioning session in case of loss of connectivity?