**3GPP TSG RAN WG2 Meeting #116-e R2-21xxxxx**

**Electronic meeting, 1st – 12th Nov, 2021**

**Source: Huawei, HiSilicon**

**Title: [Post115-e][607][POS] Integrity assistance data (Huawei)**

**Agenda item: 8.11.5**

**Document for:** **Discussion and Decision**

# Introduction

The following email discussion has been planned during RAN2#115 for the issues with integrity assistance data.

* [Post115-e][607][POS] Integrity assistance data (Huawei)

 Scope: Discuss the supported assistance data for UE-based integrity determination, considering at least the following candidates that were proposed to RAN2#115-e:

* Quality indicators (standard deviation or variance) of the GNSS error sources
* Mean values of the GNSS error sources
* Information describing the time variation of the GNSS error sources
* Probability of satellite fault
* Probability of constellation fault
* “Do Not Use” assistance data alerts
* “Do Not Use” SV and/or GNSS constellation alerts

Assistance data can be considered in relation to the following categories of feared events from the TR:

* Feared events in the GNSS Assistance Data (category 1)
* GNSS feared events (category 3)
* LMF feared events (category 5)

 Intended outcome: Report to next meeting

 Deadline: Long

This questionnaire intends to handle the issues defined within the scope of the email discussion.

# Contact Information

|  |  |
| --- | --- |
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# Discussion Phase I

In the phase I of the email discussion, we will handle the following issues regarding the integrity assistance data:

* Error bounding techniques
* State space representation vs Observation space representation
* Identify the set of possible integrity assistance data for the 3 categories of feared events
* Identify the set of possible integrity assistance data for GNSS integrity service

Error bounding techniques

[6] has discussed on limitations with the zero-mean assumption for bounding the error distribution and proposed an alternative method of “paired overbounding”, which consists of bounding the true distribution by two non-zero mean Gaussians, shifted by $-μ$ and $+μ$. In [3], it has also been mentioned that the error bound should at least include the variance/standard deviation of error sources. In [4], deviation has been proposed for bounding the error sources for satellite orbit, clock, bias, ionosphere, and troposphere.

The main difference between [6] and [3][4] is that [6] propose to add mean values of the error in the assistance data to further bound the error. Thus, companies are invited to answer the following question:

###### Question1-1: Do companies agree that we should adopt the “paired overbounding” technique for bounding the probability distribution of the errors for GNSS integrity?

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| **Company** | **Yes/No** | **Comments** |
| Swift Navigation | Yes | Paired overbounding enables tighter bounding of the error distributions (to better reflect their real-world error properties), leading to smaller PLs. The paired overbounding method in [5] is also compatible with the proposals in [3] and [4] given the mean (µ) can be set to zero if the provider only chooses to report the sigma (σ). Hence, paired overbounding leads to greater flexibility in the choice of implementation by sending both µ and σ in the assistance data. |
| ZTE | Partially yes | One concern is that how to determine the μ value, another concern is that the μ value may have an impact on the original variance/standard deviation. That is to say μ and σ should be determined as a combination. If this can be well solved(although it may be out of RAN2’s scope), then it is beneficial to adopt the paired overbounding to better describe the error model. Moreover, transmitting the μ value additionally will not introduce larger spec impact in RAN2.  |
| Nokia | Yes | It seems to be adopted in the GNSS ecosystem already, so it should be compatible for 3GPP to also take this into account. |
| CATT | Yes |  |
| vivo | Yes | We think paired overbounding is suitable because it is not only compatible with other methods but also achieves tighter bounding which reflects real-world error properties. |
| OPPO | Yes |  |
| InterDigital | Yes |  |
| ESA | Yes (partly) | We agree with Swift: [6] is building on top on a much simpler concept proposed in [3] and [4] while still keeping the simpler concept on the table. We disagree with where [5] suggest to put new fields such as mean and sigma values: new Ies as per [5] or extension of SSR Ies as per [3] and [4]. Generally speaking, we would like to keep the changes to LPP to a minimum in particular because new Ies translate to new posSIBs as well and there are already some problems with scheduling of posSIBs discussed in other email discussions. Regardless of this additional point we have in mind, we agree that paired overbouding is more complete solution. |
| Ericsson | Yes |  |
| Qualcomm | Partially No | We agree that both,  and  of the error sources should be provided in the assistance data. However, there seems no need to "adopt a paired overbounding technique" in the specifications. It was agreed that the "specific algorithms used for positioning integrity shall be up to implementation". We assume this applies to both, UE and LMF. In any case, a precise definition of "paired overbounding" technique needs to be provided before this question can be answered. |
| Samsung  | Yes  | We also see that real world error distribution can be reflected by overbounding with mean value addition. This is also not underestimating the error occurrence. Even this make some conservative estimate on the location but still good for the safety. |
| u-blox | Yes | An overbounding technique is essential because many errors are not Gaussian and can have longer tails. Using a single Gaussian assumption is not adequate given the wide range of TIRs identified and the fact that most lie far into the tails of the error distribution. |

###### Question1-1 Summary:

TBD

## Representation of error sources

Positioning errors can be represented in the following different ways as introduced in different releases in 3GPP

* Observation state representation (OSR) in R15, e.g., RTK
* State space representation (SSR) in R16, e.g., PPP and PPP-RTK.

The main difference between OSR and SSR is that SSR has independent characterization of each error source while OSR aggregates all the error sources.

In [6], it has been pointed out that SSR has the following advantages:

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| * Alignment with the SSR representation of errors.
* SSR representation can be converted to OSR but not vice versa, therefore SSR is more general.
* Better integrity KPIs, from tighter bounding of the error distribution (see ‘error overbounding’ above).
* OSR representation is specific to a single user location whereas SSR representation can cover any number of users within a geographic area, leading to much enhanced scalability.
* As OSR uses an aggregate of all errors, a single feared event will make integrity unavailable. With SSR individual components are sent separately so if one component is impacted by a feared event, the other components may still be used to allow for graceful degradation.
 |

During RAN2#115e, the following agreement has been achieved for the supported GNSS methods for GNSS integrity:

Agreements:

Proposal 1: Agree that the GNSS feared events will be addressed in the WI.

Proposal 2 (modified): Agree that all for A-GNSS positioning methods, positioning integrity determination is supported in LPP.

Proposal 3: Agree that additional IEs are needed in LPP to support A-GNSS positioning integrity determination.

Proposal 4: The specific algorithms used for positioning integrity shall be up to implementation.

Proposal 5: For interoperability, the use of “hard-coded” parameters should be minimized and instead the needed parameters should be sent explicitly in the assistance data.

Proposal 6: RAN2 agrees that the PL will be reported in the Integrity Results. It is FFS whether Mode 2 and the TIR, AL, TTA that were used in the integrity calculation will also be reported in the integrity results.

Proposal 8: Agree that the UE feared events will be handled in the implementation for UE-based (network-assisted) methods of positioning integrity determination.

Proposal 10: Agree that the LMF feared events can be handled via implementation for the UE-based (network-assisted) and UE-assisted (LMF-based) methods of positioning integrity determination.

Proposal 11: RAN2 agrees to use Common Positioning Ies to transfer the KPIs and Integrity Results.

Proposal 12: RAN2 agrees that the LPP procedures can be used to transfer the KPIs and Integrity Results. For UE-assisted, the LCS procedures remain FFS in the case of MO-LR.

While in the summary for GNSS integrity in RAN2#115 [2], it has also been argued by the feature lead that we should not do prioritization between SSR and OSR since the objective defined in the WID is to support GNSS integrity for all the GNSS positioning methods up to now, a.k.a. all the GNSS positioning methods since R9.

While based on the understanding from the rapporteur, the intention from [6] is not to deprioritize OSR and prioritize SSR. It is argued in [6] that the assistance data for SSR is a superset of OSR, that if we support the error representation with SSR for GNSS integrity, the GNSS integrity for OSR is naturally supported.

Based on the above, companies are invited to answer the following question regarding the error representation of OSR and SSR for GNSS integrity.

###### Question1-2: What additional assistance data are needed for the feared event whose error source is represented by OSR and please provide the corresponding TP (including the field by ASN.1 and field description)?

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| **Company** | **Comments** |
| Swift Navigation | None – SSR representation of integrity supports all the positioning methods including RTK/OSR.Note however that the converse is not true, OSR representation would not satisfy the PPP-RTK and PPP positioning methods (i.e. SSR methods). |
| Huawei, HiSilicon | Agree with Swift that OSR representation can be constructed by the SSR but the reverse is not possible. So SSR is enough |
| ZTE | Agree with Swift and Huawei that the indication of error source(statistical model) in SSR representation is enough |
| Nokia | SSR seems better suited to large scale industrial applications as it requires only unidirectional transmissions resources and consumes less transmission resources. Also, as commented by other companies, it can already cover OSR. So we should only consider SSR. If any need of OSR is identified in the future, we can come back to this. |
| CATT | Agree with Swift. SSR sends the individual error components separately, while OSR send the aggregate of all errors. SSR representation can support both SSR and OSR methods.  |
| Vivo | No need. SSR is enough which covers OSR. |
| OPPO | Agree with Swift Navigation OSR could be covered by SSR representation of integrity. |
| Xiaomi | Agree with Swift that SSR is enough.  |
| InterDigital | Same understanding with Swift and other companies that SSR is enough |
| Fraunhofer | Same understanding as all above. |
| ESA | Agree with the majority. |
| Ericsson | We also agree with the majority to start from SSR, but agree with QC (below) that additions for OSR integrity AD are not precluded in case the existing RTK residuals are considered insufficient. |
| Qualcomm | Integrity assistance data for OSR should be aligned with RTCM and may comprise:- General parameters, which are common to any NRTK implementation; e.g.,- integrity of cycle slips detection- Differenced parameters, which are specific for differenced approaches; e.g.- double difference covariance network matrix elements- baseline dependent integrity parameters- carrier phase double difference residuals- Undifferenced parameters, which are specific for undifferenced approaches and may be similar to SSR approach (tropo, iono, SIS integrity)Details should await a response LS from RTCM. |
| Samsung  | We also have the same view with the majority that SSR representation can autonomously handle the OSR representation, so no need further information in AD. |
| u-blox | Additional assistance data is not essential for OSR but the use of SSR representation of integrity may be complex and not optimum for OSR. We should not preclude adding OSR specific integrity parameters in the future. |

###### Question1-2 Summary:

TBD

In [7], it has been mentioned that in terms of SSR, the current spec already has basic support for GNSS integrity with the URA, specifically

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| * SSR Orbit corrections are provided as radial, along track and cross track corrections, with an optional velocity component in each of these dimensions. Corresponding uncertainty extensions per field is a natural extension
* SSR clock corrections are provided as a parameterized polynomial where an uncertainty per parameter is natural, but also an uncertainty representing the correction as a whole
* SSR code bias and phase bias are naturally extended with an uncertainty per field
* SSR atmospheric delay models already come with quality indicators for the STEC and gridded corrections
 |

In [3], it has also been mentioned that current LPP already has basic system-level and user-level support for GNSS integrity

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| ***3GPP: Is there already a solution in LPP?***Yes, the *GNSS-RealTimeIntegrity* IE. This is the most basic form of integrity capability.***3GPP: Is there already a solution in LPP?***Yes, the *navURA* fields and *GNSS-SSR-URA* IE. |

Furthermore, in the TR [1] during the study item phase, we have defined integrity KPI for the key use cases of automotive, tail, and IIoT as follows:

Table 9.2.4: KPI examples for the Automotive, Rail and IioT use cases [34][35][36][37].

NOTE: KPIs are defined by the service provider implementation.

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| **AUTOMOTIVE EXAMPLES** |
| **APPLICATION CATEGORIES** | **TIR** | **AL** | **TTA** | **Integrity Availability** |
| **Safety-Critical Applications**- Warnings (red light, obstacle, queue, curve speed, blind spot lane change, pedestrians etc)- Automated Driving (lane-level or better)- Emergency Brake Assist- Forward Collision Avoidance | Typical range: ≥10-8/hr to ≤10-6/hr | Typical range: ≥1.5m to <5m | Typically ranges from 100s of milliseconds to <10 seconds | Typically ranges from 95% to 99.9% or greater |
| **Payment Critical Applications**- Road User Charging (RUC)- Pay Per Use Insurance- Taxi Meter- Parking Fee Calculation | Typical range: ≥10-6/hr to ≤10-4/hr | Typical range: ≥1.5m to <25m | Typically ranges from 95% to 99.9% or greater |
| **Smart Mobility** - Freight and Fleet Management- Cargo/Asset Management- Vehicle Access/Clearance- Emergency Vehicle Priority- Speed Limit Information- In-Vehicle Signage- Reduce Speed Warning- Dynamic Ride Sharing |
| **RAIL EXAMPLES** |
| **APPLICATION CATEGORIES** | **TIR** | **AL** | **TTA** | **Integrity Availability** |
| **Safety-Critical Applications** - Absolute Positioning- Train Awakening- Cold Movement Detector- Track Identification- Level Crossing Protection- Train Integrity and Train Length Monitoring | Typical range: ≥10-9/hr to ≤10-8/hr | Typical range: ≥2.5m to <25m | Typically <7s | Typically ranges from 95% to 99.9% or greater |
| **Liability-Critical Applications** - Trackside Personal Protection- Management of Emergencies- Train Warning Systems- Infrastructure Charging- Hazardous Cargo Monitoring- On-Board Train Monitoring and Recording Unit- Traffic Management Systems | TBD | Typical range: ≥25m to <62.5m | Typically ranges from seconds to <30s | Typically ranges from 95% to 99.9% or greater |
| **IIOT EXAMPLES** |
| **APPLICATION CATEGORIES** | **TIR** | **AL** | **TTA** | **Integrity Availability** |
| **AGV Applications** - Mobile device tracking- Asset tracking- Process automation- Inbound logistics | Typical range: ≥10-8/hr to ≤10-1/hr | Typical range: ≥0.5m to <30m (vertical/horizontal) | Typically ranges from 100s of milliseconds to <10 seconds | Typically ranges from 95% to 99.9% or greater |

With the above, companies are invited to answer the following question to help to give a justification for the what we are doing for GNSS integrity and why this enhancement is needed for the use cases in R17.

###### Question1-3: Which use case do companies think that the current support of GNSS integrity in R16 LPP is already sufficient for?

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| **Company** | **Use Case** | **Comments** |
| Swift Navigation | None | We do not believe any of the use cases in the table will be satisfied using the existing Ies alone. The existing Ies are not useful in assisting the UE in computing a Protection Level as they are incomplete and no statement is made in the R16 specification as to the statistical meaning of these indicators (e.g. residual risk). |
| Huawei, HiSilicon | None | The current support of integrity is quite primitive that it is not able to support the above cases of rail, automotive, and IioT examples.  |
| ZTE | None |  |
| Nokia |  | In order to support these use cases, Rel-17 LPP should at least provide mechanisms to convey integrity requirements (i.e. KPIs) and integrity results – the basic form of which is already agreed in the previous meeting so we are on track. For the assistance data, however, we think the existing Ies can already be used to a certain extent, although they may not be perfect in some sense. Even if it is not ideal, we think it is more important to first observe what will be introduced by RTCM, before jumping to conclusions of adding new assistance data in 3GPP. |
| CATT | None | R16 LPP cannot sufficiently support the use cases listed above and more enhancements of integrity are needed. |
| Vivo | None | The current support of GNSS integrity is not sufficient. |
| OPPO | None |  |
| Xiaomi | None | The R16 LPP needs to enhance to support the above use cases. |
| InterDigital | None | Enhancements are needed in Ies to derive integrity metrics to support the above use cases |
| Fraunhofer | None |  |
| ESA | None | The existing Ies are sufficient to inform UE if there is a problem with a number of GNSS satellites and/or signals while navURA is not fit for real-time operations of use cases we discuss. At the same time, we feel the need to emphasise that by just adding few extra Ies as suggested in [5] will not be enough to satisfy the very stringent TIR levels (10^-6/h … 10^-9/h) from above. There are many reasons for this including but not limited to no progress on UE, LMF, communication channel feared events.Based on all what we experienced until now, we are of the opinion that the work resumes to specifying enablers for GNSS positioning integrity without actually considering the use cases (and their needs) from above. To conclude, we agree with Nokia, it is best to wait for RTCM because the work there involves design of solution based on needs and testing in the field. |
| Ericsson | None |  |
| Qualcomm | Most of them… | …where code-phase based Differential-GNSS accuracies are sufficient (e.g., ~5m). Differential GNSS (as supported since Rel-9) also provides an integrity monitoring function that detects or ameliorates large satellite signal errors. This, together with RAIM, provides integrity sufficient for most applications.However, high integrity integrated with high precision (HA-GNSS), additional assistance data are beneficial, e.g., as currently under development in RTCM. |
| Samsung  | None  | As I understand we RAN2 is specifying on this new concept in LPP domain in R17 WI. So, the definition of positioning integrity can only be available for the above cases only after R17 POS is specified. |
| u-blox | Few | It is important to remember that the TIR requirements listed in the above table are for the application. In a typical implementation the Positioning Function will accept inputs from several different navigation sources. These could include GNSS, IMU, Lidar, cameras, radar, map matching and of course RAT-dependent NR positioning sources. The Positioning Function combines inputs from multiple sources to arrive at a final navigation output. GNSS is one component of a high integrity positioning solution. Therefore it is necessary that each of the sub-systems contributing to the Positioning Function provides sufficient information about the quality of its output to allow meaningful decisions to be made. The GNSS integrity IEs in R16 do not provide sufficient information to allow different sources of position information to be combined optimally. |

###### Question1-3 Summary:

TBD

Assistance data for different feared events

During the study item of the R17 positioning, the following categories for feared events have been defined in the TR [1], illustrated by the following Figure 1:



**Figure 1: Categorization of Integrity Feared Events**

During the RAN2 discussion in R2#115, the following agreements have been made in the feared events. Thus, we have agreed that (2) can be excluded with the following agreement.



We have almost agreed on the reprioritization of LMF-based integrity calculation and with the scope of the email discussion, the part (4) can also be excluded

In addition, for the LMF-feared events for UE-based integrity, the following has been agreed, and thus we don't need to discuss on category (5):

Proposal 10: Agree that the LMF feared events can be handled via implementation for the UE-based (network-assisted) and UE-assisted (LMF-based) methods of positioning integrity determination.

Then, the assistance data for feared events in the categories (1) and (3) are open for discussion. In the following, we further discuss what assistance data are needed for the remaining 2 types of feared events.

For the text proposals submitted to the last meeting and the discussion papers, the following parameters have been provided mainly under the following contributions:

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| Swift Nav et al [5] | The assistance data for feared events are highlighted as follows(a)Integrity Bounds (b) Residual Risks (c) Correlation Times (d) Alerts (e) Validity Times (f) Service Parameters* *GNSS-CommonAssistData*
	1. gnss-Integrity-ServiceParameters
		+ irMinimum
		+ irMaximum
	2. gnss-Integrity-ServiceAlert
		+ serviceDoNotUse
		+ ionosphereDoNotUse
		+ troposphereDoNotUse
	3. gnss-Integrity-TroposphereParameters
		+ epochTime
		+ iod-ssr
		+ validityPeriod
		+ pTroposphereFault
		+ tTroposphereFault
		+ tCorrelationTroposphere
		+ tCorrelationTroposphereRate
	4. gnss-Integrity-TroposphereErrorBounds
		+ epochTime
		+ iod-ssr
		+ correctionPointSetID
		+ validityPeriod
		+ gridList SEQUENCE (SIZE(1..64)) OF Integrity-TroposphereGridElement
			- meanTroposphereVerticalHydroStaticDelay
			- stdDevTroposphereVerticalHydroStaticDelay
			- meanTroposphereVerticalWetDelay
			- stdDevTroposphereVerticalWetDelay
			- meanTroposphereVerticalHydroStaticDelayRate
			- stdDevTroposphereVerticalHydroStaticDelayRate
			- meanTroposphereVerticalWetDelayRate
			- stdDevTroposphereVerticalWetDelayRate
* GNSS-PeriodicAssistData
	1. gnss-Integrity-PeriodicServiceAlert
	2. gnss-Integrity-PeriodicTroposphereErrorBounds
	3. gnss-Integrity-PeriodicConstellationAlert
	4. gnss-Integrity-PeriodicConstellationParameters
	5. gnss-Integrity-PeriodicBiasErrorBounds
	6. gnss-Integrity-PeriodicOrbitClockErrorBounds
	7. gnss-Integrity-PeriodicIonosphereParameters
	8. gnss-Integrity-PeriodicIonosphereErrorBounds
* GNSS-GenericData
	+ - gnss-Integrity-ConstellationAlert
		- constellationDoNotUse
		- integrity-svAlertList SEQUENCE (SIZE(1..64)) OF Integrity-SVAlertElement
			* svID
			* svDoNotUse
	1. gnss-Integrity-ConstellationParameters
		+ epochTime
		+ iod-ssr
		+ validityPeriod
		+ pConstellationFault
		+ tConstellationFault
		+ pSatelliteFault
		+ tSatelliteFault
		+ tCorrelationRangeOrbit
		+ tCorrelationRangeClock
		+ tCorrelationRangeRateOrbit
		+ tCorrelationRangeRateClock
	2. gnss-Integrity-BiasErrorBounds
		+ epochTime
		+ iod-ssr
		+ validityPeriod
		+ integrity-biasErrorBoundsList SEQUENCE (SIZE(1..64)) OF Integrity-BiasErrorBoundsElement
			- svID
			- meanCodeBias
			- stdDevCodeBias
			- meanCodeBiasRate
			- stdDevCodeBiasRate
			- meanPhaseBias
			- stdDevPhaseBias
			- meanPhaseBiasRate
			- stdDevPhaseBiasRate
	3. gnss-Integrity-OrbitClockErrorBounds
		+ epochTime
		+ iod-ssr
		+ validityPeriod
		+ orbitClockErrorMeanShapeVector
		+ orbitClockErrorCovarianceShapeMatrix
		+ orbitClockRateErrorMeanShapeVector
		+ orbitClockRateErrorCovarianceShapeMatrix
		+ orbitClockErrorBounds List SEQUENCE (SIZE(1..64)) OF Integrity-OrbitClockErrorBoundsElement-r17
			- svID
			- orbitClockErrorScaleFactor
			- orbitClockRateErrorScaleFactor
	4. gnss-Integrity-IonosphereParameters
		+ epochTime
		+ iod-ssr
		+ validityPeriod
		+ pIonosphereFault
		+ tIonosphereFault
		+ tCorrelationIonosphere
		+ tCorrelationIonosphereRate
	5. gnss-Integrity-IonosphereErrorBounds
		+ epochTime
		+ iod-ssr
		+ correctionPointSetID
		+ validityPeriod
		+ gridList SEQUENCE (SIZE(1..64)) OF Integrity-IonosphereGridElement-r17
			- satList SEQUENCE (SIZE(1..64)) OF Integrity-IonosphereSatElement-r17
				* svID
				* meanIonosphere
				* stdDevIonosphere
				* meanIonosphereRate
				* stdDevIonosphereRate
 |
| ESA et al [3] | Proposal 1. Add at least the quality indicator (standard deviation or variance) to each GNSS SSR IE in the Rel17 of LPP. Additional parameters are FFS at this moment. |
| Qualcomm [4] | Proposal 6: The assistance information that will be used to support integrity determination comprise quality indicators which can either be added to the SSR assistance data IEs or defined as a separate new IE:- Uncertainty of the satellite orbit;$ σ\_{SV orbit}^{2}$ - Uncertainty of the satellite clocks; $ σ\_{SV clocks}^{2}$- Uncertainty of the GNSS signal code bias; $σ\_{code bias}^{2}$ - Uncertainty of the GNSS signal phase bias; $σ\_{phase bias}^{2}$- Uncertainty of the ionosphere model; $σ\_{Iono}^{2}$- Uncertainty of the troposphere model; $σ\_{Tropo}^{2}$ |

### Feared events in the GNSS Assistance Data

According to [1], the feared events in the GNSS assistance data is defined as incorrect computation of the GNSS Assistance Data and External feared event impacting the GNSS Assistance Data. While for the contributions submitted to the previous meeting, there are no proposals relating to this aspect. Hence, we propose the following question on whether assistance data for the feared event in GNSS assistance data should be defined, and if needed, what assistance data are needed.

###### Question1-4: Do we need to define assistance data for feared events in GNSS assistance data? If the answer is Yes, what parameters do companies think are needed for GNSS assistance data and please provide the TP for the parameters (including the field by ASN.1 and field description)? If the answer is No, please also clarify the reasons in the comments

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Swift Navigation | Yes (see comment) | The Alert parameters in [5] (e.g. Do Not Use (DNU) flags) are used to address both the ‘GNSS Feared Events’ and ‘Feared Events in the GNSS Assistance Data’. Although feared events may come from different sources, their net effect at the positioning function is the same, so they may share the same alert flag.For example, a Satellite Vehicle (SV) alert means the system has detected a potential feared event on a given satellite which could impact integrity (meaning the error will likely exceed the corresponding Integrity Bound). This event may result from a satellite fault (e.g. a GNSS feared event) or from the inability of the service to validate the assistance data to a sufficient level for integrity (e.g. a Feared Event in the GNSS Assistance Data). Either way, the SV DNU flag is sent in the assistance data to avoid the corrections being used for the purpose of integrity.NOTE: The DNU flag does not prohibit the user from continuing to use the corrections (SSR, RTK etc) to improve positioning accuracy (e.g. for applications which do not have an integrity requirement). DNU specifically refers to the usability for integrity. |
| Huawei, HiSIlicon | Yes | Some of the parameters can be used to indicate both GNSS feared events and GNSS assistance data feared events.  |
| ZTE | Yes | At least the error bounds(orbit, clock, code bias, phase bias, ionosphere and troposphere) can be reused for feared events in GNSS assistance data.  |
| Nokia |  | We would prefer to minimize the assistance data to be introduced. Error bounds such as the information in Q1-1 could be considered, but for others we prefer to first interact with RTCM before jumping to conclusions of adopting other types of assistance data.  |
| CATT | Yes | Agree with Swift and ZTE. Some parameters defined in [5] can indicate both the external feared event impacting the GNSS Assistance Data and the GNSS feared events. The error bounds can be reused. |
| vivo | Yes | Parameters indicating both GNSS feared events and GNSS assistance data feared events can be used. |
| Xiaomi | Yes | Maybe a simple indication for both GNSS feared events and GNSS assistance feared events is sufficient.  |
| InterDigital | Yes | Same view with Swift in that some flag(s) indicating whether the assistance data (e.g. corresponding to GNSS feared events and feared events in GNSS assistance data) is usable for integrity is beneficial.  |
| Fraunhofer  | Yes | The alerts can be global or local feared events. The GNSS feared events that are applicable locally needs to be signalled as having a local scope. Furthermore, in the alerts, the svDoNotUseFlag shall further specify the signals from this SV that should not be used. |
| ESA |  | Of course there will be need to introduce assistance data in LPP in support of GNSS positioning integrity. In doing this, we should aim at avoid unnecessary duplication in LPP: any item related to health of a GNSS Satellite and/or signal can already be signalled to UE by means of *GNSS-RealTimeIntegrity* IE. Therefore, we do not see the need to add new IEs achieving largely the same function.We are also supportive on Nokia´s suggestion on waiting for RTCM to finish its work on this topic.As a last note, [3] and [4] are proposing the same thing and should not be treated as different options. |
| Ericsson | Yes | We agree with Fraunhofer that NW ICE (Integrity Computing Entity) should be able to process the local feared event reported by UEs and convert these to do not use flags. |
| Qualcomm | No | …because the e.g., "Do Not Use" flag is already supported via IE *GNSS-RealTimeIntegrity* (which is mandatory):"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."In addition, a UE does not expect "faulty" assistance data today; i.e., "incorrect assistance data" shall not be provided to the target device. |
| Ericsson |  | One comment to the last QC comment about UEs not expecting faulty AD. One key case is when data is available and seemingly current but not properly validated for integrity (e.g. if redundant observations for validation is temporary not available), then “do not use” for integrity assessments can still be relevant even if the provided data is used for positioning. |
| Samsung  | See comment. | We basically agree with that at least the mean value for the error in Q1-1 can be inclucded in the AD. However, the basement on the mean value and error statistics were the fact that GNSS echo has made that value used. So it is better to interact with RTCM for further checking the parameters. |
| u-blox |  | This question is confusing. We understand it to be asking about error checks on the error check, and feel that it is not needed. What is important is to provide assistance data that includes quality measures (variance, validity time etc). It is important that this can be delivered with sufficiently reliability that we don’t need to add further checks on whether the quality measures were computed and delivered correctly. |

###### Question1-4 Summary:

TBD

### GNSS feared events

At RAN2#115, there were proposals from several contributions [3][4][5][6] suggested to capture the following integrity assistance information and this was also captured in the summary document [2].

(1) Standard deviations, quality indicators, variances of the GNSS error sources.

(2) Mean values of the GNSS error sources.

(3) Information describing the time variation of the GNSS error sources.

(4) Probability of satellite fault.

(5) Probability of constellation fault.

(6) “Do Not Use” assistance data alerts

(7) “Do Not Use” SV and/or GNSS constellation alerts

In particular, the discussion in [4] has also proposed to categorize the integrity parameters as follows:

1. Integrity Bounds
2. Residual Risks
3. Correlation Times
4. Alerts
5. Validity Times

Then, from the rapporteur’s understanding, the integrity parameters listed in [2] can be mapped to the categories in [4] as follows:

* **Integrity bounds**

(1) Quality indicators (standard deviation or variance) of the GNSS error sources

(2) Mean values of the GNSS error sources.

* **Correlation Times**

(3) Information describing the time variation of the GNSS error sources.

* **Alerts**

(6) “Do Not Use” assistance data alerts

(7) “Do Not Use” SV and/or GNSS constellation alerts

* **Residual risk**

(4) Probability of satellite fault.

(5) Probability of constellation fault.

In addition, we think that the following assistance data have also been defined in [4] according to the categorization in [2]

* **Validity times**

*(8) “Validity Period” defined for Constellation, Ionosphere and Troposphere parameters and their error bounds.*

We would first like to ask the question whether companies think the above categorization is reasonable for the assistance date for GNSS feared event. From the rapporteur’s perspective, we think that understanding this question will help us having a better understanding of the structure of the assistance data for GNSS-feared event and can be helpful to capture in the stage2 spec.

###### Question1-5: Do companies agree that the assistance data for GNSS-feared event can be categorized into the five categories of (a)Integrity Bounds (b) Residual Risks (c) Correlation Times (d) Alerts € Validity Times?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Swift Navigation | Yes | ‘Applicability’ might be an alternative name for Validity Times, given some fields in this category are not only determined with respect to time (e.g. iod-ssr). However, these categories are only intended to aid interpretation of the concepts, whereas the actual naming and description of the fields will depend on the Ies we agree to define in the WI. Hence, we don’t think these specific categories need to be defined in the specification itself. |
| Huawei, HiSilicon | Yes | We agree with the categorization and whether it should be captured in the stage2 description can be decided by the spec editor |
| ZTE | Yes | Agree with the categorization, although we think only the Integrity Bounds is essential  |
| Nokia | Yes | Such categorization would make our future discussions easier. |
| CATT | Yes | Agree with the five categories of the assistance data for GNSS-feared event. |
| Vivo | Comments | These categories are only intended to aid the interpretation of the concepts and make future discussions clearer. Which categories will be selected and what are the actual namings of the selected categories depending on Ies we agree to define in the WI. |
| OPPO | Yes | Such catogrization is helpful for future discussion |
| Xiaomi | Yes | Agree with the categorization, but the detailed assistance information need to be further discussed.  |
| InterDigital | Yes | We are ok with the proposed categorization of GNSS feared events |
| Fraunhofer | Yes | Categorisation is useful.  |
| ESA | Yes | We like moderator´s suggestion, it will make discussions more structured in the future. |
| Ericsson | OK |  |
| Qualcomm | Yes | Agree with the categorization. However, the need/usage of each category requires more justification. |
| Samsung  | Yes  | Same view with QC. Categorization is ok but usage of each category requires more discussion . |
| u-blox |  | GNSS feared events can be categorized this way, The way in which assistance data are fitted into these criteria is for future discussion. |

###### Question1-5 Summary:

TBD

From the understanding of the rapporteur, with the parameters listed in the TP and the proposal, we think the proposal in [3] and [4] are already included in the current TP in [5].

Then, we would like to ask the following question:

###### Question1-6: Do companies agree that we need additional assistance data for GNSS feared event other than those defined in text proposal in [5]? If so, what additional parameters do companies think are needed for GNSS-feared events and please provide the TP for the parameters (including the field by ASN.1 and field description)?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Swift Navigation | No |  |
| Huawei, HiSilicon | No |  |
| ZTE | No  |  |
| Nokia | No |  |
| CATT | No |  |
| vivo | No |  |
| OPPO | No |  |
| Xiaomi | No |  |
| InterDigital | No |  |
| Fraunhofer | No (comments) | Except that for svDoNotUseFlag, the following shall be added. badSignalID GNSS-SignalIDs OPTIONAL, -- Need OP |
| ESA | Yes | We suggest to wait for RTCM to complete its work before moving further with definition of complicated IEs. |
| Ericsson | No | We are also fine with Fraunhofer’s suggestion above |
| Qualcomm | Yes | See our response to Question 1-2. |
| Samsung  | No.  | We think the list up parameters seems sufficient but which can be picked up still needs further discussion. |

###### Question1-6 Summary:

TBD

Assistance data for GNSS integrity service

In [5], Integrity Risk (IR) has been defined as assistance data for UE-based integrity calculation under the IE *GNSS-Integrity-ServiceParameters-r17* for the associated assistance data. This allows the UE to check if its TIR requirement (KPI) is within a range supported by the corrections service (based on the min/max IR).

We would like to ask the following question regarding assistance data for GNSS integrity service.

###### Question1-7: Do companies think other assistance data for GNSS integrity service is needed and please provide the corresponding TP (including the field by ASN.1 and field description)?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Swift Navigation | No | We believe *irMinimum* and *irMaximum* are the only service parameters needed currently. Note that the IR min/max are not actually used (directly) for the purpose of checking the TIR KPI. They are used for computing the bounds according to the formula from [5]:[bound = ] *mean* + *K* \* *stdDev* where *K* = *normInv*(*IRallocation* / 2)*irMinimum < IRallocation < irMaximum* |
| Huawei, HiSilicon | No |  |
| ZTE | No |  |
| Nokia | No |  |
| CATT | No |  |
| vivo | No |  |
| OPPO | No |  |
| Xiaomi | No |  |
| InterDigital | No |  |
| Fraunhofer | No |  |
| ESA |  | We suggest to wait for RTCM to complete its work |
| Ericsson | No | We agree with Swift and if RTCM can provide timely input we can consider ESA’s suggestion, but we need to continue our work/progress in 3gpp. |
| Qualcomm |  | Similar to our response to Question 1-5, the need for any "Integrity Service" assistance data requires justification at first. |
| Samsung  | No  |  |

###### Question1-7 Summary:

TBD

Any other issues

For the following open question, companies are invited to input any other issues relating to assistance data for GNSS integrity. We may be able to address the issue in phase II.

###### Question1-8: Do companies think there are other issues relating to assistance data of GNSS integrity?

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | Since A-GNSS positioning supports UE-based and UE-assist(LMF-based) mode, we think LMF-based integrity should also be take into account. In LMF-based integrity, MT-LR based solution can be prioritized for discussion. |
| OPPO | Agree with ZTE. Besides, LMF-based integrity method may also reduce the power consumption of UE for integrity computation, compared with UE-based integrity method. Feared events transmission from UE towards LMF could be carried in new defined LPP msg or redefining current LPP Provide Assistance Data msg. We think if online time is not enough, at least a email discussion on this topic containing pros and cons from each interesting company during next meeting is required. |
| Fraunhofer | Monitoring of interference (inter-system or jamming) or spoofing by capable UEs could provide valuable input for the system to determine the alert not to use a certain SV or a certain constellation or a certain GNSS signal. The network could utilise the report from capable Ues to generate such assistance data applicable locally. The mechanism for generating such assistance data can be left implementation specific, but the standard should support such optional reporting by capable Ues.  |
| ESA | We agree with ZTE and OPPO. LMF-based integrity is most certainly possible: LMF has knowledge of GNSS errors and feared events (a requirement for UE-based) and all it needs is measurements from UE and indication of local feared events (e.g., multipath, etc.). From a conceptual point of view LPP already supports the transport of such information. New UE-feared events can also be reported to LMF as suggested by Fraunhofer. |
| Ericsson | We also agree that LMF-based integrity can be supported. Furthermore, we agree with Fraunhofer on interference monitoring by capable UEs for indications of local feared events that can be applied locally. |

###### Question1-8 Summary:

TBD

Conclusion of Phase I

TBD

# References

1. TR 38.857, Study on NR Positioning Enhancements (Release 17), V17.0.0.
2. R2-2109029, Summary on agenda item 8.11.5 on GNSS positioning integrity, Qualcomm.
3. R2-2108340, "Bounding GNSS errors for positioning integrity", ESA, Nokia, Nokia Shanghai Bell.
4. R2-2108385, "Considerations on GNSS positioning integrity support", Qualcomm Incorporated.
5. R2-2108475, "Text Proposal on GNSS Integrity Assistance Data", Swift Navigation, Ericsson, Mitsubishi Electric Corporation.
6. R2-2108474, "Discussion on GNSS Integrity Assistance Data", Swift Navigation, Ericsson, Mitsubishi Electric Corporation.
7. R2-2108396, " GNSS positioning integrity ", Ericsson
8. R2-2106596 LS to RTCM on GNSS integrity assistance data ESA LS out To:RTCM SC134 Cc: RTCM, RTCM SC104