**3GPP TSG-RAN WG2 Meeting #119bis-eR2-22xxxxx**

**Electronic meeting, Oct 10th – 19th, 2022**

**Agenda item:** 8.2.3

**Source:** CATT

**Title:** [AT119bis-e][429][POS] Rel-18 integrity text proposal (CATT)

**Document for:** Discussion and Agreement

# 1 Introduction

This is to describe and discuss the TP on Rel-18 RAT-dependent integrity based on RAN2 agreements. The related RAN2 agreements on RAT-dependent integrity are in accordance with the chair notes [1] [2].

* [AT119bis-e][429][POS] Rel-18 integrity text proposal (CATT)

 Scope: Draft a text proposal on the RAN2 agreements on RAT-dependent integrity.

 Intended outcome: Endorsable TP in R2-2210918

 Deadline: Monday 2022-10-17 1700 UTC

# 2 Contact information

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# 3 Draft TP on Rel-18 RAT-dependent integrity

We will review the draft TP of RAT-dependent integrity according to the reference contribution [3][4][5] and the skeleton of TS 38.859 [6] including:

* 6.1.2 Methodologies, procedures and signalling for determination of positioning integrity
* 6.1.4 Potential Specification Impact for Integrity for RAT-Dependent Positioning Techniques

## 6.1 Integrity for RAT-Dependent Positioning Techniques

### 6.1.1 Identification of error sources

### 6.1.2 Methodologies, procedures and signalling for determination of positioning integrity

#### 6.1.2.1 Integrity Principle of Operation

For integrity operation, the network will ensure that:

*P(Error > Bound for longer than TTA | NOT DNU) <= Residual Risk + IRallocation* (Equation 6.1.2.1-1)

for all values of IRallocation in the range irMinimum <= *IRallocation* <= irMaximum

for all the errors in Table 6.1.4-1, which have corresponding integrity assistance data available and where the corresponding DNU flag(s) are set to false.

The integrity risk probability is decomposed into a constant Residual Risk component provided in the assistance data as well as a variable IRallocation component that corresponds to the contribution from the Bound according to the Bound formula in Equation 6.1.2.1-2. IRallocation may be chosen freely by the client based on the desired Bound, therefore the network should ensure that Equation 6.1.2.1-1 holds for all possible choices of IRallocation. The Residual Risk and IRallocation components may be mapped to fault and fault-free cases respectively, but the implementation is free to choose any other decomposition of the integrity risk probability into these two components.

Equation 6.1.2.1-1 holds for all assistance data that has been issued that is still within its validity period. If this condition cannot be met then the corresponding DNU flag must be set.

Equation 6.1.2.1-1 holds at any epochs for which Assistance Data is provided. Providing Assistance Data without the Integrity Service Alert IE or Real Time Integrity IEs is interpreted as a DNU=FALSE condition. For any bound that is still valid (within its validity time), the network ensures that the Integrity Service Alert and/or Real Time Integrity IEs are also included in the provided Assistance Data if needed to satisfy the condition in Equation 6.1.2.1-1. It is up to the implementation how to handle epochs for which integrity results are desired but there are no DNU flag(s) available, e.g. the Time To Alert (TTA) may be set such that there is a "grace period" to receive the next set of DNU flags.

**Editor note: the DNU flag and its related description will be removed or updated later, if RAN2 conclude there is no need to indicate the DNU presence in the integrity principle equation.**

Only UEs and TRPs for which the integrity assistance data are provided are monitored by the network and can be used for integrity related applications.

Where:

**Error:** Error is the difference between the true value of a parameter (e.g. FFS etc.), and its value as estimated and provided in the corresponding assistance data as per Table 6.1.4-1

**Editor note: the error sources depend on RAN1, and the FFS will be replaced with defined error sources later once RAN1 finalize the error sources.**

**Bound:** Integrity Bounds provide the statistical distribution of the errors. The bound is computed according to the Bound formula defined in Equation 6.1.2.1-2. The bound formula describes a bounding model including a mean and standard deviation (e.g. paired over-bounding Gaussian). The bound may be scaled by multiplying the standard deviation by a K factor corresponding to an IRallocation, for any desired IRallocation within the permitted range.

Bound for a particular error is computed according to the following formula:

*Bound = mean + K \* stdDev* (Equation 6.1.2.1-2)

*K = normInv(IRallocation / 2)*

*irMinimum <= IRallocation <= irMaximum*

where: *mean*: mean value for this specific error, as per Table 6.1.4

 *stdDev*: standard deviation for this specific error, as per Table 6.1.4

**Time-to-Alert (TTA):** The maximum allowable elapsed time from when the Error exceeds the Bound until a DNU flag must be issued.

**DNU:** The DNU flag(s) corresponding to a particular error as per Table 6.1.4-1. Where multiple DNU flags are specified, the DNU condition in Equation 6.1.2.1-1 is present when any of the flags are true (logical OR of the flags).

**Editor note: the DNU flag and its related description will be removed or updated later, if RAN2 conclude there is no need to indicate the DNU presence in the integrity principle equation.**

**Residual Risk:** The residual risk is the component of the integrity risk provided in the assistance data as per Table 6.1.4-1. This may correspond to the fault case risk but the implementation is permitted to allocate this component in any way that satisfies Equation 6.1.2.1-1.

The Residual Risk is the Probability of Onset which is defined per unit of time and represents the probability that the feared event begins. Each Residual Risk is accompanied by a Mean Duration which represents the expected mean duration of the corresponding feared event and is used to convert the Probability of Onset to a probability that the feared event is present at any given time, i.e.

*P(Feared Event is Present) = Mean Duration \* Probability of Onset of Feared Event* (Equation 6.1.2.1-3)

**irMinimum, irMaximum:** Minimum and maximum allowable values of IRallocation that may be chosen by the client. Provided as service parameters from the Network according to Integrity Service Parameters.

**Correlation Times:** The minimum time interval beyond which two sets of GNSS assistance data parameters for a given error can be considered to be independent from one another.

**Q1: Please insert your comments to text proposal of** **Integrity Principle of Operation in the table below.**

|  |  |
| --- | --- |
| **Company name** | **Comments** |
| Intel | In general, the text was copied from TS38.305 with additional editor note on open issues. I doubt whether the simple way is just to say, the text from TS38.305 can be reused with exception, and then add FFS/further study points in this section. Then copy the test from 6.1.2.2, i.e. we do not need to have sub-section for 6.1.2. |
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#### 6.1.2.2 Procedures and signalling for determination of positioning integrity

Signalling and procedures to support RAT-dependent positioning integrity determination are recommended for normative work. The details of the solutions are left for further discussion in normative work, which may include the following aspects:

- Support of integrity for both UE-based and LMF-based integrity for RAT-dependent positioning.

- The assistance information that will be used to support integrity determination;

- The information that will be used to provide the positioning integrity KPIs and integrity results.

Note 1: For UE-based integrity for RAT-dependent positioning, the R17 UE-based integrity mode signaling can be used as baseline with the following aspects:

* UE sends capability info to LMF on integrity for UE-based mode using LPP capability transfer procedure
* LMF sends the assistance data for integrity calculation to UE for integrity of UE-based mode
* LMF sends integrity requirement e.g., TIR to UE in LPP request location information message for integrity of UE-based mode
* UE sends integrity result to LMF using LPP location information Transfer message

Note 2: LMF provides, in assistance data, the information of error sources (e.g., originated from RAN node) to UE for integrity in UE-based mode.

**Q2: Please insert your comments to text proposal of** **Procedures and signalling for determination of positioning integrity in the table below.**

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| **Company name** | **Comments** |
| Intel | Note 1 and Note 2 should be normative text instead of Note. We can say, RAN2 studied singalling and procedures aspect for determination of positioning integrity and concluded:For UE-based integrity for RAT-dependent positioning, the R17 UE-based integrity mode signaling can be used as baseline with the following aspects:* UE sends capability info to LMF on integrity for UE-based mode using LPP capability transfer procedure
* LMF sends the assistance data for integrity calculation to UE for integrity of UE-based mode
* LMF sends integrity requirement e.g., TIR to UE in LPP request location information message for integrity of UE-based mode
* UE sends integrity result to LMF using LPP location information Transfer message
* LMF provides, in assistance data, the information of error sources (e.g., originated from RAN node) to UE for integrity in UE-based mode.
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### 6.1.3 Summary of Evaluation Results for Integrity for RAT-Dependent Positioning Techniques

### 6.1.4 Potential Specification Impact for Integrity for RAT-Dependent Positioning Techniques

The potential specification impact for the integrity of NR Positioning Technologies comprises the following.

- Specification of the LPP/NRPPa signalling and procedure to provide the error sources for NR RAT-dependent positioning technologies (RAN2, RAN3);

- Specification of the mode of positioning integrity report from UE to LMF for UE-based positioning (RAN2);

- Specification of a new Alert Assistance Data element ("DNU") for each error source in Table 6.1.4-1 (RAN2);

- Specification of a new Integrity Service Assistance Data Element to provide the minimum and maximum allowable values of *IRallocation* that may be chosen by the client (RAN2);

- Specification of the integrity bounds (mean and standard deviation of errors and error rates) for each error source in Table 6.1.4-1(RAN1);

- Specification of the residual risk component for each error source in Table 6.1.4-1(RAN1);

- Specification of the minimum time interval beyond which two sets of NR assistance data parameters for a given error can be considered to be independent from one another (Integrity Correlation Times) (RAN1).

Table 6.1.4-1 shows the mapping between the integrity fields and the NR assistance data.

 Table 6.1.4-1: Mapping of Integrity Parameters

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| Integrity Mode | Positioning method | Error | NR Assistance Data | Integrity Fields |
| Integrity Alerts | Integrity Bounds (Mean) | Integrity Bounds (StdDev) | Residual Risks | Integrity Correlation Times |
| LMF-based |  |  |  |  |  |  |  |  |
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| UE-based |  |  |  |  |  |  |  |  |
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**Editor note1: the Mapping of Integrity Parameters will be updated later based on RAN1 input of the error sources.**

**Editor note2: The DNU related description will be removed or updated later, if RAN2 conclude there is no need to indicate the DNU presence in the integrity principle equation.**

**Q3: Please insert your comments to text proposal of** **potential specification impact for integrity for RAT-Dependent positioning techniques in the table below.**

|  |  |
| --- | --- |
| **Company name** | **Comments** |
| Intel | RAN2 did not discuss this aspects, and therefore we should leave them out, or just copy RAN2 agreements |
| Huawei, HiSIlicon | RAN1 has already agreed on the following error sources and on the modelling of the error sources. Please refer to R2-2209426 for the clarsifications for the error sources. The table can be updated with the R1 agreements in this meeting for error source modeling**RAN1#110**

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| **Agreements:*** For LMF-based positioning integrity mode, at least the followings are error sources for timing related measurements:
	+ RSTD measurement is an error source for DL-TDOA
	+ RTOA measurement is an error source for UL-TDOA
	+ UE Rx-Tx time difference measurement is an error source for Multi-RTT
	+ gNB Rx-Tx time difference measurement is an error source for Multi-RTT
* FFS : Model of the error source (e.g., distribution, mean and/or standard deviation for integrity overbounding model, range)
* Note : Definition of “LMF-based positioning integrity mode” can be found in Table 9.4.1.1.1 in TR 38.857
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| **Agreements:*** For LMF-based positioning integrity mode, at least angle of arrival measurement is an error source for UL-AoA
* FFS : Model of the error source (e.g., distribution, mean and/or standard deviation for integrity overbounding model, range)
* FFS: The error can be expressed as the error of the AoA/ZoA in LCS or GCS or the error of a defined function of AoA/ZoA in LCS.
* Note : Definition of “LMF-based positioning integrity mode” can be found in Table 9.4.1.1.1 in TR 38.857
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| **Agreements:*** For UE-based positioning integrity mode, at least the following are error sources in assistance data:
* TRP location (e.g., NR-TRP-LocationInfo in TS 37.355) and Inter-TRP synchronization (e.g., NR-RTD-Info in TS 37.355) are error sources for DL-TDOA
* TRP location (e.g., NR-TRP-LocationInfo in TS 37.355) is an error source for DL-AoD
	+ FFS: whether boresight direction of DL-PRS (e.g., NR-DL-PRS-BeamInfo in TS 37.355) is an error source
	+ FFS: whether beam information of DL-PRS (e.g., NR-TRP-BeamAntennaInfo in TS 37.355) is an error source
* FFS : Model of the error source (e.g., distribution, mean and/or standard deviation for integrity overbounding model, range)
* Other error sources are not precluded
* FFS : Applicability of the above error sources to LMF-based positioning integrity mode
* Note : Definition of “UE-based positioning integrity mode” can be found in Table 9.4.1.1.1 in TR 38.857
* For LMF-based positioning integrity mode, ARP location (e.g., ARPLocationInformation in TS 38.455) is an error source for UL-AoA.
* FFS : Model of the error source (e.g., distribution, mean and/or standard deviation for integrity)
* Note : Definition of “LMF-based positioning integrity mode” can be found in Table 9.4.1.1.1 in TR 38.857
* FFS : Whether the error statistics of ARP location is available at the gNB
* Other error sources are not precluded
* For LMF-based positioning integrity mode, at least inter-TRP synchronization is an error source for UL-TDOA.
* FFS : Specification impact of inter-TRP synchronization as an error source for UL-TDOA
* Note : Definition of “LMF-based positioning integrity mode” can be found in Table 9.4.1.1.1 in TR 38.857
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**R2#110bis****Agreement*** The following distributions are identified as candidates for modeling of the distribution for inter-TRP synchronization error (e.g., NR-RTD-Info in TS 37.355)
	+ Uniform distribution
		- Note: this may already be consistent with the existing parameter NR-RTD-Info in TS 37.355
	+ Normal distribution
* Note: it is up to RAN2 how to use the identified distributions

**Agreement*** For LMF-based positioning integrity mode, TRP location (e.g., Geographical Coordinates in TS 38.455) is an error source for DL-TDOA, DL-AoD, UL-TDOA, UL-AoA and multi-RTT.
	+ Note : Definition of “LMF-based positioning integrity mode” can be found in Table 9.4.1.1.1 in TR 38.857
	+ FFS : Specification impact of TRP location as an error source for LMF-based positioning integrity mode
	+ FFS : Model of the error source (e.g., distribution, mean and/or standard deviation for integrity)

**Agreement*** Study the following alternatives for expression of angle of arrival measurement error for determination of positioning integrity for UL-AoA, and down select between Alt 1 and Alt 2:
	+ Alt. 1 : No conversion (e.g., the measurement error is expressed as error in AoA or ZoA in LCS/GCS)
	+ Alt. 2 : conversion function ( defined function of AoA/ZoA in LCS)
* FFS : Distribution of AoA measurement error for an NLOS/LOS link
* FFS : Other Details (e.g., mean, standard deviation)

**Agreement*** Timing measurement error can be modeled as Normal distribution.
	+ Note : The timing measurement is applicable to RSTD, RTOA and UE/gNB Rx-Tx time difference measurement
	+ Note: it is assumed that the timing measurement error is associated with the first path
* Note: it is up to RAN2 how to use the identified distribution

**Agreement**Capture the following into the TR* For UE-based positioning integrity mode, potential specification impacts related to errors in assistance data (e.g., to inter-TRP synchronization error and TRP locations) are at least enhancements in assistance data sent from the LMF to the UE (e.g., inclusion of parameters related to the error sources)
	+ Note : Definition of “UE-based positioning integrity mode” can be found in Table 9.4.1.1.1 in TR 38.857

**Agreement*** For UE-based positioning integrity mode, study whether boresight direction of DL PRS (NR-DL-PRS-BeamInfo) and/or beam information (NR-TRP-BeamAntennaInfo) of DL PRS are error sources or not, focusing on the following aspects:
	+ Granularity of boresight direction of DL-PRS and its influence on positioning integrity
	+ Feasibility and complexity of modeling
	+ Feasibility of obtaining quality/statistical parameters of beam information from the gNB
	+ Influence on measurement errors at the UE
* Other aspects are not precluded
* Note : Definition of “UE-based positioning integrity mode” can be found in Table 9.4.1.1.1 in TR 38.857

**Agreement*** From RAN1 perspective, study of the application of DNU flag for determination of positioning integrity is within the scope of RAN2 discussion.

**Agreement*** The following distributions are identified as candidates for modeling of the distribution for TRP location (e.g., NR-TRP-LocationInfo in TS 37.355) error
	+ Uniform distribution
		- Note: this may already be consistent with the uncertainty related to NR-TRP-LocationInfo specified in TS 37.355
	+ Normal distribution
* Note: it is up to RAN2 how to use the identified distributions

**Agreement*** In the agreement on the distribution of the timing measurement error, it is assumed that the timing measurement error contains TEG related TX/RX timing error if the TEG related information is provided.
	+ Note: The timing measurement is applicable to RSTD, RTOA and UE/gNB Rx-Tx time difference measurement
	+ Note: it is assumed that the timing measurement error is associated with the first path
* Note: no more discussion on TEG related TX/RX timing error as an independent error source from timing measurement error

**Agreement*** Study to determine whether DL PRS RSRP/RSRPP measurement is an error source for DL-AoD, focusing at least on the following aspect
	+ Impact of RSRP/RSRPP measurement on positioning accuracy
* FFS : Model of the error source (e.g., distribution, mean and/or standard deviation for integrity overbounding model, range)
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# 4 Conclusion

 Based on the discussion, there are proposals:

# 5 References

1. RAN2-119-e-Positioning-Relay-2022-08-26-2000\_eom.docx
2. RAN2-119bis-e-Positioning-Relay-2022-10-14-0440.docx
3. R2-2210364 Integrity of NR Positioning Technologies Qualcomm Incorporated discussion
4. R2-2209403 Discussion on RAT dependent integrity CATT discussion Rel-18 FS\_NR\_pos\_enh2
5. R2-2209426 Discussion on RAT-dependent integrity Huawei, HiSilicon discussion Rel-18 FS\_NR\_pos\_enh2
6. 3GPP TR 38.859 Study on Expanded and Improved NR Positioning (Release 18) V0.1.0 (2022-08)

# Annex 1: on related RAN2 agreements

**RAN2#119-e:**

Agreements:

Proposal 1: RAN2 to confirm the integrity principle of operation defined in the section 8.1.1a of TS38.305, including integrity definition (e.g., Error, Bound, Time to Alert, DNU, Residual Risk, irMinimum, irMaximum and Correlation Times; FFS if all parameters are needed in the RAT-dependent case), Equations for the GNSS integrity are reused for RAT dependent positioning methods.

Proposal 2 (modified): RAN2 may add the mapping between Integrity definition/Fields (Integrity Alerts, error bounds (mean, StdDev), Residual Risks, Integrity correlation times ) and Error sources/assistance data for RAT-dependent positioning methods later once RAN1 identifies new error sources.

**RAN2#119bis-e:**

Agreement:

Proposal 1-2. RAN2 study the usage of DNU flag for the RAT-dependent positioning integrity (assuming RAN1 agree to leave it to RAN2) and conclude on whether to indicate the DNU presence in the integrity principle equation.

Agreement:

Proposal 4. RAN2 will study the both UE-based and LMF-based integrity for RAT-dependent cases.

Agreement:

Proposal 7 (modified). RAN2 agree that R17 UE-based integrity mode signaling can be used as baseline with the following aspects:

- UE sends capability info to LMF on integrity for UE-based mode using LPP capability transfer procedure

- LMF sends the assistance data for integrity calculation to UE for integrity of UE-based mode

- LMF sends integrity requirement e.g., TIR to UE in LPP request location information message for integrity of UE-based mode

- UE sends integrity result to LMF using LPP location information Transfer message

Agreement:

LMF provides, in assistance data, the information of error sources (e.g., originated from RAN node) to UE for integrity in UE-based mode.