**3GPP TSG RAN WG1 #112bis-e R1-23xxxxx**

**e-Meeting, April 17th – 26th, 2023**

**Agenda Item: 9.5**

**Source: Moderator (InterDigital, Inc.)**

**Title: Rapporteur summary on LS reply for error source distributions (R1-2302282)**

**Document for: Discussion**

# Introduction

## RAN1 Task

In RAN2#121, the following agreement was made.

Agreements:

RAN2 anticipate that the error sources are overbounded by a Gaussian distribution.

LS to RAN1 to check this view and ask about the parameters for the overbound distributions.

Based on the agreement, the LS (R1-2302282) was sent to RAN1. The following question and task were asked and requested, respectively, by RAN2 in the LS. The LS is also shown in Appendix in this document.

* RAN2 would like to confirm with RAN1 on the above agreement regarding the distribution of error sources
* RAN1 to provide the parameters (e.g. mean and standard deviation) for the overbound Gaussian distribution.

In section 5, proposals are made based on the views presented by companies. The draft LS reply will be written based on the agreed proposals.

## Contact information

To facilitate discussions, please provide your contact information below.

|  |  |  |
| --- | --- | --- |
| **Company** | **Point of contact** | **Email address** |
| InterDigital Inc. | Fumihiro Hasegawa | Fumihiro.hasegawa@InterDigital.com |
| ZTE | Chuangxin Jiang | jiang.chuangxin1@zte.com.cn |
| Huawei, HiSilicon | Su Huang | huangsu2@huawei.com |
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# Background information

The following table was captured in TR 38.859 as the result of the study where the table captures error sources and identified candidate(s) for the distribution of each error source.

Table “Table 6.1.1-2: Identified candidates for distributions to model the errors due to different error sources” from TR 38.859

| Error source | Candidate(s) for distribution for error source |
| --- | --- |
| Timing measurement errors (NOTE 1, 2, 3) | Gaussian distribution |
| Inter-TRP synchronization errors | - Uniform distribution (NOTE 4)- Gaussian distribution |
| TRP location error (e.g., ***NR-TRP-LocationInfo*** in [16]) | - Uniform distribution (NOTE 5)- Gaussian distribution |
| TRP location error (e.g., Geographical coordinates in [17]) | - Uniform distribution- Gaussian distribution |
| ARP location error (e.g., ***ARPLocationInformation*** in [17]) | - Uniform distribution- Gaussian distribution |
| NOTE 1: Timing measurement errors are applicable to RSTD, RTOA and UE/gNB Rx-Tx time difference measurements.NOTE 2: It is assumed that the timing measurement error is associated with the first path.NOTE 3: It is assumed that the timing measurement error contains TEG related TX/RX timing error if the TEG related information is providedNOTE 4: This may already be consistent with the uncertainty related to ***NR-RTD-Info*** in [16].NOTE 5: This may already be consistent with the uncertainty related to ***NR-TRP-LocationInfo*** in [16]. |

# Checkpoints for email discussion

Tentative checkpoints regarding the assigned email discussion can be found below.

[112bis-e-R18-Pos-08] Email discussion on RAN2 LS on error source distributions in R1-2302282 by April 26 – Fumihiro (InterDigital)

* Tentative target for the agreement : Apr. 21
* Tentative target for the agreement of the draft LS : Apr. 25

## Deadline for the 1st round

* Deadline for the comments for the 1st round: Apr. 19 17:00 UTC

## Deadline for the 2nd round

* Deadline for the comments for the 2nd round: Apr. 20 23:59 UTC

# Suggested proposals for approval and discussion

The agreed proposals will be used as baseline for the LS reply.

TBD

# Issues for discussion

## Confirmation of RAN2 agreement

**Details of proposals**

As described in the background section, RAN1 identified uniform and Gaussian distribution as candidate distributions for TRP location error, ARP location error and inter-TRP synchronization error.

For the timing measurement errors, RAN1 agreed that the distribution follows Gaussian distribution.

Gaussian distribution based overbounding enables integrity calculations. The discussion topic here is to agree whether it is possible to overbound the distribution of the identified error source by a Gaussian distribution. The following views are presented regarding the distribution for error sources and Gaussian distribution based overbounding.

* RAN2 agreement can be confirmed since Gaussian distribution was identified as one of the candidate distributions for the error sources identified during the study item [1].
* Parameterize the Gaussian bound [2].
* Inter-TRP synchronization error and TRP location error can be modeled as Gaussian distribution. In addition, timing measurement error can be model as Gaussian distribution according to the outcome of the study item [3].
* RAN2 agreement on the use of the Gaussian distribution for overbounding can be confirmed [4].
* Candidate distribution (uniform or Gaussian) for the error sources can be bounded by a Gaussian distribution. Thus, the RAN2’s assumption is correct. Depending on the distribution, the bound may be loose depending on the true distribution of the error source. RAN2 need to check whether the bound will be tight enough to be usable [5].
* Over-conservative variance may be needed for overbounding the distribution of the error source by using a Gaussian distribution. If an error source follows the Uniform distribution, it is possible to lose information of the uniform distribution by overbounding with a Gaussian distribution. A proposal is made to use both distributions (Gaussian and Uniform) instead of using a single one to overbound both [6].
* The error sources whose distributions have been identified in TR 38.859 can be assumed to have Gaussian distribution [7].
* RAN2 agreement on the use of the Gaussian distribution for overbounding can be confirmed [8].

### Issue #1 : Confirmation of RAN2 agreement

Below is a summary of companies’ inputs.

* Whether to confirm the RAN2 agreement, “RAN2 anticipate that the error sources are overbounded by a Gaussian distribution”
	+ Yes : [1,2,3,4,5,7,8]
	+ Concern : [6]

Considering two companies have questioned about tightness of the bound. Thus, the following proposal is made, capturing the LS texts in [5] about the tightness of the bound.

Rapporteur proposal #1

* Confirm the RAN2 agreement “the error sources are overbounded by a Gaussian distribution” for the error sources listed in Table 6.1.1-2 in TR 38.859 Tightness of the bound should be considered so that it is useful in the integrity framework..

Companies views

|  |  |  |
| --- | --- | --- |
| **Company** | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
| CATT |  | The intention to include “Tightness of the bound should be considered” is unclear to us. Is it related to parameter to be discussed in Section 5.2? If so, there is no need to include it in there. If not, then there is a need to clarify what the ‘tightness of the bound” means, and which WG should work on it. |
| ZTE | Support  | We suggest removing the sentence of ‘Tightness of the bound should be considered so that it is useful in the integrity framework’ if we don’t know how to judge the tightness. |
| Huawei, HiSilicon |  | Is it correct understanding that uniform distribution will not be considered at all? |
| Nokia/NSB |  | We are okay to confirm RAN2 agreement. We think the discussion on the tightness of the bound is related to the parameter values, but if it is helpful to mention the tightness of the bound here, we are okay. In addition, we have the same question. Do we exclude the uniform distribution ? |
| Moderator |  | Based on the comments received so far, the moderator would like to check if the following proposal is acceptable.* Concern from some companies is that a single Gaussian overbound cannot bound Uniform distribution.
* The majority view is that the Gaussian overbounding is applicable if the error source follows the Gaussian distribution.
* The sentence related to tightness is removed.

The modified proposal (Rapporteur proposal #1-1) attempts to capture both aspects. Changes are indicated in red.**Rapporteur proposal #1-1*** Confirm the RAN2 agreement “the error sources are overbounded by a Gaussian distribution” for the error sources listed in Table 6.1.1-2 in TR 38.859 ~~Tightness of the bound should be considered so that it is useful in the integrity framework.~~. if the error source follows a Gaussian distribution.
* From RAN1’s perspective, if an error source listed in Table 6.1.1-2 in TR 38.859 follows the Uniform distribution, the RAN2 agreement “the error sources are overbounded by a Gaussian distribution” may not be valid.
 |
| Samsung  |  | Considering that the uniform distribution and Gaussian distribution has been identified as candidates for modeling the distribution of the identified error sources in RAN1, the second bullet in the updated proposal looks strange because RAN2 has already make their decision. In our view, we only need to confirm that the error sources can be overbounded by a Gaussian distribution. That is enough. |
| Intel |  | We share similar thoughts as Samsung. The new current second sub-bullet seems to be saying that overbounding is not possible at all which is not quite correct. We could keep the first sub-bullet and to address the (valid) point about potential over-conservativeness resulting due to overbounding of a uniform distribution using a Normal distribution, we can add an “at least” to the first sub-bullet: “… at least if the error source follows a Gaussian distribution”.  |
| ZTE |  | We share the similar view as Samsung. It is obvious that the uniform distribution is not selected by RAN2. The following is sufficient:Confirm the RAN2 agreement “the error sources are overbounded by a Gaussian distribution” for the error sources listed in Table 6.1.1-2 in TR 38.859. |
| Lenovo |  | We tend to agree with the Moderator’s updated reply. We also generally agree that RAN1 has concluded on uniform and gaussian distributions depending on the error source during the study phase and this should be reflected and emphasized in our reply. While it may be straight-forward to overbound Gaussian error distributions with a Gaussian distribution, we question the accuracy of applying the same the overbounding technique to a uniform distribution given that it may limit/truncate the range values over which the uniform error distribution is defined. |
| Ericsson |  | For the last bullet, after some further check, it seems that RAN2 is aware of the potential issue. The idea was to convey that in some cases the gaussian distribution is very lose and RAN2 should consider it when using the bound. Thus, we are fine removing the last bullet regarding tightness of the bound if this helps progress for the LS.   |
| Qualcomm |  | We think the RAN2 agreement on Gaussian overbounding did not sufficiently clarify whether the overbounding is using a single Gaussian distribution or following the ‘paired Gaussian overbounding’ technique as followed in GNSS literature, e.g. in the reference [[link](http://web.stanford.edu/group/scpnt/gpslab/pubs/papers/Rife_IEEEIONPLANS_2004.pdf)]. Note that ‘reusing GNSS concepts’ was agreed to be a guiding principle throughout this effort. The concerns around overbounding of uniformly distributed error sources can also be addressed with this approach. We propose to clarify this in the wording of the original proposal 1: ‘Confirm the RAN2 agreement “the error sources are overbounded by a Gaussian distribution” for the error sources listed in Table 6.1.1-2 in TR 38.859, with the clarification that paired overbounding is used’. We can omit the part about the tightness of the bound (as done in proposal 1-1), but we don’t then need the added red text in proposal 1-1. |

#### Summary of the 1st round discussion

I would like to thank the companies for their views. They are very helpful.

Based on the inputs from Samsung, Intel, ZTE, Lenovo and Ericsson, it seems that it is better to focus on applicability of RAN2 agreement on error source which follows the Gaussian distribution. The moderator would like to remove the second bullet in Rapporteur proposal #1-2.

Based on companies’ inputs, it seems like the treatment of bounding technique for the error source which follows the Uniform distribution should be left up to RAN2.

Regarding the comment from Qualcomm, the proposed suggestion is to indicate that RAN1 assumes the paried overbounding is used. When the distribution of the error source is unknown, the paired overbounding is used, as described in R2-2108474 as an example (or reference mentioned by Qualcomm above).

However, whether paired overbounding is applicable for the error source which follows the Uniform distribution is not part of the discussion for the LS reply. Such discussion should take place in RAN2.

In addition, the moderator understands that the RAN2 agreement “RAN2 anticipate that the error sources are overbounded **by a Gaussian distribution**,” implies **a single bound** (i.e., not a paired bound) is used.

Qualcomm raised a good point and from the moderator’s point of view, it may be beneficial for clarification purpose to mention in the LS reply that RAN1 understands that the single Gaussian distribution-based bound is assumed in the RAN2 agreement.

I would like to see if the following proposal is agreeable. I have added “From RAN1’s perspective” in the proposal, removed the 2nd sub-bullet in proposal #1-2 and kept the condition. I have added the new second sub-bullet for clarification for the issue raised by Qualcomm.

The following proposal is made. If there is a strong concern about the proposal, I’d appreciate suggestions for modification.

#### **Rapporteur proposal #1-3**

* From RAN1’s perspective, the RAN2 agreement “the error sources are overbounded by a Gaussian distribution” can be confirmed for the error sources listed in Table 6.1.1-2 in TR 38.859 if the error source follows a Gaussian distribution.
* It is RAN1's understanding that a single Gaussian distribution-based bound is assumed in the RAN2 agreement.

#### Companies views

|  |  |  |
| --- | --- | --- |
| **Company** | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
|  |  |  |

## Parameters for the overbound Gaussian distribution

**Details of proposals**

The following views are presented in the contributions regarding the parameters for the overbound Gaussian distribution.

* The parameters for the Gaussian distribution can be mean and standard deviation. Zero-mean error can be assumed since any bias in the mean can be removed mostly by UE/gNB/LMF implementation. It is shown in the tables in 2.3.2 in [1] that quality information presented in TS 37.355 and TS 38.455 (e.g., nr-TimingQuality, nr-PathQuality, rtd-Quality, Timing Measurement Quality) can be used to present the standard deviation [1].
* The parameters for the Gaussian distribution can be mean and standard deviation [2]. Mean and standard deviations for each error source are listed in [2].
* The range of standard deviation for the timing measurement error can be derived from NR-TimingQuality in TS 37.355 [3]. rtd-RefQualit can be used to derive the range for the standard deviation for Inter\_TRP synchronization error [3]. locationUNC can be used to derive the value range for TRP location error. Finally, angle measurement quality can be used to derive the value range for the angle measurement error [3].
* Use existing fields to derive the range value for the standard deviation of the bound. The mean can be zero or non-zero, based on implementation [4].
* The value range for the standard deviation of the identified error source can be derived based on rtd-Quality-r16, NR-TimingQuality-r16 and LocationUncertainty-r16 [5].
* There is no need to report the mean. For the standard deviation for the overbound Gaussian distribution, it is proposed to introduce a new field [6].
* The standard deviation value can be derived based on uncertainty parameters (e.g., nr-TimingQuality, locationUNC) and TS 23.032 can be used as a reference [7].
* The parameters for the Gaussian distribution can be mean and standard deviation. It is up to RAN2 to decide the details of the parameters for the overbound Gaussian distribution [8].

Based on the above views, the following proposals are made.

### Issue #2 : Identification of parameters for an overbound Gaussian distribution

Based on the inputs from all companies, it can be agreed that parameters for the distribution of error sources can be mean and standard deviation.

#### **Rapporteur proposal #2**

* Parameters for the overbound Gaussian distribution can be mean and standard deviation

#### Companies views

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** |  | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
| CATT |  |  | If “Zero-mean” is assumed as shown in proposal#3, do we still need to include mean in the parameters? |
| ZTE |  | Yes |  |
| Huawei, HiSilicon |  |  | Share similar comments as CATT. Why do not we just combine proposal 2 and proposal 3? |
| Nokia/NSB |  |  | We are okay with the proposal. |
| Samsung  |  | Yes |  |
| Lenovo |  | Support |  |
| Ericsson |  | yes | In the RAN2 spec, the mean is used as a bias for the double gaussian distribution, and can be non-zero.  |
| Qualcomm |  | Yes with clarification | Same clarification as in our comment on Proposal 1. |
| FL |  |  | The intention of the proposal was to clarify whether mean and standard deviation are the only parameters that should be considered. It seems like companies can agree on the proposal. Mean and standard deviation should be applicable parameters regardless of single or paired overbounding is used. The moderator would like to collect more views on this. The moderator also suggests to keep the original proposal. |

### Issue #3 : Mean value for the overbound Gaussian distribution

Based on the majority view, except [4], it seems agreeable that the zero-mean can be assumed for the overbound Gaussian distribution.

Rapporteur proposal #3

* From RAN1’s perspective, Zero-mean can be assumed for the overbound Gaussian distribution for the error sources listed in Table 6.1.1-2 in TR 38.859

Companies views

|  |  |  |
| --- | --- | --- |
| **Company** | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
| CATT | Support |  |
| ZTE | Yes |  |
| Huawei, HiSilicon | Support |  |
| Nokia/NSB | Support |  |
| Samsung  |  | From our perspective, the mean and standard deviation should be decided by RAN2.  |
| Intel | Support |  |
| Lenovo | Support |  |
| Ericsson | No | At least to bound a uniform distribution we expect a non-zero value for the mean in the double gaussian. This can be left to RAN2.   |
| Qualcomm | No | There may be unknown real-world error sources not captured in the simulations done so far. So it is safer not to assume zero mean only based on simulations to date. The paired overbounding involves both mean and variance. Zero mean could always be handled as a special case by including it in the value-range. |

#### Summary of the 1st round discussion

It seems like there are some concerns for assuming zero-mean for error sources. The moderator would like to make the following proposal based on the companies’ views. The change made to the proposal is to include the possibility of non-zero mean.

#### **Rapporteur proposal #3-1**

* From RAN1’s perspective, Zero-mean or non-zero mean can be assumed for the overbound Gaussian distribution for the error sources listed in Table 6.1.1-2 in TR 38.859

#### Companies views

|  |  |  |
| --- | --- | --- |
| **Company** | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
| Huawei, HiSilicon | Disagree | If it is clear that uniform distribution is ignored by RAN2, we do not think a non-zero mean should be introduced for uniform distribution.Also from the LS, we cannot see any clue that RAN2 is assuming paired over-bounding, and we do not support to introduce the mean with Gaussian distribution for describing the paired over-bounding, at least not from RAN1 point of view.We assume that the mean should be signaled, then if a non-zero mean for the error should be signaled, then the non-zero mean should be added to the value in the AD or the value in the measurement. |
| CATT |  | Our preference is to assume zero-mean. If non-zero-mean is provided, then the question is if a UE/TRP knows the measurement error is biased, and also know bias, which is reported as non-zero-mean, why the UE/TRP does not make the correction of the bias before the measurement reporting? |

### Issue #4 : Standard deviation for the overbound Gaussian distribution

Whether to use the existing quality information and uncertainty information to derive the value range for the standard deviation for the overbound is discussed in companies’ contributions. The following views are presented.

* + Yes, existing quality information and uncertainty information can be used as a reference to derive the value range for the standard deviation for the overbound : [1,3,4,5,7]
	+ Introduce a new field for the standard deviation or range depending on the distribution of the error source : [6]

Based on the companies’ views, the moderator makes the following proposal. Whether to introduce a new field for reporting additional information related to the overbound can be discussed in RAN2.

Rapporteur proposal #4

* Existing fields corresponding to quality information (e.g., nr-TimingQuality, rtd-Quality-r16) and uncertainty information (e.g., LocationUncertainty-r16) can be used as a reference to derive the value range for the parameters (e.g., standard deviation) for the overbound Gaussian distribution for the error sources listed in Table 6.1.1-2 in TR 38.859.

Companies views

|  |  |  |
| --- | --- | --- |
| **Company** | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
| CATT | Support |  |
| ZTE |  Support in principle.More details are needed for the reply LS | The proposal is not sufficient to reply RAN2’s question which need the clear candidates/range of the parameters. So one FFS is needed to further discuss the std range.For std of timing measurement error source, we think an independent report is needed which is separate from the exiting nr-TimingQuality. That is because the std report of integrity is more like a statistic report, it is higher level, and report per TRP rather than per measurement element. The report periodicity is longer, and may not be needed to report in every measurement element. From RAN1 perspective, we suggest providing the clear parameter range, e.g. * *Std value :{0,1,2,... stdmax}, where* $std\_{max}=round (\frac{31}{n})$ *, and n= 3*
* *Resolution: {mdot1, mdot5, m1, m5, m10, m20, m30}*

For std of TRP location error, we think an independent report is not needed, and the std value can be derived from the existing parameter LocationUncertainty-r16 including all of the following sub-parameters horizontalUncertainty-r16  horizontalConfidence-r16  verticalUncertainty-r16  verticalConfidence-r16It should be noted that the confidence should be considered as it is the percentage within which the uncertainty is ensured. The details can be found in our contribution. |
| Huawei, HiSilicon |  | We slightly prefer to use new parameters for all errors including measurement error and AD error. For reusing the existing field, another indication should be provided to be backward compatible. |
| Nokia/NSB | Support |  |
| Moderator |  | Thank you very much for the views. @ZTE, @Huawei, HiSiliconFrom the moderator’s perspective, the discussion related to value range can be done in RAN2. The intention of this proposal is to present the starting point for RAN2’s analysis and present references which RAN2 can use to determine the value range.A commonality between the views presented by ZTE and Huawei, HiSilicon is that there may be a need to introduce a new report/indicator for the standard deviation of the bound.However, such discussion may be out of scope for RAN1 as it relates to signaling details. The moderator’s suggestion is to simply present the references for the standard deviation. If RAN2 determines that the reference is not useful, then RAN2 may consider introduction of a new indicator/measurement report. The moderator’s understanding is that RAN2 has not considered using available information in the current specification to determine error source parameters. The proposal (based on companies’ views) should be beneficial for RAN2.Please note that the current proposal indicates “can be used”, not eliminating possibilities of introduction of new report/indication of the standard deviation.I hope Rapporteur proposal #4 serves as the compromise. |
| Samsung  |  | From our view, the mean and standard deviation should be decided by RAN2. But we can accept to give some suggestions from RAN1’s perspective for compromise, as shown in the proposal. |
| Intel | Support. |  |
| ZTE |  | To make FL job easier, we suggest a slight change as follows. From RAN1 perspective, the value ranges of existing fields corresponding to quality information (e.g., nr-TimingQuality, rtd-Quality-r16) and uncertainty information (e.g., LocationUncertainty-r16) can be used as a reference to derive the value ranges for the parameters (e.g., standard deviation) for the overbound Gaussian distribution for the error sources listed in Table 6.1.1-2 in TR 38.859. |
| Lenovo | Support | We view this a re-use of existing quality/uncertainty value ranges to derive the parameters. Suggest an additional minor change for RAN2 guidance: From RAN1 perspective, the value ranges of existing fields corresponding to quality information (e.g., nr-TimingQuality, rtd-Quality-r16) and uncertainty information (e.g., LocationUncertainty-r16) can be reused as a reference to derive the value ranges for the parameters (e.g., standard deviation) for the overbound Gaussian distribution for the error sources listed in Table 6.1.1-2 in TR 38.859. |
| Ericsson  |  | We think the IEs for quality can be reused but we agree that separate reports may be more efficient as ZTE mention. This is up to RAN2 however.  |
| Qualcomm | Support | This is a good starting point |

#### Summary of the 1st round discussion

Thank you very much for your inputs and being constructive with the suggestion. I would like to incorporate the suggestion from ZTE and Lenovo into the proposal since the value range of existing fields can be used as a reference to determine the value range for standard deviation, if it is feasible. The following proposal is made.

#### **Rapporteur proposal #4-1**

* From RAN1 perspective, the value ranges of existing fields corresponding to quality information (e.g., nr-TimingQuality, rtd-Quality-r16) and uncertainty information (e.g., LocationUncertainty-r16) can be reused as a reference to derive the value ranges for the parameters (e.g., standard deviation) for the overbound Gaussian distribution for the error sources listed in Table 6.1.1-2 in TR 38.859.

#### Companies views

|  |  |  |
| --- | --- | --- |
| **Company** | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
| CATT | Support |  |

# References

Discussion

[1] R1-2302642, “Discussion of RAN2 LS on error source distributions,” CATT, RAN1#121bis-e, Apr. 2023.

[2] R1-2302772, “Discussion on LS on error source distributions, ” OPPO, RAN1#121bis-e, Apr. 2023.

[3] R1-2303272, “Discussion on error source distributions for integrity, ” ZTE, RAN1#121bis-e, Apr. 2023.

[4] R1-2303442, “Discussion on LS reply regarding error source distributions, ” InterDigital, RAN1#121bis-e, Apr. 2023.

[5] R1-2303544, “discussion on draft reply LS on error source distributions, ” Ericsson, RAN1#121bis-e, Apr. 2023.

[6] R1-2303859, “Discussion on error source distributions, ” Huawei, HiSilicon, RAN1#121bis-e, Apr. 2023.

Draft LS reply

[7] R1-2302448, “[Draft] Reply LS on error source distributions, ” vivo, RAN1#121bis-e, Apr. 2023.

[8] R1-2303096, “Draft reply LS on error source distributions, ” Samsung, RAN1#121bis-e, Apr. 2023.

[9] R1-2303271, “Draft Reply LS on error source distributions, ” ZTE, RAN1#121bis-e, Apr. 2023.

[10] R1-2302643, “[Draft] Reply LS on error source distributions, ” CATT, RAN1#121bis-e, Apr. 2023.

[11] R1-2303441, “Draft Reply LS to RAN2 on error source distributions, ” InterDigital, RAN1#121bis-e, Apr. 2023.

# Appendix : R1-2302282, “LS on error source distributions”

**“1. Overall Description:**

During the discussion on RAT-dependent positioning integrity, RAN2 has reached the following agreement regarding the distribution of error sources:

Agreements:

RAN2 anticipate that the error sources are overbounded by a Gaussian distribution.

RAN2 would like to confirm with RAN1 on the above agreement regarding the distribution of error sources and respectfully ask RAN1 to provide the parameters (e.g. mean and standard deviation) for the overbound Gaussian distribution.

**2. Actions**

**To RAN1 groups**

**ACTION:** RAN2 respectfully asks RAN1 to confirm above agreement and provide the parameters (e.g. mean and standard deviation) for the overbound Gaussian distribution.”

# Summary of proposals, observations and LS reply from contributions for RAN1#112b-e

## [1, CATT]

Observation 1: The error sources may be cross-correlated and time-correlated. The parameterization of the Gaussian distribution for error sources is contingent upon whether the cross correlation and time correlation of the error sources are taken into account.

Proposal 1: Confirms RAN2’s agreement: “the error sources are overbounded by a Gaussian distribution”.

Proposal 2: In Rel-18, all identified error sources can be treated as independent Gaussian distribution variables. Time correlation of the error sources will not be considered.

Proposal 3: Each identified error source can be considered as a variable following a zero-mean Gaussian distribution.

Proposal 4: Inform RAN2 that the standard deviation of Gaussian distribution of the error sources can be presented by the quality parameters defined in TS 37.355 and TS 38.455 as shown in the following table.

-Note: Whether to use existing parameters or introduce new parameters to represent the standard deviation of Gaussian distribution of the error sources can be determined by RAN2 or RAN3.

|  |  |  |
| --- | --- | --- |
| **Error source** | **Standard deviation** | **Description** |
| RSTD error | *nr-TimingQuality (TS 37.355)**nr-PathQuality (TS 37.355)* | *nr-TimingQuality* specifies the target device′s best estimate of the quality of the RSTD measurement.*nr-PathQuality* specifies the target device′s best estimate of the quality of the detected timing of the additional path*.* |
| UE Rx-Tx time difference measurement error | *nr-TimingQuality (TS 37.355)**nr-PathQuality (TS 37.355)* | *nr-TimingQuality* specifies the target device′s best estimate of the quality of the UE Rx-Tx time measurement.*nr-PathQuality* specifies the target device′s best estimate of the quality of the detected timing of the additional path*.* |
| Inter-TRP synchronization | *rtd-RefQuality (TS 37.355)**rtd-Quality (TS 37.355)* | *rtd-RefQuality* specifies the quality of the timing of reference TRP.*rtd-Quality* specifies the quality of the RTD. |
| TRP/ARP location error | *locationUNC (TS 37.355)* | *locationUNC* specifies the uncertainty of the location coordinates and comprises the following sub-fields:- *horizontalUncertainty* indicates the horizontal uncertainty of the ARP latitude/longitude.- *verticalUncertainty* indicates the vertical uncertainty of the ARP altitude. |
| RTOA measurement error | *Timing Measurement Quality (TS 38.455)* | specifies the quality of the RTOA measurement. |
| AOA measurement error | *Angle Measurement Quality (TS 38.455)* | specifies the quality of the AoA measurement |

## [2, OPPO]

Proposal 1: The parameters for overbound Gaussian distribution for each identified error source are:

-TRP location error: the mean TRP location offset, and the std of TRP location offset

-Inter-TRP synchronization error: the mean inter-TRP synchronization offset and the std of inter-TRP synchronization offset

-ARP location error: the mean ARP location offset and the std of ARP location offset

-Angle of arrival measurement error: the mean AoA measurement error, the std of AoA measurement error, the mean ZoA measurement error, the std of ZoA measurement error.

-DL-PRS RSRPP measurement error: the mean RSRPP measurement error and the std of RSRPP measurement error

-RSTD measurement error: the mean RSTD measurement error and the std of RSTD measurement error

-RTOA measurement error: the mean RTOA measurement error and the std of RTOA measurement error

-UE Rx-Tx time difference measurement error: the mean UE Rx-Tx time difference measurement error and the std of UE Rx-Tx time difference measurement error

-gNB Rx-Tx time difference measurement error: the mean gNB Rx-Tx time difference measurement error and the std of gNB Rx-Tx time difference measurement error

## [3, ZTE]

***Proposal 1:*** *For distributions of timing measurement error sources which have been agreed as Normal distribution, the range of std can be based on the maximum value of the existing parameter NR-TimingQuality-r16:*

* *Std value :{0,1,2,... stdmax}, where* $std\_{max}=round (\frac{31}{n})$ *, and n= 3*
* *Resolution: {mdot1, mdot5, m1, m5, m10, m20, m30}*

***Proposal 2:*** *Inter-TRP synchronization error is normal distribution.*

* *Std value:{0,1,2,... stdmax}, where* $std\_{max}=round (\frac{31}{n})$ *, and n= 3*
* *Resolution: {mdot1, mdot5, m1, m5, m10, m20, m30}*

***Proposal 3:*** *TRP/ARP location error distribution is modeled as normal distribution. The std can be calculated based on the existing parameter LocationUncertainty including uncertainty value and confidence value.*

* *The std value* $δ$ *should make* *, and* , *where P is the confidence value, a is the Uncertainty value, and*  *is the inverse error function, and* *.*

* *The extra signaling is not needed.*

***Proposal 4:*** *For angle related error sources, the range of the std can be based on the maximum value of the existing parameter of Angle Measurement Quality.*

* *Std value:{0,1,2,... stdmax}, where* $std\_{max}=round (\frac{255}{n})$*, and n = 3*
* *Resolution: {0.1deg,...}*

## [4, InterDigital]

Observation 1: Mean for timing measurement error can be zero nor non-zero

Observation 2: Mean for TRP location error, inter-TRP synchronization error or ARP location error can be zero or non-zero.

Proposal 1: For the discussion related to LS reply for R2-2302271, limit the scope of the discussion to the error sources listed in Table 6.1.1-2 in TR 38.859.

Proposal 2: RAN1 can confirm that error sources with options for distributions listed in Table 6.1.1-2 in TR 38.859 can be overbounded by a Gaussian distribution.

Proposal 3: Mean for the error sources shown in Table 6.1.1-2 in TR 38.859 can be zero or non-zero depending on implementations at the UE or network.

Proposal 4: References for derivation of the value range for the standard deviation for error sources shown in Table 6.1.1-2 in TR 38.859 can be uncertainty or quality indicator in specification, e.g., nr-TimingQuality for timing measurement error, locationUNC for TRP/ARP location error and NR-RTD-Info for inter-TRP synchronization error.

## [5, Ericsson]

Proposal 1 The RAN2 assumption to always overbound errors with a Gaussian distribution is valid from the RAN1 perspective.

Proposal 2 The parameters for the gaussian distribution (mean and variances) can use the uncertainty parameters for the respective error measurement as a starting point.

## [6, Huawei, HiSilicon]

Observation 1: Having an overbounding Gaussian distribution for an error source with Gaussian distribution may result in an over-conservative reporting of the variance.

Observation 2: If RAN2 intention is to use overbounding Gaussian distribution for an error source with uniform distribution, it may lose the information of the uniform distribution, and the variance of the overbounding Gaussian distribution can be arbitrarily set.

Proposal 1: RAN1 clarifies that it is preferred to use the both distributions (Gaussian and Uniform) instead of using a single one to overbound both. RAN1 sees the problem of overbounding the uniform distribution with a Gaussian distribution.

Proposal 2: To describe any Gaussian distribution for an error source, there is no need to report the mean, and a new field for the std can be introduced.

Proposal 3: To describe any uniform distribution for an error source, there is no need to report the mean, and a new field for the range can be introduced.

Proposal 4: Endorse the reply in the Appendix.

## [7, vivo]

RAN1 would like to provide the following response for the value range of mean and standard deviation for the agreed error source as the following table, where the deviation is determined according to uncertainty parameter(e.g., nr-TimingQuality, locationUNC)

| Error source | Candidate(s) for distribution for error source | Value range of mean and deviation |
| --- | --- | --- |
| Timing measurement errors (NOTE 1, 2, 3) | * Gaussian distribution
 | Mean: 0Deviation: INTEGER (0..31)Resolution:ENUMERATED (0.1m, 1m, 10m, 30m, …) |
| Inter-TRP synchronization errors | * Gaussian distribution
 | Mean: 0Deviation: INTEGER (0..31)Resolution:ENUMERATED (0.1m, 1m, 10m, 30m, …) |
| TRP location error (e.g., ***NR-TRP-LocationInfo*** in [16]) | * Gaussian distribution
 | Mean of horizontal: 0 Deviation of horizontal: INTEGER (0..255) Mean of vertical 0Deviation of vertical: INTEGER (0..255) (and the Deviation value can be mapped to the uncertainty value in TS 23.032) |
| ARP location error (e.g., ***ARPLocationInformation*** in [17]) | * Gaussian distribution
 | Mean of horizontal:0Deviation of horizontal: INTEGER (0..255) Mean of vertical 0Deviation of vertical: INTEGER (0..255) (and the Deviation value can be mapped to the uncertainty value in TS 23.032) |
| NOTE 1: Timing measurement errors are applicable to RSTD, RTOA and UE/gNB Rx-Tx time difference measurements.NOTE 2: It is assumed that the timing measurement error is associated with the first path.NOTE 3: It is assumed that the timing measurement error contains TEG related TX/RX timing error if the TEG related information is provided |

## [8, Samsung]

RAN1 reply: RAN1 confirms the RAN2 agreement but it is up to RAN2 for deciding the parameters (e.g., mean and standard deviation) for the overbound Gaussian distribution.