**3GPP TSG RAN WG1#116bis**  **R1-** **240xxxx**

**Changsha, China, April 15 – 19, 2024**

Agenda Item: 8.2

Source: Moderator (CATT)

Title: FL Summary #1 for Reply LS on NR DL and UL carrier phase positioning

Document for: Discussion and Decision

# Introduction

In R1-2312661/R2-2400031[1], RAN2 askes RAN1 to further investigate the following issues:

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| ***Issue 1: DL-PRS Rx hopping for NR DL-AoD positioning method***According to the RRC parameter list in R1-2312697 included in the LS, LMF can request UE to perform DL-PRS measurements based on receiving multiple hops of DL-PRS using the parameter *nr-Requested-DL-PRS-measurementBasedOnMultihopRx*. According to R1-2312697, the parameter nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx, which indicates that the reported measurement is based on receiving single or multiple hops of DL-PRS, is only applicable for NR DL-TDOA and NR Multi-RTT and does not mention other positioning methods. However, from RAN2’s perspective, if LMF can request UE to perform DL-PRS Rx hopping for NR DL-TDOA and NR Multi-RTT, it should also be able to request the reported measurement for NR DL-AoD.**Question 1:** Does the parameter *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* also apply to NR DL-AoD positioning?***Issue 2: Clarification on the DL-PRS ID associated with aggregated measurement report***RAN2 observed that there is neither dl-PRS-ID nor dl-PRS-IDs included in the RRC parameter list R1-2312697. It is unclear to RAN2 how to include dl-PRS-ID when reporting the nr*-aggregated-DL-PRS-ResourceSetIDList* in *NR-DL-TDOA-MeasElement* and *NR-Multi-RTT-MeasElement*.**Question 2:** Is there only one dl-PRS-ID or are there multiple dl-PRS-IDs associated with the aggregated main and additional measurement, respectively?**Question 3**: If there are multiple dl-PRS-IDs associated with main and additional measurements, respectively, should the list of the dl-PRS-IDs in additional measurements be included in the list of dl-PRS-IDs in the main measurement? |

This document provides a summary for the investigation.

# Issue 1: DL-PRS Rx hopping for NR DL-AoD positioning method

***Submitted Proposals:***

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| *vivo[2]* | **For Question 1:** Yes, *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* also applies to NR DL-AoD positioning, since there is no restriction for the PRS measurement with Rx frequency hopping according to the following RAN1 specification.  |
| *OPPO[3][4]* | Proposal 1: The answer to Question 1 is:* The parameter nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx also applies to NR DL-AoD positioning.
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| *CATT[5][6]* | **Answer 1:** The parameter *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* does not apply to NR DL-AoD positioning. |
| *Samsung[7]* | A1: Although when RAN1 decides that parameter, it’s not limiting to DL-TDoA, however the angle-based positioning method did not like timing-based method which relies on the relatively large bandwidth size for a satisfied timing resolution. So RAN1 think this parameter did not need to apply to DL-AoD positioning.  |
| *Nokia[10]* | **Question 1:** Does the parameter *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* also apply to NR DL-AoD positioning?* **Answer:** The main intention of introducing the Rx frequency hopping is to improve accuracy of timing measurements of RedCap UEs. However, given that UEs may report RSRP measurements together with RSTD and/or UE Rx-Tx time difference measurements, it is obvious that UE will perform RSRP/RSRPP measurements with the Rx frequency hopping technique. Even though NR DL-AoD positioning measurement reported is only RSRP/RSRPP measurements, the same RSRP/RSRPP measurement can be performed using Rx frequency hopping. So, DL AoD positioning with Rx frequency hopping is to be supported.
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| *Intel[11]* | **Question 1: Does the parameter *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* also apply to NR DL-AoD positioning?****Answer 1:** Yes, the parameter can also apply to NR DL-AoD positioning.  |
| Ericsson[12] | *Proposal 1 Do not include Rx hopping related parameters in DL AOD measurement reports* |
| *Huawei, HiSilicon [13]* | ***Proposal 1: Reply to RAN2 that:**** ***For the question 1, the parameter nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx is also applicable to NR DL-AoD positioning.***
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FL Comments:

About whether *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* is also applicable to NR DL-AoD positioning, the companies’ views may be summarized as follows[2-13]:

* **Yes**: vivo, OPPO, Nokia, Intel, Huawei, HiSilicon, Qualcomm
* **No**: CATT, Samsung, Ericsson

In one hand, some companies consider that when UE can perform the RSRP/RSRPP measurements together with RSTD and/or UE Rx-Tx time difference measurements with the Rx frequency hopping, and RSRP/RSRPP measurement performances can be improved with the Rx frequency hopping.

On the other hand, some other companies do not support “*nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* is applicable to NR DL-AoD positioning”. The consideration is based on that the intention of Rx frequency hopping is for improving timing measurement accuracy with larger bandwidth, although it does not necessarily mean *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* is applicable or not to NR DL-AoD positioning.

In FL’s view, another option may be considered, i.e., when *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx,* it can be up to UE on whether to obtain the RSRQ measurements for NR DL-AoD positioning based on Rx frequency hopping.

### Question 2-1

What is your view on the following response to the question on “*nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* is also applicable to NR DL-AoD positioning”?

* Option 1: Yes. *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* is also applicable to NR DL-AoD positioning.
* Option 2: No. *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* is not applicable to NR DL-AoD positioning.
* Option 3: When *nr-ReportedDL-PRS-measurementBasedOnSingleOrMultihopRx* is configured, it is up to UE on whether to obtain the RSRP measurements for NR DL-AoD positioning based on Rx frequency hopping.

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| **Company** | **comments** |
| Qualcomm | Option 1 |
| Huawei, HiSilicon | Option 1. |
| Intel | Option 1. |
| CATT | Option 3. |
| ZTE | Option 1 |

# Issue 2: DL-PRS ID associated with aggregated measurements

***Submitted Proposals:***

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| *vivo[2]* | **For Question2:**

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| AgreementSend an LS to RAN2 with the following contentWith regards to higher layer parameter *dl-PRS-ID*, RAN1 understands that the current RAN2 specification support two interpretations:* Interpretation 1: PRS resource sets in different PFLs of a TRP are configured with the same dl-PRS-ID
* Interpretation 2: PRS resource sets in different PFLs of a TRP can be configured with different dl-PRS-ID
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Based on the LS in R1-2308646 above, both one dl-PRS-ID or multiple dl-PRS-IDs associated with the aggregated main and additional measurement are supported. That is * For Interpretation 1, only one dl-PRS-ID and multiple NR-DL-PRS-ResourceSetID will be associated with the aggregated main and additional measurement
* For Interpretation 2, multiple dl-PRS-IDs will be associated with the aggregated main and additional measurement

**For Question 3:**Based on the RAN1 agreement, more than one combinations are supported, in this case, indicating the multiple dl-PRS-IDs associated with main measurement can be supported. And the main measurement and additional measurement should be associated with the same multiple dl-PRS-IDs.

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| AgreementConfiguring up to two PFL combinations is supported (e.g. PFL1 aggregated with PFL2 and PFL3 aggregated with PFL4). * Send an LS to RAN4 (CC to RAN2 and RAN3) to inform them with the above agreement and specify corre-sponding requirements.
* Note: more than one combinations are measured in TDMed manner
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| *OPPO[3][4]* | ***Proposal 2: The answer to Question 2 is:**** ***There are multiple dl-PRS-IDs associated with each aggregated main and additional measurement.***

***Proposal 3: The answer to Question 3 is:**** ***The list of the dl-PRS-IDs in additional measurements is not included in the list of dl-PRS-IDs in the main measurement.***
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| *CATT[5][6]* | **Answer 2:** For aggregated measurements, UE only reports the *dl-PRS-ID(s)* associated with one DL PFL as the non-aggregated measurements. There is no need to provide *dl-PRS-ID(s)* for all aggregated DL PFLs.**Answer 3:** No. See the answer for **Question 2.** |
| *Samsung[7]* | A2: One or multiple dl-PRS-ID(s) associated with a TRP can be associated with main measurement and additional measurement, respectively. RAN1 understands that main measurement and additional measurement can be performed based on the PRS resource sets in different PFLs of a TRP with the same dl-PRS-ID. Besides, main measurement and additional measurement can be also performed based on the PRS resource sets in different PFLs of a TRP with different dl-PRS-ID. A3: If the definition for main measurement is that the measurement is based on the PRS resource sets across the entire aggregated PFLs, the answer should be ‘Yes’. RAN1 understands that when there are multiple dl-PRS-IDs associated with a TRP for main measurement, the dl-PRS-IDs associated with a same TRP for additional measurement should be included in the multiple dl-PRS-IDs for main measurement.  |
| *ZTE[8][9]* | RAN2 observed that there is neither dl-PRS-ID nor dl-PRS-IDs included in the RRC parameter list R1-2312697. It is unclear to RAN2 how to include dl-PRS-ID when reporting the nr*-aggregated-DL-PRS-ResourceSetIDList* in *NR-DL-TDOA-MeasElement* and *NR-Multi-RTT-MeasElement*.**Question 2:** Is there only one dl-PRS-ID or are there multiple dl-PRS-IDs associated with the aggregated main and additional measurement, respectively?RAN1’s reply: There is only one dl-PRS-ID associated with the aggregated main measurement, the legacy dl-PRS-ID in NR-DL-TDOA-MeasElement/NR-Multi-RTT-MeasElement can be reused. If PRS resource sets in different PFLs of a TRP are configured with the same dl-PRS-ID, then the UE only reporting one dl-PRS-ID associated with the aggregated main measurement is sufficient. If dl-PRS-IDs in different PFLs represent the same TRP, only one dl-PRS-ID reported in the main measurement is sufficient as nr-DL-PRS-ResourceSetID is used to identify the DL-PRS resource set of the TRP across all the frequency layers.**Question 3**: If there are multiple dl-PRS-IDs associated with main and additional measurements, respectively, should the list of the dl-PRS-IDs in additional measurements be included in the list of dl-PRS-IDs in the main measurement?RAN1’s reply: There is no need to provide dl-PRS-ID(s) in additional measurement reporting since both main measurement and additional measurement are derived from the same TRP. |
| *Nokia[10]* | **Question 2:** Is there only one dl-PRS-ID or are there multiple dl-PRS-IDs associated with the aggregated main and additional measurement, respectively?* **Answer:** There is only one dl-PRS-ID.

**Question 3**: If there are multiple dl-PRS-IDs associated with main and additional measurements, respectively, should the list of the dl-PRS-IDs in additional measurements be included in the list of dl-PRS-IDs in the main measurement?* **Answer:** In our understanding, the additional measurement might be for additional paths of aggregated DL PRSs. The main aggregated measurement and the additional aggregated measurement should be made for the same DL PRS(s) transmitted from the same TRP. Based on the current LPP specification, multiple different dl-PRS-IDs can be associated with a single TRP. It is up to the LMF configuration, but whether they are associated with the same TRP is transparent from the UE perspective. Unless additional feature is supported for UE to assume a same TRP across multiple dl-PRS-IDs, it is unclear how the UE will obain aggregated measurements as it may not know which PRSs are transmitted from the same TRP. For this reason, if there are multiple dl-PRS-IDs associated with the main and additional measurement, we think the UE behavior is unclear.
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| *Intel[11]* | **Question 2: Is there only one dl-PRS-ID or are there multiple dl-PRS-IDs associated with the aggregated main and additional measurement, respectively?****Answer 2:** On the issue of one or multiple dl-PRS-ID values associated with linked DL PRS resources across aggregated DL PFLs, RAN1 had shared the following interpretations of the current specifications with RAN2 in an earlier LS in **R1-2308646**:

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| **1. Overall Description:**With regards to higher layer parameter *dl-PRS-ID*, RAN1 understands that the current RAN2 specification support two interpretations:* Interpretation 1: PRS resource sets in different PFLs of a TRP are configured with the same dl-PRS-ID
* Interpretation 2: PRS resource sets in different PFLs of a TRP can be configured with different dl-PRS-ID

For PRS bandwidth aggregation, RAN1’s agreement is that the linked PRS resource sets from two or three PFLs should be from the same TRP. RAN1 kindly requests RAN2 to capture the condition of the same TRP in RAN2 specifications for PRS bandwidth aggregation. **2. Actions:****To RAN2** **ACTION:** RAN1 respectfully asks RAN2 to take the above information into consideration for their future work, and asks RAN2 to capture the condition of the same TRP in RAN2 specifications for PRS bandwidth aggregation. |

Further, based on the above, RAN1 specifications in TS 38.214 with consideration of both single and multiple dl-PRS-IDs are incorporated. From TS 38.214, v18.2.0, Clause 5.1.6.5:

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| …Within a positioning frequency layer, the DL PRS resources are sorted in the decreasing order of priority for measurement to be performed by the UE, with the reference indicated by *nr-DL-PRS-ReferenceInfo* being the highest priority for measurement, and the following priority is assumed:- Up to 64 *NR-SelectedDL-PRS-IndexPerTRP* of the DL PRS positioning frequency layer are sorted according to priority if *nr-SelectedDL-PRS-IndexListPerFreq* is provided, or up to 64 *NR-DL-PRS-AssistanceDataPerTRP* of the frequency layer are sorted according to priority; except when the UE is requested to perform aggregated measurement(s), in which case:- A DL PRS ID associated with DL PRS bandwidth aggregation linkage has higher priority than a DL PRS ID not associated with DL PRS bandwidth aggregation linkage. If multiple DL PRS ID are associated with DL PRS bandwidth aggregation linkage, they are sorted according to priority.- Up to 2 *DL-SelectedPRS-ResourceSetIndex* per *dl-PRS-ID* of the DL PRS positioning frequency layer are sorted according to priority if *dl-SelectedPRS-ResourceSetIndexList* is provided, or up to 2 *NR-DL-PRS-ResourceSet* per *dl-PRS-ID* of the DL PRS positioning frequency layer are sorted according to priority except when the UE is requested to perform aggregated measurement(s), in which case:- A DL PRS resource set linked for a DL PRS bandwidth aggregation has higher priority than a DL PRS resource set not linked for DL PRS bandwidth aggregation. If multiple DL PRS resource sets are linked for DL PRS bandwidth aggregation, then they are sorted according to priority. |

Based on the above, it can be concluded that, from RAN1’s perspective, there can be one or multiple dl-PRS-IDs associated with the aggregated (main and additional) measurements.**Question 3: If there are multiple dl-PRS-IDs associated with main and additional measurements, respectively, should the list of the dl-PRS-IDs in additional measurements be included in the list of dl-PRS-IDs in the main measurement?****Answer 3:** If there are multiple dl-PRS-IDs associated with main and additional measurements, the list of the dl-PRS-IDs in main measurement (corresponding to IEs: NR-Multi-RTT-MeasElement or NR-DL-TDOA-AdditionalMeasurementElement) and the list of dl-PRS-IDs in each of the additional measurements (corresponding to IE: NR-Multi-RTT-AdditionalMeasurementElement or NR-DL-TDOA-MeasElement) can be indicated independently since the RAN1 design allows a UE to report whether each measurement is based on aggregated PRS resources and which DL PRS resource sets are aggregated per the following agreements. In addition, up to two different combinations of DL PFLs can be supported, implying that for a measurement using DL PRS resources from DL PRS resource sets that are linked from two different combinations of DL PFL, the corresponding dl-PRS-IDs may be different.  |
| Ericsson[12] | *Proposal 2 In one aggregated measurement, all aggregated DL PRS resources are from the same DL-PRS-ID, i.e. the same TRP.**Proposal 3 In main and additional measurements, aggregated measurements use PRS resources from the same DL-PRS-ID* |
| *Huawei, HiSilicon [13]* | ***Proposal 1:*** ***Reply to RAN2 that:**** ***For the question 2, there is only one dl-PRS-ID associated with the aggregated main measurement and additional measurement, which is the existing dl-PRS-ID.***
* ***For the question 3, there is no concept of the list of dl-PRS-IDs in RAN1.***
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FL Comments:

For Issue 2: Clarification on the DL-PRS ID associated with aggregated measurement report, there are different views from the companies [2-13].

For “**Question 2:** Is there only one dl-PRS-ID or are there multiple dl-PRS-IDs associated with the aggregated main and additional measurement, respectively?”, the companies have the following views:

* Option 1: Multiple dl-PRS-IDs are associated with each aggregated main and additional measurement

 **Supported by**: vivo, Intel, OPPO, Samsung

* Option 2: One dl-PRS-ID is associated with each aggregated main and additional measurement in the measurement report

 **Supported by**: CATT, ZTE, Nokia, Ericsson, Huawei, HiSilicon

In FL’s understanding, based on the previous RAN1’s agreement:

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| AgreementSend an LS to RAN2 with the following contentWith regards to higher layer parameter *dl-PRS-ID*, RAN1 understands that the current RAN2 specification support two interpretations:* Interpretation 1: PRS resource sets in different PFLs of a TRP are configured with the same dl-PRS-ID
* Interpretation 2: PRS resource sets in different PFLs of a TRP can be configured with different dl-PRS-ID
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It's evident that PRS resources in various PFLs of a TRP can be configured with either the same dl-PRS-ID or distinct dl-PRS-IDs. While some companies believe that multiple dl-PRS-IDs can be linked to each aggregated primary and secondary measurement, most companies consider that one dl-PRS-ID corresponds to each aggregated primary and secondary measurement.

### Question 3-1

**RAN2’s Question 2:** Is there only one dl-PRS-ID or are there multiple dl-PRS-IDs associated with the aggregated main and additional measurement, respectively?

Please provide your views on the following options of the responses to RAN2’s Question 2:

* **Option 1:** Either one dl-PRS-ID or multiple dl-PRS-IDs can be associated with the aggregated main and additional measurement in the measurement report. In addition, include the following agreement in the response LS:

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| AgreementSend an LS to RAN2 with the following contentWith regards to higher layer parameter *dl-PRS-ID*, RAN1 understands that the current RAN2 specification support two interpretations:* Interpretation 1: PRS resource sets in different PFLs of a TRP are configured with the same dl-PRS-ID
* Interpretation 2: PRS resource sets in different PFLs of a TRP can be configured with different dl-PRS-ID
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* **Option 2:** PRS resource sets in different PFLs of a TRP can be configured with the same dl-PRS-ID or different dl-PRS-IDs. However, only one dl-PRS-ID is needed to be associated with the aggregated main measurement and additional measurements.

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| **Company** | **comments** |
| Qualcomm | Option 1 |
| Huawei, HiSilicon | Option 2. |
| Intel | Option 1. Also, note that RAN1 specs already considers multiple dl-PRS-IDs associated to linked PFLs; cf. TS 38.214, v18.2.0:“… multiple DL PRS ID are associated with DL PRS bandwidth aggregation linkage …” |
| CATT | Option 2. |
| ZTE | Option 2To Intel: the multiple DL PRS ID you mentioned is related to assistance data, not in measurement report.As we provided in our discussion paper, even when interpretation 2 (PRS resource sets in different PFLs of a TRP can be configured with different dl-PRS-ID) is applied, only one dl-PRS-ID reported in the main measurement is sufficient as nr-DL-PRS-ResourceSetID can be used to identify the DL-PRS resource set of the TRP across all the frequency layers. ***nr-DL-PRS-ResourceSetID***This field specifies the DL-PRS Resource Set ID, which is used to identify the DL-PRS Resource Set of the TRP across all the frequency layers. |

### Question 3-2

**RAN2’s Question 3**: If there are multiple dl-PRS-IDs associated with main and additional measurements, respectively, should the list of the dl-PRS-IDs in additional measurements be included in the list of dl-PRS-IDs in the main measurement?

What is your view on the following options of the responses to RAN2’s Question 3:

* **Option 1:** There is only one dl-PRS-ID associated with the aggregated main measurement and additional measurements.
* **Option 2:** There is no need to provide dl-PRS-ID(s) in additional measurement reporting since both main measurement and additional measurement are derived from the same TRP.
* **Option 3:** If there are multiple dl-PRS-IDs associated with main and additional measurements, respectively, a list of the dl-PRS-IDs can be included in the additional measurements.

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| **Company** | **comments** |
| Qualcomm | Option 2 (Additional and main measurements are derived from the same TRP, so the multiple PRS-ID(s) will be the same between main and additional measurements)> |
| Huawei, HiSilicon | For each TRP, the main and the additional measurement shall be derived from a same PFL combination. Therefore, there should be no change to the additional measurement. |
| Intel | It’d be good to first clarify if the “additional measurements” can include measurements on different resources (corresponding to the up to 4 different DL PRS resources) or it’s only considering different Rx TEGs. The answer could follow from that clarification. |
| CATT | Option 1.  |
| ZTE | Option 2. |

# References

1. [R1-2401940](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2401940.zip) Questions on RAN1 parameter list RAN2, CATT
2. [R1-2402201](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402201.zip) Draft reply LS on questions on RAN1 parameter list for Rel-18 NR Positioning vivo
3. [R1-2402293](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402293.zip) Discussion on RAN2 LS on Questions on RAN1 parameter List OPPO
4. [R1-2402294](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402294.zip) Draft reply LS on Questions on RAN1 parameter List OPPO
5. [R1-2402349](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402349.zip) Discussion on questions on RAN1 parameter list CATT
6. [R1-2402350](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402350.zip) Draft reply LS on questions on RAN1 parameter list CATT
7. [R1-2402414](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402414.zip) Draft reply LS on questions on RAN1 parameter list Samsung
8. [R1-2402696](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402696.zip) Draft reply LS for questions on RAN1 positioning parameter list ZTE Corporation
9. [R1-2402697](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402697.zip) Discussion on RAN1 positioning parameter list for bandwidth aggregation ZTE Corporation
10. [R1-2402909](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402909.zip) Draft Reply LS on Questions on RAN1 parameter list Nokia
11. [R1-2403150](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403150.zip) Draft Reply LS on Questions on RAN1 parameter list Intel Corporation
12. [R1-2403319](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403319.zip) Discussion on LS to RAN1 with Questions on RAN1 parameter list Ericsson
13. [R1-2403353](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403353.zip) Disucssion on Questions on RAN1 parameter list Huawei, HiSilicon
14. [R1-2401487](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2401487.zip) FL Summary #3 for NR DL and UL carrier phase positioning Moderator (CATT)