**3GPP TSG-RAN WG2 Meeting #117-eR2-22xxxxx**

**Electronic meeting, Feb 21st – March 4th, 2022**

**Agenda item:** 8.11.2.6

**Source:** CATT

**Title:** Report of[AT117-e][618][POS] Beam and antenna information for DL-AoD accuracy enhancements (CATT)

**Document for:** Discussion and Agreement

# 1 Introduction

This is the report of following offline discussion:

* [AT117-e][618][POS] Beam and antenna information for DL-AoD accuracy enhancements (CATT)

     Scope: Treat P10/P11/P12/P13/P15 of R2-2202410 and attempt to converge.

      Intended outcome: Report to Monday online session

      Deadline:  Friday 2022-02-25 1000 UTC

The expected output of this offline discussion will include:

* Proposals for running CR

The discussion below is mainly based on the remaining open issues provided by the following contributions:

* R2-2202410 Report of [Pre117-e][611][POS] Open issues on positioning accuracy enhancements (CATT) CATT discussion

The following contributions are also reviewed.

* R2-2201722 Summary of [Post116bis-e][628][POS] 37.355 running CR (Qualcomm)
* R2-2203310 Running LPP CR for NR positioning enhancements v5 (Qualcomm)
* R2-2202005 Report of email discussion [Post116bis-e][634][POS] Positioning open issues list (Intel)

# 2 Contact Information

Respondents to the email discussion are kindly asked to fill in the following table.

|  |  |
| --- | --- |
| Company | Contact: Name (E-mail) |
| Huawei, HiSilicon | YinghaoGuo (yinghaoguo@huawei.com) |
| Ericsson | Fredrik.gunnarsson@ericsson.com; ritesh.shreevastav@ericsson.com |
| Nokia | mani.thyagarajan@nokia.com |
| ZTE | Yu Pan(pan.yu24@zte.com.cn) |
| CATT | Jianxiang Li(lijianxiang@catt.cn) |
| Apple | Sasha Sirotkin <ssirotkin@apple.com> |
| Xiaomi | Xiaolong Li（lixiaolong1@xiaomi.com） |
| vivo | Xiang Pan (panxiang@vivo.com) |
| Intel | Yi .guo@intel.com |
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# 3 Discussion

* ***UE request of the positioning calculation related information***

As for the beam/antenna information interaction between LMF and UE, RAN2 has agreed the following agreements, with details are FFS.

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| --- |
| * **Proposal 2.1-1: enhance LPP assistance data signalling to allow UE to request and LMF to provide TRP beam/antenna information.** |

Based on the above agreement, a new IE is introduced for UE to indicate the request of beam/antenna information for UE-based positioning, i.e., the *PosCalcAssistanceRequest* as in the running LPP CR [2]. However, some companies point out that the new *PosCalcAssistanceRequest* is not needed, since the LMF will provide the assistance data to the UE that supports the beam/antenna info for UE-based positioning, i.e. the legacy nr-AdType in NR-DL-AoD-RequestAssistanceData-r16 is enough with the value 'posCalc'.

Further, according to the RAN1 parameters list, the beam/antenna enhancement between UE and LMF is only for UE-based DL-AoD positioning method. But according to the current running CR [2], the beam/antenna request indication is also implemented under the DL-TDOA positioning method, thus we would like to confirm that whether the beam/antenna information request and provision only applies to UE-based DL-AoD positioning method.

|  |
| --- |
| Agreement  From the RAN1 perspective, for the TRP beam/antenna information to be optionally provided by the LMF to the UE for UE-based DL-AoD:  • The LMF provides the quantized version of the relative Power between PRS resources per angle per TRP.  o The relative power is defined with respect to the peak power in each angle  o For each angle, at least two PRS resources are reported.  o Note: the peak power per angle is not provided  • Note: up to RAN3 to decide how the TRP beam information is provided to the LMF for both UE-assisted and UE-based  • Send an LS to RAN2/RAN3 to decide on the signaling details |

**Q1: Do companies agree that the beam/antenna information request only applies to the UE-based DL-AOD positioning method if we follow the agreement allows UE to request the TRP beam/antenna information? Please provide also a brief justification for your answer.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | Yes. | It does not make much sense to have it for DL-TDOA. |
| Ericsson | Yes |  |
| Nokia | Yes | Just align to what RAN1 indicated in their LS in R2-2200082 (the text from this LS is quoted in your discussions above but the actual reference to LS is missing in this Reference section in this discussion document. Good to add it). Note that is only for DL-AoD but the assistance applies to both UE-based and UE-assisted DL-AoD. |
| ZTE | Yes |  |
| CATT | Yes |  |
| Apple | Yes |  |
| Xiaomi | Yes |  |
| vivo | Yes |  |
| OPPO | Yes |  |
| Intel | Yes |  |
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In the running CR [2], the follow information is also requested by UE for UE-based DL-AoD:

* trpLoc, i.e., the location coordinates of the antenna reference points of the TRPs;
* beamInfo, i.e., the the spatial directions of DL-PRS Resources for TRPs;
* rtdInfo, i.e., the time synchronization information between the reference TRP and neighbour TRPs;
* losNlosInfo, i.e., the expected likelihood of a LOS propagation path;
* trpTEG-Info, i.e., the TRP Tx TEG ID associated with the transmission of each DL-PRS Resource of the TRP

-- ASN1START

NR-DL-AoD-RequestAssistanceData-r16 ::= SEQUENCE {

nr-PhysCellID-r16 NR-PhysCellID-r16 OPTIONAL,

nr-AdType-r16 BIT STRING { dl-prs (0),

posCalc (1) } (SIZE (1..8)),

...,

[[

nr-PosCalcAssistanceRequest-r17 BIT STRING { trpLoc (0),

beamInfo (1),

rtdInfo (2),

beamAntInfo (3),

losNlosInfo (4),

trpTEG-Info (5)

} (SIZE (1..8)) OPTIONAL,

nr-on-demand-DL-PRS-Request-r17 NR-On-Demand-DL-PRS-Request-r17 OPTIONAL

]]

}

-- ASN1STOP

Some companies show the concern that the losNlosInfo and the trpTEG-Info are not required to be requested and rtdInfo and trpTEG-Info are only applied to DL-TDOA method, but not DL-AoD method. Based on these concerns, the following questions are addressed.

**Q2: Which assistance data is/are requested by UE for UE-based DL-AOD? Please provide also a brief justification for your answer.**

1. **trpLoc;**
2. **beamInf;**
3. **rtdInfo;**
4. **losNlosInfo;**
5. **trpTEG-Info;**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option a/b/c/d/e** | **Comments** |
| Huawei, HiSilicon | d) | a), b) are already assumed by default without explicit request for DL-AoD in Rel-16. Not clear why this needs to be added in Rel-17.  RTD info and TEG info only apply to UE-based DL-TDOA. Hence, should not be requested by the UE for UE-based DL-AoD |
| Ericsson | a, b | Agree with Huawei that a) and b) are default; however, for b) it may also be the new addition on relative beam power at certain angles if RAN1 and RAN2 have agreed to this then.  d) for UE-Based UE should be able to determine based upon UE measurements. it is unclear as how LMF will have such info on LOS NLOS |
| Nokia | d) | Agree with Huawei. |
| ZTE | d | Agree with Huawei |
| CATT | d) | Agree with Huawei |
| Apple | d |  |
| Xiaomi | d | We assume beamAntInfo is needed id default. |
| vivo | d |  |
| OPPO | d |  |
| Intel | d |  |
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Similarly, the request is applied to DL-TDOA in the running LPP CR:

-- ASN1START

NR-DL-TDOA-RequestAssistanceData-r16 ::= SEQUENCE {

nr-PhysCellID-r16 NR-PhysCellID-r16 OPTIONAL,

nr-AdType-r16 BIT STRING { dl-prs (0),

posCalc (1) } (SIZE (1..8)),

...,

[[

nr-PosCalcAssistanceRequest-r17 BIT STRING { trpLoc (0),

beamInfo (1),

rtdInfo (2),

beamAntInfo (3),

losNlosInfo (4),

trpTEG-Info (5)

} (SIZE (1..8)) OPTIONAL,

nr-on-demand-DL-PRS-Request-r17 NR-On-Demand-DL-PRS-Request-r17 OPTIONAL

]]

}

-- ASN1STOP

**Q3: Which assistance data is/are requested by UE for UE-based DL-TDOA? Please provide also a brief justification for your answer.**

1. **trpLoc;**
2. **beamInf;**
3. **rtdInfo;**
4. **losNlosInfo;**
5. **trpTEG-Info;**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option a/b/c/d/e** | **Comments** |
| Huawei, HiSilicon | d) e) | a) is already assumed by default without explicit request for DL-TDOA in Rel-16.  b) is not supported DL-TDOA  c) is a bit unclear even in Rel-16. This can be provided by the network as the best effort, we assume. |
| Ericsson | a, c, e | Yes a) and c) can be based upon Rel-16; e) is the new info added in Rel-17. d) it is unclear as how LMF will have such info on LOS NLOS. It is for UE to perform measurement |
| Nokia | d), e) |  |
| ZTE | d, e |  |
| CATT | d), e) |  |
| Apple | d, e |  |
| Xiaomi | d, e | We think beamAntInfo is not needed for DL-TDOA. |
| vivo | d, e |  |
| OPPO | D e |  |
| Intel | D,e |  |
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As for how to implement the UE request of positioning calculation related assistance information for UE-based positioning, a unified IE, i.e., *nr-PosCalcAssistanceRequest-r17*, is designed for DL-AoD and DL-TDOA in the running CR, which is similar with the A-GNSS assistance data request.

A-GNSS-RequestAssistanceData ::= SEQUENCE {

gnss-CommonAssistDataReq GNSS-CommonAssistDataReq OPTIONAL, -- Cond CommonADReq

gnss-GenericAssistDataReq GNSS-GenericAssistDataReq OPTIONAL, -- Cond GenADReq

...,

[[

gnss-PeriodicAssistDataReq-r15

GNSS-PeriodicAssistDataReq-r15 OPTIONAL -- Cond PerADReq

]]

}

-- ASN1START

GNSS-CommonAssistDataReq ::= SEQUENCE {

gnss-ReferenceTimeReq GNSS-ReferenceTimeReq

OPTIONAL, -- Cond RefTimeReq

gnss-ReferenceLocationReq GNSS-ReferenceLocationReq

OPTIONAL, -- Cond RefLocReq

gnss-IonosphericModelReq GNSS-IonosphericModelReq

OPTIONAL, -- Cond IonoModReq

gnss-EarthOrientationParametersReq GNSS-EarthOrientationParametersReq

OPTIONAL, -- Cond EOPReq

...,

We would like to further collect companies’ view that if a unified IE for request of the positioning calculation related assistance information is introduced.

**Q4: Do companies agree that one unified IE nr-PosCalcAssistanceRequest-r17 is introduced to request the positioning calculation related assistance information for both UE-based DL-AoD and DL-TDOA? Please provide also a brief justification for your answer.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | See comments | Although these two positioning methods share the same structure for PosCalcAssistanceRequest, we don’t see much need to introduce this unified IE. For which AD that the UE can be requested should be discussed case-by-case like what we are doing now. |
| Ericsson |  | It would be good to have the ASN.1 for both versions and we can check. It does not need to resolve now. We can take some time and review as part of ASN.1 |
| Nokia |  | Slight preference to use a method specific bitmap field for the position calculation assistance request since anyway we have a method specific *RequestAssistanceData* IE now. Otherwise, we need to clarify in the field description for *nr-PosCalcAssistanceRequest-r17*, which bit can be used for which positioning method. |
| ZTE | No | Based on the Q2 and Q3, it seems only losNlosInfo is common for DL AOD and DL TDOA(the other three: trpLoc, beamInf, rtdInfo are already provided as common in r16). There is no need to introduce unified IE if only losNlosInfo is included |
| CATT | Yes | Based on the answer of Q1, Q2 and Q3, the requested assistance data except the LOS/NLOS, is different for DL-TDOA and DL-AoD, thus it is better to introduce a specific bitmap for each DL RAT-dependent positioning method.  But we can take some time and review as part of ASN.1. |
| Apple |  | Agree to resolve this as part of the running CR discussion |
| Xiaomi |  | Prefer to use positioning method specific IE. |
| vivo | No | Agree with ZTE, if the conclusion of Q2 and Q3 is that only limited common IE for DL AoD and DL TDoA, then the bitmap is not needed. |
| OPPO | No | Agree with ZTE |
| Intel | Yes | We do not see the problem to do this. Agree with Ericsson. We can resolve it during ASN.1 review if companies have concern. |
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* ***LMF provision of the TRP beam/antenna information***

As for the provision of beam/antenna information from LMF to UE, it is still FFS both the azimuth and elevation can be optional. 6/12 companies support both the azimuth and elevation can be optional but at least one should be provided, in case there is linear array scenario, only azimuth or elevation will be provided by the LMF. Other companies explained that one angle seems always be needed. For a linear array, one would still need one azimuth angle (e.g., 120 degrees) and a list of elevation angles (or the other way around).

**Q5: Do companies agree that both the azimuth and elevation can be optional, but at least one should be provided? Please provide also a brief justification for your answer.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | Yes. | This works for linear array expressed in local coordinate system. |
| Ericsson | Yes | This flexibility is needed |
| Nokia | Yes | Both azimuth and elevation can be defined OPTIONAL, but the field description can be clarified to say at least one should be provided.  BTW, why are we rediscussing all these which we already discussed in [Pre117-e][611]?  [Rapporteur]: since there is not consistence among companies, thus chair would like to make further discussion, and we just follow the scope of the email. |
| ZTE | Yes |  |
| CATT | Yes |  |
| Apple | Yes |  |
| Xiaomi | Yes |  |
| vivo | No | We prefer the azimuth is mandatory referring to the UL Angle of Arrival report from gNB to LMF. The azimuth is always needed for positioning.   |  |  | | --- | --- | | IE/Group Name | Presence | | Azimuth Angle of Arrival | M | | Zenith Angle of Arrival | O |   But ok to follow the majority. |
| OPPO | Yes |  |
| Intel | Yes |  |
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As for how to implement it in the running CR, the following TP are provided, and companies are invited to decide which option is preferred.

* **Option 1: change the azimuth-r17 and elevation-r17 both to be optional, but add a restriction in the field description that at least azimuth or elevation should be present.**

-- ASN1START

NR-TRP-BeamAntennaInfo-r17 ::= SEQUENCE (SIZE (1..nrMaxFreqLayers-r16)) OF

NR-TRP-BeamAntennaInfoPerFreqLayer-r17

NR-TRP-BeamAntennaInfoPerFreqLayer-r17 ::= SEQUENCE (SIZE (1..nrMaxTRPsPerFreq-r16)) OF

NR-TRP-BeamAntennaInfoPerTRP-r17

NR-TRP-BeamAntennaInfoPerTRP-r17 ::= SEQUENCE {

dl-PRS-ID-r17 INTEGER (0..255),

nr-PhysCellID-r17 NR-PhysCellID-r16 OPTIONAL, -- Need ON

nr-CellGlobalID-r17 NCGI-r15 OPTIONAL, -- Need ON

nr-ARFCN-r17 ARFCN-ValueNR-r15 OPTIONAL, -- Need ON

lcs-GCS-TranslationParameter-r17 LCS-GCS-TranslationParameter-r16 OPTIONAL, -- Need OP

nr-TRP-BeamAntennaAngles-r17 NR-TRP-BeamAntennaAngles-r17,

...

}

NR-TRP-BeamAntennaAngles-r17 ::= SEQUENCE (SIZE(1..3600)) OF NR-TRP-BeamAntennaInfoAzimuth-r17

NR-TRP-BeamAntennaInfoAzimuth-r17 ::= SEQUENCE {

azimuth-r17 INTEGER (0..359), OPTIONAL, -- Need ON

azimuth-fine-r16 INTEGER (0..9) OPTIONAL, -- Need ON

elevation-r17 INTEGER (0..180), OPTIONAL, -- Need ON

elevation-fine-r17 INTEGER (0..9) OPTIONAL, -- Need ON

beamPowerList-r17 SEQUENCE (SIZE (2..maxNumResourcesPerAngle-r17)) OF

BeamPowerElement-r17,

...

}

BeamPowerElement-r17 ::= SEQUENCE {

nr-dl-prs-ResourceSetID-r17 NR-DL-PRS-ResourceSetID-r16 OPTIONAL, -- Need OP

nr-dl-prs-ResourceID-r17 NR-DL-PRS-ResourceID-r16,

nr-dl-prs-RelativePower-r17 INTEGER (0..500), -- FFS

...

}

| ***NR-TRP-BeamAntennaInfo* field descriptions** |
| --- |
| ***azimuth***  This field specifies the azimuth angle for which the relative power between DL-PRS Resources is provided. If the elevation is absent, the azimuth must be provided by the NW.  For a Global Coordinate System (GCS), the azimuth angle is measured counter-clockwise from geographical North.  For a Local Coordinate System (LCS), the azimuth angle is measured measured counter-clockwise from the x-axis of the LCS.  Scale factor 1 degree; range 0 to 359 degrees. |
| ***azimuth-fine***  This field provides finer granularity for the *azimuth*.  The total azimuth angle is given by *azimuth* + *azimuth-fine.*  Scale factor 0.1 degrees; range 0 to 0.9 degrees. |
| ***elevation***  This field specifies the elevation angle for which the relative power between DL-PRS Resources is provided for the given *azimuth*. If the azimuth is absent, the elevation must be provided by the NW.  For a Global Coordinate System (GCS), the elevation angle is measured relative to zenith and positive to the horizontal direction (elevation 0 deg. points to zenith, 90 deg to the horizon).  For a Local Coordinate System (LCS), the elevation angle is measured relative to the z-axis of the LCS (elevation 0 deg. points to the z-axis, 90 deg to the x-y plane).  Scale factor 1 degree; range 0 to 180 degrees. |
| ***elevation-fine***  This field provides finer granularity for the *elevation*.  The total elevation angle is given by *elevation* + *elevation-fine.*  Scale factor 0.1 degrees; range 0 to 0.9 degrees. |

* **Option 2: still follow the current running CR, and up to NW implementation. For example, in case of the linear array, all azimuths may be the same value or all elevations may be the same value.**

**Q6: Which options do companies agree on the implementation that both the azimuth and elevation can be optional, but at least one should be provided? Please provide also a brief justification for your answer.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2/Other** | **Comments** |
| Huawei, HiSilicon | Other | We think that we can merge Option 1 and Option 2 into the following TP  NR-TRP-BeamAntennaInfoAzimuth-r17 ::= SEQUENCE {  azimuth-r17 INTEGER (0..359) OPTIONAL, -- Need ON  azimuth-fine-r16 INTEGER (0..9) OPTIONAL, -- Need ON  elevationList-r17 SEQUENCE (SIZE(1..1800)) OF ElevationElement-R17,  ...  }  ElevationElement-R17 ::= SEQUENCE {  elevation-r17 INTEGER (0..180) OPTIONAL, -- Need ON  elevation-fine-r17 INTEGER (0..9) OPTIONAL, -- Need ON  nr-dl-prs-ResourceSetID-r17 NR-DL-PRS-ResourceSetID-r16 OPTIONAL, -- Need OP  nr-dl-prs-ResourceID-r17 NR-DL-PRS-ResourceID-r16,  beamPowerListAdditional-r17 SEQUENCE (SIZE (1..maxNumResourcesPerAngle-1-r17)) OF  BeamPowerElement-r17,  ...  } |
| Ericsson | Other | This email discussion should also discuss the efficiency and flexibility of the beam representation as discussed in R2-2203361 The following suggested representation is more efficient and flexible than the one in the running CR:  -- ASN1START  NR-TRP-BeamAntennaInfo-r17 ::= SEQUENCE (SIZE (1..nrMaxFreqLayers-r16)) OF  NR-TRP-BeamAntennaInfoPerFreqLayer-r17  NR-TRP-BeamAntennaInfoPerFreqLayer-r17 ::= SEQUENCE (SIZE (1..nrMaxTRPsPerFreq-r16)) OF  NR-TRP-BeamAntennaInfoPerTRP-r17  NR-TRP-BeamAntennaInfoPerTRP-r17 ::= SEQUENCE {  dl-PRS-ID-r17 INTEGER (0..255),  nr-PhysCellID-r17 NR-PhysCellID-r16 OPTIONAL, -- Need ON  nr-CellGlobalID-r17 NCGI-r15 OPTIONAL, -- Need ON  nr-ARFCN-r17 ARFCN-ValueNR-r15 OPTIONAL, -- Need ON  associated-DL-PRS-ID-r16 INTEGER (0..255) OPTIONAL,  lcs-GCS-TranslationParameter-r17 LCS-GCS-TranslationParameter-r16 OPTIONAL, -- Need OP  dl-PRS-RelativeBeamGains-r17 DL-PRS-RelativeBeamGains-r17,    ...  }  DL-PRS-RelativeBeamGains-r17 ::= SEQUENCE {  dl-PRS-RefAzimuth-r17 INTEGER (0..359), OPTIONAL, -- Need OP  dl-PRS-RefAzimuth-fine-r17 INTEGER (0..9) OPTIONAL, -- Need OP  dl-PRS-RefElevation-r17 INTEGER (0..180) OPTIONAL, -- Need OP  dl-PRS-RefElevation-fine-r17 INTEGER (0..9) OPTIONAL, -- Need OP  numberOfStepsAzimuth-r17 INTEGER (0..300), OPTIONAL. -- Need OP  numberOfStepsElevation-r17 INTEGER (0..300), OPTIONAL. -- Need OP  stepOfAzimuth-r16 ENUMERATED {d01, d02, d05, d1, d2, d3, d4, d5},  OPTIONAL, -- Need OP  stepOfElevation-r16 ENUMERATED {d01, d02, d05, d1, d2, d3, d4, d5},  OPTIONAL, -- Need OP  dl-PRS-RelativeBeamGainsList-r17 SEQUENCE (SIZE (1..maxNoOfRelativeBeamGains-r17)) OF DL-PRS-RelativeBeamGainsPerAngle-r17,  ...  }  DL-PRS-RelativeBeamGainsPerAngle-r17 ::= SEQUENCE {  dl-PRS-ReferenceResourceID-r17 NR-DL-PRS-ResourceID-r16,  dl-PRS-ReferenceResourceSetID-r17 NR-DL-PRS-ResourceSetID-r16,  dl-PRS-ResourceID-r17 NR-DL-PRS-ResourceID-r16,  dl-PRS-ResourceSetID-r17 NR-DL-PRS-ResourceSetID-r16,  nr-DL-PRS-BeamGainDiff-r17 INTEGER (0..30),  ...  }  -- ASN1STOP |
| Nokia |  | We should deal with this in the running CR discussions. |
| ZTE | Option 1 | NR-TRP-BeamAntennaInfoAzimuth-r17 in option 1 should be NR-TRP-BeamAntennaInfoElement-r17, since it also contains elevation angle information |
| CATT | Option 1 |  |
| Apple |  | Agree to resolve this as part of the running CR discussion |
| Xiaomi | Option 1 |  |
| vivo | Option 1 |  |
| OPPO | Option 1 |  |
| Intel | Option 1 |  |
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# 4 Conclusion

# 5 Reference

1. R2-2202410 Report of [Pre117-e][611][POS] Open issues on positioning accuracy enhancements (CATT) CATT discussion
2. R2-2203310 Running LPP CR for NR positioning enhancements Qualcomm Incorporated draftCRRel-17 37.355 16.7.0 B NR\_pos\_enh-Core
3. R2-2200092 LS on the reporting of the Tx TEG association information (R1-2112968; contact: CATT) RAN1 LS in Rel-17 NR\_pos\_enh-Core To:RAN2, RAN4 Cc:RAN3
4. R2-2200095 LS on updated Rel-17 LTE and NR higher-layers parameter list (R1-2112977; contact: Ericsson) RAN1 LS in Rel-17 NR\_pos\_enh, To:RAN2, RAN3 Cc:RAN4
5. R2-2202005 Report of email discussion [Post116bis-e][634][POS] Positioning open issues list (Intel) Intel Corporation
6. R2-2201722 Summary of [Post116bis-e][628][POS] 37.355 running CR (Qualcomm)
7. R2-2201768 Summary of [AT116bis-e][612][POS] Positioning accuracy enhancements (Apple) Apple discussion NR\_pos\_enh-Core