3GPP TSG RAN WG2 Meeting #116b-e R2-220xxxx

**Electronic meeting, 1st -12th November 2021**

**Agenda item:** 8.11.1

**Source:** Intel Corporation

**Title:** Report of offline discussion [AT116bis-e][610][POS] Positioning UE capabilities (Intel)

**Document for:**  Discussion and decision

# Introduction

This is the report of following offline discussion:

* [AT116bis-e][610][POS] Positioning UE capabilities (Intel)

 Scope: Start discussion of UE capabilities for positioning, with R2-2200284 as an initial input, and attempt to conclude on a baseline set of capabilities to be reflected in 38.331/38.306 and 37.355.

 Intended outcome: Report to Monday CB session

 Deadline: Friday 2022-01-21 1600 UTC

Rapporteur would like to split the discussion in 2 phases:

**Phase 1: Companies provide view on questions;(Deadline Wednesday 2022-01-19 1600 UTC)**

**Phase 2: Check potential LS, TPs and new questions raised by companies if any (Deadline Friday 2022-01-21 1600 UTC)**

# Annex: companies’ point of contact

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| **Company** | **Point of contact** | **Email address** |
| Intel Corporation | Yi Guo | Yi.guo@intel.com |
| Apple | Sasha Sirotkin | ssirotkin@apple.com |
| Qualcomm | Sven Fischer | sfischer@qti.qualcomm.com |
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# Discussion

## 3.1 General aspects

As discuss in [3]:

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| Based on [1], RAN2 discussed how to handle RAN1,4 feature lists and how to handle RAN2 capabilities, and concluded that:**For Rel17 NR UE caps:** * Aim to Work on mega CRs (one mega CR for TS38.306 and one for TS38.331) to incorporate all RAN1/RAN4 feature groups. ​There could be exceptions, case by case.
* RAN2 should only implement the feature groups from the RAN1 and 4 feature list without any FFS (no highlighted yellow, [] and marked as FFS/TBD) into the CRs. Also Caps that are dependent on FFS Caps should not be implemented.
* Include an annex containing the RAN2 determined UE capabilities in the feature list format in the running UE capability CRs (similar to annex containing RAN2 agreements) for easy compilation into the TR38.822 in the later stage.
* For capabilities developed in R2, WIs will provide input to the mega CR.

Therefore positioning WI shall follow the same principle, i.e. **Proposal 1: RAN2 confirms the following principle on how to handle positioning capability:*** RAN1/4 feature groups related to RRC/TS38.306 should be captured in the Mega CRs directly;
* RAN1/4 feature groups related to LPP should be captured in LPP running CR directly;
* RAN2 determined UE capabilities should be maintained in running UE capability CRs. RRC/TS38.306 should be merged into the Mega CRs and LPP should be merged into LPP running CR;
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**Discussion point 3.1-1: Companies are invited to provide view on whether the proposal 1 above is agreeable?**

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| **Company’s name** | **Agree/No?** | **Comments, if any** |
| Intel | Agree | RAN2 already agreed this.  |
| Apple | Agree |  |
| Qualcomm | Agree |  |
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[3] also discussed what should be led by RAN2 as

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| In addition, for RAN2 led items “Latency reduction”, “On-Demand PRS”, “positioning in RRC\_INACTIVE” and “GNSS integrity”, RAN2 should lead the discussion. **Proposal 2: RAN2 leads the discussion on positioning capability for RAN2 led items “Latency reduction”, “On-Demand PRS”, “positioning in RRC\_INACTIVE” and “GNSS integrity”.** |

Based on the contributions in this meeting, there are some RAN1 led items within “latency reduction” topic, e.g. Preconfigured MG, prioritization of PRS; RAN1 should continue to lead these items, therefore the proposal2 is updated as

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| **Updated Proposal 2: RAN2 leads the discussion on positioning capability for RAN2 led items “Latency reduction( scheduled location time, storing UE capability in the AMF and preconfigured AD)”, “On-Demand PRS”, “positioning in RRC\_INACTIVE” and “GNSS integrity”.** |

**Discussion point 3.1-2: Companies are invited to provide view on whether the updated proposal 2 above is agreeable?**

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| **Company’s name** | **Agree/No?** | **Comments, if any** |
| Intel | Agree |  |
| Apple | Agree |  |
| Qualcomm | Partly | It may be difficult to split. E.g., measurement capabilities in RRC\_INACTIVE will come from RAN1/4, most latency reduction features are also coming from RAN1 (e.g., MG, PPW, etc.). However, features without any RAN1/4 impact (such as scheduled location time, storing UE capability, preconfigured AD, GNSS) can be decided by RAN2 alone. |
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## 3.2 RAN2 led items

### 3.2.1 Latency reduction

#### 3.2.1.1 Scheduled location time

**For scheduled location time**, [3] and [4] have following proposals:

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| **[3]****Latency reduction-RAN2 led parts (were from SA2):*** Scheduled location time;
	+ The only potential impact is whether the UE supports to receive the scheduled location time from LMF via LPP. If RAN2 agrees to support this feature, we need to introduce LPP capability on this.

**Proposal 7: For the scheduled location time, FFS on whether to introduce LPP capability “support of scheduled location time”;** |

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| [4]**Proposal 2:** The time base for the scheduled location time *T* should support UTC Time, GNSS Time, LTE/NR Network Time, and Relative Time.**Proposal 3:** The Measurement Time Window might be asymmetric – instead of being *T-t* to *T+t*, might be *T-t1* to *T+t2*. **Proposal 4:** Include the capability to support scheduled location in each *method-ProvideCapabilites* message, where '*method*' can be any of the LPP positioning methods. The capability should indicate the time base(s) supported for scheduling location measurements.TP [[ scheduledLocationRequest-r17 SEQUENCE { utcTime-r17 PositioningModes OPTIONAL, gnssTime-r17 SEQUENCE { posModes-r17 PositioningModes, gnss-TimeIDs-r17 GNSS-ID-BitMap } OPTIONAL, e-utraTime-r17 PositioningModes OPTIONAL, nrTime-r17 PositioningModes OPTIONAL, relativeTime-r17 PositioningModes OPTIONAL, ... } OPTIONAL ]]}***scheduledLocationRequest*** This field, if present, specifies the positioning modes for which the target device supports scheduled location requests – i.e., supports the IE *ScheduledLocationRequest* in IE *CommonIEsRequestLocationInformation* – and the time base(s) supported for the scheduled location time for each positioning mode. If this field is absent, the target device does not support scheduled location requests. |

RAN2 has agreed

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| **Proposal 1d: Include the capability to support scheduled location in each method ProvideCapabilities message, where “method” can be any of the LPP positioning methods. The capability should indicate the time base (s) supported for scheduling location measurements.**  |

And therefore we do not need to discuss this again.

#### 3.2.1.2 Storing UE capability in AMF

**For storing UE capability in the AMF**, [3] and [5] have following proposals:

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| [3]* Storing capability in AMF;
	+ So far, it is unclear what additional changes would be, e.g. whether introduce a bit in LPP capability on whether the capability is non-variable;

**Proposal 8: For storing LPP capability in the AMF, FFS on whether to introduce an indictor in LPP capability “ the capabilities are non-variable”;** |

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| [5]

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| Intel [2] | Proposal 5: It is proposed to agree that:- RAN2 does not see the need to introduce the indication on whether UE positioning capability is “variable” or not, since the LMF can be aware of this based on received UE positioning capability.- RAN2 assumes that the issue can be resolved by network implementation considering the issue also exists in Rel-16 even if positioning capability is not stored in AMF. - Send LS to SA2 to inform them of the above RAN2 agreements so they can update their specifications accordingly.Proposal 6: Storing UE positioning capability in AMF has no RAN impact except potential stage 2 description. |
| vivo [5] | Proposal 11: No need to include an indication in the LPP indicating whether the UE capabilities are variable or not. |

Summary:- Although, TS 23.273 specifies that the UE Positioning Capability provided from an LMF to an AMF for storage includes an indication that the positioning capability is non-variable, Intel and vivo proposes that no additional information needs to be provided from the UE. - Since no input contributions on a e.g., "variability indicator" for capabilities were submitted, no proposal is formulated here. |

Looks nobody proposed to introduce “variability indicator” for capability, Rapporteur would like to check companies’ view on

**Discussion point 3.2.1.2-1: For storing LPP capabilities in AMF, companies are invited to provide view on whether LPP capablity "variability indicator" is needed?**

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| **Company’s name** | **Needed/No?** | **Comments, if any** |
| Intel | No | Do not see the need, the LMF can be aware of whether the UE LPP capabilities could be variable.  |
| Apple | No |  |
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#### 3.2.1.3 Preconfigured assistance data

Based on [5], the main discussion on preconfigured assistance data is “validity conditions”. The UE LPP capability is needed if “validity conditions” is agreed.

RAN2 has agreed:

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| Proposal 3a (modified): Pre-configured DL-PRS assistance data can be associated with a “validity area” at least in LPP. FFS on details and whether it would be included in RRC broadcast.  |

Based on this agreements, the LPP capability is needed.

**Discussion point 3.2.1.3-1: Companies are invited to provide view on whether the LPP capability “preconfigured assistance data” is needed considering RAN2 has agreed to introduce “validity conditions” for preconfigured assistance data?**

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| **Company’s name** | **Needed/No?** | **Comments, if any** |
| Intel | Needed | Since the network should only provide preconfigured AD via dedicated signalling when the UE supports it.  |
| Apple | Needed |  |
| Qualcomm | Needed | In general, LMF need to know which features a UE supports.  |
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### 3.2.2 GNSS integrity

[3] discussed the capabilities for GNSS integrity, and have following proposal:

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| **Sub-features of GNSS-Integrity:*** Support of UE based integrity;
	+ It will be supported in Rel-17;
* Support of LMF based integrity;
	+ It is unclear whether it will be supported in Rel-17;
* Support of Mode 2 (flag) based reporting
	+ It is unclear whether it will be supported in Rel-17;
* Support of integrity for SSR;
	+ It will be supported in Rel-17;
* Support of integrity for OSR;
	+ It is unclear whether it will be supported in Rel-17;

**Proposal 9: For GNSS integrity, introduce LPP capabilities “support of UE based integrity” and “support of integrity for SSR”; FFS on “support of LMF based integrity”, “support of Mode 2 based reporting” and “support of integrity for OSR”;** |

**Discussion point 3.2.2-1: Companies are invited to provide view on whether the following sub-features for GNSS integrity are agreeable?**

* Support of UE based integrity;
	+ It will be supported in Rel-17;
* Support of LMF based integrity;
	+ It is unclear whether it will be supported in Rel-17;
* Support of Mode 2 (flag) based reporting
	+ It is unclear whether it will be supported in Rel-17;
* Support of integrity for SSR;
	+ It will be supported in Rel-17;
* Support of integrity for OSR;
	+ It is unclear whether it will be supported in Rel-17;
* **Others?**

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| --- | --- | --- |
| **Company’s name** | **Yes/No?** | **Comments, if any** |
| Intel | Yes |  |
| Apple |  | Shouldn’t we wait for the integrity discussion to conclude? |
| Qualcomm | No | Capabilities should be added to the assistance data capability elements; e.g., GNSS-SSR-OrbitCorrectionsSupport, GNSS-SSR-CodeBiasSupport, etc. with appropriate granularity. For the new assistance data additional capability IEs are needed.The A-GNSS-ProvideCapabilities IE should include whether the UE supports reporting of calculated PL.  |
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**Discussion point 3.2.2-2: Companies are invited to provide view on whether the LPP capabilities on “support of UE based integrity” and “support of integrity for SSR” are needed; FFS on “support of LMF based integrity”, “support of Mode 2 based reporting” and “support of integrity for OSR”?**

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| **Company’s name** | **Needed/No?** | **Comments, if any** |
| Intel |  | Wait for the progress.  |
| Apple |  | Shouldn’t we wait for the integrity discussion to conclude? |
| Qualcomm | No | There is no "UE-based" and "LMF-based" integrity. The UE may support the assistance data fields defined for integrity and may support providing integrity results. (A UE may also support integrity determination without any assistance data as today (although, with limited functionality)). |
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### 3.2.3 On-Demand PRS request

In RAN1 table, RAN1 also provided the draft on RAN2 led items “On-Demand PRS” as

27-5-1 [UE-initiated] on-demand PRS, UE’s capability to support UE-initiated on-demand DL PRS [request signalling], FFS: Need for location server to know if the feature is supported.

[3] proposed:

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| **Capability on “On-Demand PRS”,**27-5-1 [UE-initiated] on-demand PRS* From RAN2 perspective it is needed in case RAN2 agree “Proposal 3 UE initiates on-demand PRS request only after NW provides the available DL-PRS configurations to UE either using posSIB or LPP dedicated Signaling.” based on [3];

**Proposal 3:For On-Demand PRS, introduce LPP capability on UE-initiated on-demand PRS Request;** |

**Discussion point 3.2.3-1: Companies are invited to provide view on whether the LPP capability “UE initiated On-Demand PRS request” is needed?**

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| **Company’s name** | **Needed/No?** | **Comments, if any** |
| Intel | Needed | The LMF should only provide the preconfigured set when the UE can support it.  |
| Apple | Needed |  |
| Qualcomm | Yes |  |
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In [6], On-Demand PRS request is captured as positioning method specific capability.

**Discussion point 3.2.3-2: Companies are invited to provide view on whether the LPP capability“UE initiated On-Demand PRS request” should be positioning method specific capability?**

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| **Company’s name** | **Yes/No?** | **Comments, if any** |
| Intel | No | Do not see the different among different positioning methods.  |
| Apple | No | Agree with Intel |
| Qualcomm | Yes | The capability should be included in each 'method'-ProvideCapabilities, with 'method' = DL-TDOA, DL-AoD, and Multi-RTT. However, it may make sense to define the actual capabilities in 6.4.3 (Common NR Positioning Information Elements), similar to other common DL-PRS capabilities. |
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### 3.2.4 positioning in RRC\_INACTIVE

In RAN1 table, RAN1 also provided the draft on RAN2 led items “positioning in RRC\_INACTIVE”. [3] discussed it and have following proposals:

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| **Capabilities on positioning in RRC\_INACTIVE**27-6 DL PRS processing capabilities in RRC inactive state* This capability is same 27-3-3. Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports PRS processing capability or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should only introduce 27-3-3 instead of separate 27-3-3 and 27.6.

27-15 Support of positioning SRS transmission in RRC\_INACTIVE state [for initial BWP]* Regarding Uu interface, i.e. RRC capability, it is related to whether the gNB can configure SRS via RRCRelease message and therefore the capability in Uu interface is needed;

27-16 OLPC for positioning SRS in RRC\_INACTIVE state* Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 OLPC or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability.
* Regarding Uu interface, i.e. RRC capability, it is related to whether the gNB can configure SRS via RRCRelease message and therefore the capability in Uu interface is needed;

27-17 Support of [PRS measurement in RRC\_INACTIVE]* Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 PRS measurements or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability.

27-18a Support of PRS measurement in RRC\_INACTIVE state for DL-TDOA* Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 DL-TDOA measurements or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability.

27-18b Support of PRS measurement in RRC\_INACTIVE state for DL-AoD* Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 DL-AoD measurements or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability.

27-18c Support of PRS measurement in RRC\_INACTIVE state for Multi-RTT* Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 Multi-RTT measurements or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability.

27-19 Spatial relation for positioning SRS in RRC\_INACTIVE state* Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 spatial relation or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability.
* Regarding Uu interface, i.e. RRC capability, it is related to whether the gNB can configure SRS via RRCRelease message and therefore the capability in Uu interface is needed;

In summary:**Proposal 4: For positioning in RRC\_INACTIVE, do not introduce RRC\_INACTIVE specific LPP capabilities (27-6, 27-16, 27-17, 27-18a, 27-18b, 27-18c, 27-19);****Proposal 5: For positioning in RRC\_INACTIVE, introduce RRC\_INACTIVE specific RRC capabilities (27-15, 27-16, 27-19);****Proposal 6: Send LS to RAN1 to inform them of RAN2 RRC\_INACTIVE capabilities related agreements;** |

**Discussion point 3.2.4-1: For positioning in RRC\_INACTIVE, Companies are invited to provide view on whether RRC\_INACTIVE specific LPP capabilities (27-6, 27-16, 27-17, 27-18a, 27-18b, 27-18c, 27-19) are needed or not?**

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| **Company’s name** | **Needed/No?** | **Comments, if any** |
| Intel | No | It contradicts with RAN2 agreements. RRC state is transparent to the LMF. Do not see how the LMF use these capabilities even if RAN2 agree to introduce them.  |
| Apple | No | Agree that RRC state should be transparent to LMF |
| Qualcomm | Yes | "RRC State awareness" and "capabilities" are separate issues. Since the measurement/DL-PRS processing/SRS transmission capabilities are different in different RRC states, a LMF would need to take this into account e.g., when selecting a proper positioning method, etc.. For example, response time is likely longer than in RRC\_CONNECTED, measurement accuracy may be lower, etc. It may also impact which "assistance data" an LMF provides to a gNB, e.g., to keep the UE in RRC\_INACTIVE. |
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**Discussion point 3.2.4-2: For positioning in RRC\_INACTIVE, Companies are invited to provide view on whether the RRC\_INACTIVE specific RRC capabilities (27-15, 27-16, 27-19) are needed?**

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| **Company’s name** | **Needed/No?** | **Comments, if any** |
| Intel | Needed | The gNB can only configure the SRS via RRCRelease message when the UE supports it.  |
| Apple | Agree |  |
| Qualcomm | No | These capabilities can be provided from an LMF to the gNB in the new NRPPa "Assistance Information" or in the NRPPa Positioning Information Request (e.g., together with the Requested SRS Transmission Characteristics). Generally, we prefer to keep all positioning related capabilities in LPP, where possible. |
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## 3.3 RAN1 led items

RAN1 feature lists is provided in [2]. Based on RAN2 guidance, all of them should not be implemented into CRs since all of them contains FFS (highlighted yellow, [] and marked as FFS/TBD.) [3] discussed RAN2 impact based on RAN1 feature lists.

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| Therefore here we only try to analyse potential RAN2 impact (see the last column RAN2 impact”.  |

Note: Rapporteur updated the table a bit with change mark.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional | RAN2 impact |
| 27-1-1 | Support of UE-RxTEGs [for UE-assisted DL TDOA and/or Multi-RTT positioning] | The maximum number of UE-RxTEG, which is supported and reported by UE for UE assisted DL TDOA and/or Multi-RTT positioning | 13-1, one or more of {13-3, 13-4} | No | UE-RxTEG reporting is not supported and no assumption can be made on the mitigation of UE Rx timing delays for the measurements | [per band or FS] | n/a | n/a | n/a | The candidate values are {[1,] 2,[ 3,] 4, 6, 8[, 12, 16, 24, 32]}Need for location server to know if the feature is supportedFFS: Separate row for “Support of UE-RxTEG reporting for DL-TDOA”, and “Support of UE-RxTEG reporting for M-RTT”If UE supports this capability with the values > 1, and if the UE does not include RxTEG-ID associated with a measurement, no assumption can be made on the mitigation of UE Rx timing delays for this measurement[If value=1 is indicated by the UE, the UE Rx timing errors differences between two measurements are within a margin only if the UE reports the same Rx-TEG-ID associated with both measurements, otherwise, no assumption can be made about the timing error differences between these measurements.]Note: The “per band” reporting on this capability does not imply, that the RxTEG IDs in the measurement report are grouped per band; In the measurement report, the RxTEG ID can span from 0, up to 31 | Optional with capability signaling | **LPP CR**: Extend DL TDOA and/or Multi-RTT capability (NR-DL-TDOA-ProvideCapabilities-r16 and NR-Multi-RTT-ProvideCapabilities-r16 ) to contain this UE-RxTEGs capability; See [6]FFS on whether common IE should be defined in 6.4.3 Common NR Positioning Information Elements. |
| 27-1-2 | Support of UE-TxTEGs for UL TDOA  | The maximum number of UE-TxTEG, which is supported and reported by UE for UL TDOA  | [13-4, ]13-8 | Yes | UE-TxTEGs for UL TDOA is not supported and no assumption can be made on the mitigation of UE Tx timing for the SRS” and “UE-TxTEGs for RTT is not supported and no assumption can be made on the mitigation of UE Tx timing for the SRS | FFS: per band or per FS | n/a | n/a | n/a | The candidate values are {[1, ]2, 4, 6, 8}[Need for location server to know if the feature is supported]Note: It should support the serving gNB to request the UE to provide the association information of UL SRS resources for positioning with Tx TEGs to the serving gNB for UL TDOA [if UL TDOA is supported by UE][Note: It should support the LMF to request the UE to provide the association information of UL SRS resources for positioning with Tx TEGs directly to the LMF for Multi-RTT if Multi-RTT is supported by UE] | Optional with capability signaling | **RRC CR**: Extend SRS capability to contain this UE-TxTEGs capability;**LPP CR (TBD)**: Extend NR UL capability (NR-UL-ProvideCapabilities-r16 ) to contain this UE-TxTEGs capabilityNote: 27-1-2 and 27-1-2a can be common from capability perspective;FFS on whether common IE 27-1-2 and 27-1-2a can be defined under NR-UL-SRS-Capability-r16 in 6.4.3 Common NR Positioning Information Elements. |
| 27-1-2a | Support of UE-TxTEGs for Multi-RTT [and/or UL TDOA]positioning | The maximum number of UE-TxTEG, which is supported and reported by UE for Multi-RTT positioning | 13-4, 13-8 | No | UE-TxTEGs for Multi-RTT positioning is not supported  | [per band per FS] | n/a | n/a | n/a | The candidate values are {[1, ] 2, 4, 6, 8}Need for location server to know if the feature is supportedIf UE supports this capability with the values > 1, and if if the UE does not include TxTEG-ID associated with a measurement, no assumption can be made on the mitigation of UE Tx timing delays for this SRS resource [If value=1 is indicated by the UE, the UE Tx timing errors differences between two SRS resources are within a margin only if the UE reports an Tx-TEG-ID associated with the SRS resources, otherwise, no assumption can be made about the timing error differences between these SRS resources.][Note: It should support the serving gNB to request the UE to provide the association information of UL SRS resources for positioning with Tx TEGs to the serving gNB for UL TDOA][Note: It should support the LMF to request the UE to provide the association information of UL SRS resources for positioning with Tx TEGs directly to the LMF for Multi-RTT if Multi-RTT is supported by UE] | Optional with capability signaling | **LPP CR**: Extend NR UL and/pr Multi-RTT capability (NR-UL-ProvideCapabilities-r16 and NR-Multi-RTT-ProvideCapabilities-r16 ) to contain this UE-TxTEGs capabilityNote: 27-1-2 and 27-1-2a can be common from capability perspective;FFS on whether common IE 27-1-2 and 27-1-2a sould be defined under NR-UL-SRS-Capability-r16 in 6.4.3 Common NR Positioning Information Elements. |
| 27-1-3 | Support of UE-RxTxTEGs for Multi-RTT | The maximum number of UE-RxTxTEG, which is supported and reported by UE for Multi-RTT positioning | [13-4 or 13-8] | No | Mitigation of UE RxTx timing delays is not supported | per band | n/a | n/a | n/a | The candidate values are {[1, ]2, 4, 6, 8, 12, 16, 24, 32[, 64, 128, 256]}Need for location server to know if the feature is supportedIf UE supports this capability with the values > 1, and if the UE does not include RxTxTEG-ID associated with a measurement, no assumption can be made on the mitigation of UE RxTx timing delays for this measurement[If value=1 is indicated by the UE, the UE RxTx timing errors differences between two measurements are within a margin only if the UE reports an RxTx-TEG-ID associated with the measurements, otherwise, no assumption can be made about the timing error differences between these measurements]Note: The “per band” reporting on this capability does not imply, that the RxTxTEG IDs in the measurement report are grouped per band; In the measurement report, the RxTxTEG ID can span from 0, up to [255] | Optional with capability signaling | **LPP CR**: Extend Multi-RTT capability (NR-Multi-RTT-ProvideCapabilities-r16 ) to contain this UE-RxTxTEGs for Multi-RTT capability; |
| 27-1-4 | Support of UE Rx TEGs for measuring the same DL PRS resource | The maximum number of different UE-RxTEGs that a UE can support to measure the same DL PRS of a TRP | 27-1-1 | No | Up to 1 RxTEG is used to measure the same DL PRS resource of a TRP |  per band | n/a | n/a | n/a | The candidate values are {2, 3, 4, 6, 8}Need for location server to know if the feature is supported | Optional with capability signaling | **LPP CR**: Extend DL TDOA and/or Multi-RTT capability (NR-DL-TDOA-ProvideCapabilities-r16 and NR-Multi-RTT-ProvideCapabilities-r16 ) to contain this maximum number of different UE-RxTEGs capability;Note: there is no FFS for this capability, but the Prerequisite feature groups 27-1-1 has FFS. |
| 27-1-4a | Support of UE Rx TEGs for measuring the same DL PRS resource simultaneously | The maximum number of UE Rx TEGs for measuring the same DL PRS resource simultaneously |  | No |  | Per band | n/a | n/a | n/a | [The candidate values are {1,2, 4, 8}] | Optional with capability signaling | **LPP CR**: Extend DL TDOA and/or Multi-RTT capability (NR-DL-TDOA-ProvideCapabilities-r16 and NR-Multi-RTT-ProvideCapabilities-r16 ) to contain this maximum number of UE-RxTEGs capability; |
| 27-2-1 | [UE-assisted] DL PRS RSRP of the first path for DL-AoD | 1.) Support of [measuring and reporting the] PRS RSRP of the first path for DL-AoD positioning method2.) The maximum number of first path PRS RSRP per TRP | [13-2 or 13-3, 13-4, 13-5, 13-8] | No |  | FFS: Per UE or per band | n/a | n/a | n/a | Component 2 candidate values: [2,4,8,16,24]Need for location server to know if the feature is supported | Optional with capability signaling | **LPP CR**: Extend DL AoD capability (NR-DL-TDOA-ProvideCapabilities-r16 ) to contain this DL PRS RSRP of the first path for DL-AoD capability;Note: seems it is sufficient to only introduce component 2, i.e. The present of component 2 means the UE supports this feature.  |
| 27-2-2 | DL PRS RSRP reporting for more than 8 measurements for UE-assisted DL-AoD positioning | Support reporting K> 8 DL PRS RSRP measurements per TRP.Note: Multiple RSRPs corresponding to same or different Rx Beam index should be able to be reported for a given PRS resource for different timestamps.  | [13-5, 13-2] | No | UE report of more than 8 DL PRS-RSRP is not supported.  | FFS: Per UE or per band | n/a | Yes | n/a | The candidate values are {[12, ]16, 24[, 32, 64]}Need for location server to know if the feature is supported | Optional with capability signaling | **LPP CR**: Extend DL AoD capability (NR-DL-TDOA-ProvideCapabilities-r16 ) to contain this DL PRS RSRP report more than 8 for DL-AoD capability;Note: seems it is sufficient to only introduce the candidate value, i.e. The present of candidate value means the UE supports this feature.  |
| 27-3-1 | M-sample measurements [of DL PRS measurement on single DL PRS period/occasion] | [The capability to support reporting a measurement based on measuring M samples (instances) of a DL PRS resource set] | [13-1, 13-4, 13-8] | No |  | FFS: Per UE or per band | n/a | n/a | n/a | [The candidate values are {1}]If the UE does not provide the capability, the UE [is assumed to] support M=4 only.Need for location server to know if the feature is supported | Optional with capability signaling | **LPP CR**: Extend PRS capability (NR-DL-PRS-ProcessingCapability-r16 ) to contain this M-sample measurements capability; |
| 27-3-2 | DL PRS measurement outside MG [and in a PRS processing priority window] - processing types | 1. Supported PRS processing types subject to the UE determining that DL PRS to be higher priority for PRS measurement outside MG [and in a PRS processing priority window]Candidate values: {Type 1A, Type 1B, Type 2}.Note:* Type 1A refers to DL PRS being prioritized over other DL signals/channels in all OFDM symbols within the PRS processing priority window. The DL signals/channels from all DL CCs (per UE) are affected.
* Type 1B refers to DL PRS being prioritized over other DL signals/channels in all OFDM symbols within the PRS processing priority window. The DL signals/channels from certain DL CCs are affected.
* Type 2 refers to DL PRS being prioritized over other DL signals/channels only in DL PRS symbols within the PRS processing priority window.

Note: When the UE determines higher priority for other DL signals/channels over the PRS measurement/processing, the UE is not expected to measure/process DL PRS which is applicable to all of the above capability options[Note: Within a PRS processing window, UE measurement is inside the active DL BWP with PRS having the same numerology as the active DL BWP] | [13-1] | FFS |  | FFS: Per UE or per band | n/a | n/a | n/a | Need for location server to know if the feature is supportedFFS: Separate feature group for a UE to declare support of each of the Type-1A, Type-1B, Type-2” capabilities | Optional with capability signaling | **LPP CR**: Extend PRS capability (NR-DL-PRS-ProcessingCapability-r16 ) to contain this PRS measurement outside MG capability;**RRC CR (TBD)**: Note: intention is not clear. Is the motivation that the gNB may need to know this capability in order to determine whether to configure MG? But the gNB is not aware of the positioning, then should not LMF indicate this to the gNB? |
| 27-3-3 | DL PRS Processing Capability outside MG - buffering capability | 1. DL PRS buffering capability: Type 1 or Type 2a) T: [{8, 16, 20, 30, 40, 80, 160, 320, 640, 1280}] msb) Type 2 – slot level buffering2. Duration of DL PRS symbols N in units of ms a UE can process every T ms assuming maximum DL PRS bandwidth in MHz, which is supported and reported by UE.a) Type 1 – sub-slot/symbol level bufferingb) N: {0.125, 0.25, 0.5, 1, 2, 4, 6, 8, 12, 16, 20, 25, 30, 32, 35, 40, 45, 50} ms3. Max number of DL PRS resources that UE can process in a slot under ita) FR1 bands: {1, 2, 4, 6, 8, 12, 16, 24, 32, 48, 64} for each SCS: 15kHz, 30kHz, 60kHzb) FR2 bands: {1, 2, 4, 6, 8, 12, 16, 24, 32, 48, 64} for each SCS: 60kHz, 120kHz | 27-3-2 | No |  | Per band | n/a | n/a | n/a | FFS: Separate feature group for a UE to declare PRS processing capabilities of each of the Type-1A, Type-1B, Type-2” capabilities | Optional with capability signaling | **LPP CR**: Extend PRS capability (NR-DL-PRS-ProcessingCapability-r16 ) to contain this buffering capability in case of PRS measurement outside MG capability; |
| 27-4-1 | LOS/NLOS Indicator for UE-assisted positioning | Support reporting LoS/NLoS indicator to LMF [for RSTD and UE Rx-Tx time difference measurements to LMF for DL and DL+UL positioning]FFS: whether to have separate capability component/FG for RSTD and UE Rx-Tx time difference measurementsFFS: whether to have separate capability component for hard and soft indication |  | No |  | FFS: Per UE or per band | n/a | n/a | n/a | [The candidate value are [0,1]]Need for location server to know if the feature is supported | Optional with capability signaling | **LPP CR**: Extend DL TDOA, Multiple RTT capability (NR-DL-TDOA-ProvideCapabilities-r16 and NR-Multi-RTT-ProvideCapabilities-r16 ) to contain this LOS/NLOS indicator capability |
| 27-5-1 | [UE-initiated] on-demand PRS | UE’s capability to support UE-initiated on-demand DL PRS [request signalling] | [13-1] | No |  | Per UE | n/a | n/a | n/a | FFS: Need for location server to know if the feature is supported | Optional with capability signaling | **LPP CR**: Extend PRS capability(NR-DL-PRS-ProcessingCapability-r16 ) or (NR-DL-TDOA-ProvideCapabilities-r16, NR-DL-AoD-ProvideCapabilities-r16 and NR-Multi-RTT-ProvideCapabilities-r16 ) to contain this UE indicated On-Demand PRS capabilityNote: This is RAN2 led item. The capability can be decided in RAN2, related to **Discussion point 3.2.3** |
| 27-6 | DL PRS processing capabilities in RRC inactive state | 1. DL PRS buffering capability: Type 1 or Type 2a) Type 1 – sub-slot/symbol level bufferingb) Type 2 – slot level buffering2. Duration of DL PRS symbols N in units of ms a UE can process every T ms assuming maximum DL PRS bandwidth in MHz, which is supported and reported by UE.a) Type 1 – sub-slot/symbol level bufferingb) N: {0.125, 0.25, 0.5, 1, 2, 4, 6, 8, 12, 16, 20, 25, 30, 32, 35, 40, 45, 50} ms3. Max number of DL PRS resources that UE can process in a slot under ita) FR1 bands: {1, 2, 4, 6, 8, 12, 16, 24, 32, 48, 64} for each SCS: 15kHz, 30kHz, 60kHzb) FR2 bands: {1, 2, 4, 6, 8, 12, 16, 24, 32, 48, 64} for each SCS: 60kHz, 120kHz |  |  |  |  |  |  |  |  |  | **LPP CR**: Extend PRS capability(NR-DL-PRS-ProcessingCapability-r16 ) to contain this buffering capability in case of PRS measurement outside MG capability;Note 1: This is RAN2 led item. The capability can be decided in RAN2. Note 2:- This capability is same 27-3-3. Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports PRS processing capability or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should only introduce 27-3-3 instead of separate 27-3-3 and 27.6. Note: Related to discussion point 3.2.4. |
| 27-7 | Maximum number of measurement instances which can be included in a single measurement report | Maximum number of measurement instances which can be included in a single measurement report |  |  |  |  |  |  |  |  |  | **LPP CR**: Not sure the details. |
| 27-8 | Support of PRS TEG association information for UE-based DL-TDOA | Support of reception of association between PRS and TRP Tx TEG for UE-based positioning |  | No | Positioning calculation assistance data containing association between PRS and TRP Tx TEG is not supported by UE | Per UE | n/a | n/a | n/a | Need for location server to know if the feature is supported.Agreement:Support the LMF to provide the association information of DL PRS resources with Tx TEGs to a UE for UE-based positioning if the TRP has multiple TEGs | Optional with capability signaling | **LPP CR**: Extend DL TDOA capability (NR-DL-TDOA-ProvideCapabilities-r16) to contain this Support of reception of association between PRS and TRP Tx TEG capability; |
| 27-9 | Support of lower Rx beam sweeping factor | 1. Support of the lower Rx beam sweeping factor than 8 for FR22. Number of Rx beam sweeping factors: {1,2,3,4,5,6,7} |  | No | UE only supports 8 as the Rx beam sweeping factor defined by RAN4. | Per band (FR2 only) | n/a | n/a | n/a | Need for location server to know if the feature is supported | Optional with capability signaling | **LPP CR**: Extend PRS capability (NR-DL-PRS-ProcessingCapability-r16 ) to contain this of lower Rx beam sweeping factor capability;Note: This is to reduce the PRS measurement latency for FR2 positioning frequency layers. Need RAN4 confirm. |
| 27-10 | Support of UL MAC CE based MG activation request | 1. Support of using UL MAC CE to request measurement gap. |  | Yes | Using UL MAC CE to indicate PRS measurement to the gNB is not supported. | Per UE | No | No | No |  | Optional with capability signaling | **RRC CR**: introduce support of UL MAC CE to request MG capability, e.g. new IE *MeasPosParameters-r17*;Note: the MG gap is still under RAN2 discussion.  |
| 27-11 | Support of DL MAC CE based MG activation | 1. Support of preconfiguration of MGs in RRC2. Support of using DL MAC CE to activate the MG |  | Yes | Using DL MAC CE to activate the preconfigured MG is not supported | Per UE | No | No | No |  | Optional with capability signaling. | **RRC CR**: introduce support of DL MAC CE to activate MG capability, e.g. new IE *MeasPosParameters-r17*;Note: the MG gap is still under RAN2 discussion.  |
| 27-12 | LOS/NLOS indicator for UE-based positioning assistance data | Support reception of the assistance data containing the LOS/NLOS indicator.1. LOS/NLOS indicator type: {softValue, hardValue, both}2. LOS/NLOS indicator granularity {resourceSpecific, trpSpecific, both} |  | No |  | Per UE | No | No | No | Need for location server to know if the feature is supported. | Optional with capability signaling. | **LPP CR**: Extend TRP or PRS capability (NR-DL-PRS-ProcessingCapability-r16 ) or (NR-DL-TDOA-ProvideCapabilities-r16, NR-DL-AoD-ProvideCapabilities-r16 and NR-Multi-RTT-ProvideCapabilities-r16 ) to contain this LOS/NLOS indicator capability;Note: • Option 1: LMF associates UE-based LoS/NloS indicators with each DL PRS resource for each TRP, provided the LMF can give different values for Los/NLos indicators of different DL PRS resource of one TRP.o Option 2: LMF associates UE-based LoS/NloS indicators with each TRP |
| 27-13 | Additional path reporting for UE-assisted DL-TDOA | [1. Support of TOA reporting for more than 2 additional paths.]2. Support of path RSRP reporting for additional paths if path RSRP reporting is supported. |  | No |  | Per UE | No | No | No | Need for location server to know if the feature is supported. | Optional with capability signaling. | **LPP CR**: Extend DL-TDOA capability (NR-DL-TDOA-ProvideCapabilities-r16) to contain this additional path reporting capability;Note: it can be common IE for 27-13 and 27-14 |
| 27-14 | Additional path reporting for Multi-RTT | 1. Support of TOA reporting for more than 2 additional paths2. Support of path RSRP reporting for additional paths if path RSRP reporting is supported. |  | No |  | Per UE | No | No | No | Need for location server to know if the feature is supported. | Optional with capability signaling. | **LPP CR**: Extend Multi-RTT capability( NR-Multi-RTT-ProvideCapabilities-r16 ) to contain this additional path reporting capability;Note: it can be common IE for 27-13 and 27-14 |
| 27-15 | Support of positioning SRS transmission in RRC\_INACTIVE state [for initial BWP] | 1. Max number of SRS Resource Sets for positioning supported by UE per BWP.Values = {1, 2, 4, 8, 12, 16}.2. Max number of periodic SRS Resources for positioning per BWP.Values = {1,2,4,8,16,32,64}3. Max number of periodic SRS Resources for positioning per BWP per slot.Values = {1, 2, 3, 4, 5, 6, 8, 10, 12, 14}4. FFS: Applicability for initial BWPOLPC for SRS for positioning based on SSB from the last serving cell (the cell that releases UE from connection) is part of this FG.Note: no dedicated capability signaling is intended for this component |  | Yes |  | Per band | n/a | n/a | n/a |  | Optional with capability signaling | **RRC CR**: Extend SRS capability to contain this support of positioning SRS transmission capability;Note 1: This is RAN2 led item. The capability can be decided in RAN2. Note 2: - Regarding Uu interface, i.e. RRC capability, it is related to whether the gNB can configure SRS via RRCRelease message and therefore the capability in Uu interface is needed;Note: Related to the discussion point 3.2.4 |
| 27-16 | OLPC for positioning SRS in RRC\_INACTIVE state | Same asLPPOLPC-SRS-Pos-r16RRCOLPC-SRS-Pos-r16 |  | Yes |  | Per band | n/a | n/a | n/a | Need for location server to know if the feature is supported. | Optional with capability signaling | **RRC CR**: Extend SRS capability to contain this support of OLPC for positioning SRS in RRC\_INACTIVE statecapability;Note 1: This is RAN2 led item. The capability can be decided in RAN2. **LPP CR:**Extend SRS capability to contain this support of OLPC for positioning SRS in RRC\_INACTIVE statecapability;Note 2: - Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 OLPC or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability. - Regarding Uu interface, i.e. RRC capability, it is related to whether the gNB can configure SRS via RRCRelease message and therefore the capability in Uu interface is needed;Note: Related to the discussion point 3.2.4 |
| 27-17 | Support of [PRS measurement in RRC\_INACTIVE] | Support of PRS measurement in RRC\_INACTIVENote: UE supporting this feature may support at least one from DL RSTD, DL PRS-RSRP, or UE Rx – Tx time difference |  | Yes |  | Per UE | No | No | No |  | Optional with capability signaling. | **RRC CR**: Introduce this PRS measurement in RRC\_INACTIVE capability;Note 1: This is RAN2 led item. The capability can be decided in RAN2. Note 2: - Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 PRS measurements or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability. Note: Related to the discussion point 3.2.4 |
| 27-18a | Support of PRS measurement in RRC\_INACTIVE state for DL-TDOA | Support of PRS measurement in RRC\_INACTIVE state for DL-TDOANote: Other PRS capabilities follows the same as the RRC\_CONNECTED state for DL-TDOA. |  | No |  | Per UE | No | No | No | Need for location server to know if the feature is supported. | Optional with capability signaling. | **LPP CR**: Introduce this PRS measurement in RRC\_INACTIVE capability;Note 1: This is RAN2 led item. The capability can be decided in RAN2. Note 2: - Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 DL-TDOA measurements or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability. Note: Related to the discussion point 3.2.4 |
| 27-18b | Support of PRS measurement in RRC\_INACTIVE state for DL-AoD | Support of PRS measurement in RRC\_INACTIVE state for DL-AoDNote: Other PRS capabilities follows the same as the RRC\_CONNECTED state for DL-AoD. |  | No |  | Per UE | No | No | No | Need for location server to know if the feature is supported. | Optional with capability signaling. | **LPP CR**: Extend DL AOD (NR-DL-AoD-ProvideCapabilities-r16 ) Introduce this PRS measurement in RRC\_INACTIVE capability;Note 1: This is RAN2 led item. The capability can be decided in RAN2. Note 2: - Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 DL-AoD measurements or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability. Note: Related to the discussion point 3.2.4 |
| 27-18c | Support of PRS measurement in RRC\_INACTIVE state for Multi-RTT | 1. Support of PRS measurement in RRC\_INACTIVE state for Multi-RTT2. Support of positioning SRS transmission in RRC\_INACTIVE state.Note: Other PRS capabilities follows the same as the RRC\_CONNECTED state for Multi-RTT. |  | No |  | Per UE | No | No | No | Need for location server to know if the feature is supported. | Optional with capability signaling. | **LPP CR**:Extend Multi-RTT (NR-Multi-RTT-ProvideCapabilities-r16 ) Introduce this PRS measurement in RRC\_INACTIVE capability;Note 1: This is RAN2 led item. The capability can be decided in RAN2. Note 2: - Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 Multi-RTT measurements or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability. Note: Related to the discussion point 3.2.4 |
| 27-19 | Spatial relation for positioning SRS in RRC\_INACTIVE state | Same as*LPP**SpatialRelationsSRS-Pos-r16**RRC**SpatialRelationsSRS-Pos-r16* |  | Yes |  | Per band | n/a | n/a | n/a | Need for location server to know if the feature is supported. | Optional with capability signalling | **RRC CR**: Extend SRS capability to contain this support of spatial relation for positioning SRS in RRC\_INACTIVE state capability;Note 1: This is RAN2 led item. The capability can be decided in RAN2. **LPP CR:**Extend SRS capability to contain this support of spatial relation for positioning SRS in RRC\_INACTIVE state capability;Note 2: - Based on RAN2 agreements, there is no different handling on PRS for different RRC state. From LMF perspective, the LMF only needs to know whether the UE supports Rel-16 spatial relation or not. If the UE cannot support it in RRC\_INACTIVE, the UE should trigger the transition to RRC\_CONNECTED. Therefore dedicated LPP capability for RRC\_INACTIVE is not needed, we should rely on existing LPP capability. - Regarding Uu interface, i.e. RRC capability, it is related to whether the gNB can configure SRS via RRCRelease message and therefore the capability in Uu interface is neededNote: Related to the discussion point 3.2.4 |

**Discussion point 3.3-1: Companies are invited to provide views on how to capture RAN1 capabilities (Rapporteur listed the suggestions in the last column), e.g. LPP or RRC capabilities, where to put, etc.**

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| **Company’s name** | **Comments, if any** |
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## 3.4 Other issues

**Discussion point 3.4: Companies are invited to provide views on whether any issues need to be addressed.**

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| **Company’s name** | **Comments, if any** |
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# Summary report and proposals

# Reference

1. R2-2111259 Preparation for Rel-17 UE capability Intel Corporation
2. R1-2112902 Rel17 RAN1 UE feature List
3. R2-2200284 Rel-17 positioning capabilities Intel Corporation
4. R2-2200962 Remaining Issues on Scheduling Location in Advance Qualcomm Incorporated
5. R2-2201652 Summary on agenda item 8.11.2 on Latency Enhancements Qualcomm Incorporated
6. R2-2200959 Running LPP CR for NR positioning enhancements Qualcomm Incorporated