3GPP TSG-RAN WG2 #111-e *DRAFT* R2-2008261

Electronic Meeting, August 17 - 28, 2020

Agenda Item: 8.11.2

Source: Ericsson

Title: [AT111-e][612][POS] Assumptions for analysis of commercial use cases (Ericsson)

Document for: Discussion, Decision

# 1 Introduction

This document provides templates and eventually summaries for the following email discussion:

* [AT111-e][612][POS] Assumptions for analysis of commercial use cases (Ericsson)

Scope: Align understanding of the RAN2 scope and assumptions for accuracy, latency, and efficiency objectives for commercial use cases. Attempt to capture a summary of proposals to this meeting that can be discussed in RAN2 directly.

Intended outcome: Summary in R2-2008261

Deadline: Wednesday 2020-08-26 1200 UTC

The email discussion is based on the contributions [1]-[13] in agenda item 8.11.2 “Enhancements for commercial use cases”, which is related to the following study item [14] objective:

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| 1. Study enhancements and solutions necessary to support the high accuracy (horizontal and vertical), low latency, network efficiency (scalability, RS overhead, etc.), and device efficiency (power consumption, complexity, etc.) requirements for commercial uses cases (incl. general commercial use cases and specifically (I)IoT use cases as exemplified in section 3 above (Justification)):    1. Define additional scenarios (e.g. (I)IoT) based on TR 38.901 to evaluate the performance for the use cases (e.g. (I)IoT). [RAN1]    2. Evaluate the achievable positioning accuracy and latency with the Rel-16 positioning solutions in (I)IoT scenarios and identify any performance gaps. [RAN1]    3. Identify and evaluate positioning techniques, DL/UL positioning reference signals, signalling and procedures for improved accuracy, reduced latency, network efficiency, and device efficiency. Enhancements to Rel-16 positioning techniques, if they meet the requirements, will be prioritized, and new techniques will not be considered in this case. [RAN1, RAN2] |

**References**:

1. R2-2006672 Discussion on ehancements for commercial use cases, CATT
2. R2-2006578 Discussion on R17 positioning enhancement, Huawei, HiSilicon
3. R2-2006567 Discussion on potential positioning enhancement, vivo
4. R2-2006956 Enhancements for commercial use cases, Ericsson
5. R2-2007049 Discussion on positioning enhancements for commercial use cases, Spreadtrum Communications
6. R2-2007629 NR Positioning Enhancements, Qualcomm Incorporated
7. R2-2006750 Consideration on the support of low latency requirement, Intel Corporation
8. R2-2007587 End-to-end latency reduction for DL/UL positioning, InterDigital, Inc.
9. R2-2007128 On-demand PRS transmission and dynamic PRS resource allocation, Nokia, Nokia Shanghai Bell
10. R2-2007159 Discussion on on-demand DL-PRS, OPPO
11. R2-2007170 Discussion on PRS enhancements, Beijing Xiaomi Electronics
12. R2-2007157 Positioning for UE in RRC Idle and Inactive state, OPPO
13. R2-2007173 Positioning enhancements for RRC IDLE and RRC INACTIVE state UE, Beijing Xiaomi Electronics
14. RP-200928 Study on NR Positioning Enhancements

The contribution proposals have been categorized in the following main categories:

* DL/UL positioning reference signals
* Signaling and procedures
* Latency analysis
* Network and device efficiency

The corresponding contribution proposals are discussed per category in the sections. Please let the email Rapporteur know of any accidental oversights as part of the initial review phase.

# 2 DL/UL positioning reference signals

The proposals related to DL/UL positioning reference signals is strongly related to RAN1, and the corresponding discussions needs to be aligned. Therefore, companies are asked to provide comments regarding what can be discussed in RAN2 independent of RAN1 and what needs RAN1 alignment, in addition to general comments.

## 2.1 Rel 15 reference signals

The use of Rel 15 reference signals for positioning purposes was evaluated in the Rel 16 study phase. These include Rel 15 SRS [2] and SSB/CSI-RS/CSI-RS for tracking (TRS) [4]. These have been discussed in the general positioning context or restricted to specific positioning methods and/or measurements and/or serving/neighbour cell combinations.

Companies are asked to comment on the use of Rel 15 RS for positioning, which RS to consider, possible restrictions to positioning methods, measurements, serving/neighbour cell aspects what can be discussed in RAN2, and what needs to be aligned with RAN1.

**2.1 Rel 15 reference signals**

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| Company | Comments |
| Huawei/HiSilicon | The action from RAN2 can be triggered upon RAN1 conclusion. |
| vivo | Whether R15 signals can be used should be determined by RAN1. Then RAN2 can decide signal procedure and assistant data for each method for example UL-SRS configuration via RRC. |
| Fraunhofer | This is currently discussed in RAN1.  The SID mentions the RAN2 objectives as:  Further identify and evaluate potential enhancement of signalling and procedures  for supporting positioning technologies for improved accuracy, reduced latency, network efficiency and device efficiency.  Note: RAN2’s work may take in to account the outcome from RAN1 (e.g., IIOT scenarios, Rel-16 enhancements, and new positioning techniques).  We think we should discuss this topic in RAN1 first and work on signaling and procedures based on RAN1 agreement. |
| Ericsson | R15 signals such as CSI-RS, CSI-RS for tracking (TRS) and SRS are configured for communication purposes and also have attractive properties from timing and RSS estimation purposes. For some of these signals, some work will be required in RAN1, but there are signalling and procedure aspects to consider in RAN2 which essentially is about extending existing mechanisms.  Examples include  - serving cell RTT estimation based on TRS and SRS measurements  - DL TDOA measurements based on TRS |
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## 2.2 Rich reference signal measurements

Rich reference signals measurements were introduced in LTE and in a similar fashion in NR based on relative timing reporting for up to two additional paths, but more detailed rich reference signal measurements were studied and evaluated in Rel 16.

The proposals address

* angle and power information associated with each path, NLOS/LOS identification, channel impulse response (CIR) or channel frequency response (CFR), etc [2]
* further additional paths beyond 2, richer path information including received signal strength per path, relative signal strength per path, indication of the strongest path, phase information per path, line-of sight indication, etc [4]

Companies are asked to comment on a rich reference signal measurement scope as well as what can be discussed in RAN2, and what needs to be aligned with RAN1.

**2.2 Rich reference signal measurements**

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| Company | Comments |
| Huawei/HiSilicon | RAN1 already agreed to study potential enhancement on multi-path mitigation and utilization.  The action from RAN2 can be triggered upon RAN1 conclusion. |
| vivo | Whether to support rich reference signal in R17 should be determined by RAN1. Then RAN2 can decide signal procedure and assistant data for each method. |
| Fraunhofer | In principle we support enhancements on measurement reporting. The outcome of the discussion is however not clear here. In our understanding, RAN1 shall study the different approaches and the required signaling or enhancement needed can (will) be part of RAN2 work. Having said that, it’s clear that determining what can be reported will be the scope of WI phase. Hence, we would like to ask the FL on what should RAN2 study during SI phase.  We agree to enhance multipath reporting. We suggest reporting information from a portion of channel impulse response around the first arrival path. |
| Ericsson | These enhancements were discussed already in R16, and are discussed in R17 RAN1. From a RAN2 perspective, the enhancements concerns signalling and procedure enhancements, which essentially need to be based on input from RAN1. We see that the current limitation of max two additional paths that can be reported in Rel16 should be extended to more paths, and finer information per path and LOS/NLOS indications are valuable enhancements in indoor scenarios. |
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## 2.3 Rx/Tx diversity measurements

Rx diversity was studied by RAN1 and was decided to be up to the UE implementation. The Rx diversity and Tx diversity could be further studied in Rel-17, especially for scenarios with diversity antennas [2].

Companies are asked to comment on a Rx/Tx diversity measurement scope as well as what can be discussed in RAN2, and what needs to be aligned with RAN1.

**2.3 Rx/Tx diversity measurements**

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| Company | Comments |
| Huawei/HiSilicon | The action from RAN2 can be triggered upon RAN1 conclusion. |
| vivo | Whether to support RX/TX diversity measurement can be determined by RAN1. Then RAN2 can decide signal procedure and assistant data for each method. |
| Fraunhofer | We don’t really understand the scope, is the intention to support diversity by simultaneous transmission/reception. In any case, we share the view of HW and vivo here. |
| Ericsson | The Rx/Tx diversity discussion in R16 RAN1 resulted only in some beam index reporting for RSRP measurements, and this can be enhanced after more work in RAN1. |
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## 2.4 DL PRS cyclic shifts

Rel 16 supports interference suppression via muting, orthogonal reference signal patterns, beam-based reference signals and reference signal processing gains. Additional orthogonalization can be introduced via DL PRS cyclic shifts [4].

Companies are asked to comment on a DL PRS cyclic shifts scope as well as what can be discussed in RAN2, and what needs to be aligned with RAN1.

**2.4 DL PRS cyclic shifts**

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| Company | Comments |
| Huawei/HiSilicon | The action from RAN2 can be triggered upon RAN1 conclusion. |
| vivo | Whether to support DL PRS cyclic shift can be determined by RAN1. Then RAN2 can decide signal procedure and assistant data for each method. |
| Fraunhofer | This could be discussed in RAN1 first. |
| Ericsson | Orthogonalization via DL-PRS cyclic shifts is not yet exploited in 3GPP, while the benefits from orthogonalization have been stressed in evaluations. Indoor scenarios with very strict accuracy requirements and difficult propagation can imply a need to deploy densely, which automatically puts requirements on sufficient orthogonalization. It is therefore seen as important to study the cyclic shift option in RAN1 with subsequent RAN2 signalling design. |
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# 3 Signalling and procedures

Enhancements of signalling and procedures of previous releases needs to be aligned with other RAN and SA groups. Therefore, companies are asked to provide comments regarding what can be discussed in RAN2 independent of other groups and what needs alignments with other groups, in addition to general comments.

## 3.1 Positioning in RRC\_IDLE/RRC-INACTIVE modes

Idle/inactive mode aspects of positioning was not in particular focus in Rel 16. Specific low—complexity device consideration in LTE Rel-14 resulted in support for downlink positioning measurements in idle mode. In an NR context, there are many aspects for positioning in idle/inactive mode [1], [2], [3], [5], [12], [13] such as

* DL-only positioning measurements
* SRS transmission in inactive
* UE-assisted measurement reporting from idle/inactive

Companies are asked to comment on positioning in RRC\_IDLE/RRC-INACTIVE modes as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.1 Positioning in RRC\_IDLE/RRC-INACTIVE modes**

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| Company | Comments |
| InterDigital | RAN2 should study the procedures and signalling for both UE-based and UE assisted positioning methods when operating in RRC idle/inactive state. These may include procedures for PRS measurement/SRS transmission and power efficient transmission of measurement reports in RRC idle/inactive states. An evaluation to compare the performance achievable when applying different positioning methods from device efficiency and latency perspective may be beneficial in the TR. |
| Huawei/HiSilicon | The scope may further need check from RAN1. Currently, we think three bullets above are possible. |
| vivo | The details of how to enable DL/UL PRS configuration and positioning reporting based on different positioning method in idle/inactive modes should be studied in RAN2.  More specifically, for positioning reporting in control plane we need to align with SA2 TS23.273 section 6.7 for low power Periodic and Triggered 5GC-MT-LR Procedures. For positioning reporting in use plane we need to align with SDT team where small data transmission WI also mentioned to support positioning reporting. |
| Fraunhofer | Please see our response to 2.1 |
| Xiaomi | We think above three bullets can be discussed in RAN2. And how to initiate location service request need to be discussed. |
| Ericsson | Agree, idle/inactive mode positioning aspects should be studied in Rel 17. However positioning measurements reporting should also be studied as part of this. How can the UE performing idle/inactive state can provide prompt measurement reports to the NW? |
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## 3.2 On demand DL-PRS/SRS

On demand DL-PRS was studied in Rel 16 but was not supported. Several contributions [2],[6], [8], [9],[10] proposes to support on-demand positioning support in Rel. 17. The ability to enable DL-PRS when needed implies that DL-PRS can be disabled when there is no UE to be positioning. That leads to requirements on time to DL-PRS enablement, and a need to define signalling. There can be a number of pre-defined DL-PRS levels of intensity, and there can be different network elements and protocols that trigger the configuration and reconfiguration of positioning reference signals.

Companies are asked to comment on On demand DL-PRS/SRS as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.2 On demand DL-PRS/SRS**

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| Company | Comments |
| InterDigital | We agree with [2][6] that supporting on-demand PRS/SRS enables improving network efficiency and minimizing end-to-end latency. We propose RAN2 to discuss the impacting aspects related to i) signalling for configuring different PRS/SRS configurations in RAN and/or UE, ii) procedures for transmitting on-demand request for PRS/SRS based on triggering conditions (e.g. coverage) determined at UE, iii) signalling for dynamic activation/deactivation of PRS/SRS configurations. |
| Huawei/HiSilicon | From the perspective of NW efficient, we suggest to prioritize LMF triggered on-demand DL-PRS allocation, since it can be discussed without RAN1 involvement, coordinate PRS transmissions between multiple gNBs and less impacts to the UE. |
| vivo | On-demand PRS has been agreed to be investigated by RAN1. For RAN2, details on on-demand PRS configuration/ reconfiguration /triggering/request for different methods (UE-assisted/based, DL positioning/Multi-RTT) should be studied.  For on-demand SRS, we think the meaning of on demand SRS is unclear. SRS is a UE-specific signals and it can be configured or triggered ‘on demand’ based on current specification. There is no need to discuss ‘on demand SRS’ again. |
| Fraunhofer | On demand PRS/SRS could improve accuracy and latency. Nevertheless coordination of resources between TRPs could be important. Especially for on-demand SRS, we need to clarify what assumptions we make on the resources used for on-demand SRS on neighbouring cells or serving-cell. For example: a neighbouring cell may schedule PUSCH transmission on such resources primarily intended for on-demand SRS, when they are not used. |
| Xiaomi | We support on-demand PRS and the related signaling procedures should be discussed in RAN2. |
| Ericsson | It is essential that RAN2 strive for solution that leads to be energy efficient.  The PRS transmission to all beam sweeping directions results in an unnecessary transmission of PRSs. Thus, a study is required to identify a mechanism to optimize the PRS transmission.  By selecting the optimum number of beams for PRS transmission and by switching off the PRS transmission in a more opportunistic way, it should be possible to be energy efficient. For this to happen,   * + the UE should provide the RSRP result of PRS being transmitted from different beams.   + LMF should compute the PRS utilization from different beams.   + LMF should provide a list of low utilized or un-utilized beams to gNB to be turned off.   We do not think the solution where UE asks for on demand PRS request would work as it may request to a serving cell; however, GDOP etc play important roles and far distant TRP may also be required to transmit PRS. How to co-ordinate such? It increases RACH load and also would cause massive co-ordination in the NW perspective.  None of the NR existing reference signal are requested on demand. Hence, we do not see mechanism needed for DL-PRS as well.  Hence, LMF co-ordinated solution is our priority. |
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## 3.3 Serving gNB RTT

LTE ECID supports determination of serving cell RTT via UE and gNB RxTx time different reports. However, the corresponding serving gNB RTT was not included in Rel 16 NR ECID. Therefore, it is proposed to support gNB RTT as part of NR E-CID in Rel. 17 [2].

Companies are asked to comment on supporting serving gNB RTT as part of NR E-CID as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.3 Serving gNB RTT**

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| Company | Comments |
| Huawei, HiSilicon | Support in general. However we acknowledge that this may need to be agreed in RAN1 first. |
| vivo | This issue is being discussed by RAN1, we can wait for the conclusion of RAN1 to make a decision |
| Ericsson | The E-CID mechanism is seen as a mechanism to retrieve position related information from the UE which essentially is used for other purposes. One exception in LTE E-CID is UE RxTX time difference which is particularly focused on retrieving the first received path of a DL signal. It is relevant to consider a corresponding exception in NR E-CID. |
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## 3.4 Serving cell base Multi TRP for Positioning in IIOT

In NR rel-16, single DCI based Multi-TRP features are specified. In these features, the DCI can be originating from one TRP while different PDSCH may be transmitted from different TRPs. In case multiple TRPs belong to the same serving cell, a DCI transmitted from one TRP can schedule a PDSCH transmission from one or more other TRPs that belong to the same serving cell. This setup can be exploited also for positioning purposes [4], such as to control PRS signals and measurements via efficient, low latency signalling.

Companies are asked to comment on Rel 16 DCI-based multi-TRP features for positioning as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.4 Serving cell base Multi TRP for Positioning in IIOT**

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| Company | Comments |
| Huawei/HiSilicon | Rel-16 single DCI-based mTRP transmission is mainly targeting data transmission, while AP CSI-RS triggering from multiple TRP was supported in Rel-15.  We assume the item should better be discussed under the generic topic of aperiodic PRS. |
| vivo | It is OK to support multi-TRP transmitted by single DCI for positioning. But this need to align with RAN1 first. |
| Ericsson | Given the focus on low latency in Rel 17, it is relevant to evaluate serving cell based Multi TRP configurations based upon RRC and MAC and compared to LPP for positioning especially for IIOT scenario |
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## 3.5 Positioning continuity during gNB handover,

In LPP, there is support for a cell change event, but there are many relevant positioning aspects for UE transferring from one gNB to the next to analyse [2], including DL-PRS measurements, SRS assignments, configuration updates, etc

Companies are asked to comment on positioning continuity during gNB handover as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.5 Positioning continuity during gNB handover**

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| Company | Comments |
| InterDigital | We agree with [2] that positioning continuity during HO is an important scenario. However, we think that studying solutions intended to meet the objectives in Rel17 SID such as improving network efficiency and minimizing end2end latency (e.g. supporting prioritized PRS/SRS) should be considered with higher priority than solutions for achieving positioning continuity. |
| Huawei/HiSilicon | Support to study. |
| Fraunhofer IIS | It needs to be investigated further in RAN2. |
| Ericsson | LPP currently has the possibility for the UE to report measurements upon cell change, but the raised concerns are relevant so it seems relevant to study positioning continuity |
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## 3.6 Finer response time and reporting intervals granularity

Given the focus on low-latency positioning in Rel 17, some attribute representation needs to be refined with finer granularity, including response time and reporting intervals in *CommonIEsRequestLocationInformation*.

Companies are asked to comment on positioning in finer response time and reporting intervals granularity as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.6 Finer response time and reporting intervals granularity**

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| Company | Comments |
| Huawei/HiSilicon | Agree. But we think this can be addressed directly in the work item phase |
| vivo | Signals and range of parameters should be studied by RAN2, for example Introduce 10 ms level granularity for the response time and reporting intervals in CommonIEsRequestLocationInformation mentioned in [3] |
| Fraunhofer | We agree with Huawei’s view. |
| Ericsson | Seems reasonable as a work item discussion. |
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## 3.7 Aperiodic positioning measurement reports

In LPP, there is support for a periodic, immediate and triggered reporting. In addition, Rel 17 could support also aperiodic measurement reporting [3], such as a DCI-triggered report request from gNB.

Companies are asked to comment on whether aperiodic positioning measurement reports shall be considered in Rel 17 as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.7 Aperiodic positioning measurement reports**

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| Company | Comments |
| Huawei/HiSilicon | We do not think this can be feasible. Normally lower layer triggering shall be transparent to the higher layer packets. If the report is also in physical layer, probably it should be discussed in RAN1 in details. |
| vivo | Aperiodic positioning measurement reports need to be studied in R17. Procedures and architectures can be studied by RAN2.DCI format can be studied by RAN1. |
| Ericsson | We consider this to be of lower priority |
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## 3.8 Pre-allocated uplink grant

Grant Free UL Transmission enables to reduce UL transmission delays and achieve URLLC Reliability targets. For low latency and reliability requirements, it is required to support UL GF transmission with multiple repetitions. If pre-allocated can be used for positioning periodic report, then signals and multiple configuration latency can be saved, and this pre-allocated grant should adapt to the positioning report period, so the best latency result is performed [3].

Companies are asked to comment on positioning in pre-allocated uplink grants for positioning as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.8 Pre-allocated uplink grant for positioning**

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| Company | Comments |
| Huawei, HiSilicon | We are not sure about the spec impact for this because currently, LPP messages can be transmitted with CG-PUSCH. In terms of configuration, the network can perform proper configuration of the UE based on the UE traffic pattern. |
| vivo | Pre-allocated uplink grant should be studied for R17 latency requirement. MAC CE signaling and procedure can be studied by RAN2 and configure grant format can be studied by RAN1.  Response to HW: In R17, the reducing latency is our objective, therefore CG need adopt the positioning window, but gNB doesn't know the offset or the timing of the completed positioning measurement/calculation. So, a new type or separate CG for positioning need to be introduced. |
| Ericsson | Once the use cases and needs have been analyzed, then different protocol aspects can be studied and what lower layer features that are relevant. |
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## 3.9 Measurement gap enhancements

The measurement gaps agreed in Rel 16 does not match the agreed DL-PRS periodicities. the PRS periodicity is:

slots, and the measurement gap periodicity is ms according to the RAN4 conclusion. It is observed that some PRS periodicity (such as 8,16,32, 64 ms) is not matched with MG periodicity [3].

Companies are asked to comment on positioning measurement gap enhancements as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.9 Measurement gap enhancements**

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| Company | Comments |
| Huawei/HiSilicon | It needs to be discussed in RAN1 and RAN4 first. |
| vivo | Measurement gap related issues are being discussed by RAN1. Some issues such as on demand gap configuration and request, enhancements in MG configuration & triggering (e.g., DCI/MAC-CE triggered MG, Positioning-specific MG, band-specific/layer-specific MG) are also related to RAN2. RAN2 can study signalings and configuration structures related to MG. |
| Ericsson | It is reasonable to study measurement gaps, but needs to be initiated in RAN1/4. |
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## 3.10 Reference point measurements for error reduction

GNSS RTK is based on reference station GNSS measurements at precisely known geographical positions. The same technique could be considered also for NR RAT-dependent positioning, where detailed NR measurements at precisely known geographical positions are harvested, processed and shared to enable error reductions [3]

Companies are asked to comment on NR Reference point measurements for error reduction as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.10 Reference point measurements for error reduction**

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| Company | Comments |
| Huawei/HiSilicon | If our understanding is correct, this corresponds to differential NR positioning, and we support it. |
| vivo | We should support reference point error correction. Similar with GNSS, it is an important method to improve positioning accuracy for R17.And it also helps positioning calibration. |
| Fraunhofer | Support |
| Ericsson | GNSS RTK reference stations are relevant when errors are highly correlated, like atmospheric delays in the vicinity of the reference station. It seem like there is a need for more analysis of how applicable a reference station can be in an IIoT environment, and it seems to be something to be discussed in RAN1 first. |
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## 3.11 Prioritized DL-PRS reception/SRS transmission

In Rel-16, both PRS and SRSp are assigned with low priorities. As a result, PRS is not received or SRSp is not transmitted when either transmission of data in DL/UL or other reference signals are scheduled.

In Rel-17, it can be envisioned that supporting prioritized positioning based on the assignment and indication of higher priority for the reception/transmission of PRS/SRS may enable to satisfy the low latency positioning requirements [8].

Companies are asked to comment on prioritized DL-PRS reception/SRS transmission as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.11 Prioritized DL-PRS reception/SRS transmission**

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| Company | Comments |
| InterDigital | Our proposal in [8] is intended to show that prioritized PRS/SRS enables achieving low end2end latency positioning. As such, different aspects that can be studied with potential RAN2 impacts are: i) signaling for indicating the priority assigned for the reception of PRS and transmission of SRS ii) handling of prioritized PRS/SRS transmission and data when priority level assigned to positioning is comparable to or higher than data reception/transmission and iii) triggering of positioning measurement reports with low latency for prioritized positioning. |
| Huawei/HiSilicon | This should be discussed in RAN1 first. |
| vivo | We think it should be discussed by RAN1. |
| Fraunhofer | We think this should be discussed by RAN1 |
| Ericsson | Should be discussed in RAN1 first. |
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## 3.12 Beam shape information for UL measurements

In Rel 16 it was agreed that LMF will determine angle of arrival based on UL beam measurements provided to LMF. Therefore, the LMF needs beam shape information associated to the UL beams in order to estimate AoA. Such information can be provided via OAM or NRPPa, or the decision in Rel 16 can be changed and the UL beam information can be provided to gNB for AoA determination [2].

Companies are asked to comment on beam shape information handling for AoA estimation as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.12 Beam shape information for UL measurements**

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| Company | Comments |
| Huawei/HiSilicon | The proposal from [2] was not entirely correctly captured.  Suggested change of description based on [2] as follows  In Rel 16 it was agreed that LMF will determine angle of departure based on DL PRS-RSRP provided to LMF. Therefore, the LMF needs beam shape information associated to the DL PRS beams in order to estimate AoD. Such information can be provided via OAM or NRPPa, or the decision in Rel 16 can be changed and the DL PRS beam information can be provided to gNB for AoD determination [2].  Companies are asked to comment on beam shape information handling for AoD estimation as well as what can be discussed in RAN2, and what needs to be aligned with other groups.  We support this |
| Fraunhofer | We do not support this. We don’t think beam shape information is helpful for AoA determination (Assuming RSRP-AoA is the intention here). |
| Ericsson | Beam shape information can be shared via OAM. In any case, it can be better to await RAN1 input in relation to the UEB beam shape discussion, see below in 3.13a |
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## 3.13 Assistance data/enhancements for UE-based positioning

There are several enhancements proposed for UE-based, and they are gathered under the same subsection here, while there are separated tables for comments for the different proposals.

DL-PRS beam measurements can be used to determine AoD in the UE. Currently, the UE-based assistance data includes beam directions for beams in a beam set (associated to a DL-PRS resource set) but no information about beam shape is defined [6].

Companies are asked to comment on beam shape information in the UE-based assistance data as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.13a Beam shape information for UEB assistance data**

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| --- | --- |
| Company | Comments |
| Huawei/HiSilicon | Suggest to fix beam shape for UE-assisted DL-AoD first. |
| vivo | It’s OK to have beam shape information for UE-based assistant data. |
| Ericsson | Beam shape representation information needs to be studied and evaluated in RAN1 before RAN2 can act. |
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UE-based DL-PRS timing measurements together with the TRP relative time difference (RTD) information is used by the UE for estimating the position in Rel 16. Enhancements includes the timing drift rate per TRP and RTD per DL-PRS resource [6].

Companies are asked to comment on enhanced RTD information in the UE-based assistance data as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.13b Enhanced RTD information for UEB assistance data**

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| Company | Comments |
| vivo | Ok to support. |
| Ericsson | Enhanced RTD information needs to be studied and evaluated in RAN1 before RAN2 can act. |
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UE-based DL-PRS timing measurements together with the TRP relative time difference (RTD) information is used by the UE for estimating the position in Rel 16. Enhancements includes the timing drift rate per TRP and RTD per DL-PRS resource.

Companies are asked to comment on enhanced RTD information in the UE-based assistance data as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.13c TRP and DL-PRS location information in Cartesian coordinates**

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| Company | Comments |
| vivo | We prefer not to represent TRP location information in Cartesian coordinates.  In 37.355 Element TRP-LocationInfo can be indicated by RelativeLocation which include “ delta-latitude, delta-longitude, delta-height” those can also help provide location in IIoT scenarios and they’re more flexible and easy understand by factories scenarios. In these case UE only need know the relative location information for positioning and doesn’t always need know the earth geodetic longitude and latitude information. |
| Fraunhofer | We support this. |
| Ericsson | Cartesian coordinates are most appropriate for indoor environments, and this is naturally supported by the information the operator has at hand from the deployment.. It also matches well with how the motion models relates to the device movements etc. |
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Rel 16 introduced support for DL-only UE-based positioning, and this can be extended to also include support for multi-RTT UE-based positioning [6].

Companies are asked to comment on supporting multi-RTT UE-based positioning as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.13d Multi-RTT UE-based positioning**

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| Company | Comments |
| Huawei/HiSilicon | We have doubts on the potential benefit of UE-based Multi-RTT. |
| vivo | Multi-RTT UE-based positioning should be studied and assistant data can be analyzed by RAN2. |
| Ericsson | Before we proceed with a new UE based positioning method, we need to also evaluate NW complexity /overhead in terms of signalling and PRS transmission.  We need to study how UE operating in UE based can compute the position with low latency and at the same time help/co-operate with the NW in minimizing NW overhead.  Also, in the Rel 16 study phase, there were different multi-RTT proposals discussed. It is important to study scalability aspects for non-DL-only UE-based positioning. Therefore, there is a need to study and evaluate different multi-RTT proposals with respect to accuracy as well as scalability. |
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Rel 16 discussed positioning performance observability for UE-based positioning, but no features or measurements were agreed. Among the contributions, there are two proposals for such positioning observability and calibration:

* Positioning performance observability and positioning measurements to enable positioning (re)configuration [4]
* UE and network assistance for positioning calibration [6]

Companies are asked to comment on supporting positioning performance observability and calibration as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.13e Positioning performance observability and calibration**

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| Company | Comments |
| vivo | We think this is part of error correction and should be considered together with 3.10. |
| Fraunhofer | Support, this has impact on reliability and UE efficiency.  Despite a UE supporting multiple positioning methods, one or other may be more suitable. For example: A-GNSS may be more suitable outdoors and multi-RTT may be suitable for example indoors. UE reporting of performance observability (i.e. reporting the situational quality) can reduce signalling overhead and processing at the UE. |
| Ericsson | It is important that the operator is able to observe the performance of the offered service, both to evaluate the service level agreement fulfilments, and to be able to manage the network configuration |
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IIoT scenarios may feature constrained movements of objects which constitute important information for the positioning engine. Such information could be considered available in some application layer and could be shared in assistance data [6].

Companies are asked to comment on supporting kinematics constraints in assistance data as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**3.13f Kinematics constraints in AD**

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| Company | Comments |
| Fraunhofer | In our view, Rel-17 shall enhance LPP the motion information signalling. On example is by introducing movement models. |
| Ericsson | This is a new and interesting topic, and benefits needs to be properly analysed and evaluated in RAN1 before RAN2 can act. |
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# 4 Latency analysis

Latency is one of the key requirements to consider and analyse in Rel 17. Therefore, it is important to understand what parts of the end 2 end latency between LMF and device to include in the RAN2 analysis, and how much signalling delays per each part contribute to the end2end latency, see details in [1], [2], [7], [8].

For snapshot positioning, the end2end latency should be determined as the time from when LMF triggers the positioning via LPP until the device reports measurements via LPP, while for periodic measurements, the latency is the latency that the device provides measurement results [7]. In the first case, the signalling includes capability exchange and assistance data provisioning, but can be excluded in the latter case. What needs to be included and what can be omitted depends on the use case.

Moreover, the end2end could also include signalling between LMF and some application layer, which seems to be outside the RAN2 scope [7], and the focus should be on procedures between UE, LMF, AMF and gNB.

Therefore, it is important to discuss what parts of the end2end latency that should be considered in RAN2.

Companies are asked to comment what parts of the end2end latency that shall be analysed in RAN2 as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**4.1 Parts of end2end latency to be analysed in RAN2**

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| Company | Comments |
| InterDigital | We are of the opinion that at the initial phase, the different parts/components that contribute to end2end latency for different positioning methods (e.g. UE-based, UE-assisted, DL, UL, UL+DL) should be identified and determined on the basis of different impacting working groups. For RAN, all latency components from a start time duration (e.g. sending of location request) to an end time duration (e.g. reception of measurement report), excluding PHY components (e.g. PRS measurement/SRS transmission and L1 processing), should be identified. Such an evaluation would be beneficial to identify the parts that are common/different for different positioning methods and to determine end2end latency model.  For RAN2, we propose to study the latency components with potential impacts such as i) signalling related to provisioning of PRS/SRS configurations, ii) procedures related to scheduling of PRS reception/SRS transmission and iii) signalling related to transmission of measurement reports. |
| Huawei/HiSilicon | OK to study. RAN2 needs to narrow down which part of E2E latency should be analysed. |
| vivo | We think we can analyze latency components of NR/NG-RAN/5GC higher layer positioning protocols and provide a list of latency components based on the latest conclusion of RAN1.  Agreement:  Text proposal for LS to RAN WG2 and CC SA WG2 and RAN WG3 for analysis of latency of NR positioning protocols defined in Rel.16:  RAN1 evaluates physical layer latency and its potential reduction for NR Rel-17 positioning solutions. In order to evaluate End-To-End latency of NR positioning solutions the input from RAN2 is needed on latency components of NR/NG-RAN/5GC higher layer positioning protocols. RAN1 respectfully asks if RAN2 can provide a list of latency components with corresponding range of values for the existing and any potential enhanced NR positioning solutions, keeping in mind the End-To-End latency described as desired in the study item description (RP-200928) |
| Fraunhofer | We share similar view to InterDigital, RAN2 shall evaluate the E2E latency for UL-only, DL-only and UL-DL in UE-assisted and UE-based modes. |
| Xiaomi | The latency between UE, LMF, AMF and gNB should be analysed in RAN2 and the signalling procedures between them should be optimized. |
| Ericsson | It is relevant to analyze the different options including also RRC and multi-TRP MAC-based signaling options to get an understanding of the different alternatives that are available. Also, RAN2 needs to settle what part of the e2e that can be in focus. |
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The contributions [1], [2], [7], [8] have analysed latency contributions per part of the end2end procedure.

Companies are asked to comment on the analysis in [1], [2], [7], [8], and what can be concluded for the TR as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**4.2 Comments to latency analysis per part in [1], [2], [7], [8]**

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| Company | Comments |
| InterDigital | The latency analysis considered in [1] for both Rel16 architecture (LFM in CN) and Local LFM based architecture (LFM in RAN) provides good insight into the parts that impact the end2end latency. Similarly, [7] provides a good overview of end2end latency for multi-RTT based positioning, assuming Rel16 architecture. While [2] provides a comprehensive analysis of end2end latency for different positioning methods, it is unclear how the values of each of the components are determined (e.g. 0.5ms for a transmission segment in network). Our analysis in [8] provides a breakdown of different components for DL/UL based positioning and describes the latency parts/components that fall under the domain of RAN2.  For end2end latency analysis for different positioning methods, a latency model that identifies the different latency parts/components between a start time duration (e.g. sending of a location request) and end time duration (e.g. reception of measurement report) should be considered. |
| vivo | Agree with[1],for latency analysis we need consider higher layer signal procedure and we should have typical latency analysis model.  [2]also mentioned higher layer signal latency should be analyzed.  Agree with [7] that application treat time shouldn’t be considered.  All documents mentioned R17 requirement cannot be satisfied by current implementation. We agree that methods for reducing higher layer positioning latency are needed to meet R17 especially IIoT requirement. |
| Xiaomi | According to the analysis in reference contributions, the end2end latency should be reduced to satisfy requirements of IIOT use case. |
| Ericsson | We agree that latency contributions of different parts needs to be considered, including also RRC- and MAC-based signaling. |
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# 5 Network and device efficiency

Network and device efficiency need to be aligned with other RAN and SA groups. Therefore, companies are asked to provide comments regarding what can be discussed in RAN2 independent of other groups and what needs alignments with other groups, in addition to general comments

## 5.1 DL-PRS Reconfiguration

Overtime and context, there are most probably different optimal DL-PRS configurations depending on positioning requirements and device activity. There are different ways to reconfigure DL-PRS:

* Via OAM as in LTE
* LMF to decide [3],[9] or suggest [4] to gNB new DL-PRS configurations
* gNB to reconfigure DL-PRS [4],[9]

Important questions concerns the signalling between network elements, the adequate measurements

Companies are asked to comment on DL-PRS reconfiguration and suitable signalling, measurements and procedures as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**5.1 DL-PRS Reconfiguration**

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| Company | Comments |
| InterDigital | DL-PRS reconfiguration should be considered and discussed from the perspective of both Rel16 architecture (i.e. LMF-based PRS configuration) and RAN-based architecture with local LFM functionality. On-demand or dynamic DL-PRS, where the DL-PRS can be reconfigured based on request from UE, is beneficial from the perspective of network efficiency. We propose RAN2 to discuss the signalling and procedures associated with supporting on-demand DL-PRS. |
| Huawei/HiSilicon | We consider it in the general discussion of on-demand PRS.  Our view is that gNB may offer a PRS pool (by OAM) that contains transmission opportunities for PRS transmission.  LMF may request PRS transmission or advise to shut down PRS transmission for some transmission occasions.  gNB may further confirm. |
| vivo | Support LMF reconfigure PRS. LMF knows the accuracy requirement and neighbor cell configurations, so it can decide on-demand PRS, therefore LMF is more suitable to reconfigure PRS. |
| Xiaomi | We think this may associate the on-demand and/or dynamic PRS, and RAN2 can discuss the related signaling and procedures. |
| Ericsson | Only NG-RAN is in control over the RAN resources, which means that LMF at most can suggest how RAN resources can be used, nothing more. |
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## 5.2 LMF-based SRS pooling

There can also be reasons to coordinate the use of UL SRS for positioning to manage interference and also support mobility. The coordination could be via the LMF [1].

Companies are asked to comment on LMF-based SRS pooling and coordination as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**5.2 LMF-based SRS pooling**

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| Company | Comments |
| Huawei/HiSilicon | 5GC should not directly be involved in RAN resource allocation. SRS resource is too general, including symbol/RB resource, comb size and offset, sequence. It is unclear what the scope of resource management for LMF are mentioned.  This should be discussed in RAN1 first |
| vivo | Low priority. |
| Fraunhofer | We support studying coordination mechanisms and resulting interference in general. Here we note the following interferences possible:  SRS (Pos.) to PUSCH (inter-cell)  SRS (Pos.) to SRS (Pos/other SRS)  PUSCH to SRS (inter-cell)  We need to clarify what pooling exactly means here.  For interference coordination with SRS, LMF could coordinate at least the REs (comb factor, REs) used by multiple TRPs. Alternatively, the LMF could interact with RAN nodes to identify the most suitable configuration to multiple gNBs/TRPs. This could alternatively also be something that could be a functionality of local LMF. |
| Ericsson | This seems to be handled well via OAM already for Rel 15 SRS. If discussed, it should start in RAN1. |
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## 5.3 RRC-based positioning procedures

Most of the positioning applications require that localization be done spontaneously. Latency is critical factor. LMF-based control over positioning implies multiple hop routing of LPP messages. However, the existing RRC protocol is essentially tailored to enable timely handling of configurations and measurements. RRC-based procedures should therefore be considered for positioning [4].

Companies are asked to comment on RRC-based positioning procedures as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**5.3 RRC-based positioning procedures**

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| --- | --- |
| Company | Comments |
| InterDigital | RAN2 should discuss procedures and RRC signalling related to configuration of DL-PRS and UL-SRS from the perspective of both Rel16 architecture (i.e. LMF-based PRS configuration) and RAN architecture supporting local LFM functionality. |
| Huawei, HiSilicon | We need to have better understanding on what will be the gain with this RRC-based positioning procedure. The proposed scheme seems highly correlated with on-demand PRS and we want to understand the relationship between these two. Positioning methods similar to NR E-CID can be the baseline if we go with RRC-based positionng methods. |
| Fraunhofer | We think this can be triggered by the latency analysis. |
| Xiaomi | For RRC-based positioning procedures, we are not clear and more details may be needed.  For latency reduction, whether RRC-based and Local LMF/LSS architecture could provide the same benefit. |
| Ericsson | When analysing latency aspects, RRC and MAC signalling shall be among the options that are discussed, since their procedures are designed for real-time, low-latency handling of configurations and measurements |
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## 5.4 Local LMF/LSS

The architecture change with a local LMF was discussed in Rel 16, and the consideration of a local LMF is addressed in [5][6]

Companies are asked to comment on the applicability of a local LMF as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**5.4 Local LMF/LSS**

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| Company | Comments |
| InterDigital | Supporting local LMF functionality in RAN architecture enables satisfying the low latency positioning requirement and provides more control/flexibility to RAN for provisioning of positioning RS. In light of this, procedures and signalling which have RAN2 impacts, such as provisioning of PRS/SRS configurations, scheduling of PRS reception/SRS transmission and fast transmission of measurement reports, should be further discussed. |
| Huawei, HiSilicon | We don’t think this discussion is part of the scope defined in the SID now. We had a long discussion on this in RAN2 during R16 study item and there is no conclusion on this after a study item lead by RAN3 and some further analysis by SA2. We don’t want to open the discussion again. |
| vivo | Local LMF will help latency but we need align with SA2/RAN3 first, as the last LS we received was said local LMF is not supported. |
| Fraunhofer | Other than latency, one benefit of local LMF could be coordination of resources among multiple cells, especially in the uplink. This would be relevant if the on-demand positioning signals are activated and deactivated dynamically in different cells. |
| Xiaomi | We agree with vivo |
| Ericsson | This seems to be outside the scope now. The RAN3-led discussion did not lead to any agreements in Rel 16 and it seems to be unwise to spend time on this here in Rel17. Anyway, this is for RAN3 to initiate. |
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## 5.5 Management of simultaneous LPP and SIB AD distribution

In Rel 16 it is possible to provide AD via both unicast/LPP and broadcast/RRC-SIB. In case these are in conflict, there could be reasons to analyse the conflicts and define suitable conflict handling [11].

Companies are asked to comment on management of simultaneous LPP and SIB AD distribution as well as what can be discussed in RAN2, and what needs to be aligned with other groups.

**5.5 Management of simultaneous LPP and SIB AD distribution**

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| --- | --- |
| Company | Comments |
| Huawei, HiSilicon | Should be deprioritized |
| Xiaomi | Our proposal in [11] is intended to discuss the PRS configuration. We think LPP or Pos SIB could provide multiple sets PRS configuration, and then the fast PRS configuration updating could be achieved based on the multiple sets PRS configuration.  For the problem of conflict between LPP and Pos SIB, we think this is the implementation issue and network could handle it. |
| Ericsson | We do not believe that the network will have reasons to configure AD differently via unicast and broadcast. |
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# 6 Missing aspects

Some aspects raised in contributions might have been overlooked in this summary. Below, companies are asked to provide comments about any additional aspects raised in contributions together with a reference to the contribution

**6.1 Missing aspects**

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| Company | Comments |
| vivo | How to notify neighbouring cells to measure A-SRS on time which we discussed in r16 and agree to leave to R17 need to be discussed. |
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# 7 Conclusion

TBD