**3GPP TSG-RAN WG2 Meeting #113-eDRAFT R2-2xxxxxx**

**Electronic meeting, Jan 25th – Feb 5th, 2021**

**Agenda item:** 8.11.2

**Source:** CATT

**Title:** [Post112-e][617][POS] Evaluation of latency enhancement solutions (CATT)‎

**Document for:** Discussion and Agreement

# 1 Introduction

This is to continue discussion of the solutions considered in [AT112-e][607], and evaluate for performance the solutions identified. Related RAN1 and RP agreements can be taken into account and evaluated for RAN2 impact. The latency enhancements in this discussion is limited in [AT112-e][607] [1].

* [Post112-e][617][POS] Evaluation of latency enhancement solutions (CATT)

 Scope: Continue discussion of the solutions considered in [AT112-e][607], and evaluate for performance the solutions identified. Related RAN1 and RP agreements can be taken into account and evaluated for RAN2 impact.

 Intended outcome: Report to next meeting

 Deadline: Long

Rapporteur would like to have the following schedule for this email discussion to have enough time for preparing the summary report.

* Phase 1 (2021-01-06): Companies are invited to provide inputs and comments to questions.
* Phase 2 (2021-01-12): Rapporteur will provide draft summary with proposals, companies are invited to provide comments to the summary proposals.

The remainder of this document is organized as the following. Section 2 provides related RAN1 and RP agreements. Section 3 contains the questionnaire on performance evaluation of the latency solutions. The purpose is to collect the views and identify the commonalties and differences in order to provide proposals for suitable TP.

# 2 RAN1 and RP agreements

The agreement on latency in potential positioning enhancements after RAN1 #103-e meeting is below:

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| Agreement:Capture the following in the TR:* The enhancements of signaling & procedures for reducing NR positioning latency are recommended for normative work, including DL and DL+UL positioning methods
	+ The details of the solutions are left for further discussion in normative work, which may include the following aspects:
		- Latency reduction related to the measurement gap
		- Latency reduction related to the reporting and request of the measurements (e.g., via RRC signaling, MAC-CE and/or physical layer procedure, and/or priority rules)
		- Latency reduction related to measurement time
* The following enhancements of signaling & procedures for reducing NR positioning latency can be studied and specified, if needed
	+ Latency reduction related to the request and response of positioning assistance data (e.g., via RRC signaling, MAC-CE and/or physical layer procedure)
	+ Latency reduction related to the reception of DL PRS (e.g., priority rules for the reception of DL PRS)
* No assumptions are made on whether the LCS architecture specified in TS 23.273 is enhanced or not.
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There is no any agreement on latency in RAN #90-e and no relative objective is added in new WID of ePOS [2]. All participants to this discussion are encouraged to leave their name/contact in section 6.

# 3 Latency enhancement

In section 3.1-3.5, several aspects about latency enhancements will be discussed.

Latency enhancement solutions on measurement gap and the reporting and request of the measurements were discussed in RAN2#112-e meeting, which are parts of agreement in RAN1#103-e meeting on latency. Meanwhile there is no any latency reduction aspects mentioned in WID of ePOS in RAN #90-e because it depends on the agreement both from RAN1 and RAN2.

So we are going to discuss here how to align with the agreement from RAN1 from RAN2’s perspective in section 3.1 and 3.2.

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| * + The details of the solutions are left for further discussion in normative work, which may include the following aspects:
		- Latency reduction related to the measurement gap
		- Latency reduction related to the reporting and request of the measurements (e.g., via RRC signaling, MAC-CE and/or physical layer procedure, and/or priority rules)
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## 3.1 Measurement gaps optimizations (recommended by RAN1)

Measurement Gap is about 18-22ms (step 13-14) based on the analysis in R2-2009023. The request and configuration of measurement gap results in additional latency due to the transmission and reception of RRC signaling.

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| Step 13 RRC Measurement Gap configuration | 13-13.5 | TgNBProc-RRC+ TUE-gNB+ TUEProc-RRCReconfProcessing delays: 13ms- UE:  TUEProc-RRCReconf = 10ms- gNB: TgNBProc-RRC= 3msSignalling delay:0-0.5ms- UE-gNB: TUE-gNB= 0-0.5ms |
| Step 14 a DL PRS measurement | TUE-measc  | RAN1 inputs |
| Step 14 b UL SRS measurement | TgNB-measc  | RAN1 inputs |

So measurement gaps (MG) optimizations can reduce the latency caused by measurement gap request procedure. Solutions are summarized below according to R2-2009023 and R2-2008886:

* Option1: MG-less operation e.g. UE may operate w/o measurement gaps to process DL PRS.

Measurement Gap is about 18-22ms (step 13-14). The latency caused by measurement gap request procedure could be reduced.

* Option2: Support of semi-persistent a-periodic MGs, their pre-configuration and association with MG configuration ID
* Option 3: Avoiding or minimizing the latency due to measurement gap configuration.

As an example, the UE may be triggered to perform measurement of DL PRS based on lower layer signaling (e.g. in MAC CE) from gNB without configuration of measurement gap. The configuration of certain criteria/rules in the UE for determining whether to perform measurement of PRS based on a configured timer or priority indication can be considered for eliminating measurement gap configuration.

* Option4: Fast activation of measurement gap configuration:

UE sends indication to gNB using lower layer signaling to either skip or request a measurement gap configuration. The gNB may then activate/deactivate a preconfigured measurement gap (e.g. in MAC CE) based on the indication sent by the UE.

**Rapporteur’s comments:**

7/11 companies thought it was RAN1/4 business during the email discussion in [AT112-e][607].

Since there is agreement on measurement gaps optimizations from RAN1, so RAN2 will review this aspect in this email discussion.

**Q1-1: Do you agree with RAN1 agreement to study the following aspect for latency reduction from RAN2’s perspective?**

* **Latency reduction related to the measurement gap (MG) optimizations.**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Q1-2: If you agree above aspect which can be further discussed, please provide your views: e.g. performance evaluation of the solutions above, or specifying the solutions above in detail.**

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| **Company name** | **Comments** |
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## 3.2 Measurement report optimization (recommended by RAN1)

According to R2-2009897, it is proposed to introduce a positioning measurement report, with configured grant (CG) mechanism. The gNB can allocate resources for the UE that has been requested to perform positioning procedure. The configured grant resources are used by the UE to transmit the positioning measurement results. Note: configured grant mechanism has been part of the NR URLLC. Hence, the specification impact can be kept the minimum.

Additionally, in R2-2009039, it is also stated that Grant Free UL Transmission enables reduce UL transmission delays and achieve URLLC Reliability targets.

Grant Free UL Transmission enables 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 (i.e. UL data transmission without scheduling request). Additionally, this pre-allocated grant should adapt to the PRS period, so the best latency result is performed.



Figure3-1: configured grant resource adapt PRS repetition period

This configured grant can be defined as positioning use only uplink resources. CG need adopt the positioning window, but gNB doesn't know the offset or the timing of the completed positioning measurement/calculation.

The following proposed solutions are from companies, according to the comments in [AT112-e][607].

* Option 1(summarized from companies’ comments): Using the existed CG-based transmission for a certain logical channel.

It is already supported by the configuration of logical channel in NR Rel-16 which is up to the network implementation to configure CG. However there is NRPPa impact. gNB may get the PRS period from LMF via NRPPa.

* Option2: New type or separate CG for positioning which is used to adapt the PRS period and positioning specific configured grant may be introduced in Rel-17.

This can be used as positioning use only uplink resources, so that periodic positioning measurement report could be sent without waiting any L1 signals.

**Rapporteur’s comments:**

Five companies’ comments in [AT112-e][607] are summarized as option1 i.e. using the existed CG-based transmission for a certain logical channel. Companies are invited to review the two options above in this email discussion.

**Q2-1: Do you agree with RAN1 agreement to study the following aspect for latency reduction from RAN2’s perspective?**

* **Latency reduction related to the reporting and request of the measurements.**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Q2-2: If you agree above aspect which can be further discussed, please provide your views: e.g. performance evaluation of the solutions above, or specifying the solutions above in detail.**

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| **Company name** | **Comments** |
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## 3.3 Other potential aspects

RAN1 agreed in RAN1#103-e meeting:

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| * The following enhancements of signaling & procedures for reducing NR positioning latency can be studied and specified, if needed
	+ Latency reduction related to the request and response of positioning assistance data (e.g., via RRC signaling, MAC-CE and/or physical layer procedure)
	+ Latency reduction related to the reception of DL PRS (e.g., priority rules for the reception of DL PRS)
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### 3.3.1 Request and response of positioning assistance data optimization

According to R2-2009023, SRS configuration+activation (step 3-8) is 66- 133ms and LPP assistance data is 28-44.5ms, if the latency consumption of these two parts can be reduced, the total E2E latency can be further optimized.

According to R[2-2010096](file:///E%3A%5CWORK%5C1%203GPP%5CMeeting%5CRAN2%20112-e%5C2%20During%5CDocs%5CR2-2010096.zip), Latencies for Deferred MT-LR Event Reporting is provided as below:

**Table 19: Latencies for Deferred MT-LR Event Reporting.**

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|  | **End-to-End Latency [ms]** |
| **LMF only** | **LMF and LSS** |
| **Baseline** | **Configuration Signalling in Advance** | **Configuration Signalling in Advance for DL-only Positioning** | **Configuration Signalling in Advance and LSS** | **Configuration Signalling in Advance and LSS for DL-only Positioning** | **LSS with Positioning and Event Reporting in RRC\_INACTIVE state** |
| UL+DL Positioning | 284-535.5 | 164-320 | NA | 100-150 | NA | 61-98.5 |
| UL-only Positioning | 221-448 | 139-287.5 | NA | 76-120.5 | NA | 55-91 |
| DL-only Positioning | 218-402.5 | 124-229.5 | 72-135.5 | 92-137.5 | 54-89.5 | 53-86.5 |

So SRS configuration and PRS configuration optimizations can reduce the latency caused by SRS/PRS confi[guration](file:///E%3A%5CWORK%5C1%203GPP%5CMeeting%5CRAN2%20112-e%5C1%20Before%5C%E6%96%87%E7%A8%BF%E8%A7%84%E5%88%92%5CPOS%5CCR%5Cbackup%5CR2-200xxxx%20Minor%20corrections%20on%20description%20of%20sfn0-Offset%20in%20SSB-Configuration.docx). Here are the solutions proposed in R2-2009023 and R2-2010096:

* Option 1: DL PRS assistance information can be pre-configured to UE which can reduce the LPP assistance data (step 11 LPP Request Location Information): 28-44.5 ms. Multiple DL PRS configurations can be associated with DL PRS configuration ID and activated when necessary;
* Option 2: SRS for positioning configuration information can be pre-configured to UE which can reduce SRS configuration+activation (step 3-8): 66- 133ms. Multiple configurations of SRS for positioning can be associated with SRS for positioning configuration ID and activated when necessary;
* Option 3: Specify signalling and procedures for Deferred MT-LR (as proposed in R2-2010096) to support positioning configuration signalling in advance;

**Rapporteur’s comments:**

8/11 companies supported request and response of positioning assistance data aspect to be further studied, and 6/10 companies support option 3 in [AT112-e][607]. Some companies’ comments show that they were not sure what preconfiguration means. Preconfiguration means PRS configuration before LPP session, in order to reduce the latency of step 11 in option 1.

**Q3-1: Do you agree with RAN1 agreement to study the following aspect for latency reduction from RAN2’s perspective?**

* **Latency reduction related to the request and response of positioning assistance data (SRS and PRS configuration optimizations).**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Q3-2: If you agree above aspect which can be further discussed, please provide your views: e.g. performance evaluation of the solutions above, or specifying the solutions above in detail.**

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| **Company name** | **Comments** |
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### 3.2.2 Enhancements for prioritized transmission of PRS/SRS

According to R2-2008886, in Rel-16, both PRS and SRSp are assigned with low priorities. As a result, PRS is not received or SRSp is not transmitted/dropped 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/SRSp may enable satisfying the low latency positioning requirements. For DL-based positioning, the priority indication for PRS may be either indicated by LMF in assistance information or indicated by RAN in lower layer/RRC signalling. The UE may trigger the reception and measurement of PRS based on the received priority indication.

For UL-based positioning, the UE may trigger the transmission of SRSp based on the reception of the priority indication in lower layer/RRC signalling. The priority of the positioning reference signal can be associated with the type of the positioning reference signal (e.g. periodic vs. aperiodic positioning reference signals).

So some company proposed to support prioritization of PRS and/or SRSp.

**Rapporteur’s comments:**

10/11 companies thought it would be better handled by RAN1at first in [AT112-e][607]. It seems RAN2 can study the signalling procedure based on RAN1 input.

According to the latest agreement from RAN1 in #103-e meeting, only DL PRS is included:

* + Latency reduction related to the reception of DL PRS (e.g., priority rules for the reception of DL PRS)

Rapporteur invites companies to discuss if RAN2 agrees to align with RAN1.

**Q4-1: Do you agree with RAN1 agreement to study the following aspect for latency reduction from RAN2’s perspective?**

* **Latency reduction related to the reception of DL PRS (e.g., priority rules for the reception of DL PRS).**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Q4-2: If you agree above aspect which can be further discussed, please provide your views: e.g. performance evaluation of the solutions above, or specifying the solutions above in detail.**

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| **Company name** | **Comments** |
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### 3.2.3 Architecture enhancement aspect

The functionality of Support for Location Server functionality in the RAN is mentioned in some contributions and according to the analysis of R2-2010096.

Location Server functionality in the RAN (e.g., LMC) could reduce the positioning procedure latency significantly analysed by R2-2010096.

One architecture to support Location Server functionality in the RAN (e.g., LMC) is shown in following figure:



A possible Rel-16 procedure for splitting between LMF (for "component A") and LSS (for "component B") defined in R2-2010096 would be the Deferred MT-LR for periodic and triggered events specified for commercial location services. The procedures for "component A" can be performed in advance of when it is needed. A location request for an MT-LR or MO-LR can include a time T of when the location is required. The LMF would then perform the procedures required for "component A" before the time T. A very small latency for "component B" would allow a client to treat a location estimate as current as there would be little time for location degradation due to movement of the target UE.

Additionally, in R[2-2009023](file:///E%3A%5CWORK%5C1%203GPP%5CMeeting%5CRAN2%20112-e%5C2%20During%5CDocs%5CR2-2009023.zip), it is also proposed to reduce the number of Hops between gNB, AMF and LMF as far as possible, so as to achieve the positioning requirement of greatly reducing end-to-end delay.

Both two companies mentioned local positioning functionality as below:

R2-2010096 Proposal 2: Specify support for location server functionality in the RAN (referred to as "Location Server Surrogate" (LSS)). The LSS should support at least the following functions:

- Processing of LCS Event Reports;

- cordinating UE and TRP measurement reports;

- performing position calculation (in case of UE-assisted mode);

- reporting UE location estimates to (external) clients.

R2-2009023 Proposal: To reduce the latency, following enhancement directions are considered in WI phase:

* Reduce the number of hops between gNB, AMF and LMF, e.g. Local NR positioning in NG-RAN (To reduce the latency caused by the transmission/processing from AMF/LMF, i.e. only gNB is shown in the positioning);

It is not within RAN1 scope to analyse positioning architecture enhancements to enable such more efficient signaling & procedures.

**Rapporteur’s comments:**

4/8 companies in [AT112-e][607] supported the architecture enhancement can be studied in this SI because the positioning procedure latency significantly is reduced (at least 23% - 41% ) proposed by R2-2010096 which are based on RAN2 assumptions.

4/8 companies didn’t support it because of the following reasons in [AT112-e][607]:

1. The evaluation for local LMF-based positioning has extensively discussed in past by SA2 and RAN3, which does not make any conclusion on the latency gain of local LMF compared with LMF being deployed physically adjacent to gNB.

2. The privacy issue of user data may be occurred if we introduce the location server.

3. The way to compare the latency of LSS/local LMF-based positioning with that of LMF-based positioning in R2-2010096 and R2-2009023 is questionable.

4. Other options such as deploy 5GS within factory premises may be looked for if there is latency caused by transport. For example, with Non Public Network one can deploy not only local LMF but also local AMF; as such the whole 5G Core can be within factory premises.

Companies are invited to discuss this aspect here to find a way forward.

**Q5-1: Do you agree to study the architecture enhancement aspect for latency reduction in this SI?**

* **E.g. functionality of support for Location Server functionality in the RAN.**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Q5-2:** **If you agree above aspect which can be further discussed, please provide your views: e.g. performance evaluation of the solutions above, or specifying the solutions above in detail.**

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### 3.2.4 Capability procedure aspect

Based on R2-2009023, LPP capability exchange is about 33-88.5 ms. In R2-2008810, it is stated that Positioning capabilities of UE may be reported to AMF directly before there is a location request, instead of to LMF via LPP session, in order to reduce the positioning latency. This solution also works for the positioning in Idle/Inactive mode. AMF can store these capabilities before UE steps into RRC\_CONNECTED mode.

Additionally, in R2-2010072, it is stated that Time to First Fix should be considered for positioning latency studies:

As defined in 22.261: **Time to First Fix (TTFF):** time elapsed between the event triggering for the first time the determination of the position-related data and the availability of the position-related data at the positioning system interface.

Hence, before starting first positioning measurements; any activity/transactions that the device would require should be part of TTFF; for example, capability exchange, any pre-requisite procedure such as NR-ECID, retrieval of first assistance data to perform measurements.

**Observation 1**: Time to first fix should be considered in latency studies and any improvements in this area can be studied. Considering TTFF in latency may relax the other core latency requirements for performing measurements and reporting to the location server for positioning computation.

Potential improvement during TTFF can be storage of UE positioning capabilities by AMF. AMF would thus forward it to LMF as depicted in below diagram for the MT-LR procedure.

Below are the proposals from the three companies:

R2-2008810 Proposal 7: Support the process that UE location capabilities report to AMF in idle/inactive directly without entering into RRC\_CONNECTED mode in LPP session, in order to reduce the latency and support the positioning in Idle/Inactive mode.

R2-2010072 Proposal 2: RAN2 to consider solutions that would save latency during capability transfer and send an LS to SA2 to provide solution that minimizes latency in retrieving capability from UE to LMF via LPP.

R2-2009023 Proposal: To reduce the latency, following enhancement directions are considered in WI phase:

* Skip the capability procedure (can reduce the latency caused by exchange of capability as above)

**Rapporteur’s comments:**

The capability procedure aspect seems more like a requirement to SA2 to provide solution. So the requirement can be analyzed following the steps from RAN2’s perspective:

* Step1: Does capabilities of UEs stored in core network (e.g. AMF or LMF, etc) save the latency of capability procedure in LPP session?

Some company believes that Time to first fix should be considered in latency studies considering TTFF in latency may relax the other core latency requirements for performing measurements and reporting to the location server for positioning computation.

The latency of capabilities procedure in LPP session will be saved if LMF already knew the capabilities of this UE, whatever LMF how gets the capabilities, e.g. by itself or from AMF before.

* Step2: Which node of core network is supposed to store the location capabilities of UEs?

There are several options discussed in [AT112-e][607]:

* AMF: Some companies support AMF because it is already storing UL SRS for positioning capabilities. Further AMF stores other NAS capabilities, paging capabilities, UE NW capabilities.

The reason why LMF is not supported is that LMF as such should be stateless and different LMF will be chosen by AMF. Further, it is not guaranteed that UE ID (SUPI) would always be available in LMF. As providing UEID to LMF is OPTIONAL.

* LMF: Some companies believed the capabilities could also be stored at an LMF (which seems a possible implementation option already since Rel-9).
* Either: It’s up to SA2 to make the decision which node should take the responsibility.

Since 5/11 companies in [AT112-e][607] thought this requirement was unclear that why an AMF should store positioning capabilities, companies are invited to discuss the aspect.

**Q6-1: Do you agree to study the capability procedure aspect for latency reduction in this SI?**

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**Q6-2: If you agree above aspect which can be further discussed, please provide your views: e.g. which node is supposed to store the capabilities?**

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### 3.2.5 Parallel handling enhancement aspect

In some contributions, it was proposed that in parallel handling some location-related messages and steps can further reduce the total end to end latency.

Here are the solutions proposed in R[2-2009577](file:///E%3A%5CWORK%5C1%203GPP%5CMeeting%5CRAN2%20112-e%5C2%20During%5CDocs%5CR2-2009577.zip) and R[2-2008886](file:///E%3A%5CWORK%5C1%203GPP%5CMeeting%5CRAN2%20112-e%5C2%20During%5CDocs%5CR2-2008886.zip):

Option 1：For UL-TDOA/UL-AOA positioning method, some NRPPa messages can be merged into one message, such that the total end to end latency can be further reduced.

The main enhancements are as following:

* NRPPa positioning information request and NRPPa measurement request are merged into one message;
* NRPPa positioning information response and NRPPa measurement response are merged into one message;
* gNB can immediately active SRS without SRS activation request from LMF and it implies LMF don’t need to send SRS activation request.

Option 2：For UL&DL-based positioning methods, RAN2 to study potential enhancements related to provisioning of PRS and SRSp, coordinated triggering of SRSp transmission and PRS reception, and measurement report transmission/forwarding

**Rapporteur’s comments:**

8/11companies didn’t support the parallel handling enhancement aspect because of the following reasons mentioned in [AT112-e][607] :

* 6 companies believed the merging of message appeared more implementation and could be possibly done by implementation.
* One company mentioned that option 1 seems generally not feasible, since TRPs can only be configured e.g., once the SRS is known.

So companies are invited to discuss this aspect here.

**Q7-1: Do you agree to study the parallel handling aspect for latency reduction in this SI?**

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**Q7-2: If you agree above aspect which can be further discussed, please provide your views: e.g. performance evaluation of the solutions above, or specifying the solutions above in detail.**

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# 4 Conclusion

Based on company feedback, the following is observed and proposed:

TBD

# 5 References

1. R2-2010868 [AT112-e][607][POS]Gathering of latency enhancement solutions (CATT), CATT
2. RP-202900 New WID on NR Positioning Enhancements, CATT, Intel Corporation, Ericsson
3. 3GPP TR 38.857 V1.0.0 (2020-12)
4. R2-2010669 Summary of 8.11.2 Enhancements for commercial use cases
5. R2-2008810 Further discussion on enhancements for commercial use cases, CATT
6. R2-2008886 Discussion on End-to-End Latency Reduction for DL/UL Positioning, InterDigital, Inc.
7. R2-2009001 Report of [Post111-e][625][POS] End-to-end latency analysis (Intel), Intel Corporation
8. R2-2009023 Solution directions to reduce end-to-end latency, Intel Corporation
9. R2-2010096 NR Positioning Latency Analysis and Enhancements, Qualcomm Incorporated
10. R2-2010276 Discussion on IDLE INACTIVE pos, on-demand PRS and latency analysis, Huawei, HiSilicon
11. R2-2010277 Discussion on R17 positioning enhancement, Huawei, HiSilicon
12. R2-2010072 Enhancements for commercial use cases, Ericsson
13. R2-2009039 Discussion on positioning enhancement, vivo
14. R2-2009137 Discussion on positioning enhancements for commercial use cases, Spreadtrum Communications
15. R2-2009577 Positioning enhancements on RRC idle/inactive UE and latency reduction, Beijing Xiaomi Electronics
16. R2-2009897 Considerations on potential positioning enhancements, Sony
17. R2-2010627 Discussion on enhancement for commercial use cases, Samsung R&D Institute UK
18. R2-2008261 [AT111-e][612][POS] Assumptions for analysis of commercial use cases, Ericsson

# 6 Participants

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| **Company Name** | **Participant name/contact** |
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