3GPP TSG-RAN WG2 Meeting #117-e R2-220xxxx

**Online, 21st Feb – 3rd Mar 2022**

Source: CATT

Title: Report of [AT117-e][005][ePowSav] TRS / CSI-RS Open Issues Input (CATT)

Agenda Item: 8.9.3.1

Document for: Discussion and Decision

# Introduction

This contribution provides a summary of the following offline:

* [AT117-e][005][ePowSav] TRS / CSI-RS Open Issues (CATT)

 Scope: Progress the discussion on Using TRS / CSI RS with eDRX, e.g. a) Clarify necessary restrictions assumptions for how this can work assuming no specific modifications, b) Consider if and how to handle situation when such restrictions assumptions seems unreasonable (are there such situations?), e.g. if to exclude eDRX UEs (and how), whether some simple enhancement can improve the situation.

 Intended outcome: Report

 Deadline: In time for CB online W2 Tuesday

# Contact Points

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Name** | **Email Address** |
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# Discussion

As background, the following agreements were achieved regarding the use of TRS/CSI-RS with eDRX UEs:

- in RAN2#116bis-e:

|  |
| --- |
| * RAN2 confirm TRS/CSI-RS can be applied to eDRX UEs.
 |

- in RAN2#117-e (1st week) the topic was very briefly touched without progress:

|  |
| --- |
| R2-2203059 Summary of [Pre117-e[005][ePowSav] TRS / CSI-RS Open Issues Input (CATT) CATT discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core LateDISCUSSIONP1- OPPO think we have different acquisition for eDRX up to 6h, which may be difficult. May make the feature not useful. - LGE think that during PTW UE can understand SI change, by SIB modification for eDRX as discussed for redcap.  |

## Problem statement

The issue is described in [7] as follows:

RAN2 agreed to reuse the legacy SI update procedure for changing the TRS configuration as well as legacy (LTE) SI modification mechanism for SI change (based on eDRX acquisition period and eDRX-specific *systemInfoModification-eDRX* SI change indication) in NR for eDRX UEs. One key difference with most other SI configuration changes, is that when the next (e)DRX-ON interval comes, the UE wakes-up and the very first thing it does is it monitors TRS to acquire time/freq synchronization. In other words, unlike most other parameters, when a TRS configuration changes, the UE can no longer receive a SI change notification, if it is not aware of the configuration change. And because both DRX and eDRX UEs use the same set of TRSs, any new TRS configuration must be updated synchronously for both DRX and eDRX UEs. It results that a very large delay may be imposed by eDRX UEs to all other UEs for updating the TRS configuration. Indeed, as shown in Figure 1, if the network decides to change the TRS configuration shortly after the start of an eDRX acquisition period (e.g. #k-1 in Figure 1), the network has to wait until next eDRX acquisition period (e.g. #k in Figure 1) to indicate the SI modification notification for eDRX UEs, and send the update configuration in eDRX acquisition period #k+1.



**Figure 1: Issue with TRS/CSI-RS configuration update for eDRX UEs**

Because the TRS configuration must be updated synchronously for both DRX and eDRX UEs, the network cannot notify DRX UEs of the configuration change before the last SI modification period of the eDRX acquisition period #k. Thus, given it was agreed that the eDRX acquisition period is the maximum configurable value of the eDRX cycle (= 1024 H-SFN), the maximum delay for updating TRS resources configuration for *all* idle/inactive UEs is ~2 \* 3 hours.

**Q1-1: Do you agree that the maximum delay for updating TRS resources configuration is ~6 hours for all idle/inactive UEs in a cell serving eDRX UEs? If not, please provide your analysis.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| CATT | Yes |  |
| LGE | Yes |  |
| Ericsson | No | The assumption in the problem statement is not correct, the UE can wake up and monitor SSB instead of TRS if it is not sure of TRS availability. The agreements are clear if the UE is not sure of TRS availability, then it should consider it as unavailable. In this case, if the UE knows that it may have missed an SI update regarding TRS, then it can not be sure of availability, so it should use SSB. |
| Huawei, HiSilicon | Yes |  |
| Sequans | Yes | Currently this is correct. If we want the UE to assume it has missed an SI update when its eDRX cycle is longer than the modification period it has to be agreed (but this would anyway be similar to solution 2 in Q2). |
| Sharp | Yes |  |
| Vivo | Yes |  |
| Futurewei | Yes |  |
| Xiaomi | Yes? | eDRX acquisition period is the maximum configurable value of the eDRX cycle (= 1024 H-SFN), 2.9 hours. Why the the maximum delay of TRS resources configuration for all idle/inactive UEs is ~2 \* 3 hours? Not 3 hours?Correct me if I am wrong…[Rapporteur] The worst-case is when NW decides it needs to change the configuration shortly after an eDRX acquisition period has started. It cannot notify eDRX UEs of the SI change in this eDRX acquisition period (as it would miss those UE which PTW occured in the beginning of this acquisition period) and so has to wait for the next eDRX acquisition period for notifying the eDRX UEs. Hence the factor 2. |
| Intel | Yes |  |
| OPPO | Yes |  |
| ZTE | No | Regarding the maximum delay, we share the same view with Ericsson, NW can update the configuration whenever it wants and no need to wait for eDRX UEs.eDRX UE can use the SSB instead of TRS if they are not aware of availability.[Rapporteur] We don’t think we can rely on an assumed UE implementation if it is not standardized. Especially the condition quoted from Ericsson “…if it (UE) is not sure of the TRS availability…”: it is unclear what “not sure” means. |
| Nokia | No | It has been agreed that legacy system information update procedure will be used also for SIB-X and network can change the configuration whenever it wants. In addition, we don’t assume frequent changes for the TRS configuration itself, but TRS availability can change more dynamically instead.  |
| DENSO | Yes |  |
| MediaTek | Yes |  |

**Summary**:

15 companies provided inputs to this question.

12/15 companies acknowledge the analysis. 2 companies that do not agree assume the UE can assess when the TRS is present/not present by implementation and in this case can use SSB instead. Rapporteur commented that it may not be reasonable to rely on a possible UE implementation to solve a protocol issue.

Based on the above, it is proposed:

**Proposal 1 (easy agreement 12/15): RAN2 confirms the worst-case delay in updating the TRS configuration for DRX UEs can be up to ~6 hours to cope with eDRX UEs.**

**Q1-2: Do you think the above restriction is acceptable?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| CATT | No | Unlike other parameters which are also crucial for paging reception, e.g. *defaultPagingCycle*, *nAndPagingFrameOffset*, *pagingSearchSpace*, the TRS configuration is shared with RRC Connected UEs and hence is subject to more frequent configuration changes. This aspect was also one of the RAN1 motivations for developing the L1-based availability indication (which is TRS specific only).  |
| LGE | No | When the TRS configuration needs to be updated, it is unreasonable to always wait for the time(~6hours) for the eDRX UEs. For this, we think a solution is needed. |
| Ericsson | Don’t think there is a restriction for the NW | We do not agree that there is a problem or restriction here to address. If the UE is configured with such long eDRX that would lead to uncertainty, e.g., exceeding the SI modification period, with risk of TRS configuration change, then it just monitors SSB, no need for anything further specific. |
| Huawei, HiSilicon | No | We also think that it is unreasonable to wait for ~6hours and a solution is needed  |
| Sequans | No? | Configuration and availability are not the same, we are not sure that the L1 indication necessarily means the configuration also changes frequently. However, it is likely as it is for after all for RRC\_CONNECTED and it would be better to not have such a restriction on the NW, so we are fine to agree on a solution this meeting, assuming it is simple enough. |
| Sharp | No | It is unreasonable to wait for several hours to update SIB-X and a solution is needed. |
| vivo | Yes? | Per our understanding, for the case that the TRS configuration for connected UE is shared with idle/inactive state. When the connected UE leaves this cell, the related TRS won’t be available, but this could be solved by L1 availability indication. Hence, our understanding is that the TRS configuration won’t be changed frequently, and the update delay can be acceptable considering SI change won’t happen frequently.Thus, we prefer not to introduce additional optimizations on this issue. |
| Futurewei | No | Waiting for up to ~6 hr is unacceptable. |
| Xiaomi | Yes | Can accept that change of TRS/CSI-RS configuration is aligned with e-DRX acquisition period. In this way, both DRX and e-DRX UE will not miss the change of TRS/CSI-RS configuration.NW also has the flexibility to switch off the TRS resource occasion even though keep the TRS/CSI-RS configuration unchanged. For example, the connected UE providing TRS/CSI-RS handovers to other cells. In such case, the network will set the TRS resource set(s) available for very short time or unavailable anymore. Note the L1-based availability indication has already reduced the delay by ~max 20mins.And for e-DRX UEs, it would miss the L1-based availability indication which set as “1” when sleeping, but it would not be a huge problem. It can keep the previous status as unavailable or use the rest valid duration it previous got as currently the L1-based availability indication is only used to extend the availability or keep the previous status, not to set TRS/CSI-RS immediately unavailable. The impact is that UE just use TRS less. For e-DRX UEs who has less opportunity to monitor paging because of the long paging cycle, the impact is acceptable.All the solutions in 3.2 are to solve the problem raised by e-DRX UEs missing the configuration change leading to TRS unavailable when sleeping. If we align the TRS/CSI-RS configuration with e-DRX acquisition period, there is no serious problem. |
| Intel | Yes | Our view is that the TRS configuration won’t be changed frequently and thus the delay can be acceptable. Hence we do not see any need of further optimization with this respect. |
| OPPO | No | The restriction may make this feature useless. |
| ZTE | Share the same view with Ericsson |  |
| Nokia | Yes | We don’t assume frequent changes for the TRS configuration itself, but TRS availability can change more dynamically instead.  |
| DENSO | Yes | We think that L1 availability indication was introduced so that SIB-X does not need to be changed frequently just for turning on/off TRS.But we can follow the majority view. |
| MediaTek | Yes | Agree with Ericsson |

**Summary**:

15 companies provided inputs to this question.

7 companies think the delay is overkill and a solution should be found.

8 companies think the delay is affordable because TRS configuration won’t be changed frequently, or, similar to Q1, the issue can be left to UE implementation e.g. a UE assessing a risk of TRS configuration change would monitor SSB instead.

There is exact split, so:

**Proposal #2 (for discussion 7 vs 8): RAN2 discuss whether a solution is needed to allow updating the TRS configuration of DRX UEs quicker when eDRX is supported in the cell.**

## Solutions

During offline [55] of RAN2#116bis-e [14] this issue was discussed and several options were presented for addressing the delay in updating SIB-X, discussed in Section 3.1. More discussions where the various solutions were further detailed/questioned/clarified occurred in pre-meeting offline [005] of RAN2#117-e [16]. One solution (option 4) was supported by only one company so we suggest removing it from the discussed set.

A first observation is that RAN1 agreed the *validityDuration* is up to 512 default paging cycles. And a default paging cycle can be up to 256 radio frames. So the *validityDuration* is up to 512\*256\*10ms = 1310 s ~ 22 min. So in practice, an eDRX UE with an eDRX cycle > 22min that would receive a L1-based TRS activation in its PTW of cycle #k would always consider that the TRS is not available at the beginning of its next PTW (cycle #k+1). In other words, the TRS is useless for such UEs with an eDRX cycle > *validityDuration* (at most 22min), unless of course if it receives a new L1-based availability indication during the PTW (cycle #k+1), which would then be like some kind of re-activation for the rest of this PTW.



**Figure 2: Case of eDRX UE with TeDRX > *validityDuration***

A 2nd observation is that RAN1 agreed in RAN1#107bis-e the L1 availability indicator with below mechanism:

|  |
| --- |
| **Agreement**UE can receive L1 based signaling for TRS availability indication before the expiration/end of validity duration associated with previous L1 based signaling for TRS availability indication * For each bit indicated as ‘1’ in the availability indication field of the current L1 based signaling, the UE assumes the corresponding TRS resource set(s) are available from the reference point until the end of the validity duration associated with the current L1 based signaling.
* For each bit indicated as ‘0’ in the availability indication field of the current L1 based signaling, the UE keeps the existing assumption on the availability or unavailability of the corresponding TRS resource set(s).

Note: the validity duration for different group of TRS resources sets correspond to different bits in the availability indication field can be different and are maintained independently.  |

We now try to summarize the solutions.

**Solution 1: Use separate TRS availability indications for DRX and eDRX UEs**

In this solution, the network can indicate the TRS availability separately for DRX and eDRX UEs. For example, eDRX UEs could ignore the current L1-based TRS availability indicator according to a reserved bit in the Short Message [7]. [*[1] had a similar solution with separate indications for DRX and eDRX UEs, and involving RAN1, but given the late stage, Rapporteur favors solutions with no RAN1 impacts*]. Given the limited number of reserved bits (4) in the Short Message, a single bit is preferred which just indicates that currently TRS is not applicable to eDRX UEs. The network can then leverage this dual L1-based TRS availability control by simply not re-activating the TRS configuration subject to change until the timer expires (T2 in Figure 3), which takes no longer than the maximum value of *validityDuration* (at most 22min). In the meantime, the network can send a SI modification notification for DRX UEs during T1-T2. After T2, the network can send the updated SIB-X along with a L1-based availability indication. DRX UEs can use this L1-based availability once they have obtained the updated SIB-X.

Now, for eDRX UEs, the network sends, along with above L1-based availability indication reactivating DRX UEs after T2, a separate TRS availability indication (above bit set to “1”) which just indicates that the L1-based availability indication is not applicable to eDRX UEs. The eDRX UEs understand TRS cannot be used if they receive this indication. Meanwhile, the network sends SI modification notification for eDRX UE in the eDRX acquisition period #k. The separate TRS availability indication maintains TRSs unavailable for eDRX UEs until they acquire the updated SIB-X in the next eDRX acquisition period (#k+1). After that, the TRSs can be re-activated for eDRX UEs via a regular L1-based availability indication and absence of their separate TRS availability indication (steady state behavior).



**Figure 3: Using separate TRS availability indications for DRX and eDRX UEs**

**Solution 2: eDRX UEs cannot use TRS from the time they receive change notification for eDRX UEs to the time they receive the updated SI [2][7]**

This solution follows a similar principle as solution 1 by leveraging the separate SI modification notifications for DRX and eDRX UEs: the eDRX SI change notification is sent from the beginning of the acquisition period #k, which implicitly deactivates all TRS configurations for eDRX UEs until they acquire the updated SIB-X in eDRX acquisition period #k+1. This leaves freedom to NW to update the configuration of DRX UEs in the meantime.



**Figure 4: An eDRX SI change notification deactivates TRS for eDRX UEs**

**Solution 3: eDRX UEs do not use TRS for the first PO monitored after waking up**

If the availability duration is longer than eDRX cycle, though the TRS is updated during deep-sleep, UE doesn’t know whether the TRS is still valid or not when it wakes up. Therefore, the eDRX UE should not use TRS for the first PO monitoring after waking up. If the eDRX UE receives the SIB change notification indication for eDRX within the first PO, the UE tries to acquire new SIB-X at the next acquisition period. Otherwise, the UE can consider the current TRS is still valid.



**Figure 5: eDRX UEs do not use TRS for the first PO monitoring after waking up**

*Rapporteur’s understanding is that this solution has in common with solution #2 that a SIB change notification indication for eDRX UEs deactivates the TRS for such UEs until the next acquisition period. So it could be considered as a variant of solution #2.*

Rapporteur suggests checking companies’ views on the solutions discussed above:

**Q2: If you answered “no” to Q1.2, which of the above solution(s) do you prefer?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Solution(s)** | **Comments** |
| CATT | In preferred order:1, 2 | Both solutions 1 and 2 do not require RAN1 involvement but the benefit of solution 1 is that eDRX UEs can be told to ignore the TRS only when the TRS configuration change, whereas with option 2, any SI change notification (also for any other SIB but SIB-X) would prevent the eDRX UEs to use the TRS.We view solution 3 as a variant of solution 2 (so with same drawback compared with solution 1 as mentioned above) but it mandates that eDRX UEs always ignore the TRS when waking-up for the first PO after deep sleep, which somehow defeats the purpose of the TRS. So from this perspective, we think solution 3 is less efficient than solutions 2 and 3. |
| LGE | 2+3 | With solution 2, when the eDRX UEs receive the systemInfoModification-eDRX in the Paging Time Window(PTW), it can recognize the update in SIB-X and stop using TRS. However, with only solution2, when the network updates the SIB-X outside the PTW, there is a problem that the UE does not have a chance to get the SI change information. So, It can be solved by not using TRS to monitor the first PO after eDRX UE wakes up and checking TRS validity first.(Solution 3)  |
| Ericsson | Option 1 **from previous round**: “No need to introduce standardized solution for TRS/CRI-RS for eDRX UEs” | One solution which had quite a large support (at least 10 companies) is missing in the proposed ones, i.e., “Option 1: No need to introduce standardized solution for TRS/CRI-RS for eDRX UEs”. As mentioned above eDRX UE can just follow the same specifications and configurations as other UEs, if it has knowledge about TRS availability it uses it, if not then it assumes it is not available and uses SSB. We do not need to specific the UE behavior beyond what it exists. The rapporteur should bring back this option.We also would like to stress that the major savings in eDRX comes from the eDRX itself. TRS availability has very minor additional advantages for the UE power consumption. Therefore, we don’t think that complex solutions should be introduced for it. |
| Huawei, HiSilicon | Solution 2 | We prefer Solution 2 as this solution is simple and efficient. |
| Sequans | Solution 2 | It is simplest. Since anyway most of the power saving will come from the eDRX, we think this strikes a good balance between UE complexity, feature applicability and NW flexibility. |
| Sharp | Comments | For solution 1, DRX UE may be impacted since the separate TRS availability indication is in Short Message and extra power is cost to receive and handle this for DRX UE. For solution 2, for UE with eDRX cycle < TRS validity duration, if SIB-X is changed when it sleeps, it still will monitor invalid TRS. For solution 3 (or 2+3), does it request NW to always send eDRX SIB modification indication in the first PO? We still think checking SIB-X validity when eDRX UE wakes up just like the behavior before eDRX UE initiating RRC connection is possible way. |
| vivo | 2 (If the majority want a solution) | If the majority want to solve this issue, we think option 2 is easier than option1 and more efficient than option3. |
| Futurewei | Solution 2 | Same view as Sequans. |
| Xiaomi | - | For solution1:“a separate TRS availability indication (above bit set to “1”) which just indicates that the L1-based availability indication is not applicable to eDRX UEs.”Does that mean we need to have a separate TRS availability indication to set “1”to indicated e-DRX as unavailable? Is this a new indication that would have impact in RAN1?[Rapporteur] The bit discussed in this solution is a reserved bit in the Short Message. When NW sends a L1-based availability indication (re)activating a TRS configuration, presence of this bit in the Short Message indicates that the L1-based availability indication is not applicable to eDRX UEs.For solution2:It seems that we send the eDRX SI change notification more, e.g., in the first PO of PTW.[Rapporteur] Not sure why. The eDRX SI change notification is sent so as to reach all eDRX UEs in the eDRX acquisition period, as is normal use.Solution3: It needs UE to verify SIB-X’s validity upon waking up from eDRX to get latest SIB-X;[Rapporteur] Our understanding of Solution 3 is that UE checks if any SI change notification was received upon waking up (which is normal behavior) in which case it would assume TRS is unavailable (as Solution 2) and check SIB-X validity at next acquisition period |
| Intel | See comments | Based on our previous response, we also prefer the previous Option 1 as in the previous discussion. But we are also fine with Solution 2 with the understanding that the only change is that UE assumes TRS occasion is unavailable when it receives SI change notification for eDRX UE. |
| OPPO | Solution 1 | Firstly, we think that the figure in option 2 does no support the statement that “the maximum delay for updating TRS resources configuration for all idle/inactive UEs is ~2 \* 3 hours”, because it assumes NW can send the eDRX SI change notification in the same eDRX acquisition period where SI modification notifications is sent for DRX UEs. We think option 2 has a wrong interpretation on how eDRX SI change notification works.[Rapporteur] Slightly different understanding: we are not sure why “same” does not work. As long as eDRX UEs inactivate TRS upon receiving the eDRX SI change notification, then the TRS configuration can be changed and reactivated after all eDRX UEs with cycle < validity duration have been reached (within at most ~22min) provided other eDRX UE get their TRS inactivated anyways due to their eDRX cycle is larger than the validity duration.In our understanding, eDRX SI change notification should be sent in the next eDRX acquisition period following the eDRX acquisition period where SI modification notifications is sent. And this is where the delay of ~2 \* 3 hours comes from.With this understanding, we think option 2 does not work, because it almost means that as long as SI can change for DRX UEs, eDRX UE should not consider the TRS configuration as not available. Because for the duration before eDRX SI change notification is received, SI may also be updated (for DRX UEs). This will lead to the consequence that eDRX UEs will never consider the TRS configuration as available. |
| ZTE | - | Share the same view with Ericsson and Xiaomi, if eDRX UE wake up within the validity period,eDRX UE can use the stored TRS configuration, if out of the validity duration, then eDRX UE shall monitor SSB. It can work, optimization is not needed. |
| Nokia | See comments | We also prefer the previous Option 1 as in the previous discussion.  |
| DENSO | 2+3 | Same view as LGE.If TRS validity duration is longer than eDRX cycle and SIB-X is changed outside the PTW, eDRX UE may monitor TRS occasions based on the old configuration. Option 2 requires a new restriction that SIB-X should not be changed before TRS validity duration is expired. |
| MediaTek | See comments | Solution 2 seems a reasonable UE behavior, but we share Ericsson’s view that no standardized solution needs to be introduced. |

**Summary**:

15 companies provided inputs to this question, out of which 4 companies repeated that no solution is required, with no indication of preferred solution in case a solution would be pursued. Hence, 11 companies provided a preference for a solution in case a solution is needed.

Solution 1: 2/11 companies.

Solution 2: 8/11 companies.

Solution 3: 2/11 company

Other solution: 1 company (Sharp) suggests eDRX always checks SIB-X validity when it wakes up just like the behavior before eDRX UE initiating RRC connection.

We propose to follow the majority view:

**Proposal 3 (easy agreement 8/11): If a solution is needed after Proposal #2, RAN2 selects the solution where an eDRX UE cannot use TRS from the time it receives change notification for eDRX UEs to the time it receives the updated SI.**

# Conclusion

**Proposal 1 (easy agreement 12/15): RAN2 confirms the worst-case delay in updating the TRS configuration for DRX UEs can be up to ~6 hours to cope with eDRX UEs.**

**Proposal 2 (for discussion 7 vs 8): RAN2 discuss whether a solution is needed to allow updating the TRS configuration of DRX UEs quicker when eDRX is supported in the cell.**

**Proposal 3 (easy agreement 8/11): If a solution is needed after Proposal #2, RAN2 selects the solution where an eDRX UE cannot use TRS from the time it receives change notification for eDRX UEs to the time it receives the updated SI.**

# Reference

1. R2-2200240 , Discussion on TRS/CSI-RS applicability for eDRX UEs, OPPO
2. R2-2200466 , Discussion on TRS CSI-RS for RRC-IDLE and RRC-INACTIVE State UE, Beijing Xiaomi Communications
3. R2-2200593, Discussion on TRS CSI-RS in idle inactive mode, vivo
4. R2-2201204 , R17 NR UE Power Save SIB-X sizing aspects, Apple
5. R2-2201220, Further Consideration on TRS for Idle and Inactive UE, ZTE Corporation,Sanechips
6. R2-2201240, Discussion on TRS/CSI-RS and eDRX, Sharp
7. R2-2201270, TRS/CSI-RS for idle/inactive: leftover issues, CATT
8. R2-2201307, Discussion on TRS/CSI-RS for idle/inactive, LG Electronics Finland
9. R2-2201556, TRS exposure, Ericsson
10. R2-2200095 LS on updated Rel-17 LTE and NR higher-layers parameter list; RAN1
11. R2-2200091, LS on updated Rel-17 RAN1 UE features list for NR, RAN1
12. R2-2201497, Potential TRS/CSI-RS occasion(s), Nokia, Nokia Shanghai Bell
13. R2-2201677 Summary of 8.9.2.2 TRS/CSI-RS for idle/inactive (CATT)
14. R2-2201918 Report of [055][ePowSav] TRS CSI-RS for idle inactive
15. R1-2200700 LS on updated Rel-17 NR higher-layers parameter list, RAN WG1
16. Report of [Pre117-e][005][ePowSav] TRS / CSI-RS Open Issues Input (CATT)