**3GPP TSG RAN meeting #91e RP-20XXXX**

**Electronic Meeting, March 15-25, 2021**

## Status Report to TSG

**Agenda item:** 9.8.7 UE power saving enhancements for NR [RAN2 WI: NR\_UE\_pow\_sav\_enh]

|  |  |
| --- | --- |
| **WI / SI Name** | UE power saving enhancements for NR |
| included in this status report | Study Item: - | Core part: Yes | Performance part:No | Testing part:- |
| **Acronym** | NR\_UE\_pow\_sav\_enh |
| **Unique ID** | 860047 |
| **TSG Tdoc of latest approved WI/SI description (if any)** | RP-200938 |
| **Target Completion Date****(indicate if changed)** | Study Item: - | Core part: 09/2021 | Performance part: 03/2022 | Testing part: - |
| **Overall Completion level** | Study Item: - | Core part: Overall: 30% RAN1: 35%RAN2: 30%RAN4: 25% | Performance Part: Overall: 0% RAN1: 0%RAN2: 0%RAN4: 0% | Testing part: - |

Note: Overall completion level percentage numbers should use one of the colors below:

* xx%: Normal progress, no RAN plenary action needed
* xx%: Progress behind schedule, may need RAN plenary intervention. If so, SR should clearly define requested action
* xx%: Progress critically behind, RAN plenary shall intervene. SR should define requested action

**Source:**

|  |  |
| --- | --- |
| **Leading WG** | RAN2 |
| **Rapporteur** | **Name** | Weide Wu |
| **Company** | MediaTek Inc. |
| **Email** | weide.wu@mediatek.com |

## 1 Work plan related evaluation

|  |  |
| --- | --- |
| **Do you want to modify the time budget for this WI/SI compared to what was endorsed at the last RAN meeting?** | No |

*If you answered No: Then please remove the Excel file from the zip file of this status report.*

*If you answered Yes: Then please fill out the attached Excel template to request a modification of the time budgets for your WI /SI. The Excel table has to be filled out for all affected RAN WGs and up to the target date of the WI/SI. The basis are the endorsed time budgets of the last RAN meeting. Please highlight all changes of the values.
 One time unit (TU) corresponds to ~ 2 hours in the meeting.
 If this status report covers a WI with Core and Performance part, then please have one line for each in the attached Excel table.
 Note: If no Excel table is attached, then this means no time budget change.*

**Additional explanations/motivations for the time budget changes in the attached Excel table: N/A**

## 2. Detailed progress in RAN WGs since last TSG meeting (for all involved WGs)

 NOTE: Agreements and Open issues impacted cross-TSG aspects shall be explicitly highlighted

## 2.1 RAN1

#### 2.1.1 Agreements

|  |
| --- |
| **Relating to scope item 1) – a):**1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]
	1. Study and specify paging enhancement(s) to reduce unnecessary UE paging receptions, subject to no impact to legacy UEs [RAN2, RAN1]
* NOTE: RAN1 to check and update, if needed, evaluation methodology in RAN1 #102-e meeting

**The following agreements are achieved:** |
| **RAN1 #104-e meeting****R1-2101940 [Draft] Reply LS on Paging Enhancement MediaTek****Decision:** As per email decision posted on Feb 4th, the draft LS is endorsed. Final LS is approved in [R1-2102136](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2102136.zip).Agreement:* Carrying UE subgroups information is considered in physical layer design for paging enhancement

Agreements:For the evaluation and comparison of PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, the following are assumed:* Behv-A:
	+ PEI indicates UE should monitor a PO if UE’s group/subgroup is paged
	+ UE is not required to monitor a PO if UE does not detect PEI at all PEI occasion(s) for the PO
* Behv-B:
	+ PEI indicates whether or not UE should monitor a PO
	+ UE is required to monitor a PO if UE does not detect PEI at all PEI occasion(s) for the PO

Agreements:For the evaluation and comparison of PEI candidate designs, companies to report* Description of how PEI design can co-exist with existing channels/signals, and impact to legacy UEs.
	+ Rel-15 designs for multiplexing PEI with legacy channels/signals are assumed as baseline
	+ Other multiplexing method with legacy channels/signals can be additionally reported with justification

Agreements:* Take Alt 1 as mandatory, and Alt 2 as optional

**Alt 1:** For the performance evaluations of PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, 1. The following are assumed, at the SNR where the Miss-Detection Rate (MDR) of paging PDSCH is 1%,
	1. When Behv-A is assumed:
		1. The joint miss-detection rate (MDR) of PEI and paging PDCCH defined below should be no worse than 1%: MDR\_Joint\_A = MDR\_PEI + (1 – MDR\_PEI) MDR\_PagingPDCCH
		2. The False-Alarm Rate (FAR) of PEI should be no larger than [1%]
	2. When Behv-B is assumed:
		1. The joint miss-detection rate (MDR) of PEI and paging PDCCH defined below should be no worse than 1%: MDR\_Joint\_B = FAR\_PEI + (1 – FAR\_PEI) MDR\_PagingPDCCH
		2. The MDR of PEI should be no larger than [1%]
	3. Note: The CFO is modeled at the input of PEI detection and based on LLS assumptions agreed in RAN1 #102-e. Companies should justify the applied random range for the CFO.
2. Companies to provide:
	1. Information on the utilized detection method for each PEI candidate design (e.g., non-coherent detection or coherent detection)
	2. The required #REs to comply with the performance assumptions
	3. The maximum number of subgroups that can be carried in PEI, subject to the performance assumptions

**Alt 2:** For the performance evaluations of PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, 1. The following are assumed, at the SNR where the Miss-Detection Rate (MDR) of paging DCI is 1%,
	1. When Behv-A is assumed:
		1. The MDR of PEI should be no larger than 0.1%
		2. The False-Alarm Rate (FAR) of PEI should be no larger than 1%
	2. When Behv-B is assumed:
		1. The FAR of PEI should be no larger than 0.1%
		2. The MDR of PEI should be no larger than 1%
	3. Note: The CFO is modeled at the input of PEI detection and based on LLS assumptions agreed in RAN1 #102-e. Companies should justify the applied random range for the CFO.
2. Companies to provide:
	1. Information on the utilized detection method for each PEI candidate design (e.g., non-coherent detection or coherent detection)
	2. The required #REs to comply with the performance assumptions
	3. The maximum number of subgroups that can be carried in PEI, subject to the performance assumptions

Agreements:For the evaluation of resource overhead with PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, companies to provide estimated overheads for PEI candidate designs based on the following factors:1. Assumption of Behv-A/B
2. Required #REs from performance evaluations
3. 10% group paging rate per PO as baseline; other group paging rates can be optionally considered

and based on the following assumptions with justification (up to each company)1. Whether and how coexistence with legacy UEs is considered
2. Whether and how indication(s) to multiple POs and/or UE subgroups by one PEI is considered
3. Whether and how multi-beam transmission is considered

Agreements:Further study the design on how to provide the indications for UE subgroups over PEI and/or paging PDCCH, subject to the metrics agreed in RAN1 102e. |
| **RAN1 #103-e meeting**Agreements:Observation: For NR idle/inactive-mode UEs with 10% group paging rate, paging early indication without UE sub-grouping can achieve the following power saving gains w.r.t. Rel-16:* [0%] - [22.8%] where the baseline assumes 1 SS burst for synchronization before PO reception
	+ Note: [0%] means UE can apply the baseline behavior if the time offset between the utilized SS burst and PO is small.
* [5.0%] - [32.0%]  where the baseline assumes 2 SS bursts for synchronization before PO reception
* [10.2%] - [67.7%]  where the baseline assumes 3 SS bursts for synchronization before PO reception

The power saving gains will become lower for higher group paging rate.The power saving gains are dependent on the assumptions about placement of PEI and PO relative to SSB.The power saving gains may vary with different paging early indication design.Agreements:Observation: For NR idle/inactive-mode UEs, UE sub-grouping indication within a PO can provide the following power saving gains w.r.t. Rel-16:* If the original group paging rate is 10%:
	+ [0.3%] - [1.1%] where the baseline assumes 1 SS burst for synchronization before PO reception
	+ [0.4%] - [0.8%] where the baseline assumes 2 SS bursts for synchronization before PO reception
	+ [0.3%] - [1.0%] where the baseline assumes 3 SS bursts for synchronization before PO reception
* Some sources also evaluated performance if the original group paging rate is in the range between 20% and 80% and showed following results:
	+ [0.7%] - [7.6%] where the baseline assumes 1 SS burst for synchronization before PO reception
	+ [0.8%] - [3.0%] where the baseline assumes 2 SS bursts for synchronization before PO reception
	+ [0.5%] - [4.7%] where the baseline assumes 3 SS bursts for synchronization before PO reception

The number of UE sub-groups evaluated ranges from 2 to 16.Some companies show concern on assuming group paging rate larger than 60%.Note: It is FFS in RAN1 another group paging rate > 10% for the evaluation of Rel-17 paging enhancement. Agreements:Observation: For NR idle/inactive-mode UEs, UE sub-grouping indication carried in paging early indication can provide the following power saving gains w.r.t Rel-16:* If the original group paging rate is 10%:
	+ [10.6%] –[19.1%] where the baseline assumes 1 SS burst for synchronization before PO reception
	+ [16.0%] –[36.0%] where the baseline assumes 2 SS bursts for synchronization before PO reception
	+ [14.3%] –[46.0%] where the baseline assumes 3 SS bursts for synchronization before PO reception
* Some sources also evaluated performance if the original group paging rate is in the range between 20% and 60% and showed following results:
	+ [8.0%] –[19.1%] where the baseline assumes 1 SS burst for synchronization before PO reception
	+ [18.1%] –[34.0%] where the baseline assumes 2 SS bursts for synchronization before PO reception
	+ [20.6%] –[42.0%] where the baseline assumes 3 SS bursts for synchronization before PO reception

The additional power saving gains w.r.t. paging early indication without UE sub-grouping are given as follows:* If the original group paging rate is 10%:
	+ [0.6%] –[2.7%] where the baseline assumes 1 SS burst for synchronization before PO reception
	+ [0.6%] –[4.0%] where the baseline assumes 2 SS bursts for synchronization before PO reception
	+ [0.6%] –[4.7%] where the baseline assumes 3 SS bursts for synchronization before PO reception
* Some sources also evaluated performance if the original group paging rate is in the range between 20% and 60% and showed following results:
	+ [1.3%] –[8.0%] where the baseline assumes 1 SS burst for synchronization before PO reception
	+ [2.1%] –[13.0%] where the baseline assumes 2 SS bursts for synchronization before PO reception
	+ [3.3%] –[16.1%] where the baseline assumes 3 SS bursts for synchronization before PO reception

The number of UE sub-groups evaluated ranges from 2 to 16.The power saving gains are dependent on the assumptions about placement of PEI and PO relative to SSB.Note: It is FFS in RAN1 another group paging rate > 10% for the evaluation of Rel-17 paging enhancement.Note: Not all sources providing results for paging early indication without UE sub-grouping also provide results for paging early indication with UE sub-grouping. Agreements:Observation:For NR idle/inactive-mode UEs with 10% group paging rate, cross-slot scheduling with K0 = 1, which can be supported by Rel-15/Rel-16 for Type 2 CSS, can provide the following power saving gains w.r.t. same-slot scheduling (K0 = 0):* [<1%] –[2.5%] where the baseline assumes 1 SS burst for synchronization before PO reception
* [<1%] -[1.6%] where the baseline assumes 2 SS bursts for synchronization before PO reception
* [<1%] -[1.44%] where the baseline assumes 3 SS bursts for synchronization before PO reception

One source shows that cross-slot scheduling with K0 = 32, which cannot be supported by Rel-15/Rel-16 for Type 2 CSS, can provide the following power saving gains w.r.t. same-slot scheduling (K0 = 0):* [0%] where the baseline assumes 1 SS burst for synchronization before PO reception
* [6.3%] where the baseline assumes 3 SS bursts for synchronization before PO reception

The power saving gain will become lower with higher group paging rate.Agreements**:** For NR idle/inactive-mode paging enhancement, paging early indication before paging occasion is supported from RAN1 perspective* FFS: Physical layer design based on DCI, SSS or TRS/CSI-RS
* Send LS to inform RAN2 and kindly ask RAN2 to inform RAN1 if there is anything that RAN1 should take into consideration in the physical layer design for this feature, including any other progress RAN2 has made in this WI which may has RAN1 impact

Draft LS in [R1-2009754](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2009754.zip) is approved. Final LS in [R1-2009801](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2009801.zip). |
| **RAN1 #102-e meeting**Agreements:For study of Rel-17 paging enhancement, the following are assumed as a baseline for FR1 and FR2:* Reference configuration for FR1/FR2 as specified in Section 8.1.1/8.1.2 of TR 38.840
	+ Note: the setting for some PDSCH parameters may not be applicable for RedCap UEs
* Baseline paging cycle length: [1.28] second
* SS burst related assumptions:
	+ 20 ms periodicity
	+ 2 ms duration for serving cell RRM measurement, which can overlap with the one for synchronization before PO
	+ FFS time/frequency tracking
* Measurement related assumptions:
	+ 20 ms SMTC periodicity
	+ 2 ms SMTC window for intra-frequency RRM measurement, assuming synchronized deployment
	+ [5 ms SMTC window and 6 ms measurement gap for inter-frequency RRM measurement]
	+ Note: RAN4 requirement assumes one frequency layer per measurement gap, and 0.5 ms is assumed for switch in/out a frequency layer
* Note: the inclusion of potential TRS/CSI-RS occasions can be considered

Agreements:The following power consumption model for FR1 is utilized for the evaluations of Rel-17 UE power saving enhancements in idle/inactive mode* FFS: FR2 power consumption model for idle/inactive mode operations

|  |  |  |
| --- | --- | --- |
| Power State | Relative Power(FR1 reference from TR ~~84~~38.840) | Relative Power (Idle/inactive-mode operation with reception bandwidth 20 MHz) |
| Deep Sleep (PDS) | 1 | 1 |
| Light Sleep (PLS) | 20 | 20 |
| Micro sleep (PMS) | 45 | 45 |
| PDCCH-only (PPDCCH) | 100 | 50Note |
| PDCCH + PDSCH (PPDCCH+PDSCH) | 300 | 120 |
| PDSCH-only (PPDSCH) | 280 | 112 |
| SSB/CSI-RS proc. (PSSB) | 100 (synchronization or serving cell measurement) | 50 |
| Intra-frequency RRM measurement (Pintra) |         150 (synchronous case, N=8, measurement only; Pintra, meas-only)        200 (combined search and measurement; Pintra, search+meas) |         [60](synchronous case, N=8, measurement only; Pintra, meas-only)** [80] (combined search and measurement; Pintra, search+meas) |
| Inter-frequency RRM measurement (Pinter) | ·        150 (measurement only per freq. layer; Pinter, meas-only)·        150 (neighbor cell search power per freq. layer; Pinter, search-only)·        Micro sleep power assumed for switch in/out a freq. layer | ·        [60] (measurement only per freq. layer; Pinter, meas-only)·        [150](neighbor cell search power per freq. layer; Pinter, search-only)·        Micro sleep power assumed for switch in/out a freq. layer |
| Note: Power scaling to 20MHz reception bandwidth follows the rule in Section 8.1.3 of TR 38.840, i.e., max{reference power \* 0.4, 50}. |

Agreements:Group paging rate of 10% is assumed for the evaluation of Rel-17 paging enhancement* FFS: Another group paging rate > 10%
* Note: If UE sub-grouping is applied, the sub-group paging rate can be reduced w.r.t. the total sub-group number for a PO

Agreements:For the study on paging enhancements to reduce unnecessary paging reception, the following metrics are considered:* UE power saving gain (relative to a given feature or overall)
* Impact to UE paging detection probability
	+ FFS: Link level simulation assumptions
* System impact, including
	+ Additional resource overhead and its implications
	+ Impact to Rel-15/Rel-16 idle/inactive-mode UEs and connected-mode UEs
	+ Impact to other legacy functionalities, including SI change and ETWS indication
	+ [Note: NW energy consumption evaluation is not precluded]

Agreements:For the study of paging enhancement, 1, 2, or 3 SS burst processing is assumed before PO* Note: in choosing one or more values (1, 2, or 3) for the evaluations, companies to provide justification

AgreementsSend a LS with for evaluation methodology updates related to paging enhancement(s) to RAN2* Draft LS in [R1-2007355](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2007355.zip), which is endorsed, with final LS in [R1-2007356](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2007356.zip) -> (typo fix) [R1-2007425](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2007425.zip)

Agreements:For the study on paging enhancements, the following LLS assumptions are considered.* For investigating the residual frequency error after one or multiple SS burst processing, at least -6 dB SNR should be considered

|  |  |  |
| --- | --- | --- |
| Parameters | Values | Note |
| Carrier Frequency | 4GHz (FR1) |  |
| Transmission BW | 20MHz (FR1) |  |
| Antenna Configuration | 1/2TX and 2/4 RX | Companies to report |
| Channels | TDL-C or CDL-C300 ns delay spread100 Hz Doppler shift |  |
| Frequency error | Uniform distribution in the range [-X, +X]ppmCompanies to report the utilized X value(s) with justification | Modelled at the input of the considered paging channel/early indication design(s) |
| Paging PDCCH configuration | AL8, 41 info + 24 CRC bits, REG bundle size 6 | Companies to report additional setting(s), e.g., CORESET duration, etc. |
| Paging PDSCH configuration | Mapping type A, MCS 0, 48 PRB, TB scaling 1, DMRS type 1 with 2 additional DMRS | Companies to report additional setting(s), e.g., other TB scaling factor, other DMRS type(s), etc. |
| Paging early indication design(s) | Companies to report |  |

Agreements:For potential paging enhancements, RAN1 to study the following candidate schemes:* Paging early indication before a target PO to indicate UE whether to monitor PDCCH scrambled with P-RNTI at the PO. Potential candidate indication methods include
	+ DCI-based indication, e.g., based on
		- Extending existing DCI format 1\_0 or 2\_6
		- New DCI format
	+ RS-based or sequence-based indication, e.g., based on TRS/CSI-RS or SSS
* Sub-grouping for paging, based on
	+ Legacy paging DCI
	+ Paging early indication
	+ Additional reception occasions in time/frequency domain
	+ Multiple P-RNTIs
* Cross-slot scheduling for paging PDSCH
* Other proposal is not precluded
 |
| **Relating to scope item 1) – b):**1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]
	1. Specify means to provide potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode UEs, minimizing system overhead impact [RAN1]
* NOTE: Always-on TRS/CSI-RS transmission by gNodeB is not required

**The following agreements are achieved:** |
| **RAN1 #104-e Meeting**Agreements:Configuration of TRS/CSI-RS occasion(s) for idle/inactive Ues include at least:* powerControlOffsetSS,
* scramblingID
* firstOFDMSymbolInTimeDomain,
* startingRB.
* nrofRBs,
* FFS other parameters
* FFS applicable values

Agreements:The SCS configuration of TRS/CSI-RS occasion(s) for idle/inactive UEs can be discussed and down-selected from following alternatives at RAN1#104b-e:* Alt1: same as initial BWP
* Alt2: configurable parameter

Agreements:Multiple RS resources can be configured for TRS/CSI-RS occasion(s) for idle/inactive UEs. * FFS details (including whether or not to restrict the RS to be TRS only)

Agreements:For a cell with TRS/CSI-RS occasions configured for IDLE/Inactive UEs, IDLE/Inactive UE’s assumption on the availability of TRS/CSI-RS at the configured occasion(s) is informed to the idle/inactive UE based on explicit indication.* FFS details (e.g., the signalling, detailed information for the TRS/CSI-RS, etc.)
* There is no intended blind detection of the presence/absence of TRS/CSI-RS at the UE side in this feature. That is, the UE assumes TRS/CSI-RS is not present if the network does not indicate it is available (or indicates it is unavailable).

**Conclusion**From RAN1 perspective, there is no consensus on supporting RRM measurement for serving cell functionality for TRS/CSI-RS occasion(s) for idles/inactive UEs.Agreements:The configuration of the frequency location of TRS/CSI-RS occasion(s) for idle/inactive UEs are discussed and down-selected from following alternatives at RAN1#104bis-e:* Alt-1: within initial DL BWP
* Alt-2: is not restricted by initial BWP
	+ IDLE/INACTIVE mode UE is not expected to receive TRS/CSI-RS outside the initial DL BWP.

Agreements:To study QCL information of TRS/CSI-RS occasion(s) for idle/inactive UEs from following alternatives: * Alt-1: From higher layer configuration, e.g. qcl-InfoPeriodicCSI-RS
* Alt-2: QCL assumptions associated with transmitted SSBs implicitly, e.g. similar to PDCCH monitoring in PO
* FFS details
* Other alternatives are not precluded

**Conclusion:**Decide at RAN1#104b-e, whether or not to support periodic CSI-RS in addition to periodic TRS for TRS/CSI-RS occasion(s) for idle/inactive UEs. |
| **RAN1 #103-e Meeting**Agreements:* Functionality of RRM measurement for neighbour cell is not supported for TRS/CSI-RS for idle/inactive UE(s).

Agreements:* SIB signalling provides the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s).
	+ Up to RAN2 to decide which SIB is to be used.
	+ Whether or not to additionally support other high-layer signalling methods (e.g., dedicated RRC, RRC release message, etc.) is up to RAN2

Send an LS to RAN2 informing the above agreements, and* To further add that RAN1 is working on the detailed physical layer design

Draft LS is endorsed, with final LS in [R1-2009791](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2009791.zip). 🡪 R1-2009848Agreements:* Aperiodic TRS and semi-persistent/aperiodic CSI-RS are not used as TRS/CSI-RS occasion(s) for idle/inactive UEs.

Agreements:- Target sending an LS to RAN2 and RAN4 to ask whether it is feasible to allow a UE to use the potential TRS/CSI-RS occasion to enhance the SSB based IDLE/Inactive mode evaluations of the serving cell. (to also include agreements from last meeting)\* Further discussion whether any additional information needs to be included in the LS or not, including potential re-wording of the leading sentenceAgreements:* Discuss further based on the following alternatives and down-select at RAN1#104-e:
	+ Alt 1: The availability of TRS/CSI-RS at the configured occasion(s) is NOT informed to the UE.
	+ Alt 2: The availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.
	+ Alt 3. The conditional availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.
		- The condition can be, e.g., existence of paging.
	+ Alt 4. Combination of the above alternatives.
	+ FFS for details
	+ FFS for UE behavior when the availability is not informed.
	+ Other techniques are not precluded.
	+ Companies encourage to provide sufficient information for the proposal, e.g.,
		- how to achieve power saving gain
		- how to minimize impact on NW

how to minimize extra UE implementation complexity* + - feasibility check on sharing the TRS/CSI-RS between connected UEs and idle/inactive UEs
	+ Proposals should be consistent with the WID objective.

**Conclusion:*** TRS/CSI-RS based PEI is discussed in AI 8.7.1.1.
* PEI functionality is not further discussed under AI 8.7.1.2.
* Note: This does not prevent to potentially use PEI to carry the indication for TRS/CSI-RS presence.
 |
| **RAN1 #102-e Meeting**Agreements:* New types/patterns of TRS/CSI-RS are not introduced specifically for idle/inactive mode UE.

Agreements:The TRS/CSI-RS occasion(s) that may be for connected mode UEs can be shared to idle/inactive mode UEs. -  Note: It is understood that gNB can potentially share the occasions to idle/inactive (which would just mean it up to NW whether to share or not share).-  Note: It is understood that TRS/CSI-RS in the TRS/CSI-RS occasion(s) may or may not be transmitted.-  Note: Always-on TRS/CSI-RS transmission by gNodeB is not required-  At least TRS/CSI-RS occasion(s) corresponding to periodic TRS is supported - FFS for other RS types-  FFS: Whether UE blind detection is required or not.Agreements:Idle/inactive UE may use the TRS/CSI-RS occasion(s) that are shared to it for functionalities such as: -           AGC, time/frequency tracking-           FFS: RRM measurement for serving cell, RRM measurement for neighbor cell, paging reception indication**Observation:**It is up to gNB implementation whether or not to transmit a TRS/CSI-RS to idle/inactive UEs even when the TRS/CSI-RS is not needed by connected UEs (e.g., when there is a connected mode UE in a cell but the UE is no longer using the TRS/CSI-RS, or when there is no longer connected mode UE in a cell, etc.)Agreements:The configuration of TRS/CSI-RS occasion(s) for idle/inactive mode UE(s) is provided by higher layer signalling-           FFS higher layer signalling candidates (e.g., SIB, dedicated RRC, RRC release message, etc.)-           FFS for other signalling candidates (e.g., pre-configuration, etc.)-           FFS for detailed configuration parameters (e.g., whether and how to reduce the signalling overhead for configuration, etc.)Agreements:Further study whether and how to inform the availability of TRS/CSI-RS to idle/inactive mode UE (implicitly or explicitly).- Note: Availability corresponds to the information for whether TRS/CSI-RS is actually transmitted or not. |
| **Relating to scope item 2) – a):**1. Study and specify, if agreed, enhancements on power saving techniques for connected-mode UE, subject to minimized system performance impact [RAN1, RAN4]
	1. Study and specify, if agreed, extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time for an active BWP, including PDCCH monitoring reduction when C-DRX is configured [RAN1]
* NOTE: Rel-15 and Rel-16 available power saving solutions should be supported by the UE and included in the evaluation. RAN1 will ask the confirmation from RAN2 that Rel-15 and Rel-16 available power saving solutions are properly utilized.

**The following agreements are achieved:** |
| **RAN1 #104-e Meeting**Agreements:* Strive for a common design for DCI based PDCCH monitoring adaptation in active time for an active BWP to support functionalities inclusive of both SSSG switching and PDCCH skipping for a duration.
	+ Details FFS

Agreements:* Further study whether and how to minimize the impact to data scheduling for new transmissions and retransmissions.
	+ FFS details
* Further study the application delay for PDCCH adaptation indication

Agreements:* For DCI based PDCCH skipping in active time for an active BWP (if supported), the following can be further considered,
	+ Explicit indication of PDCCH adaptation
		- Scheduling DCI
			* Format 1\_1
			* Format 0\_1
			* Format 0\_2/1\_2
		- Non-scheduling DCI
			* Format 2\_6 in active time
			* Format 2\_0
			* Format 1\_1 (SCell dormancy case 2)
		- additional indication mechanism
			* By reusing Rel-16 SCell dormancy indication when CA is configured, FFS details
			* By reusing Rel-16 cross-slot scheduling indication when R16 cross-slot scheduling is configured, FFS details
	+ DCI dynamically indicates a duration/periodic interval for skipping
		- FFS: how to indicate the duration/period interval, e.g., number of slots or skipping current DRX
	+ PDCCH skipping for a duration indicated by minimum scheduling offset
	+ Others are not precluded

Agreements* For DCI based SSSG switching in active time for an active BWP (if supported), the following can be further considered,
	+ Explicit indication of PDCCH adaptation
		- Scheduling DCI based
			* Format 1\_1,
			* Format 0\_1,
			* Format 0\_2/1\_2
			* ~~Format 1\_0~~
		- Non-scheduling DCI
			* Format 2\_6 in active time
			* Format 2\_0
			* ~~Format 1\_0~~
			* Format 1\_1 (SCell dormancy case 2)
		- additional indication mechanism
			* By reusing Rel-16 SCell dormancy indication when CA is configured, FFS details
			* By associating Rel-16 cross-slot scheduling indication when R16 cross-slot scheduling is configured, FFS details
		- DCI dynamically indicates a duration for the switched SSSG, UE switch back to previous/default SSSG after duration ends
	+ Timer-based SSSG switching, including RRC configured a timer, UE switch back after timer expired.
	+ SSSG activation/deactivation
	+ FFS: Implicit SSSG switching
		- SSSG switching triggered by SR
		- SSSG switching triggered by RACH
		- Default SSSG that a UE monitors when coming out of DRX to monitor an ON duration.
* FFS: whether/how to support SSSG switching for multiple groups of cell(s).
* FFS: whether/how to support SSSG switching in active time with DCP outside active time
* FFS: whether / how to support more than 2 SSSGs,
	+ FFS: number of SSSGs
* FFS: a search space set group to emulate PDCCH skipping
* Others are not precluded

Agreements:* The following alternatives can be considered for DCI based PDCCH monitoring adaptation in active time for an active BWP for power saving
	+ Alt 1: Enhancement of Rel-16 SSSG switching to support PDCCH monitoring adaptation including skipping for a duration
	+ Alt 2a: Enhancement of DCI(s) utilized for Rel-16 power saving adaptation for supporting both skipping PDCCH monitoring for a duration and SSSG switching
	+ ~~Alt 2b: Enhancement of DCI(s) utilized for Rel-16 power saving adaptation for supporting both skipping PDCCH monitoring for a duration and PDCCH monitoring periodicity adaptation~~
	+ Others not precluded
 |
| **RAN1 #103-e Meeting**Agreements:Observation: * Each of the following schemes is individually shown to be beneficial for UE power saving compared to the baseline.
	+ Dynamically switching search space set
	+ Dynamically skipping PDCCH monitoring for a certain duration or until next DRX ON
* At least the following Rel-15 and/or Rel-16 power saving solutions have been utilized for baseline,
	+ For eMBB traffic,
		- DRX setting(including using short DRX or long DRX with a short IAT or long IAT), Wake-up signal, Cross-slot scheduling, CA/Scell dormancy, MAC-CE skipping, BWP switching
	+ For VoIP traffic,
		- DRX setting(only long DRX cycle with a short IAT), Wake-up signal,  Cross-slot scheduling, MAC-CE skipping
	+ For IM traffic,
		- DRX setting(long DRX cycle [with a short IAT]), Wake-up signal
	+ For intensive eMBB traffic,
		- DRX setting(including using short DRX or long DRX with a short IAT), Wake-up signal, Cross-slot scheduling, [CA/Scell dormancy], MAC-CE skipping, BWP switching
		- Note: intensive eMBB traffic is optional and companies may use FTP model 3 with different packet size and mean data arrival time, e.g., 15ms, 30ms, 50ms or 100ms.
* Note 1: For Search space switching, switching from 1slot monitoring to 2, 4, 8, 10, 16 or 32 slot with 30kHz SCS (FR1) and 120kHz (FR2) is utilized.
* Note 2: For PDCCH skipping , skipping 2ms, 4ms, 5ms, 8ms, 15ms, 16ms, 32ms,  64ms or to next DRX cycle is utilized
* Note 3: the baseline assumed may vary across companies

Agreements:* **Specify at least one of the following options for Rel-17 dynamic PDCCH adaptation ~~in time-domain~~ for active time,**
	+ **Option 1: Search space set group switching,e.g., ~~potential adjustments/enhancements for~~including explicit and implicit search spaceset group switching ~~specified in R16 for NR-U~~**
	+ **Option 2: PDCCH skipping for a certain duration / DRX cycle**
* **FFS: which option(s)~~(e.g. taking into account additional gain of option 1 over option 2, or vice-versa)~~**
* **Candidate DCI formats for dynamic PDCCH adaptation include DCI formats 1\_1(including scheduling and non-scheduling DCI), 0\_1, 1\_2, 0\_2, 2\_0, 2\_6.**
* **Note:**
	+ **Companies are encouraged to provide analysis on specification impact, power saving benefit and system impact (e.g., packet latency, system overhead)**
* **FFS: other schemes are not precluded for further study**
 |
| **RAN1 #102-e Meeting**Agreements:* Reusing power model in TR38.840 for evaluation of DCI-based power saving adaptation schemes.
	+ Note: company reporting additional power model for missing state or update is not precluded.

Agreements:* Company should report assumptions used for periodic measurement activities for the Rel-17 DCI-based power saving adaptation evaluation.
	+ The periodic activities defined in TR38.840 can be reused.
	+ Measurement for RLM/BFD every C-DRX cycle can be optionally modelled

Agreements:* The performance metrics described in TR38.840 section 8.2 is reused for power saving evaluation of Rel-17 DCI-based power saving adaptation during ActiveTime.
* The following Rel-15 / 16 features is recommended of the power consumption as reference for baseline. Company can report the feature(s) being used in the baseline.
	+ DRX
		- C-DRX cycle 40msec for VoIP
			* 10ms IAT, 8ms On-duration
			* Assume max two packets bundled
		- C-DRX cycle 160msec for FTP
			* Alt 1: 20 msec IAT, 8ms On-duration
			* Alt 2: short DRX
				+ 20 ms [or 40ms as optional] IAT, 8ms On-duration
				+ 20 ms for short DRX cycle, 4 cycles
			* Note: 100 msec IAT, 8ms On-duration can also be used with sufficient justifications that available Rel-15/16 Techniques being used to reduce UE power saving
	+ DCP for DRX adaptation,
		- DCP offset  to DRX ON = 2 ms, other values are not precluded
	+ Cross-slot scheduling adaptation
		- Minimum K0 can be adapted from 0 to 1 for FR1, 0 to [4] for FR2
	+ BWP switching, including
		- MIMO layer adaptation,
			* Max # of MIMO layer can be adapted from 4 layer to 2 layer for FR1, 2 layer to 1 layer for FR2
		- PDCCH monitoring period adaptation
			* PDCCH monitoring period can be adapted from per slot monitoring to X slot monitoring
				+ X = [2] for FR1 and [8] for FR2
		- Bandwidth adaptation
			* Bandwidth can be adapted from 100MHz to 20MHz for FR1,FFS for FR2
		- Note:
			* BWP transition time type 2 is assumed, BWP transition duration is
				+ 5 slot @ 30kHz SCS for FR1,
				+ 18 slot@120kHz SCS for FR2
				+ the slot-average power level for BWP transition duration is according to TR38.840
				+ BWP transition time type 1 can be optional modelled
			* BWP switching is Y (ms) after last packet/data burst.
				+ Y = [8], other values are not precluded
			* Whether BWP switching is modeled depends on the assumed UE capability and evaluated schemes.
	+ Scell dormancy assumption for CA capable UEs
		- FR1 & FR2: SCell dormancy with [160 ms] periodic CSI measurement and reporting
* Other settings
	+ CA assumption if configured for CA capable UEs
		- For FR1, FFS
		- For FR2, 4\*100MHz can be considered.
	+ Assumptions for scheduler
		- For FR1, no restriction on the beam assumptions being used in each slot
		- For FR2, up to each company, e.g., gNB equally schedule the slots for UEs targeting to different beams.
		- Note: the assumptions does not necessary mean to restrict or precluded any implementation. Other assumptions are not precluded and can be reported by companies.
	+ Company to report the used assumption for the interruption and also power savings impact due to presence/absence of interruptions .

Agreements:Legacy traffic models in TR38.840 can be considered for Rel-17 DCI-based power saving adaptation evaluation, other traffic models can be optionally modelled and company report which traffic model(s) is used.Update on 8/28:Draft LS is approved (with generic RAN2 action), with final LS in [R1-2007419](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2007419.zip). |

#### 2.1.2 Remaining open issues

RAN1 continues discussing and deciding the physical layer details for idle-mode and connected-mode power saving enhancements. In particular, the following are the remaining open issues:

* For scope item 1) - a):
	+ Decide and specify the physical layer design based on DCI, SSS or TRS/CSI-RS for paging early indication (PEI) before paging occasion, according to the agreed criteria in RAN1 #104e
	+ Further study how to provide the indications for UE subgroups over PEI and/or paging PDCCH, subject to the metrics agreed in RAN1 #102e
	+ Specify the association and timing relation between PEI and UE groups and subgroups, if supported, as well as UE paging monitoring behaviour with PEI.
* For scope item 1) - b):
	+ Decide at RAN1#104b-e, whether or not to support periodic CSI-RS in addition to periodic TRS for TRS/CSI-RS occasion(s) for idle/inactive UEs
	+ Specify how gNodeB indicates the availability of TRS/CSI-RS at the configured occasion(s) for idle/inactive UEs based on explicit indication
	+ Specify details for the configuration of TRS/CSI-RS occasion(s) for idle/inactive UEs
* For scope item 2) - a):
	+ Discuss and decide the approaches to support both skipping PDCCH monitoring for a duration and SSSG switching for a common framework by considering Alt 1 (Enhancement of Rel-16 SSSG switching) and/or Alt 2a (Enhancement of DCI(s) utilized for Rel-16 power saving adaptation).
	+ Discuss and decide, if agreed, design details, including whether and how to minimize impact to data scheduling (for new transmissions and retransmissions), application delay, DCI format(s) for explicit indication, etc.

## 2.2 RAN2

#### 2.2.1 Agreements

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| --- |
| **Relating to scope item 1) - a)** 1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]
	1. Study and specify paging enhancement(s) to reduce unnecessary UE paging receptions, subject to no impact to legacy UEs [RAN2, RAN1]
* NOTE: RAN1 to check and update, if needed, evaluation methodology in RAN1 #102-e meeting

**The following agreements are achieved:** |
| RAN2 #113-e MeetingR2-2100389 Report of [POST112-e][064][Pow17] Group Determination (Intel) Intel CorporationR2-2101301 Network assigned subgrouping Intel Corporation FOR BOTH DOCS ABOVE* There is support to have UE ID based enhancement
* There is still significant interest to have other additional methods (but also some concerns). The approach to have a single mechanism that can take several aspects into account can be a way forward. There are still questions on the details, e.g. whether CN or RAN would provide a parameter.

Chair: Plan to make decisions at next meeting this topic is treated, so companies that have preferences for certain methods need to clearly explain justifications. - MTK think that the study phase is supposed to be concluded at this meeting.   |
| RAN2 #112-e Meeting* Confirm that UE grouping is considered a candidate of paging enhancement for UE power saving
* RAN2 have discussed and considered “paging indication for UE subgroups using paging DCI”, “paging early indication or wake-up signal (WUS) for UE subgroups”, “cross-slot scheduling of paging for UE subgroups”.
* RAN2 understands that RAN1 have started to evaluate performance and complexity. RAN2 assumes that RAN1 continues with this evaluation, in order that decisions can be made regarding the paging indication/scheduling solution. As R2 is the leading group for this WI objective it is expected that final decisions are made by R2.
* Will send an LS to R1 (action to be discussed offline).
* The solution of PRNTI based group discrimination is deprioritized from RAN2 perspective
* The solution of “paging for UE subgroups using different time/frequency resources” is de-prioritized from RAN2 perspective.
* [AT112-e][047][ePowSav] LS on Paging enhancement (Mediatek)

 Scope: LS covering decisions and clarifying work split to the extent possible.  Intended outcome: Approved LS to R1 (R2-2010884) Deadline: EOM* [Post112-e][0xx][Pow17] Paging subgroup determination ()

 Scope: For how to determine which paging subgroup a UE belongs to, several methods have been proposed, applying hash based on UE-ID similar to today, take into account paging probability, power consumption sensitivity etc. Objective to pave the way for agreements next meeting. Quantitative analysis argumentation is allowed (this is RAN2 scope).  Intended outcome: Report Deadline: Long |
| RAN2 #111-e Meeting* For PowSav solutions for Idle/Inactive (for smart phones) that can easily also be applied to redcap, R2 assume they may be applied. Details FFS and to be discuss case by case when the maturity is high (might in the end just be a question of UE caps).
* Dual DRX not in the scope of current WID.
* [Post111-e][xxx][ePowSav] UE grouping (Mediatek)

 Scope: UE grouping, put solutions on the table, describe intentions / how they work (high level), and their potential to save power. Possibly take into account R1 evalaution methodology (if they have agreements on the evaluation parameters). Intended outcome: Report Deadline: Long |
| **Relating to scope item 1) – b):**1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]
	1. Specify means to provide potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode UEs, minimizing system overhead impact [RAN1]
* NOTE: Always-on TRS/CSI-RS transmission by gNodeB is not required

**The following agreements are achieved:** |
| RAN2 #113-e Meeting* [AT113-e][041][ePowSav] TRS/CSI-RS for IDLE INACTIVE (Xiaomi)

 Scope: Take the documents in 8.9.3 into account, except availability signalling which is postponed. Collect comments, determine agreeable points, open points and their main options and related justifications.  Intended outcome: Report, Agreements (if possible).  Deadline: Thursday Feb 4 UTC 1100: Deadline for comments on agreements. Deadline for other aspects: EOM* [041] On signalling providing the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s):

SIB signalling is the baseline;Other dedicated high-layer signalling methods (e.g., dedicated RRC, RRC release message, etc.) can be additionally considered with justification. It is assumed they do not work alone.* [041] RAN2 will down select from the following options on SIB signalling providing the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s):

Option 2: Existing SIB, other than SIB1;Option 3: New SIB type, e.g. SIB-x; |

#### 2.2.2 Remaining open issues

With the above, the following are remaining issues for idle-mode power saving enhancements in RAN2:

* For scope item 1) – a):
	+ Discuss and decide UE grouping design for paging enhancement, including paging subgroup determination.
	+ Reply RAN1 LS to provide information of RAN2 decision(s) on UE sub-grouping for paging enhancement.
	+ Specify configurations for UE grouping as well as paging early indication based on RAN1 design
* For scope item 1) – b):
	+ Discuss and decide whether and how dedicated high-layer signalling methods (e.g., dedicated RRC, RRC release message, etc.) can be additionally utilized with justification.
	+ Discuss and decide SIB type, Option 2 (Existing SIB) or Option 3 (New SIB type), for providing the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s), based on RAN1 design on detailed configurations.

## 2.3 RAN3

#### 2.3.1 Agreements: N/A (RAN3 is not involved in the WI)

#### 2.3.2 Remaining Open issues: N/A

## 2.4 RAN4

#### 2.4.1 Agreements

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| **Relating to scope item 2) - b)** 1. Study and specify, if agreed, enhancements on power saving techniques for connected-mode UE, subject to minimized system performance impact [RAN1, RAN4]
	1. Study the feasibility and performance impact of relaxing UE measurements for RLM and/or BFD, particularly for low mobility UE with short DRX periodicity/cycle, and specify, if agreed, relaxation in the corresponding requirements [RAN4]
* NOTE: Supplementary RAN2 work, if needed, can be triggered by RAN4 LS

**The following agreements are achieved:** |
| **RAN4 #98-e Meeting****Approved: WF on R17 UE power saving RLM/BM relaxation (R4-2103670)**Issue 2-2-1: Confirmation on beneficial Scenarios, from UE power saving gain perspective* Agreements
	+ Further evaluate UE power saving gains for the following UE implementations:
		- UE meets Rel-15 RRM measurement period and accuracy requirements
		- Option 1:
			* UE uses all L1 samples for RRM measurements based on Rel-15 assumptions
		- Option 2:
			* How many L1 samples UE applies for RRM measurements is up to UE implementation (e.g. UE can use lower number of measurement samples for RRM measurements)
			* Further discuss how many samples to use for evaluations
			* Companies shall evaluate RRM measurements accuracy for the proposed number of samples.
		- FFS whether Option 2 can be considered for requirements definition
		- Further assess impact on PDCCH monitoring due to relax UE measurements for RLM/BFD

Issue 2-2-1: Confirmation on beneficial Scenarios, from UE power saving gain perspective* RAN4 to identify the scenarios that power saving gain can be observed.

Issue 2-2-2: Feasible Scenarios for Power Saving, from system impact perspective* RAN4 to identify the scenarios that system impact can be acceptable.
* FFS the feasibility of following scenarios from system level perspective:
	+ SSB-based and CSI-RS based RLM/BFD measurement relaxation in FR1 for low mobility and high/medium SINR UE.
	+ CSI-RS based RLM/BFD measurement relaxation in FR2 for low mobility and high/medium SINR UE
	+ SSB-based RLM/BFD measurement relaxation in FR2 for stationary and high/medium SINR UE

Issue 2-2-3: DRX cycle* The applicability of DRX cycles for RLM/BFD relaxation should be studied and decided based on the ongoing simulation study.
	+ FFS DRX cycle length <= 80 ms

Issue 2-3-1: Criteria which the UE is allowed to relax the RLM/BM requirements* At least take UE mobility into account as the relaxation criteria.
* also take serving cell’s quality into account
* FFS whether and how to take other aspects into account

Issue 2-3-3: How to consider serving cell’s quality as relaxation criteria* RAN4 to further discuss how to take serving cell’s quality into account for the relaxation criteria
	+ FFS how to consider serving cell’s quality. E.g. Based on SINR or BLER.
	+ FFS how to address different UE implantation issues.
	+ FFS: When radio link quality > Qout + X (dB) for RLM and Qout,LR + Y (dB) for BFD relaxation
		- X and Y are FFS.

Issue 2-3-2: How to consider UE mobility as relaxation criteriaFFS the following options* + Option 1: R16 low-mobility criterion should not be directly reused in R17 SINR-based criterion for RLM/BFD relaxation.
	+ Option 2: R16 RRM relaxation criterion can be used as baseline for RLM/BFD relaxation.
	+ Option 3: “low mobility criteria” should consider both UE velocity and the channel quality variation.
	+ Option 4: Consider time associated with a given condition when determining UE mobility state.
	+ Option 5: Low mobility scenario under which the UE is allowed to apply the RLM/BFDBM requirements is determined and configured to UE by the network

Other options are not precludedIssue 2-3-4: Network or UE to determine if the relaxation criteria is fulfilled* Network to enable and disable this feature.
	+ FFS Should the relaxation criteria be predefined or configurable?
	+ FFS Should it be network or UE to determine the relaxation criteria is fulfilled or not?

Issue 2-4-1: Scheme of RLM/BFD measurements relaxation* Use of a scaling factor to extend the RLM/BFD evaluation period.

Issue 2-4-2: relaxation factor determination* Scaling factor defining the relaxed RLM/BFD evaluation period is defined based on
	+ DRX cycle and RLM-RS periodicity
		- FFS based on max(TDRX, TSSB)
		- FFS other factors are not precluded, e.g. estimated SINR level, UE mobility, N factor, P factor, RS type, FR1 or FR2.
* FFS whether scaling factor can be different for different SINR regions (e.g. high/medium SINR)

Issue 2-4-3: relaxation factor: different relaxation factor in FR1 and FR2* RAN4 further to discuss whether different relaxation factors can be allowed for FR1 and FR2 based on ongoing simulation study.

Issue 2-5-1: Reverting to the normal RLM operationThe UE while performing relaxed RLM upon detecting certain number of out-of-sync indications or upon triggering T310 or upon observed link quality degradation or mobility state change reverts to the normal RLM operation (i.e. without relaxation).* FFS the following options
	+ Option 1a: revert when the relaxation criterion is not met
	+ Option 1b: revert when N310 starts to count, i.e. 1 out-of-sync indication.
	+ Option 1c: revert when T310 is running, i.e. N310 out-of-sync indication.
	+ Option 1d: revert when observed link quality degradation.
	+ Option 1e: revert regarding observed mobility state change.

Other options are not precludedIssue 2-5-2: Reverting to the normal BFD operation* Option 1: Reverting to the normal BFD operation upon detect 1 beam failure instance indication.
* Option 2: The UE while performing relaxed BFD upon beam failure detection reverts to the normal BFD operation (i.e. without relaxation).
* Option 3: There might be no benefit to configure conditions for UE reverting to normal BFD.
* Option 4: Whether reverting to normal BFD operation aligns with whether reverting to normal RLM operation

Other options are not precluded.Issue 2-5-3: Relaxation of RLM/BFD when not all serving cells in intra-band CA/DC meets relaxation criteriaThe following options have been discussed in this meeting* + Option 1: For intra-band CA case, the UE should relax only on serving cells where the relaxed criteria is fulfilled.
	+ Option 2: if UE has fulfilled the criterion for operating RLM/BFD in relaxed mode in one serving cell (SpCell), then it is allowed to operate RLM/BFD in relaxed mode in all other serving cells (e.g. Scells).
	+ Option 3:if UE has failed to fulfil the criterion for operating RLM/BFD in relaxed mode in one serving cell (SpCell), then it shall revert to normal RLM/BFD operation (i.e. without relaxation) in all other serving cells (SCells).
	+ Other options are not precluded.
	+ FFS how many cells that UE is required to perform RLM/BFD in intra-band CA/DC.

Issue 2-5-4: Relaxation on PDCCH monitoringNot to further discuss whether PDCCH monitoring should be relaxed until RAN1 design is stable.Agreement: Issue 2-5-4 Relaxation on PDCCH monitoring is kept as FFS.Issue2-5-5: Relaxation rules among serving cells for intra-band CA/DC scenario* FFS
	+ Option1: For intra-band CA case, RAN4 to define the same RLM/BFD measurement relaxation criteria for the serving cells.

Other options are not precluded**The following are for information*** Based on simulation results submitted for RAN4#98e meeting, it can be observed that
	+ With FTP model is considered with DRX of 40 ms, if L1 measurement intervals for RRM are also extended K times
		- For FR1 SSB-based RLM/BFD relaxation, at least 3 sources show that the power saving gain is 8.7% to 16.4% for K=2, 13% to 20.5% for K=4, and 15.1% to 25.8% for K=8.
		- For FR2 CSI-RS based RLM/BFD relaxation, one source shows that the power saving gain is 15.6% for K=2, 21.8% for K=4.
	+ By extending only RLM/BFD measurement interval without extending RRM measurement interval
		- At least 2 sources show minimal or no power saving gain.
* Based on simulation results submitted for RAN4#98e meeting, it can be observed that
	+ Regarding delta SINR, for FR1 SSB-based RLM OOS relaxation,
		- with mobility of 3 km/h, at least 2 sources show that the delta SINR is 1.3 dB to 2dB for K=2 , 2.6 dB for K=4, less than 8dB for K=8.
		- with mobility of 30 km/h, at least 2 sources show that the delta SINR is 2.8 dB to 4.6dB for K=2 , 5.1 to 6.2 dB for K=4, 7.4 to 8.8 dB for K=8.
	+ Regarding delta SINR, for FR1 SSB-based BFD/INS relaxation, it can be observed that the delta SINR is less than the delta SINR observed for FR1 SSB-based RLM OOS relaxation.
	+ Regarding increased RLF latency, for FR1 SSB-based RLM OOS relaxation,
		- with mobility of 3 km/h, at least 2 sources show that the increased latency is less than 40ms for K=2, less than 120ms for K=4, and less than 280ms for K=8 with 95% probability.
			* The increase is less than 2.5% for K=2, less than 7.5% when K=4 and less than 17.5% when K=8, as T310 = 1000ms and N310 = 1.
		- with mobility of 30 km/h, at least 2 sources show that the increased latency is less than 40ms for K=2, less than 120ms for K=4, and less than 280ms for K=8 with 95% probability.
			* The increase is less than 2.5% for K=2, less than 7.5% when K=4 and less than 17.5% when K=8, as T310 = 1000ms and N310 = 1.

**Approved: Updated evaluation assumptions for R17 RLM/BFD relaxation (R4-2104066)****Approved: Work Plan of Rel-17 Power Saving Enhancements (R4-2103669)** |
| **RAN4 #97-e Meeting****Approved: WF on NR UE Power Saving Enhancements (R4-2017269)**Issue 2-1-1: Evaluation assumption for SLS on mobility impact* Evaluation assumptions are in section 2 of R4-2017306
	+ Note: Further updates in future meetings are not precluded.

Issue 2-1-2: Evaluation assumption for power consumption* Power consumption model in 38.840 is used as the starting point of evaluation assumption. Other options are not precluded, e.g.,
	+ LS R1-2007419
	+ VoIP traffic model as in TR 38.840
	+ Evaluation assumptions in section 3 of R4-2017306
		- Note: Further updates in future meetings are not precluded.

Issue 2-1-3: From configuration perspective, factors to be studied and evaluated for RLM/BFD relaxation* At least the following factors are prioritized for RLM/BM relaxation study,
	+ DRX cycle (option 1) for both 20ms and 40ms cycle length
	+ The following factors can also be considered for evaluation. Companies are encouraged to evaluate the following factors and clarify the corresponding assumption.
	+ Option 2: RS configurations,
		- 2a: RLM/BFD-RS types
		- 2b: Periodicity of SSB or CSI-RS resource
		- 2c: BW of RLM/BFD-RS types
		- 2d: the relation to RSs for RRM
		- 2e: relation to RS for other L1 measurement
		- 2f: WUS is applied or not
	+ Option 3: N factor (# of RX beams for FR2)
	+ Option 4: P (scale factor with consideration of overlap with measurement gap and/or SMTC window)

Issue 2-2-2: Evaluation metrics, system impact aspects* + Study the system impact of relaxed RLM/BFD measurements, taking in to account the following evaluation metrics:
		- increased latency in RLF triggering (for RLM)
		- increased latency in beam failure detection and the initiation of beam recovery procedure (for BFD)
		- Delta SINR as one of the performance statistic to evaluate the RLM/BFD performance impact
	+ RAN4 to discuss the impact of RLM/BM relaxation on PDCCH monitoring.

Issue 2-3-1: Scheme of RLM/BFD measurements relaxation* At least extending evaluation period of RLM/BFD measurement (Option 1) to be considered as the scheme of RLM/BFD measurements relaxation. FFS schemes as follows
	+ Option 1a: RAN4 to further discuss use of a scaling factor for defining the relaxed RLM/BM evaluation period and indication intervals.
	+ Option 2: Reducing the number of candidate beams when UE fulfilled relaxed criteria can be a feasible way to reduce power consuming.
	+ Option 3: Reducing the number reducing the sample number.

Issue 2-3-2: Criteria which the UE is allowed to relax the RLM/BM requirements* RAN4 to further study the criteria which the UE is allowed to relax the RLM/BM requirements, according to UE mobility and/or serving cell’s quality.
* Note: The options discussed in RAN4 97e meeting are listed below for information.
	+ Option 1: UE mobility
		- 1a: Low mobility criteria, e.g. R16 RRM relaxation criterion can be used as a starting point.
		- 1b: other solutions.
	+ Option 2: Serving cell’s quality (e.g. RSRP, SINR)
		- 2a: at-cell-center criteria, e.g. R16 RRM relaxation criterion can be used as a starting point.
		- 2b: the measured SINR is above one additional threshold (e.g. SINR > 2dB).
		- 2c: other solutions.

Issue 2-3-3: Network or UE to determine if the criteria for relaxation is fulfilledThe following options are FFS* Option 1: Low mobility scenario under which the UE is allowed to relax the RLM/BM requirements is determined by the network.
* Option 2: Low mobility scenario under which the UE is allowed to relax the RLM/BM requirements is determined by the UE.
* Option 3: Low mobility scenario under which the UE is allowed to relax the RLM/BM requirements is determined by both the network and UE.

Issue 2-4-1: Reverting to the normal RLM operationThe following options are FFS* Option 1: The UE while performing relaxed RLM upon detecting certain number of out-of-sync indications or upon triggering T310 reverts to the normal RLM operation (i.e. without relaxation).
* Other options are not precluded

Issue 2-4-2: Reverting to the normal BM operationThe following options are FFS* Option 1: The UE while performing relaxed BFD upon beam failure detection reverts to the normal BFD operation (i.e. without relaxation).
* Other options are not precluded

Issue 2-4-3: Relaxation of BM when not all serving cells in intra-band CA/DC meets relaxation criteria* RAN4 to further discuss the relaxation of BFD when not all serving cells in intra-band CA/DC meets relaxation criteria.
* The following options are FFS
	+ Option 1A: relax on all serving cells when the relaxed criteria is fulfilled in one serving cell.
	+ Option 1B: relax only on serving cells where the relaxed criteria is fulfilled.
	+ Option 1C: Other solutions

**Approved: Evaluation assumptions for R17 RLM/BFD relaxation (R4-2017306)****Approved: Work Plan of R17 UE Power Saving Enhancements WI (R4-2017270)** |

#### 2.4.2 Remaining open issues

With the above, the following are remaining open issues for RLM/BFD relaxation in RAN4:

* Prioritized topics for study phase:
	+ Confirmation on beneficial Scenarios, from UE power saving gain perspective
	+ Feasible Scenarios for Power Saving, from system impact perspective
	+ Criteria which the UE is allowed to relax the RLM/BM requirements
	+ Scheme of RLM/BFD measurements relaxation
	+ Reverting to the normal RLM operation
	+ Reverting to the normal BM operation
* Other topics for further specification:
	+ The applicability of DRX cycles for RLM/BFD relaxation
	+ How to consider serving cell’s quality as relaxation criteria
	+ How to consider UE mobility as relaxation criteria
	+ Network or UE to determine if the criteria for relaxation is fulfilled
	+ Relaxation factor determination
	+ Relaxation factor: different relaxation factor in FR1 and FR2
	+ Relaxation of BM when not all serving cells in intra-band CA/DC meets relaxation criteria
	+ Relaxation on PDCCH monitoring
	+ Relaxation rules among serving cells for intra-band CA/DC scenario
	+ NOTE: Supplementary RAN2 work, if needed, can be triggered by RAN4 LS

## 2.5 RAN5

#### 2.5.1 Agreements: N/A (RAN5 is not involved in the WI)

#### 2.5.2 Remaining Open issues: N/A

#### 2.5.3 Remaining Open issues with cross-WG dependencies: N/A

## 2.6 RAN6

#### 2.6.1 Agreements: N/A (RAN6 is not involved in the WI)

#### 2.6.2 Remaining Open issues: N/A

## 3. Detailed progress in SA/CT WGs since last TSG meeting (for all involved WGs)

NOTE: This section only needs to be filled in for WI/SIs where there is a corresponding relevant WI/SI in SA/CT.

## 3.1 SAx/CTs

#### 3.1.1 Agreements with cross-TSG impacts: N/A

#### 3.1.2 Remaining Open issues with cross-TSG impacts: N/A

## 4. References

|  |
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| **RAN1 Contributions** |
| **RAN1 #104-e Meeting*** **Potential paging enhancements:**

R1-2101948 Summary for Paging Enhancements Moderator (MediaTek)R1-2100168 Further discussion on Paging enhancements for power saving OPPOR1-2100216 Paging enhancement(s) for UE power saving in IDLE/inactive mode Huawei, HiSiliconR1-2100392 Paging enhancement for UE power saving CATTR1-2100394 Details of PEI configuration CATTR1-2100452 Paging enhancements for idle/inactive mode UE power saving vivoR1-2100454 Discussion on paging grouping vivoR1-2100523 Discussion on power saving enhancements for paging ZTE , SanechipsR1-2100525 Additional simulation results of UE power consumption in RRC idle and inactive state ZTE , SanechipsR1-2100544 Potential paging enhancements TCL Communication Ltd.R1-2100591 Design of paging early indication for idle/inactive-mode UE power saving MediaTek Inc.R1-2100662 On paging enhancements for UE power saving Intel CorporationR1-2100824 Discussion on potential paging enhancements Spreadtrum CommunicationsR1-2100866 Paging enhancement in Idle/Inactive state SonyR1-2100903 Discussion on potential paging enhancements LG ElectronicsR1-2100998 Paging enhancement for UE power saving Lenovo, Motorola MobilityR1-2101052 Discussion on paging early indication design CMCCR1-2101125 Paging enhancement for power saving XiaomiR1-2101217 Discussion on paging enhancements SamsungR1-2101300 On paging enhancement PanasonicR1-2101392 Paging early indication for idle/inactive-mode UE AppleR1-2101474 Paging enhancements for idle/inactive UE power saving Qualcomm IncorporatedR1-2101503 Paging enhancements for UE power saving InterDigital, Inc.R1-2101720 Paging indication based on sub-time units InterDigital, Inc.R1-2101555 Design of Paging Enhancements EricssonR1-2101622 Discussion on paging enhancements NTT DOCOMO, INC.R1-2101664 On paging enhancements for UE power saving Nokia, Nokia Shanghai Bell* **TRS/CSI-RS occasion(s) for idle/inactive UEs**

R1-2101218 Moderator summary for TRS/CSI-RS occasion(s) for idle/inactive UEs Moderator (Samsung)R1-2100169 Further discussion on RS occasion for idle/inactive UEs OPPOR1-2100217 Assistance RS occasions for IDLE/inactive mode Huawei, HiSiliconR1-2100393 Configuration of TRS/CSI-RS for paging enhancement CATTR1-2100453 TRS/CSI-RS occasion(s) for idle/inactive UEs vivoR1-2100524 TRS for RRC idle and inactive UEs ZTE , SanechipsR1-2100545 TRS/CSI-RS occasion(s) for idle/inactive UEs TCL Communication Ltd.R1-2100592 On TRS/CSI-RS occasion(s) for idle/inactive mode UE power saving MediaTek Inc.R1-2100663 TRS/CSI-RS functionality during idle/inactive mode Intel CorporationR1-2100814 Consideration on TRS/CSI-RS occasion(s) for idle/inactive UEs Spreadtrum CommunicationsR1-2100867 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs SonyR1-2100904 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs LG ElectronicsR1-2100999 Provision of TRS/CSI-RS for idle/inactive UEs Lenovo, Motorola MobilityR1-2101053 Discussion on TRS/CSI-RS occasion(s) for IDLE/INACTIVE-mode UEs CMCCR1-2101126 On TRS/CSI-RS occasion(s) for idle/inactive UEs XiaomiR1-2101219 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs SamsungR1-2101301 Potential enhancements for TRS/CSI-RS occasion(s) for idle/inactive UEs PanasonicR1-2101393 Indication of TRS/CSI-RS for idle/inactive-mode UE power saving AppleR1-2101475 TRS/CSI-RS for idle/inactive UE power saving Qualcomm IncorporatedR1-2101504 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs InterDigital, Inc.R1-2101544 On TRS/CSI-RS occasions for idle/inactive UEs SharpR1-2101556 Provisioning of TRS occasions to Idle/Inactive UEs EricssonR1-2101623 Discussion on TRS/CSI-RS occasion for idle/inactive UEs NTT DOCOMO, INC.R1-2101665 On RS information to IDLE/Inactive mode Ues Nokia, Nokia Shanghai Bell* **Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time**

R1-2101893 FL summary#1 of power saving for Active Time Moderator (vivo)R1-2100170 DCI-based power saving adaptation solutions OPPOR1-2100218 Extension(s) to Rel-16 DCI-based power saving adaptation for an active BWP Huawei, HiSiliconR1-2100395 PDCCH monitoring adaptation CATTR1-2100455 Discussion on DCI-based power saving adaptation in connected mode vivoR1-2100498 Extension to Rel-16 DCI-based power sabing adaptation during DRX Active Time GDCNIR1-2100526 Extension to Rel-16 DCI-based power saving adaptation during DRX Active Time ZTE , SanechipsR1-2100593 On enhancements to DCI-based UE power saving during DRX active time MediaTek Inc.R1-2100664 Discussion on PDCCH monitoring reduction techniques during active time Intel CorporationR1-2100815 Discussion on power saving techniques for connected-mode UEs Spreadtrum CommunicationsR1-2100905 Discussion on DCI-based power saving adaptation during DRX ActiveTime LG ElectronicsR1-2100980 Discussion on extension(s) to Rel-16 DCI-based power saving adaptation Asia Pacific Telecom, FGIR1-2101000 Enhanced DCI based power saving adaptation Lenovo, Motorola MobilityR1-2101054 Discussion on PDCCH monitoring reduction during DRX active time CMCCR1-2101220 Discussion on DCI-based power saving techniques SamsungR1-2101285 DCI-based Power Saving Enhancements Fraunhofer HHI, Fraunhofer IISR1-2101302 Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime PanasonicR1-2101394 Enhanced DCI-based power saving adaptation AppleR1-2101476 DCI-based power saving adaptation during DRX ActiveTime Qualcomm IncorporatedR1-2101505 PDCCH monitoring reduction in Active Time InterDigital, Inc.R1-2101558 Design of active time power savings mechanisms EricssonR1-2101567 Power saving adaptation during Active Time ASUSTeKR1-2101624 Discussion on extension to DCI-based power saving adaptation NTT DOCOMO, INC.R1-2101666 UE power saving enhancements for Active Time Nokia, Nokia Shanghai Bell* **Others**

R1-2101557 Modeling of Network Power Consumption EricssonR1-2101740 Analysis on power consumption for IDLE mode UE Huawei, HiSiliconR1-2100171 Discussion on RLM relaxation OPPOR1-2100396 System overhead analysis of PEI and TRS/CSI-RS for IDLE mode UE CATTR1-2100456 Discussion on RLM/BFD/RRM relaxation vivoR1-2100527 Further discussion on potential power saving schemes for RRC connected UEs ZTE , SanechipsR1-2100816 Discussion on other power saving techniques Spreadtrum CommunicationsR1-2101257 Other considerations on power saving in Rel-17 Huawei, HiSiliconR1-2101559 Evaluation results for UE power saving schemes Ericsson |
| **RAN1 #103-e Meeting*** **Potential paging enhancements:**

R1-2007600 Paging enhancement(s) for UE power saving in IDLE/inactive mode Huawei, HiSiliconR1-2007673 Paging enhancements for idle/inactive mode UE power saving vivoR1-2007867 Paging enhancement for UE power saving CATTR1-2007890 Potential paging enhancements TCL Communication Ltd.R1-2007898 Paging enhancement for power saving Beijing Xiaomi Software TechR1-2007971 Discussion on power saving enhancements for paging ZTER1-2008021 Discussion on paging enhancement CMCCR1-2008053 Discussion on potential paging enhancements LG ElectronicsR1-2008103 Discussion on potential paging enhancements Spreadtrum CommunicationsR1-2008175 Discussion on paging enhancements SamsungR1-2008265 Further discussion on Paging enhancements for power saving OPPOR1-2008287 Potential paging enhancements for idle/inactive-mode UE power saving PanasonicR1-2008368 Paging enhancement for idle/inactive mode UE SonyR1-2008474 Paging enhancements for idle/inactive-mode UE power saving AppleR1-2008689 Paging enhancements for UE power saving InterDigital, Inc.R1-2008933 On paging enhancements for UE power saving Nokia, Nokia Shanghai BellR1-2008964 Paging enhancements for idle/inactive-mode UE power saving MediaTek IncR1-2008992 On paging enhancements for UE power saving Intel CorporationR1-2009105 Paging enhancement for UE power saving Lenovo, Motorola MobilityR1-2009187 Discussion on paging enhancements NTT DOCOMO, INC.R1-2009200 Discussion on potential paging enhancements for UE power savings EricssonR1-2009266 Paging enhancements and evaluation methodology Qualcomm Incorporated* **TRS/CSI-RS occasion(s) for idle/inactive UEs**

R1-2007601 Assistance RS occasions for IDLE/inactive mode Huawei, HiSiliconR1-2007674 TRS/CSI-RS occasion(s) for idle/inactive UEs vivoR1-2007868 Configuration of TRS/CSI-RS for paging enhancement CATTR1-2007891 TRS/CSI-RS occasion(s) for idle/inactive UEs TCL Communication Ltd.R1-2007899 TRS CSI-RS occasion(s) for idle inactive UEs Beijing Xiaomi Software TechR1-2007972 Reference signal for RRC idle and inactive UEs ZTER1-2008022 Discussion on TRS/CSI-RS occasion(s) for idle/inactive-mode UEs CMCCR1-2008054 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs LG ElectronicsR1-2008176 Discussion on TRS/CSI-RS occasion(s) for idle/inactive Ues SamsungR1-2008177 Discussion on DCI-based power saving techniques SamsungR1-2008266 Further discussion on RS occasion for idle/inactive UEs OPPOR1-2008288 Potential enhancements for TRS/CSI-RS occasion(s) for idle/inactive Ues PanasonicR1-2008369 Considerations on TRS/CSI-RS occasion(s) for idle/inactive mode UE SonyR1-2008475 Indication of TRS/CSI-RS for idle/inactive-mode UE power saving AppleR1-2008690 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs InterDigital, Inc.R1-2008934 On RS information to IDLE/Inactive mode Ues Nokia, Nokia Shanghai BellR1-2008965 On TRS/CSI-RS occasion(s) for idle/inactive mode UE power saving MediaTek Inc.R1-2008993 Discussion on TRS/CSI-RS reception during idle/inactive mode Intel CorporationR1-2009106 Provision of TRS/CSI-RS for idle/inactive UEs Lenovo, Motorola MobilityR1-2009151 Consideration on TRS/CSI-RS occasion(s) for idle/inactive UEs Spreadtrum R1-2009188 Discussion on TRS/CSI-RS occasion for idle/inactive UEs NTT DOCOMO, INC.R1-2009201 Provisioning of potential TRS/CSI-RS occasion(s) for Idle/Inactive UEs EricssonR1-2009267 TRS CSI-RS for idle and inactive UE power saving Qualcomm Incorporated* **Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time**

R1-2007602 Extension(s) to Rel-16 DCI-based power saving adaptation for an active BWP Huawei, HiSiliconR1-2007676 Discussion on DCI-based power saving adaptation in connected mode vivoR1-2007701 Extension to Rel-16 DCI-based power sabing adaptation during DRX Active Time GDCNIR1-2007870 PDCCH monitoring adaptation CATTR1-2007974 Extension to Rel-16 DCI-based power saving adaptation during DRX Active Time ZTER1-2008023 Discussion on PDCCH monitoring reduction during DRX active time CMCCR1-2008055 Discussion on DCI-based power saving adaptation during DRX ActiveTime LG ElectronicsR1-2008267 Discussion on DCI-based power saving adaptation OPPOR1-2008289 Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime PanasonicR1-2008476 Enhanced DCI-based power saving adapation AppleR1-2008691 PDCCH-based power saving signal design considerations InterDigital, Inc.R1-2008711 DCI-based Power Saving Enhancements Fraunhofer HHI, Fraunhofer IISR1-2008714 Power saving adaptation during Active Time ASUSTeKR1-2008935 UE power saving enhancements for Active Time Nokia, Nokia Shanghai BellR1-2008966 Discussion on DCI-based power saving adaptation during DRX active time MediaTek Inc.R1-2008994 On PDCCH monitoring reduction techniques during active time Intel CorporationR1-2009056 Discussion on extension(s) to Rel-16 DCI-based power saving adaptation Asia Pacific Telecom co. LtdR1-2009107 Enhanced DCI based power saving adaptation Lenovo, Motorola MobilityR1-2009150 Discussion on power saving techniques for connected-mode UE Spreadtrum R1-2009189 Discussion on extension to DCI-based power saving adaptation NTT DOCOMO, INC.R1-2009203 Discussion on potential enhancements for power savings during active time EricssonR1-2009268 DCI-based power saving adaptation during DRX ActiveTime Qualcomm IncorporatedR1-2009299 On power saving adaptation during the DRX active time Sony* **Others**

R1-2007675 Discussion on paging grouping vivoR1-2007869 Link level performance of IDLE UE for UE power saving CATTR1-2007973 Additional simulation results of UE power consumption in RRC idle and inactive state ZTER1-2008335 Analysis on power consumption for IDLE mode UE Huawei, HiSiliconR1-2009202 High-level UE energy consumption profiling EricssonR1-2009300 On network power consumption model Nokia, Nokia Shanghai BellR1-2007677 Discussion on RAN2 and RAN4 related power saving relaxation vivoR1-2007871 Feature interaction between Secondary DRX group and DCP/SCell dormancy CATTR1-2007975 Further discussion on potential power saving schemes for RRC connected UEs ZTER1-2008268 Discussion on RLM relaxation OPPOR1-2008330 Other considerations on power saving in Rel-17 Huawei, HiSiliconR1-2008477 Power saving evaluation for RLM/BFD relaxation AppleR1-2009204 Evaluation of additional UE power saving schemes Ericsson |
| **RAN1 #102-e Meeting*** **Potential paging enhancements:**

R1-2005388 Discussion on paging enhancements for idle/inactive mode UE power saving vivoR1-2005615 Evaluation methodology and paging enhancement for idle/inactive mode UE power saving MediaTek Inc.R1-2005262 Paging enhancement(s) for UE power saving in IDLE/inactive mode Huawei, HiSiliconR1-2005520 Discussion on power saving enhancements for paging ZTER1-2005582 Considerations on paging enhancements SonyR1-2005719 Paging enhancement for UE power saving CATTR1-2005738 Paging enhancement for power saving Beijing Xiaomi Software TechR1-2005773 Potential paging enhancements TCL Communication Ltd.R1-2005884 On paging enhancements for UE power saving Intel CorporationR1-2005935 Power efficient paging Lenovo, Motorola MobilityR1-2006041 Paging enhancements for power saving OPPOR1-2006157 On potential paging enhancements SamsungR1-2006221 Discussion on paging enhancement CMCCR1-2006291 Discussion on potential paging enhancements Spreadtrum CommunicationsR1-2006311 Discussion on potential paging enhancements LG ElectronicsR1-2006385 Potential paging enhancements for idle/inactive-mode UE power saving PanasonicR1-2006527 Potential paging enhancements for idle/inactive-mode UE power saving AppleR1-2006544 Paging enhancements for UE power saving InterDigital, Inc.R1-2006665 Discussion on potential paging enhancements for UE power savings EricssonR1-2006736 Discussion on paging enhancements NTT DOCOMO, INC.R1-2006815 Paging enhancements and evaluation methodology Qualcomm IncorporatedR1-2006896 On paging enhancements for UE power saving Nokia, Nokia Shanghai Bell* **TRS/CSI-RS occasion(s) for idle/inactive UEs**

R1-2006158 On TRS/CSI-RS occasion(s) for idle/inactive UEs SamsungR1-2006386 Potential enhancements for TRS/CSI-RS occasion(s) for idle/inactive UEs PanasonicR1-2005263 Assistance RS occasions for IDLE/inactive mode Huawei, HiSiliconR1-2005389 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs vivoR1-2005521 Reference signal for RRC idle and inactive UEs ZTER1-2005583 On the usage of TRS/CSI-RS for the UE in Idle Mode SonyR1-2005616 On TRS/CSI-RS occasion(s) for idle/inactive mode UE power saving MediaTek Inc.R1-2005720 Configuration of TRS/CSI-RS for paging enhancement CATTR1-2005739 Discussion on TRS CSI-RS occasions for idle/inactive UEs Beijing Xiaomi Software TechR1-2005885 Discussion on TRS/CSI-RS reception during idle/inactive mode Intel CorporationR1-2006042 RS occasion for idle/inactive UEs OPPOR1-2006222 Discussion on potential TRS CSI-RS occasion(s) for idle/inactive UEs CMCCR1-2006269 Consideration on TRS/CSI-RS occasion(s) for idle/inactive UEs Spreadtrum CommunicationsR1-2006312 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs LG ElectronicsR1-2006528 Indication of TRS/CSI-RS for idle/inactive-mode UE power saving AppleR1-2006666 Provisioning of potential TRS/CSI-RS occasion(s) for Idle/Inactive UEs EricssonR1-2006737 Discussion on TRS/CSI-RS occasion for idle/inactive UEs NTT DOCOMO, INC.R1-2006816 TRS/CSI-RS for idle/inactive UE power saving Qualcomm IncorporatedR1-2006897 On RS information to IDLE/Inactive mode UEs Nokia, Nokia Shanghai Bell* **Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time**

R1-2006738 Discussion on extension to DCI-based power saving adaptation NTT DOCOMO, INC.R1-2005264 Extension(s) to Rel-16 DCI-based power saving adaptation for an active BWP Huawei,  HiSiliconR1-2005391 Discussion on DCI-based power saving adaptation vivoR1-2005523 Extension to Rel-16 DCI-based power saving adaptation during DRX Active Time ZTER1-2005617 Evaluation methodology and enhancement for connected mode UE power saving MediaTek R1-2005721 PDCCH monitoring adaptation CATTR1-2005886 On PDCCH monitoring reduction techniques during active time Intel CorporationR1-2005936 Potential enhancement to DCI based power saving adaptation Lenovo, Motorola MobilityR1-2006043 DCI-based adaptation for PDCCH OPPOR1-2006159 On enhancements of power saving techniques during DRX active time SamsungR1-2006223 Discussion on PDCCH monitoring reduction during DRX active time CMCCR1-2006271 Discussion on power saving techniques for connected-mode UE Spreadtrum CommunicationsR1-2006313 Discussion on DCI-based power saving adaptation during DRX Active Time LG ElectronicsR1-2006387 Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time PanasonicR1-2006529 PDCCH based power saving enhancements for connected-mode UEs AppleR1-2006548 PDCCH-based power saving signal design considerations InterDigital, Inc.R1-2006668 Discussion on potential enhancements for power savings during active time EricssonR1-2006755 Power saving adaptation during Active Time ASUSTEK COMPUTER (SHANGHAI)R1-2006817 DCI-based power saving adaptation during DRX Active Time Qualcomm IncorporatedR1-2006898 UE power saving enhancements for Active Time Nokia, Nokia Shanghai BellR1-2006946 Power saving enhancements for connected mode UEs Sony* **Others**

R1-2005392 Discussion on RLM/BFD relaxation vivoR1-2005524 Further discussion on potential power saving schemes for RRC connected UEs ZTER1-2006044 Discussion on RLM Relaxation OPPOR1-2006404 Other considerations on power saving in Rel-17 Huawei, HiSiliconR1-2006669 Evaluation of UE power saving schemes Ericsson |
| **RAN2 Contributions** |
| **RAN2 #113-e Meeting****Organizational, Scope and Requirements:**R2-2100029 LS on Paging Enhancement (R1-2009801; contact: MediaTek) RAN1 LS in Rel-17 NR\_UE\_pow\_sav\_enh-Core To:RAN2R2-2100030 LS on signalling method for TRS/CSI-RS occasion(s) for idle/inactive UE(s) (R1-2009848; contact: Samsung) RAN1 LS in Rel-17 NR\_UE\_pow\_sav\_enh-Core To:RAN2**Idle/inactive-mode UE power saving:**R2-2100389 Report of [POST112-e][064][Pow17] Group Determination (Intel) Intel CorporationR2-2101301 Network assigned subgrouping Intel CorporationR2-2100143 Paging Enhancements\_UE Grouping Samsung Electronics Co., LtdR2-2100144 Paging Enhancements\_DRX cycle for monitoring paging Samsung Electronics Co., LtdR2-2100153 Discussion on paging enhancement for power saving OPPO discussionR2-2100298 Considerations on UE grouping mechanism with Paging Enhancement CATTR2-2100313 Power saving enhancements for paging reception Qualcomm IncorporatedR2-2100390 Discussion on paging enhancement Xiaomi CommunicationsR2-2100457 Paging enhancement in idle inactive mode for power saving vivoR2-2100682 Paging Enhancements for UE Power Savings Convida WirelessR2-2100852 NR UE Power Save Paging IDLE/INACTIVE UE Grouping Schemes AppleR2-2100911 Discussion on enhancements for idle/inactive-mode UE power saving SonyR2-2100993 UE subgrouping for paging enhancement LG Electronics Inc.R2-2100994 draft LS on Paging Enhancement for UE power saving LG Electronics Inc.R2-2101115 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola MobilityR2-2101148 Detail on paging sub-grouping indication and determination Nokia, Nokia Shanghai BellR2-2101274 Paging enhancements for idle/inactive mode UE Huawei, HiSiliconR2-2101539 UE-Group Paging Early Indication MediaTek Inc.R2-2101738 Paging enhancements EricssonR2-2101841 Paging Enhancements for Power Saving Asia Pacific Telecom, FGIR2-2101887 Considerations on UE paging enhancement CMCCR2-2101895 Further discussion on UE grouping ZTE corporation, Sanechips * Other aspects RAN2 impacts

R2-2100458 RAN2 impacts on TRS/CSI-RS in idle inactive mode vivoR2-2100816 TRS/CSI-RS for idle and inactive mode UE SHARP CorporationR2-2100912 Discussion on TRS/CSI-RS configuration of idle/inactive-mode UEs SonyR2-2101275 On potential TRS/CSI-RS for idle/inactive mode UE Huawei, HiSiliconR2-2101310 Potential TRS/CSI-RS occasion(s) Nokia, Nokia Shanghai Bell R2-2101739 TRS/CSI-RS exposure EricssonR2-2101888 Considerations on TRS CSI-RS occasion(s) for idle inactive UE(s) CMCCR2-2100853 NR UE Power Save TRS/CSI-RS Signaling for IDLE/INACTIVE UEs AppleR2-2100154 Discussion on signaling aspects of TRS/CSI-RS occasion(s) for idle/inactive Ues OPPOR2-2100299 Considerations on configuration of TRS/CSI-RS CATTR2-2100345 Discussion on TRS CSI-RS for RRC-IDLE and RRC-INACTIVE State UE Xiaomi CommunicationsR2-2101302 TRS/CSI-RS configuration and availability for idle/inactive-mode UE Intel Corporation   |
| **RAN2 #112-e Meeting****Organizational, Scope and Requirements:**R2-2008716 LS on evaluation methodology for connected mode UE power saving enhancements (R1-2007419; contact: vivo, MediaTek) RAN1 LS in Rel-17 NR\_UE\_pow\_sav\_enh To:RAN2 Cc:RAN4.R2-2008719 LS on evaluation methodology for UE power saving enhancements (R1-2007425; contact: MediaTek) RAN1 LS in Rel-17 NR\_UE\_pow\_sav\_enh-Core To:RAN2 Cc:RAN4**Idle/inactive-mode UE power saving:*** + General

R2-2009784 Report of [Post111-e][907][ePowSav] UE grouping (Mediatek) MediaTek Inc.R2-2008952 Discussion on paging enhancement Xiaomi Communications discussionR2-2009785 Paging Enhancements for UE Power Saving in NR MediaTek Inc.R2-2010244 Paging enhancements for idle/inactive-mode UE Huawei, HiSilicon, British TelecomR2-2009955 Paging enhancement to reduce unnecessary UE paging receptions EricssonR2-2010079 Paging Enhancements for UE Power Savings Convida WirelessR2-2009878 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola Mobility* + Group determination

R2-2009274 Paging enhancement using UE subgrouping Intel CorporationR2-2009092 Paging Enhancements to Reduce False Alarms Samsung Electronics Co., LtdR2-2010397 UE Power profile based UE subgrouping CMCC R2-2010629 Further consideration on the UE grouping methods ZTE corporation, Sanechips* + **Paging / Group indication**

R2-2008892 Power saving enhancements for paging reception Qualcomm IncorporatedR2-2009083 Paging enhancement in idle inactive mode for power saving vivoR2-2009442 Paging enhancement for power saving LG Electronics Inc.R2-2009351 General requirements for potential paging enhancement Nokia, Nokia Shanghai BellR2-2009503 NR UE Power Save Wakeup and Paging Reception Apple R2-2009893 Discussion on reduction of unnecessary UE paging receptions SonyR2-2009642 Discussion on the UE grouping method ITRIR2-2009464 Discussion on UE group based paging OPPO discussion* + Other

R2-2009502 NR UE Power Save False Paging Mitigation AppleR2-2009504 NR UE Power Save UE Paging Grouping Apple* + **TRS CSI-RS for Idle Inactive**

R2-2010245 On potential TRS/CSI-RS for idle/inactive-mode UE Huawei, HiSiliconR2-2009956 Exposure of connected mode TRS occasions to Idle and Inactive mode EricssonR2-2008946 Discussion on TRS CSI-RS for RRC-IDLE and RRC-INACTIVE State UE Xiaomi R2-2009918 Potential TRS/CSI-RS occasion(s) Nokia, Nokia Shanghai Bell R2-2009465 Potential RAN2 impacts for TRS/CSI-RS configuration OPPO   |
| **RAN2 #111-e Meeting****Organizational, Scope and Requirements:**R2-2007189 RAN2 Work Plan for UE Power Saving Enhancements WI MediaTek Inc.R2-2007440 Discussion on RAN2 scope for UE Power Saving Huawei, HiSilicon R2-2006730 Views on Rel-17 NR UE power saving Xiaomi Communications R2-2006789 Discussion on use cases of UE power saving enhancements OPPO R2-2007326 Discussion on RAN2 scope in Power saving LG Electronics.R2-2007436 Initial consideration on RAN2’s work on UE power saving CMCC**Idle/inactive-mode UE power saving:*** + General

R2-2007190 Paging Enhancements for UE Power Saving in NR MediaTek Inc.R2-2006775 Power Consumption by RRC IDLE\_INACTIVE UE Samsung Electronics Co., LtdR2-2006790 Paging enhancement for power saving OPPO R2-2006608 Power saving enhancements for paging reception Qualcomm IncR2-2006729 Discussion on UE Power saving for RRC-IDLE and RRC-INACTIVE State Xiaomi  CommunicationsR2-2007182 Discussion on reduction unnecessary UE paging receptions SonyR2-2007115 False Paging Mitigation AppleR2-2006690 Paging enhancement in idle inactive mode for power saving vivoR2-2006654 UE power saving for paging procedures ETRIR2-2006689 Coordination between RAN1 and RAN2 for paging enhancement vivoR2-2006720 Paging enhancements to reduce UE power consumption Intel CorporationR2-2006774 Paging Enhancements to Reduce Unnecessary Paging receptions Samsung  Electronics Co., LtdR2-2006874 Solutions to reduce unnecessary paging reception ZTE corporation, Sanechips R2-2006990 Considerations on paging enhancements for Power saving CATTR2-2007116 Wakeup and Paging Reception AppleR2-2007249 Discussion on the UE grouping based solution for idle/inactive-mode UE power saving ITRIR2-2007260 Paging enhancement to reduce unnecessary UE paging receptions EricssonR2-2007437 Paging enhancement for idle inactive-mode UE power saving CMCCR2-2007441 Discussion on paging enhancements Huawei, HiSiliconR2-2007468 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola MobilityR2-2007563 IDLE / INACTIVE mode UE power saving Nokia, Nokia Shanghai Bell R2-2007990 Paging enhancement for power saving LG Electronics Inc.* + TRS / CSI-RS

R2-2007261 Exposure of connected mode TRS occasions to Idle and Inactive mode EricssonR2-2007562 Potential TRS/CSI-RS occasion(s) Nokia, Nokia Shanghai Bell  |
| **RAN4 Contributions** |
| **RAN4 #98-e Meeting**R4-2103719 Email discussion summary: [98e][238] NR\_UE\_pow\_sav\_enh\_RRM Moderator (MediaTek)* **General and work plan [NR\_UE\_pow\_sav\_enh]:**

R4-2103669 Work plan of Rel-17 Power Saving Enhancements MediaTek inc.* **UE measurements relaxation for RLM and/or BFD [NR\_UE\_pow\_sav\_enh-Core]**

R4-2100043 On RLM and RLF relaxation for UE power saving ZTE CorporationR4-2100219 UE measurements relaxation for RLM and/or BFD AppleR4-2100474 Discussion on RLM/BFD relaxation factor CATTR4-2100478 Initial performance evaluation for for RLM/BFD relaxation factor CATTR4-2100725 Discussion on relaxation of RLM/BFD measurements XiaomiR4-2100821 Discussion on RLM/BFD relaxation for NR power saving enhancement CMCCR4-2101139 Discussion and simulation results for RLM/BFD measurement relaxation NokiaR4-2101222 Evaluation on Rel-17 RLM/BFD measurement relaxation MediaTek inc.R4-2101462 Discussion on R17 RLM/BFD relaxation vivoR4-2101463 Simulation results for R17 RLM/BFD relaxation vivoR4-2101542 Discussion on UE measurement relaxation for RLM and/or BFD OPPOR4-2101685 Discussion on feasibility of RLM/BFD measurement relaxation scheme for power saving enhancements Huawei, HiSiliconR4-2102239 Updated simulation assumptions for evaluating UE power saving for RLM and BM EricssonR4-2102240 Simulation results on UE power saving for RLM and BM EricssonR4-2102241 Discussions on UE power saving for RLM and BM EricssonR4-2102587 Discussion on RLM/BFD Relaxation Qualcomm IncorporatedR4-2103670 WF on R17 UE power saving RLM/BM relaxation MediaTekR4-2104066 Updated evaluation assumptions for R17 RLM/BFD relaxation vivo, MediaTek |
| **RAN4 #97-e Meeting*** **General and work plan [NR\_UE\_pow\_sav\_enh]:**

R4-2014366 Work plan of Rel-17 Power Saving Enhancements MediaTek inc.R4-2014367 Evaluation on Rel-17 RLM/BFD measurement relaxation MediaTek inc.R4-2014534 Evaluation assumptions for R17 RLM/BFD relaxation vivo, MediaTekR4-2014219 Discussion on feasibility and performance impact of RLM/BFD relaxation AppleR4-2014428 Discussion on RLM relaxition for NR power saving CATTR4-2014535 Discussion and initial results for R17 RLM/BFD relaxation vivoR4-2014654 Discussion on RRM measurement relaxation in connected mode for NR power saving enhancement XiaomiR4-2014797 Discussion on RLM BFD measurement relaxation OPPOR4-2015199 Discussion about evaluation methodology for relaxation of RLM/BFD measurements Nokia Solutions & NetworksR4-2015485 Preliminary discussion on RLM/BFD relaxation in power saving enhancements Huawei, HiSiliconR4-2016150 Discussions on UE power saving for RLM and BM Ericsson |