3GPP TSG-RAN WG2 #111e Tdoc draftR2-2008199

Electronic meeting, August 17th – 28th 2020

Agenda Item: 8.12.1

Source: Rapporteur (Ericsson)

Title: Summary of [AT111][108][REDCAP] Scope and skeleton update

Document for: Discussion, Decision

# 1 Introduction

This document summarizes the following discussion during RAN2#111-e:

* [AT111e][108][REDCAP] Scope and skeleton update (Ericsson)

Scope: Discuss the SI scope in [R2-2006910](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_111-e/Docs//R2-2006910.zip) and the skeleton update in [R2-2007366](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_111-e/Docs//R2-2007366.zip)

Initial intended outcome: summary of the offline discussion with e.g.:

* + - List of agreeable proposals (if any)
    - List of proposals that require online discussions

and skeleton update

Initial deadline (for companies' feedback): Monday 2020-08-24 16:00 UTC

Initial deadline (for rapporteur's summary in R2-2008189): Monday 2020-08-24 18:00 UTC

The discussion in based on [R2-2006910](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_111-e/Docs//R2-2006910.zip) [2] and there are questions related to the TR skeleton [3] as well.

As background for the discussion on the study item scope, the SID includes the following objectives [1]:

*The study item includes the following objectives:*

*Identify and study potential UE complexity reduction features, including [RAN1, RAN2]:*

* *Reduced number of UE RX/TX antennas*
* *UE Bandwidth reduction*

*Note: Rel-15 SSB bandwidth should be reused and L1 changes minimized*

* *Half-Duplex-FDD*
* *Relaxed UE processing time*
* *Relaxed UE processing capability*

*The study includes evaluations of the impact to coverage, network capacity and spectral efficiency*

*Note1: The work defined above should not overlap with LPWA use cases. The lowest data rate and bandwidth capability considered should be no less than an LTE Category 1bis modem.*

*Study UE power saving and battery lifetime enhancement for reduced capability UEs in applicable use cases (e.g. delay tolerant) [RAN2, RAN1]:*

* *Reduced PDCCH monitoring by smaller numbers of blind decodes and CCE limits [RAN1].*
* *Extended DRX for RRC Inactive and/or Idle [RAN2]*
* *RRM relaxation for stationary devices [RAN2]*

*Study functionality that will enable the performance degradation of such complexity reduction to be mitigated or limited, including [RAN1]:*

* *Coverage recovery to compensate for potential coverage reduction due to the device complexity reduction.* 
  + *Note: For FR1, coverage analysis for wearables can include consideration of potential reduced antenna efficiency due to device size limitations as part of the antenna gains. The extent of additional recovery of coverage loss due to reduced antenna efficiency is to be limited to 3 dB*
* *The study includes evaluations of the impact to network capacity and spectral efficiency*

*Study standardization framework and principles for how to define and constrain such reduced capabilities – considering definition of a limited set of one or more device types and considering how to ensure those device types are only used for the intended use cases [RAN2, RAN1].*

*Study functionality that will allow devices with reduced capabilities to be explicitly identifiable to networks and network operators, and allow operators to restrict their access, if desired [RAN2, RAN1].*

*Note2: Potential overlap with coverage enhancements study is discussed and resolved in RAN#87 or later.*

*Note3: Coexistence with Rel-15 and Rel-16 UE should be ensured*

*Note4: This SI should focus on SA mode and single connectivity*

Companies are asked to provide input on the described scope in questions below. Please indicate especially if some objective is not clear, or if there are some aspects missing from the proposed scope of discussion.

# 2 Discussion

## 2.1 UE complexity reduction features

As discussed in [1] and in other submitted contributions, RAN1 has the main responsibility of defining the features which describe a RedCap UE, where a number of agreements have been made already.

For RAN2, it mainly remains to be discussed which particular aspects of RAN2 protocols and procedures are impacted and whether changes are needed. Companies are welcome to provide their initial views on what RAN2 should further consider or discuss related to the UE complexity reduction features.

The RAN1 agreements before RAN2#111-e are listed in the Appendix for reference. It should be noted the final feature list is not yet completed and the evaluation from RAN2 side is subject to change.

**Question 1 (Expected RAN2 impact): What are expected impacts in RAN2 protocols and procedures due to introduction of RedCap UEs in NR/5GS? What other aspects, not already covered by the objectives in the SID [3], RAN2 should consider in their work?**

*Note: The discussion can be based on already agreed features in RAN1 and based on expectations on possible not yet agreed RedCap features.*

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| --- | --- |
| **Company** | **View** |
| Qualcomm | * Study the impact of reduced coverage on cell re-/selection and RACH procedures * Discuss whether Redcap should have reduced maximum number of DRBs, HARQ processes (DL/UL), active CG/SPS, and Scells to help lower complexity/cost. Or what the minimum number of those configurations that RedCap should support. * Discuss whether RRC processing delay requirement may be relaxed, due to RedCap UE’s lower processing capability * Discuss whether any simplification to user plane protocols may be made for RedCap UE’s, due to their reduced capabilities and/or lower performance requirements |
| OPPO | Discuss whether to balance the load for RedCap UEs and normal UEs, if they are served in the same cell. |
| Xiaomi | We agree with the rapporteur that RAN1 defines what describes a RedCap UE and RAN2 should study if those complexity reduction features, such as bandwidth reduction will have impact on RAN2 procedures.  To ensure the Redcap UEs coexistence with Rel-15 and Rel-16 UE, the potential specification impacts can be considered from the control plane and user plane respectively.  For the control plane, except form UE capability and access restrictions, we would like to study the RAN1 impacts of control channel messages (SIB, RAR and paging) as well as cell re-/selection. Regarding to the impact to user plane, we would like to study the data transmission and possible DRX enhancement for specific IoT scenarios. More details can be found in our submitted contribution. |
| Ericsson | Relaxed processing time (RAN2), half-duplex FDD and reduced number of HARQ processes (brought up in RAN1) are features where we think gains may not warrant the additional complexity. Relaxed processing time should in our preference have no impact in RAN2. At minimum RAN2 should understand the impact of these features in RAN2 specifications and further provide input to TR/RAN1 on the potential impact. |
| Futurewei | Signaling and procedure related to initial access and cell (re)selection, such as system information acquisition, random access, access control, RRM measurements, etc. |
| Convida Wireless | Study the impacts of complexity reduction on cell (re-)selection, SI acquisition, Paging and RACH procedures. |
| Apple | In general, we agree with the comments from companies above. In addition, we would like to bring up the validity of the scenario where the NW (gNB) only caters to RedCap UEs. We do NOT see the practicality of this, but want RAN2 to make a decision on whether this needs to be supported (i.e., bar legacy UEs and allow only RedCap UEs). |
| Sequans | In general, we agree with the comments from companies above and would like to second QC’s point on maximum number of DRBs, HARQ processes, active CG/SPS and Scells. In addition, RAN2 should consider the case where regular UEs act as REDCAP UEs, e.g. for power saving puporses, which may affect other REDCAP UEs performance specifically and NW performance in general. |
| NEC | A potential impact due to smaller bandwidth support by RedCap UE will be on cell camping and access procedure. Especially depending on whether SIB1 (CORESET#0) reception and initial BWP validation can be same as legacy or not, the impact may become bigger. This anyway needs RAN1 conclusion though. |
| Huawei, HiSilicon | Considering the reduced bandwidth of REDCAP UEs, we need to discuss the following impacts if REDCAP UEs and normal UEs are served by the same cell, e.g.   * For initial access: common/separate DL/UL initial BWP, common/separate SIB1, OSI transmission, paging transmission, etc. * For RRM measurement, whether the active BWP of all REDCAP UEs should be configured to cover CD-SSB. |
| Samsung | Agree with QC |
| CATT | - Agree with previuos comments regarding potential impact to bandwidth reduction on initial acces  s.  - Also we are not sure about the gain from RRC processing time reduction.  - Furthermore, we’s suggest any UP enhancements (e.g., HARQ, etc) should first be justified by its potentail gain. |
| Intel | Potential impact could be paging, initial access, system information due to reduced bandwidth. Relaxed UE processing time may also impact the initial access.  Further analysis is needed on other aspects.  But we have to wait for RAN1 to see what they really agreed before we dig into the details. |
| vivo | 1. Discuss reduced capability from RAN2 point of view, e.g. RRC processing delay, number of DRBs, HARQ processes, etc. 2. Discuss any impact of reduced capability agreed in RAN1, e.g. the initial access procedure/cell (re-)selection due to introduction of new configuration of initial BWP or CORESET#0 3. Study the signaling and procedure to support the reduced capability defined in RAN1. |
| LG | - There may be an impact on processing delay requirements for RRC procedures due to relaxed UE processing time and initial access based on RAN1 agreement.  - Idle mobility, System information acquisitio  n, paging, and AS-NAS interface may need to be discussed. |
| Lenovo | Depending on RAN1 progress, RedCap UE could be further analyzed in the field of cell reselection/reselection and initial access. |
| Nokia | * Bandwidth reduction may impact initial access e.g. in cases where the UE does not support the bandwidth of legacy CORESET#0 or initial UL/DL BWPs. * UE capabilities * Some features may be inherited e.g. from UE power saving and small data work items |
| MediaTek | RAN2 should discuss the impact of RAN1 agreements on BW reduction and reduced number of antennas on Idle mode procedures.  The impact to legacy behaviour should be minimised, as RedCap is still an NR device. For the same reasons, we would prefer not to reduce processing time/capability, nor do we see a strong need to modify user-plane procedures/requirements. |
| **Spreadtrum** | RAN2 can study some general RAN2 impacts for supporting a new type UE as the case supporting eMTC in LTE. For example, networking supporting indication broacasting for cell selectino/reselection, new UE type identification as early as possible, UAC enhancement, taking the NR-specific features into count, e.g. beam and BWP. |
| ZTE | There are some RAN2 impact due to physical layer capability reduction, mainly in initial access and idle mode procedures. Potential impact include DL/UL repetition for coverage recovery, separate system information, separate initial BWP or RACH resources.  Optimization in cell re-selection to avoid unnecessary idle mode measurement on the frequency which can not support REDCAP. |
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Summary:

20 replies (21 companies) have been provided on Q1. As the question is open-ended, many different aspects were pointed out. The purpose of the question was to find out which topics companies think RAN2 should consider which were not explicitly mentioned in the SID. Therefore, the proposal is to prioritize further study/focus on 3-4 most often mentioned aspects. These prioritized topics should not limit discussion on possible other topics, but for the limited study item phase RAN2 should prioritize some discussions.

1. Discussion on the following expected impacts on RAN2 procedures are prioritized:
   1. Impact on cell (re)selection
   2. Impact on initial access
   3. Impact on idle mode procedures (i.e. SI acquisition, paging)

**Question 2 (RAN2 input on features): Do you think there is need for RAN2 to provide other input to RAN1 regarding the UE complexity reduction features. If yes, please elaborate on what input you think is needed.**

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| **Company** | **Yes / no** | **Comments** |
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**Summary:**

No input to Q2.

## 2.2 UE power saving and battery lifetime enhancement

Two RAN2-specific objectives related to UE power saving are mentioned in the SID [3]: 1) Extended DRX for RRC Inactive and/or Idle, and 2) RRM relaxation for stationary devices.

Discussion paper [1] contains proposal for RAN2 to provide solutions and analysis to TR 38.875 on extended DRX for RRC Inactive and Idle modes and RRM relaxation for stationary RedCap devices. This is inline with the SI scope and companies are asked to confirm the understanding of this scope and provide additional comments, if any:

**Question 3 (Power saving scope): Do you agree that for UE power saving and battery lifetime enhancement, RAN2 should focus only on studying extended DRX for RRC Inactive and Idle modes and RRM relaxation for stationary RedCap devices, and provide input on these objectives to TR 38.875?**

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| --- | --- | --- |
| **Company** | **Yes / no** | **Comments** |
| Qualcomm | No | We think other power saving enhancements not mentioned in the SID (for example, C-DRX enhancements for target RedCap use cases) can be studied too during the SI phase, as long as their power saving benefits can be justified. |
| OPPO | Yes |  |
| Xiaomi | No | We also think other power saving enhancements can be taken for Redcap devices. At least we can take some from in R16/R17 UE power saving.  For instance, the current scope mentioned E-DRX for RRC Inactive and/or Idle, however we think it is equally important to reduce the power consumption for Redcap UE during RRC\_CONNECTED mode. So some skemes can be taken from R16 UE power saving which was mainly focused on RRC-Connected mode.  And we can also pick up some schemes form R17 UE power saving once they have got some progress. |
| Ericsson | Yes | We think introduction of eDRX should be prioritized.  Any other power saving enhancements can already apply to RedCap Ues as well, assuming they do not depend on capabilities which RedCap UE would not have.  Regarding other possible enhancements, such should only be studied (or further, standardized) if clear benefits vs. complexity can be shown. RAN2 is unfortunately short on time just to complete the existing objectives already so we think we should stick to the existing scope. |
| Futurewei | Yes | Given the available time, it is already very challenging to complete this study.  This study also has close relation with other R17 SI/Wis, such as power saving. Hence, extending its scope without approval from RAN is not recommended. |
| Convida Wireless | Yes | Our view is the scope should be limited to what is included in the SID. |
| Apple | No | C-DRX should also be considered for power-saving. The RedCap Ues should also benifit from power-saving in connected mode. |
| Sequans | No | While the objectives in the SID should be prioritized, other objectives should be at least considered to see if they are justified. Agree with above views that C-DRX seem like a prime example. It may also depend on the decision for the next question. |
| NEC | Yes |  |
| Huawei, HiSilicon | Yes | Similar viwe as Ericsson and Futurewei. |
| Samsung | Yes | It should be discussed in the plenary first. We indeed have sympathy to study power saving enhancements in RRC\_CONNECTED (as it is equally important), but are not sure it can be done from the SID. |
| CATT | Yes | We also think first priority is on eDRX. This should use LTE as baseline to save R2’s effort.  For the rest of the possible enhancement there is a concern on limited and potenital effort time in SI and WI phase. |
| Intel | Yes | Let’s stick to the SI scope, focus on   * *Extended DRX for RRC Inactive and/or Idle [RAN2]* * *RRM relaxation for stationary devices [RAN2]* |
| vivo | Yes, but | We agree RAN2 should focus firstly on studying extended DRX for RRC Inactive and Idle modes **AND** RRM relaxation for stationary RedCap devices.  But we don’t think eDRX should be prioritized. In our understanding, both eDRX and RRM relaxation should be treated equally, as they have been already involved clearly in the SI scope.  Besides, we can also study other power saving mechanism if time allows.  In summary, we should prioritize eDRX and RRM relaxation in SI. But other enhancement for power saving can be also discussed if time allows. |
| LG | Yes | We would like to focus on objectives in the SID. |
| Lenovo | Yes | Considering the limited time, it is not necessary to extend the scope to other technique. |
| Nokia | No | We think any power saving enhancement can be studied during the SI phase. |
| MediaTek | Yes | We agree with Ericsson that E-DRX should be prioritised.  We should also assume that all Rel-16 PS enhancements that have been defined, as well as all Rel-17 PS enhancements that will be defined, are available for RedCap UEs. We do not have sufficient TUs to extend the scope of RedCap discussions. |
| Spreadtrum | Yes | The SI scope has been confirmed during the SI approal procedure. |
| ZTE | Yes | Due to limited time budget, RAN2 should focus on eDRX and RRM relaxation. Other power saving mechanism which will be discussed in power saving WI can be reused if applicable. |
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**Summary:**

20 replies have been provided, where 16 companies reply 'yes' and 5 companies 'no'. Of the 5 companies, 4 companies explicitly mention connected mode DRX enhancements as potential additional topic. In multiple answers Rel-16 and Rel-17 power saving work is also mentioned – it can also be noted that no explicit restrictions for such features have been agreed or identified so far.

The limited time for the SI was also mentioned, and in order to finalize the objectives explicitly mentioned in the SI scope, proposal is to focus on the mentioned eDRX and RRM relaxation topics during the SI phase. C-DRX and other topics can be considered as 2nd priority or discussion left for the normative phase.

1. For power saving, study on extended DRX for idle and inactive modes and RRM relaxation for stationary RedCap devices is prioritized, and input to be provided to TR 38.875. Further topics can be discussed as 2nd priority or potentially left for WI phase.

The SID only mentions "RRM relaxation for stationary devices", and it is not explicitly stated whether such relaxation should apply to neighboring cells and/or the serving cell. Also, it is not explicitly stated whether relaxation should apply in RRC\_IDLE and/or RRC\_INACTIVE and/or RRC\_CONNECTED. Companies are asked to provide preliminary input on what they think should be the scope of the RRM relaxation objective.

**Question 4 (RRM relaxation scope): Which cells and RRC states RAN2 should focus on when studying RRM relaxation for stationary RedCap devices?**

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| --- | --- | --- | --- |
| **Company** | **Neighboring/serving cell** | **RRC state(s)** | **Comments** |
| Qualcomm | Both | all | We may prioritize RRM relaxation in RRC Idle/Inactive over RRC Connected, but in the SI phase we do not have to eliminate a particular RRC state without discussion. |
| OPPO | Both | all | In the study phase, we don’t have to limit the scope, i.e. we can study all these combinations. However, we have the opinion of down-prioritizing serving cell RRM relax in the WI phase. |
| Xiaomi | Both | all | We are open to study all those cases. |
| Ericsson | Both | all | Preference to study both cell types for RRC\_IDLE and RRC\_INACTIVE, whereas for RRC\_CONNECTED only neighboring cell measurements to avoid impacts on NW performance. |
| Futurewei | Both | all | Both serving cell and neighboring cell can be considered for RRM relaxation in RRC\_IDLE/INACTIVE and RRC\_CONNECTED states, given the vastly diverse use cases of Redcap UE. |
| Convida Wireless | Both | all | RRM relaxation in RRC\_CONNECTED can be studied with a lower priority. |
| Apple | Both | All states |  |
| Sequans | Both | All | Agree with above. It may also be worth to weigh, for example, RRM relaxation in Connected vs. C-DRX (see previous question). |
| NEC | Both | all | Regarding RRC states, probably no need to limit a scope. However, given considering stationary devices here (Q4), relaxation on neighbour cell measurement in Connected seems important. For Idle/Inactive, we assume eDRX is more important rather than RRM relaxation which is anyway ralaxed compared to Connected. |
| Huawei, HiSiIicon | Both | All | We think reusing neighboring cell RRM relaxation mechanism supported in Rel-16 for REDCAP UEs is higher priority.  We are open to study other cases. |
| Samsung | Both | all | - |
| CATT | Both | all |  |
| Intel | Both | All | All RRC states and both neighboring/serving should be studied. |
| vivo | Both | All | In SI phase, there is no motivation to exclude any potential RRM relaxation direction (e.g. neighboring/serving), or RRM relaxation in different RRC states. |
| LG | Both | all | We think it is not good way to remove any scope at the beginning of SI discussion. It seems companies have different understanding on relaxation in connected mode, so after initial discussion, we can down-prioritize some issues. |
| Lenovo | Both | All | In SI, We are open to all the cases.The RRM relaxation for UE in inacitve/Idle and for UE in connected mode both should be research, since the UE is stationary and no significant mobility issue will be introdcued |
| Nokia | Both | All |  |
| MediaTek | Neighbour | Connected | RAN4 will study serving cell relaxation in connected mode as part of Rel-17 power savings WI. There is no need to duplicate this work in RedCap – we can follow RAN4’s recommendations on the topic.  In Idle mode, there are limited power saving opportunities with serving cell measurements as the UE has to monitor the serving cell for paging. As part of paging reception, the UE will monitor the SSB of the serving cell, and therefore serving cell measurements come for free.  As we have already defined Idle mode neighbour cell meas relaxation in Rel-16, what remains is Connected mode neighbour cell meas relaxation, which can be the focus of RedCap. |
| Spreadtrum | Both | all | All theses cases are valuable. |
| ZTE | Both | all |  |
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Summary:

20 replies have been provided for Q4, where one company proposes to study neighboring cell relaxation in RRC\_CONNECTED – all other companies are open to study all possibilities. Regarding prioritization, some companies mention e.g idle/inactive mode neighboring cell measurements and connected mode serving cell measurements as best candidates. However, many replies also mention no prioritization should be done at early state of the SI.

1. For stationary UEs, RRM relaxation for both neighboring cell and serving cell measurements, for any RRC state, are studied further.

## 2.3 Standardization framework and principles for constraints for reduced capabilities

One of the objectives in the SI is to "study standardization framework and and principles for how to define and constrain such reduced capabilities". Proposal in [1] is for RAN2 to focus on providing RAN2 view on how and how many RedCap UE types should be defined and for RAN2 to further study how to possibly constrain or extend the capability signaling framework for RedCap UEs or use cases.

**Question 5 (UE types): Do you agree that RAN2 should study if, how and how many UE types should be defined for RedCap UEs from RAN2 point of view and provide input to RAN1 and TR 38.875?**

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| --- | --- | --- |
| **Company** | **Yes / no** | **Comments** |
| Qualcomm | Yes | RAN2 can discuss at high-level how many types of RedCap UEs are needed. RAN1 can discuss details in the definition of a RedCap UE type. |
| OPPO | Yes | But the final decision may not be mad by RAN2 only. |
| Xiaomi | No | RAN1 should define the specific capabilities or group of capabilities that can be reduced. So we think how and how many UE types should be defined in RAN1 and RAN1 is currently discussing this. We should wait for their inputs and based on which to study capability signalling. |
| Ericsson | Yes | RAN2 can discuss the need for UE types from RAN2 point of view, understanding that the final decision is not only up to RAN2 but RAN1 is involved as well. |
| Futurewei | Yes | This is related to the email dicussion [109]. |
| Convida Wireless | Yes | We should strive to minimize the number of device types. The definition of each device type requires discussion, but in our view a maximum of 2 device types for each FR should be sufficient. |
| Apple | Yes | We also agree this is related to email disc 109. Our view is for RAN2 to study the UE types, but we are hesitant to use these types in RRC signaling. We think the types can be primarily used for marketing purposes, and instead of using these types explicitly for constraining RedCap UEs, RAN2 can work with what RAN1 agrees and try to not add too many types in signaling to be used for restricting access.  The main concern with such approach is the backward compatibility with the addition of newer types. We think it’s better to define a very small set of types into which any new future RedCap additions would go into. We see that RAN2 will probably use these types for access restriction and we want to make sure that this is not complicated. |
| Sequans | Eventually yes | This will in any case be based on RAN1 decisions. How these affect differentiation and whether further differentiation is needed can only be decided later. |
| NEC | Yes | however, if only limited number of types are to be introduced, then RAN1 (L1) oriented aspects should be prioritized to decide, i.e. respect to RAN1 decision. |
| Huawei, HiSilicon | No | RAN2 should focus on how to define UE type.  How many UE types should be left to RAN1 as it is related to the minimum set of reduced capabilities. |
| Samsung | No | We are not sure whether separate UE types should be defined. For all the features from RedCap, we could follow the legacy principle (to have a separate capability), and a few features among the features that impact to initial access can be reported earlier to the network without introducing a separate UE type. |
| CATT | Yes | We think R2 can discuss on this aspect. But on the other hand we should take into account request from R1 on UE types. Definition of UE type should baed on compreshensive understandings of the use case/requirements. |
| Intel | Partially yes | This is related to offline discussion #109. RAN2 should discuss and conclude the need/purpose of the device type, and how the device type is defined. But the number and the details are related to what physical layer capabilities are reduced, therefore RAN1 involvement is needed when discuss the number and the associated capabilities. |
| vivo | Yes | How UE types should be defined and captured in specification should be determined in RAN2.  How many UE types should be discussed and decided in both RAN1 and RAN2. At least, RAN2 decision should be based on the detailed reduced capability defined in RAN1.  All these issues are being discussed in offline #019. |
| LG | Yes | RAN2 should discuss RedCap UE types in RAN2 point of view and provide RAN2 input. |
| Lenovo | Yes | It is mentioned in the email[109]. |
| Nokia | Yes | RAN2 can discuss UE types together with RAN1. It should be noted that there is no necessarily need to signal the UE type to the network. |
| MediaTek | Yes | Yes, RAN2 should study how a RedCap device type is to be defined. Of course, as normal operation, we take the input from other WGs into account. |
| Spreadtrum | Yes | High-level discussion can be performed in RAN2, but RAN1 does the final conclution. |
| ZTE | Yes | The number of device type is related to the intention of introducing device type, and how to apply device type in access control and service restriction, i.e. to what granularity RedCap device are identified for access control and service restriction. These issues are mainly RAN2 related.  However, the exact definition of redcap device should be defined along with RAN1 since the main reduced capability is related to physical layer. |
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**Summary:**

20 replies from 21 companies, where 4 companies reply 'no' and rest 17 reply 'yes'. One company replying 'no' mentions RAN1 should work on this – this aspect was brough up in many other comments as well and it should be clear this is not RAN2 work alone. One company replying 'no' mentions RAN2 should focus only on the defining UE type and one company thinks no UE types should be defined (however it can be mentioned the question also asked "if").

The study of UE types is part of the SI scope (RAN2 is even listed as leading WG), therefore proposal is to continue studying. However, as highlighted, this should be a common work between RAN1 and RAN2 where RAN1 focuses on the physical capabilities defining a RedCap device.

It can further be noted that concept of "UE type" can be interpreted differently based on the replies and company contributions. As mentioned, further details are already being discussed in offline#109.

1. RAN2 studies whether / how RedCap UE type is defined. Both RAN1 and RAN2 should be included in final determination where RAN1 studies the objective from physical layer (complexity reduction) point of view and RAN2 studies how potential definition would be captured and relation e.g. to UE capabilities.

**Question 6 (Capability framework): Do you agree that RAN2 should discuss whether there is need to constrain or extend the existing capability signaling framework due to introduction of RedCap UEs in NR/5GS, and provide possible input in TR 38.875?**

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| **Company** | **Yes / no** | **Comments** |
| Qualcomm | No | We do not see strong needs to extend/enhance the existing capability signaling framework for RedCap. |
| OPPO | No | RAN2 may need to first confirm to use existing capability signaling framework as baseline and then consider how to accommodate the new UE type. |
| Xiaomi | - | See above. It is too early to discuss this. |
| Ericsson | - | RAN2 should indeed discuss whether there is need for extensions, the outcome would depend on if/how UE types would be defined and how this would map into capabilities.  Agree with OPPO that existing capability framework should be taken as the baseline. |
| Futurewei | Yes | This is related to the email dicussion [109]. |
| Convida Wireless | Yes | The existing capability signaling framework should be used as the baseline. How to constrain or extend the existing capability signaling framework can be determined after deciding on the number of device types and the features each device type supports. |
| Apple | ?? | We do not fully understand by what extend means. Our view is that RedCap should use the existing capability transfer framework, where newer capabilities are added (just like addition of capabilities for any new feature). We may also have to define capabilities for mandatory without signaling features, and here we have to put a requirement that only RedCap UEs will set these fields. If this is what is meant by extension, then yes. If a new (seperate) capability enquiry/reply procedure is what extends means, then we do not see the need. |
| Sequans | Eventually yes | This is related to the previous question, but we can agree to have the existing framework as baseline |
| NEC | No | at least, should not spend much time on this during SI |
| Huawei, HiSilicon | - | We think capability signaling framework is RAN2 job but it is not clear to us what does “constrain or extend the existing capability signaling framework“ mean:   * Can we add REDCAP type indication or other new capability (if any agreed by RAN1, e.g. HD-FDD)? * If the REDCAP UE can be identified by the network, do they still need to report the mandatory capability, e.g. support of 20Mhz? |
| Samsung | No | At this stage, we think the existing framework can be reused. |
| CATT |  | This question seems not very clear. Does it ask whether exsiting UE cap framework can be reused? If so we think definitely YES. If anything needs to be added it can be discussed and done based on consensus. |
| Intel | - | The question is quite confusing, should not it already clear in the SI cope, that RAN2 should discuss this.  *Study standardization framework and principles for how to define and constrain such reduced capabilities – considering definition of a limited set of one or more device types and considering how to ensure those device types are only used for the intended use cases [RAN2, RAN1].*  Or the question is only on whether to capture the discussion in the TR? If so, we agree. |
| vivo | - | We think we can discuss further whether this is need to constrain or extend the capability signaling framework after there is clear decision on the redueced capability and UE types definition.  We also agree that the existing signaling can be used as the baseline. |
| LG | No | We think the existing capability signallign framework can be used without extension to introduce RedCap UEs. |
| Lenovo | No | It seems there is no critical reason to change the exsting capability signalling framework for RedCap UEs. It is better to reuse the exsting capability signalling framework as much as possible. |
| Nokia | No | Existing UE capability signalling framework seems sufficient for us. |
| MediaTek | - | Agree with Intel. The purpose of this question is unclear.  We should look at the UE capability framework as part of this SI, and take associated reduced capabilities into account. The outcome of this discussion ought to be captured in the TR |
| Spreadtrum | - | Maybe the current capability signaling framework can be the baseline, considering the less specification work. |
| ZTE | ?? | Not sure about the intention of this question.  Current capability signaling should be taken as baseline. And RAN2 should focus how to achieve SID target. RAN2 can make decision if necessary extension/constrain are identified during later study and the definition of reduced capabilities is clearer (e.g. whether lower capability can be indicated only be redcap UE) |
|  |  |  |

**Summary:**

Again 20 replies. 3 explicit 'yes', 7 explicit 'no' and rest don't understand the intention or mention the question is confusing. Rapporteur needs to agree the question was not very well formulated. Several companies mention existing capability framework can be used as baseline – however this, overlaps with offline#109 and can be discussed further in that context. No proposal is made.

**Question 7 (Constraining of reduced capabilities): Do you agree that RAN2 should discuss whether and how it can be ensured RedCap Ues are used only for intended use cases, and provide possible input in TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / no** | **Comments** |
| Qualcomm | Yes | We think RAN2 can discuss what enhancements are needed to ensure RedCap Ues are used only for their intended use cases. If necessary, we can involve other working group (e.g. SA) too. |
| OPPO | Yes | This is already indicated in the SID. |
| Xiaomi | Yes | RAN2 should study the signalling framework for defining reduced capabilities UE to ensure those device types are identifiable to the network for intended use cases.  However, whether it involves early identification of RedCap UE during initial access should be first discussed in RAN1. |
| Ericsson | Yes | Note that CT/SA must be involved for the part on „*ensure those device types are only used for the intended use cases”* in the SID as this (use case) cannot be determined by RAN alone. |
| Futurewei | Yes | This is related to the email dicussions 109 &110. |
| Convida Wireless | Yes | This is in line with the SID. |
| Apple | Yes, butsssss | Yes to discuss, but ensuring RedCap Ues are used for intended purposes is something that can be taken care of by CT (NAS signaling). |
| Sequan | Yes | And (as mentioned in our answer to Q1) also consider how regular Ues can work as REDCAP Ues, if at all. |
| NEC | Yes | This needs to be discussed in RAN2 and may require a collaboration with RAN3 and SA2. |
| Huawei, HiSilicon | Yes | We think this is RAN2 scope. We agree with Qualcomm that other WGs may need to be involved. |
| Samsung | Yes | As stated in the SID. |
| CATT | Yes | As per SID yes. |
| Intel | - | The question is quite confusing, should not it already clear in the SI scope, that RAN2 should discuss this?  *Study standardization framework and principles for how to define and constrain such reduced capabilities – considering definition of a limited set of one or more device types and considering how to ensure those device types are only used for the intended use cases [RAN2, RAN1].*  Or the question is only on whether to capture the discussion in the TR? If so, we agree. |
| vivo | Yes | RAN2 could discussed whether and how the RedCap UE can be ensured to be used only for intended use cases. After we have clear mechanism or requirements, we can involve SA or CT. |
| LG | Yes | We are fine to discuss this as indicated in SID |
| Lenovo | Yes | RedCap UEs are used only for intended use cases is one of the objective at the study item. And the details to ensure the objective can be futher disscussed by RAN2. |
| Nokia | Yes | We think that other working groups may need to be involded. |
| MediaTek | Yes | Agree with Ericsson that this needs to be discussed along with SA and CT groups |
| Spreadtrum | Yes | At least if RAN procedure is used for this purpose. |
| ZTE | Yes | RAN2 can discuss the potential solutions and identify whether SA/CT WG are to be involved. |
|  |  |  |

**Summary:**

20 replies, where 20 companies reply 'yes' and one company doesn't explicitly confirm but based on comment seems to agree with rapporteur intention (i.e. discussion is of scope – and what to eventually capture in TR). Several replies mention potential CT/SA impact on determining the use case. It can also be mentioned that the discussion of access restrictions as such was not the intention of this question (but see next instead).

1. RAN2 studies, and provides input to TR 38.875, on whether and how it can be ensured RedCap UEs are used only for intended use cases. This may require coordination with other WGs (e.g. RAN3 / SA / CT).

## 2.4 Functionality for identification of restricted capability Ues

The network should be able to identify RedCap Ues from “normal” NR Ues e.g. to control access of such Ues to the system. Couple of different ways to achieve this are discussed in the submitted contributions and according to the SI [3], RAN2 should study the options and provide view on which would be the best way. Correspondingly, proposal in [1] is for RAN2 to provide input to TR 38.875 on the possible identification mechanisms, and on the possible access restriction mechanisms. Companies are asked to confirm the understanding of the RAN2 scope.

**Question 8 (Identification of Ues in RAN): Do you agree that RAN2 should discuss and provide input to TR 38.875 on mechanisms how to identify RedCap Ues and how to control the access of RedCap Ues in RAN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / no** | **Comments** |
| Qualcomm | Yes | We think some form of explicit indication is necessary for network to identify RedCap Ues. Control access of RedCap Ues in RAN can be based on access barring and UAC. |
| OPPO | Yes | For early RedCap UE’s identification, e.g. in RACH procedure, we should wait for RAN1’s input. For RedCap UE’s access control, we also think extension to access barring and UAC can be studied by RAN2. |
| Xiaomi | Yes | Whether it involves early identification of RedCap UE during initial access should be first discussed in RAN1.  For RedCap UE’s access control, the UAC can be reused and further studied. Other tools, e.g., random access back-off for Redcap can be considered further. |
| Ericsson | Yes |  |
| Futurewei | Yes | This is related to the email dicussions 109 &110. |
| Convida Wireless | Yes | RAN2 should discuss access barring and UAC-based access restriction mechanisms for RedCap Ues. The scope of the discussion should also include early identification of RedCap Ues during initial access. |
| Apple | Yes, but | Yes to discuss. But we are not keen on identifying mechanisms to idenity RedCap Ues (they are known anyway with Ue capability). If identification is needed for restricting acces, we do not see the need for the NW to identify before restricting, UAC can just bar without the need for the NW to identify. |
| Sequans | Yes | Access barring and UAC principles should be used. Inital access can wait advancement in RAN1. |
| NEC | Yes | Regarding identification, this will need to wait for RAN1 decision (or maybe assumption during SI) about e.g. whether existing MIB and CORESET#0 can be reused or not?  Regarding access control, we assume existing UAC mechanism will be used or reused with some modification. |
| Huawei, HiSilicon | Yes | REDCAP Ues can be identified by UE capability, this will be covered by above discussion on capability signalling framework.  On top of this, whether to identify REDCAP Ues in early stage, i.e. during RACH, needs to be discussed in RAN2.  For control access, at least UAC needs to be discussed in RAN2. |
| Samsung | Yes | - |
| CATT | yes | As per SID yes.  For the detailed mechainism, e.g., whether the ue type is determined explicilty based on some indication or implicilty based on the reported ue cap, we can discuss further. Differnet mechainisms seem to have their pros and cons. |
| Intel | - | The question is quite confusing, should not it already clear in the SI scope, that RAN2 should discuss this?  *Study functionality that will allow devices with reduced capabilities to be explicitly identifiable to networks and network operators, and allow operators to restrict their access, if desired [RAN2, RAN1].*  Or the question is only on whether to capture the discussion in the TR? If so, we agree. |
| vivo | Yes | RAN2 should focus on the access control of RedCap UEs. We also think the current UAC mechanism can be used as the baseline.  For the early identification, we think we should first discuss the motivation in RAN1 and RAN2. After that, we can discuss the potential mechanisms (e.g. during RACH) based on the requirements. Otherwise, it is hard to discuss the potential solutions with no use cases. |
| LG | Yes |  |
| Lenovo | Yes | To control the access of RedCap UEs, the access barring and UAC machanisms can be disccusse in RAN2.  To identify and further control the access of the RedCap Ues, it can be discussed in RAN1 firstly. |
| Nokia | Yes |  |
| MediaTek | Yes | Again, agree with Intel – the purpose of this question is unclear. |
| Spreadtrum | Yes | RAN2 may give some analysis on early indication during RACH procedure, and RAN1 should be involved.  And for UAC, as discussed in several papers, RAN2 can discuss how to control the access of the RedCap UEs based on UAC mechanism. |
| ZTE | Yes | How to perform access control are mainly RAN2 issue. While identification is also RAN1 related. Early identification may be achieved by separate RACH resource or separate initial BWP if RAN1 reach such agreement. |
|  |  |  |

**Summary:**

20 replies, in which 20 companies reply 'yes' and one company doesn't explicitly reply yes or no but seems to understand rapporteur's intention correctly.

1. RAN2 studies, and provides input to TR 38.875, on how and when to identify RedCap UEs and how to control RedCap UE access in RAN. Before concluding the identification discussion, further progress is needed in RAN1.

## 2.5 TR skeleton for TR 38.875

The TR skeleton for TR 38.875 is provided in [2]. This version is based on the initial version v0.0.1 endorsed in RAN1#101-e and further revised.

The above questions cover the sections in TR 38.875 where RAN2 input is expected. Companies are asked to provide input on the TR skeleton, e.g. if there are sections which should be added, changed or removed, etc.

**Question 9: Please provide input, if any, on the TR skeleton in [2].**

|  |  |
| --- | --- |
| **Company** | **Input** |
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|  |  |
|  |  |
|  |  |
|  |  |

**Summary:**

1. No RAN2 input on TR 38.875 skeleton is identified, for now.

## 2.6 Organization of the RAN2 work during the study phase

If RAN2 identifies need to update the skeleton or provide other text input already from RAN2#111-e, it should be possible to send LS to RAN1 e.g. containing RAN2 changes on the skeleton, if needed. This can be evaluated once the discussion has progressed.

Otherwise, RAN2 should consider whether to start email discussions on the different aspects discussed above, to facilitate the eventual input to TR 38.875.

**Question 10: Do you agree that RAN2 should initiate email discussions Post-RAN2#111-e on the different aspects and objectives discussed above, where the scope is drafting input to TR 38.875, to be agreed in RAN2#112.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / no** | **Comments** |
| Qualcomm | Yes | The scope of the post meeting email discussion can be reviewing the draft TR which captures agreements made in this meeting (#111-e). |
| OPPO | Yes | Post-meeting email discussion can help to progress the study phase. |
| Xiaomi | Yes |  |
| Ericsson | Yes | Email discussions should be utilized to progress the work. The details can be further discussed once we see what kind of progress is achieved during RAN2#111-e. |
| Futurewei | Partially Yes | Only limited number, no more than 2, please! |
| Convida Wireless | Yes | For some aspects, a two-part email discussion may be helpful to discuss the technical details of an approach before attempting to draft the input to the TR. |
| Apple | Partially Yes | Same view as Futurewei. |
| Sequans | Yes | This can be agreed in the online session or in a dedicated email discussion after the progress in this meeting is clearer. Number of discussions should be limited with clear scopes. |
| NEC | Yes | considering limited time for SI phase, good to have email discussion but should select and decide carefully. |
| Huawei, HiSilicon | Yes | We are fine to have email discussions to progress the work. |
| Samsung | - | This can be done *only if* the scope and outcome of the email discussion are clear. |
| CATT | Yes | We are generally fine with discussing this in email. |
| Intel | Yes | # of email discussions should be limited with clear scope. |

|  |  |  |
| --- | --- | --- |
| vivo | Yes | Let’s see what progress can be made in this meeting. Post Email discussion on TR capturing the agreements can be helpful. |
| LG | Yes | No strong view. We are fine with Post-meeting email discussion. |
| Lenovo | Yes |  |
| Nokia | Yes | If scope is very well defined. |
| MediaTek | Partially yes | Agree with Futurewei that the number of email discussions should be limited, with a clear scope |
| Spreadtrum | Yes |  |
| ZTE | Yes |  |
|  |  |  |

**Summary:**

20 replies where all are OK to continue after the meeting with email discussions, with some concerns on clearly limiting the discussion scope and number of email discussions. As the study item is really short, and outcome should be input to TR 38.875 rapporteur proposal is to have TPs to the TR as output of the email discussion. Looking at the skeleton TR 38.875 [2], there are 3 clear areas where RAN2 input is expected, also reflected in the other proposals in this discussion.

1. RAN2 to consider running email discussions with TPs to TR 38.875 as intended output until next meeting. The exact scope should be clarified once progress during RAN2#111 is clear. The proposed topics, per sections in TR skeleton, are:
   1. UE power saving features (eDRX in idle and inactive, RRM relaxation for stationary devices)
   2. Definition and constraining of reduced capabilities
   3. UE identification and access restrictions

# Grouping of proposals

**Agreeable, directly in SI scope, consensus:**

**Proposal 5 RAN2 studies, and provides input to TR 38.875, on whether and how it can be ensured RedCap UEs are used only for intended use cases. This may require coordination with other WGs (e.g. RAN3 / SA / CT).**

**Proposal 6 RAN2 studies, and provides input to TR 38.875, on how and when to identify RedCap UEs and how to control RedCap UE access in RAN. Before concluding the identification discussion, further progress is needed in RAN1.**

**Easily agreeable, about SI scope:**

**Proposal 2 For power saving, study on extended DRX for idle and inactive modes and RRM relaxation for stationary RedCap devices is prioritized, and input to be provided to TR 38.875. Further topics can be discussed as 2nd priority or potentially left for WI phase.**

**Proposal 3 For stationary UEs, RRM relaxation for both neighboring cell and serving cell measurements, for any RRC state, are studied further.**

**May require some discussion:**

**Proposal 1 Discussion on the following expected impacts on RAN2 procedures are prioritized:**

**a. Impact on cell (re)selection**

**b. Impact on initial access**

**c. Impact on idle mode procedures (i.e. SI acquisition, paging)**

**Proposal 4 RAN2 studies whether / how RedCap UE type is defined. Both RAN1 and RAN2 should be included in final determination where RAN1 studies the objective from physical layer (complexity reduction) point of view and RAN2 studies how potential definition would be captured and relation e.g. to UE capabilities.**

**Proposals on organizational matters:**

**Proposal 7 No RAN2 input on TR 38.875 skeleton is identified, for now.**

**Proposal 8 RAN2 to consider running email discussions with TPs to TR 38.875 as intended output until next meeting. The exact scope should be clarified once progress during RAN2#111 is clear. The proposed topics, per sections in TR skeleton, are:**

**a. UE power saving features (eDRX in idle and inactive, RRM relaxation for stationary devices)**

**b. Definition and constraining of reduced capabilities**

**c. UE identification and access restrictions**

# References

1. [R2-2006910](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_111-e/Docs//R2-2006910.zip), Scope of RedCap SI, Ericsson, RAN2#111-e, Electronic meeting, August 2020.

1. [R2-2007366](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_111-e/Docs//R2-2007366.zip), R38.875 skeleton updates for Study on support of reduced capability NR devices, Ericsson, RAN2#111-e, Electronic meeting, August 2020.

1. [RP-201386](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_88e/Docs/RP-201386.zip), Revised SID on Study on support of reduced capability NR devices, Ericsson, RAN#88e, Electronic meeting, June 29 – July 3, 2020.

# Appendix: RAN1 agreements from RAN1#101-e

RAN1 made the following agreements related to **use case requirements**:

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| --- |
| Agreements:   * For safety related sensors, latency requirements apply to traffic initiated from RRC\_CONNECTED. |

RAN1 made the following agreements related to **study of UE complexity reduction**:

|  |
| --- |
| Agreements:   * For FR1, study at least 20MHz maximum UE bandwidth at least for initial access   + Other bandwidths FFS * For FR2, study 50MHz and 100 MHz maximum UE bandwidth at least for initial access   + Other bandwidths FFS   Agreements:   * For FR1, study two antenna configurations for RedCap UEs, namely 1Rx/1Tx and 2Rx/1Tx. * For FR2, study two antenna configurations for RedCap UEs, namely 1Rx/1Tx and 2Rx/1Tx.   Agreements:   * Study HD-FDD operation Type A and Type B (as defined in LTE) in RAN1, where study of Type A is prioritized.   Agreements:   * For UE complexity reduction through relaxed UE processing time, study a more relaxed UE processing time in terms of N1/N2 compared to capability #1.   Agreements:   * Use the TR 36.888 methodology for UE cost/complexity evaluation as a starting point and determine what major updates are needed. * Cost/complexity breakdowns can be separate for FR1 and FR2 if found beneficial. * Include antenna parts at least in the cost/complexity breakdown for FR2. * Potential benefits in terms of reduced device size can be mentioned where applicable in the TR (e.g. in the section on reduced number of antennas), but the SI will not aim to quantify such benefits.   Agreements:  The reference NR device for evaluation of cost/complexity reduction supports the following:   * All mandatory Rel-15 features (with or without capability signaling) * Single RAT * Operation in a single band at a time * Maximum bandwidth:   + For FR1: 100 MHz for DL and UL   + For FR2: 200 MHz for DL and UL * Antennas:   + For FR1 FDD: 2Rx/1Tx   + For FR1 TDD: 4Rx/1Tx   + For FR2: 2Rx/1Tx * Power class: PC3 * Processing time: Capability 1 * Modulation:   + For FR1: support 256QAM for DL and 64QAM for UL   + For FR2: support 64QAM for DL and 64QAM for UL * Access: Direct DL/UL access between UE and gNB   Note: The study will consider impacts on the cost/complexity reduction from support of multiple RF bands within FR1 or FR2. |

RAN1 made the following agreements related to **study of UE power saving**:

|  |
| --- |
| Agreements:   * Study the impact of BD and CCE limits reduction on power saving and PDCCH blocking probability (quantitatively) and impacts on latency and scheduling flexibility (at least qualitatively).   Agreements:   * Reuse the power consumption models and scaling factors for FR1 and FR2 provided in TR 38.840 (sections 8.1.1, 8.1.2, 8.1.3) as appropriate. * For evaluation of UE power saving, for wearables, use the traffic models FTP model 3 and VoIP from TR 38.840 to characterize the wearables service types including IM, VoIP, heartbeat, etc. with proper modification of at least packet size and mean inter-arrival time. Values are FFS. * For evaluation of UE power saving, for industrial wireless sensor use cases, use a traffic model based on the service performance requirements for the process monitoring use case in TS 22.104 Table 5.2-2. At least 64 bytes UL message (plus headers, e.g. MAC, RLC, etc.) transmitted periodically with a periodicity 100 ms should be considered (other values are encouraged). |

RAN1 made the following agreements related to **study of coverage loss/recovery**:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Agreements:   * If/when coverage evaluations outside the CE SI are needed,   + The basic evaluation methodology is based on link-level simulation for FR1.     - ­Step 1: Obtain the required SINR for the physical channels under target scenarios and service/reliability requirements.     - ­Step 2: Obtain the baseline performance based on required SINR and link budget template.     - ­Note: aspects related to identifying target performance and coverage bottlenecks based on target performance metric is to be handled separately   + The evaluation methodology for FR2 is the same as FR1.   Agreements:   * If/when link-level coverage evaluations outside the CE SI are needed,   + The CE SI link-level simulation assumptions can be used as a starting point.   + For calibration purposes, the following settings can be used:  |  |  |  | | --- | --- | --- | | **Parameters** | **FR1 values** | **FR2 values** | | Scenario and frequency | Urban:  2.6 GHz (TDD) (primary choice)  4 GHz (TDD) (secondary choice)  Rural:  700 MHz (FDD) | Indoor: 28 GHz (TDD) | | Frame structure for TDD | For 2.6 GHz:  DDDDDDDSUU  (S: 6D:4G:4U)  For 4 GHz:  DDDSUDDSUU  (S: 10D:2G:2U) | DDDSU  (S: 10D:2G:2U) | | Channel model | TDL-C | TDL-A | | UE velocity | 3 km/h | 3 km/h | |

RAN1 made the following agreements related to **study of performance impacts**:

|  |
| --- |
| Agreements:   * The evaluation of performance impacts includes at least peak data rate, latency and reliability (as needed for the use cases). Other performance metrics such as power consumption, spectral efficiency and PDCCH blocking probability may also be considered if appropriate for a specific technique. |

# Delegate contact information

|  |  |
| --- | --- |
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|  |  |