RAN#94e-R18Prep-05 - RedCap Evolution - Version 0.0.6
RAN

3GPP TSG RAN#94e RP-21xxxx

Electronic Meeting, December 06 - 17, 2021

Agenda Item: 8A.1

Source: Ericsson

Title: Moderator's summary for discussion [RAN94e-R18Prep-05] RedCap Evolution

Document for: Information & Discussion

1 Introduction

This discussion covers the topic of "**RedCap evolution**" incl. the area of Wake-up Signal/Receiver (WUS/WUR). Guidance, deadlines, and further background can be found in [RP-212608] and [RP-212657].

The goal of the discussion is to discuss and finally provide the scope of the potential WI/SI(s). This should include information on the overall primary / secondary lead WG, the WG(s) involved in each objective, and any potential interaction with SA/CT.

The discussion will be a continuation of the RWS discussion on RedCap and will take its final summary as the starting point [RP-212221]. Note that the RWS discussion on "UE power savings" under the additional RAN1/2/3 candidate topics, Set 1 [RP-211664] also touched upon WUS/WUR and came to very similar conclusions.

Please avoid any input like "We support / we do not support" without giving additional justification and motivation as this is no "number counting" driven discussion. Instead justify your view with strong technical arguments and/or tangible commercial interests (near & longer terms).

2 Initial Round

Please provide your comments of the initial round in the below feedback forms. The initial round takes place from Wed., Oct. 20, 08:00h UTC to Fri., Oct. 22, 23:59h UTC.

2.1 RedCap justification and background

The RWS discussion in Sep. concluded on the following [RP-212221]:

- **Main goal of the RedCap evolution is to further embrace new use cases, especially requiring low-cost devices and low energy consumption.**

Please provide your views on aspects that should be captured in the justification part of a potential Work Item Description.

Based on the Sep. outcome, the moderator proposes that this area targets a Work Item with RAN1 as the primary lead WG and RAN2 secondary. It is however noted that, based on the outcome of the below discussions, some of the WI objectives may start with an initial study phase.

Feedback Form 1: Views on the justification and background of a RedCap WID

1 – TELECOM ITALIA S.p.A.

Not to enter in the like/dislike discussion, but it is not clear the boundary between this discussion and other discussions, namely discussion 28 on passive IoT and in general UE/network energy savings. Moreover, there are clearly two aspects in the proposal: a work item on objectives 2.2 and 2.3 and a study item for 2.4. It would be better to clearly split the two activities.

Finally, on Rel 17 leftovers: what is the reason they were not completed in Rel17? lack of consensus / insufficient gain? if this is the case, we should avoid reopening the discussion in Rel 18, since the situation will not likely change.

2 – vivo Communication Technology

1. We are in general fine with the justification part for Rel-18 eRedCap. Might be good to also mention that the Rel-18 eRedCap is intended to fill in the gap between Rel-17 RedCap and LPWA (eMTC/NB-IOT) and the Rel-18 eRedCap target data rate might be lower than 10Mbps.

2. We are in general fine with the proposed plan to have a work item for Rel-18 eRedCap, study phase may be required for some of the objectives as discussed in the later part of the document. Regarding the leading group, we think RAN4 should be added as the secondary working group since at least lower UE power class is clearly RAN4 related.

3. Regarding Telecom Italia's question, our understanding is that eRedCap WI (2.2, 2.3) and low power WUR/WUS SI (2.4) are intended to be sepreate projects by moderator proposal. Would be good to confirmt this.

3 – Nokia France

We agree with the main goal above, and that RAN1 would be the lead WG.

4 – Guangdong OPPO Mobile Telecom.

We agree that the main goal should embrace new use cases. We think this one can be the general guidance in the justification of the WID. The RedCap primary WGs should be based on how many items primarily by RAN1 or RAN2 or other group will be finally included. And the study phase could be also item dependent.

5 – Futurewei Technologies

We are ok with embracing new use cases.

There are two main aspects of this discussion: study for 5MHz, study for WUS/WUR, and two small parts (lower UE power class and a possible leftover for Enhanced DRX). So, we disagree with the assessment that this should be a WI directly. Rather, it looks like it should be:

- SI for 5 MHz (with a possible WI to follow in R18) [RAN1, RAN2]
- SI for WUS/WUR (TBD: full release SI or possible WI also in R18) [RAN1, RAN2]

- The Enhanced DRX can be considered with either a Rel-17 exception or with a Rel-18 TEI.
- The use cases and protocol enhancements for energy harvesting look to be related to the passive IoT study.
- The lower power class can be discussed further, and would be RAN4-led and standalone. The amount of RAN1 effort needs further discussion, and that could make the difference between a direct RAN4-led WI or a SI.

6 – Sierra Wireless

WRT Justification part:

OK with general direction as long as the interpretation of "new" includes the use cases identified and targeted in the Rel 17 Redcap WID.

In general, a lot of the Rel17 Redcap justification could be re-used, specifically with these main points being re-stated :

· At least these exemplary use cases mentioned: massive industrial wireless sensor network (IWSN), surveillance cameras, smart city devices, wearables

· UE Complexity targeting between LPWA (NB-IOT/eMTC) and eMBB/URLLC

· Power consumption is a KPI (several years)

· Device size is a KPI (no specific target)

· Deployment scenarios: should support all FR1/FR2 bands for FDD and TDD

Agree that some objectives can be WI objectives and some can start with a study objectives. WI can be primary lead by R1 but of course each specific objective will have its primary WG decided independently (i.e., normal procedure).

7 – CATT

Generally fine with the justification. RAN1 should be the leading group.

We have sympathy with Futurewei that 5MHz, energy harvesting should be SI or SI phase.

Low power WUS/WUR can be a separate item, which is not limited to RedCap use case.

8 – Xiaomi Communications

Xiaomi

Generally, we are OK with the goal. For the support of 5MHz, we tend to agree with Futurewei, a SI should be set for further study rather than going to WI directly. For the Low power WUR/WUS, we share similar view with vivo that a separate SI can be set.

9 – Spreadtrum Communications

We are fine with the main goal of the RedCap evolution. Some comments or questions are as follows:

1. For the aspects that should be captured in the justification part, our view is that the RedCap evolution is driven by the need of vertical industry. In addition to the industrial wireless sensors and surveillance cameras, there are many other scenarios in the vertical market that require a low cost/power equipment, e.g., industrial controller, smart grid and so on. Therefore, new use cases for vertical market should be

justified and captured. Further, the potential new or improved KPIs for the new use cases need to be confirmed and captured.

2. We want to clarify that it would be good to mention that the Rel-18 eRedCap is intended to further reduce the supported peak data rate, since the R17 RedCap is over designed for low-end RedCap scenarios, e.g., sensors and video surveillance in R17 and possible new low-end use cases in R18.

3. For the potential objectives listed in the chapter 2.2-2.4, which objective(s) can be specified in the work item directly, which objective(s) targets a study item before WI, and which objective(s) may start with an initial study phase? These objectives should be clearly stated for future projects handling. In our understanding, if the objective need to be studied in a SI, then a separated SID and a technique report for the study are needed, while a study phase means we just need to study the feasibility, i.e., no SID and TR are needed.

10 – Samsung Electronics Polska

We don't see new use cases for even lower cost devices. For the proposed use cases, we suggest to have clear target that can differentia from Rel-17 RedCap, as well as NB-IoT/eMTC (including Cat M2.)

For low energy consumption, we think it is important for RedCap UE, e.g., for wearable devices days or weeks life time is expected. Similarly, for eMBB UE, it may also require lower power consumption.

Besides, there are some ongoing discussion in Rel-17 RedCap, on traffic offloading in idle/inactive/connect mode, to support massive connection, i.e., separate BWP operation. We think this is quite important for massive connections for MTC type of device in NR system. Therefore, we suggest to also include supporting massive connections for RedCap, as one main motivation of Rel-18 eRedCap. The scope can depend on the progress of Rel-17.

11 – Intel Corporation (UK) Ltd

[Intel]

While offering potential reduction in device cost/complexity and power consumption compared to "eMBB" or "URLLC/IIoT" UEs, Rel-17 NR RedCap offers a considerable over-design in terms of device cost/complexity or power consumption for IoT use cases with reduced requirements on QoS (data rates, latency, reliability) but with higher sensitivity to cost/complexity and power consumption.

Thus, the primary motivation for evolution of RedCap in Rel-18 is to address new and existing use-cases with lower device cost/complexity and power consumption to cater to use-cases with significantly reduced data rate requirements (e.g., peak rates of a few Mbps) compared to Rel-17 RedCap (peak rates 80+ Mbps). Such evolution can pave a path for eventual migration of LTE-based solutions for low-to-mid-tier cellular IoT use cases, e.g., wireless sensors, low-end wearables, surveillance and alarm systems, tracking devices with mobility support, etc., from Cat 1, Cat 1bis to NR-based solutions.

12 – Sequans Communications

We would prefer to focus REDCAP evolution on higher end low cost devices that require larger BW.
As mentioned by Samsung, we also don't forsee relevant new use cases for even lower cost devices. We agree that it is necessary to have clear targets that can differentiate the proposed new use cases from existing Rel-17 RedCap, as well as NB-IoT/eMTC (including Cat M2) in order to justify the standardization efforts. We do not agree with vivo that Rel 18 REDCAP should fill the gap between Rel 17 REDCAP and LPWA, since there are efficient solutions to support the existing market requirements. Rel 18 should focus on expanding markets.

13 – NTT DOCOMO INC.

We agree with the main goal above to fulfill the gap between Rel-17 RedCap and LTE eMTC/NB-IoT.

Regarding SI/WI and leading WGs, those can be discussed based on the outcome in Sections 2.2 – 2.4.

14 – Lenovo (Beijing) Ltd

We support the main goal and have RAN1 as the primary lead WG and RAN2 secondary.

15 – Telia Company AB

Main goal if fine but quite high level. So, would there be more details on the possible use cases and techniques targeted?

Also we should have clear understanding of the Release 17 ”leftovers”.

16 – LG Electronics Inc.

We are fine with the proposed way forward.

For the use cases in the justification part of the potential WID, we can refer to the RedCap-specific target use cases that are summarized in Rel-17 SID/WID among which Rel-18 RedCap targets the low-end use case scenarios (wireless sensors, low-end wearables, etc.). While Rel-17 RedCap WI has mainly focused on the high-end use case scenarios (e.g., low-/high-end smart watches, high resolution surveillance camera) and supports the high-end and low-end use case scenarios by a single UE type, Rel-18 RedCap shifts the focus onto the low-end use case scenarios (industrial wireless sensors, low-end wearables, etc.) providing further reduced cost/complexity and extended battery lifetime and filling the gap b/w Rel-17 RedCap and LPWA.

17 – China Mobile Com. Corporation

Some new use cases are discussed, such as low-end wearables, industry controller, smart grid, smart meters and so on. However, these use cases are not new, and most of them has been satisfied by current designs such as R17 RedCap, NB-Iot or eMTC. Therefore, whether to introduce a new design to satisfy this use cases needs to be carefully discussed, especially when the new design is not compatible with legacy NR system. It should be noticed that LTE-M or NB will still be there for a long time, without additional coverage extension for RedCap, and also considering the higher cost of NR devices, it is unlikely to replace LTE-M or NB by RedCap. So the intention of RedCap design should be use cases that cannot be satisfied by LPWA rather than overlapped use cases. Redesign a new system without compatibility with legacy NR system should be avoided, besides this, we are welcome for further cost/complexity reduction and power consumption reduction to meet requirement of new use cases.

18 – DENSO CORPORATION

Agree with the main goal and primary/secondary responsible WGs.

19 – VODAFONE Group Plc

Any 5 MHz variant of RedCap will reduce the economies of scale for the 20 MHz Redcap variant. Hence it is essential that any work on 5MHz is a study, and any study’s results are analysed and only then is a decision is made on whether or not to specify it.

(using some FutureWei text,) we see that a reasonable work breakdown could be:

- SI for 5 MHz (with a possible WI to follow in R18) [RAN1, RAN2]

- SI for WUS/WUR (TBD: full release SI or possible WI also in R18) [RAN1, RAN2]
- eDRX>10.24 s for RRC Inactive can be Rel-18 TEI.
- The use cases and protocol enhancements for energy harvesting look to be related to the passive IoT study.
- The lower power class can be discussed further, and would be RAN4-led and standalone.

20 – Ericsson LM

In our view, the justification can include aspects of further UE power savings/ energy efficiency enhancement and cost reduction. The UE energy efficiency enhancement can be the main goal. For further UE cost reduction, based on our initial analysis, it is more appropriate to have a study phase to first justify the potential gain and impacts before specifying any new complexity/cost reduction techniques including reduced UE BW.

We agree that RAN1 ought to be the primary lead WG and RAN2 the secondary.

21 – CEWiT

We are fine with the main goal. The objective 2.2 on the power saving based on harvested energy part needs a study phase before work item as it requires changes in protocols and RAN1 processes.

Regarding the leading group, RAN1 should be the leading working group with RAN2 as secondary WG for objectives 2.2 on power saving with harvested energy. RAN1 should be the leading WG for objective 2.4 on WUS/WUR SI.

22 – MediaTek Inc.

We are fine with the main goal, and to have RAN1 as the lead WG. However, some of the objectives in the rest of this document may need to be spun out as part of other or new Study/Work Items.

23 – InterDigital Communications

We are fine with the main goal and that RAN1 should be the lead WG. We think some of the identified areas should first have a study phase, e.g., the low power wake-up radio.

24 – Huawei Tech.(UK) Co.. Ltd

We are fine with the two main streams of the justification for RedCap evolution in Rel-18. Especially considering that many low-tier IoT use cases (other than LPWA) in the real world are quite cost-sensitive and/or energy-sensitive, and typically require only a few Mbps data rate. Such markets are growing quickly in recent years and the near future. RedCap evolution needs to target addressing those IoT markets where nowadays industry customers are still hesitating to select 5G.

RAN1 would be the lead WG and RAN4 might also be involved as well as RAN2, depending on the outcomes. And of course RedCap evolution shall be a WI, except the low power WUS/WUR part which needs to start from a study.

In addition, we suggest a placeholder objective for potential Rel-17 leftovers should be reserved, at least during the RAN discussions until December

25 – China Unicom

We agree that RAN1 should be the leading group. As for new use cases needed to be studied in Rel-18, we suggest to have a SI rather than go to WI directly.

26 – ZTE Corporation

We are generally fine with the justification for RedCap.

For the new use cases, industrial controller, industrial sensor, smart city, handheld devices may be considered. The target data rate for new use cases could range from 1M 10Mbps. Moreover, it is not expected that these use cases would be overlapping with NB-IoT/MTC.

27 – Fraunhofer IIS

Fraunhofer In our view, RedCap Evolution is particularly important for industrial applications. We think that Rel-18 RedCap should fill the existing gap between Rel-17 RedCap and NB-IoT/eMTC. However, it should be clear to anyone that there are differences between RedCap and NB-IoT/eMTC, especially in respect to bandwidth, coverage and data rate.

Rel-18 work item for Evolved RedCap should include RRM relaxations in serving cell and reduced PDCCH processing capabilities.

We see the Rel-18 work for RedCap as an opportunity to not only enhance power saving and low-complexity features, but also to enable RedCap devices for more use-cases and broaden market opportunities. Two examples for new use-cases are energy harvesting and operation in specific NPNs, i.e. train communication, campus networks.

28 – Everactive

Everactive agrees we should focus on new use cases, specifically low-cost and low-energy for IoT applications.

We differentiate energy-harvesting (EH) from passive IoT, being discussed in a separate thread. EH does not imply passive devices. Rather, EH devices can be active, supporting high-power transmitters (intermittently) and all of the functionality of a RedCap device. The average power consumption is what will drive the size of the harvester, and the size of local energy storage, such as a supercapacitor.

The IoT has fallen far short of the expectations on scaling, which originally projected 1T devices by 2015. The main limitation on deploying large numbers of IoT devices is the battery. Quoted battery lifetimes are never long enough, and furthermore the expected lifetime is rarely achieved due to battery aging and/or operating in anything less than ideal conditions. The solution is energy harvesting. This requires dramatically reducing the power consumption of the entire device to <10uW, without compromising wireless performance.

The following are examples of industrial IoT use cases that would benefit from the higher peak data rates of RedCap and low-cost, energy-harvesting devices.

Top 5 IoT Use Cases - from IoT Analytics, October 2021

- Remote asset Monitoring
- IoT-based process automation
- Remote asset monitoring and control
- Vehicle fleet management
- Location tracking

Remote Asset Condition Monitoring (Smart Operations)

The global machine condition monitoring market size is projected to grow from USD 2.6 billion in 2021 to USD 3.6 billion by 2026; it is expected to grow at a CAGR of 7.1% from 2021 to 2026. The vast majority of assets in these facilities are unmonitored today. These include machines, air handlers, compressors, pumps, steam traps, pressure release valves, heat exchanges, clean room air pressure and flow, etc. This equipment is present in many industries including food and beverage, chemical, oil and gas, pharma, consumer packaged products, pulp and paper, automotive manufacturing, semiconductor manufacturing, etc. and also in commercial applications including hospitals, universities, commercial buildings, etc. Batteryless solutions are maintenance free, removing one major barrier to widespread adoption. Cellular connectivity simplifies the provisioning, installation, and networking by bypassing customer IT networks and worldwide coverage. These IoT devices require connectivity with latencies of 10-60 seconds and an average throughput of 100bps, with the ability to periodically send large files leveraging RedCap's higher data rate when high fidelity data is needed in the cloud for further analysis on the operating condition.

Asset Tracking (Smart Supply Chain)

Asset Tracking Market was valued at USD 17.14 billion in 2020 and is expected to reach USD 35 billion by 2026 at a CAGR of 13.45% during the forecast period 2021 - 2026. Given the high price of enterprise and industrial assets, especially fleet equipment, the need for monitoring and tracking these assets is paramount. Furthermore, in a bid to determine the total cost of ownership, managers across industries are finding the need for a centralized system that provides critical information, such as location, maintenance history, and contract (if any), for all assets, in real time. **Cellular connectivity provides the ability to not only track assets on premise, but more importantly between premises through the supply chain**. Currently asset tracking solutions are primarily based on GPS which require expensive devices that are power-hungry, limiting the adoption of asset tracking to high price industrial assets and fleet equipment. Batteryless solutions can offer a low cost and zero maintenance solution to triple the size of the market by expanding the adoption (90% adoption) of asset tracking to millions of medium to low price industrial assets and products to improve operations, efficiency, customer satisfaction and energy consumption.

IoT Based process automation (Smart Operations)

The size of the global industrial automation market reached **169 billion U.S. dollars in** 2019. The market is expected to grow at a compound annual growth rate (CAGR) of around eight percent until 2026. In 2026, the size of the global industrial automation market should reach almost 300 billion U.S. dollars. This type of process automation describes operational processes that were either entirely manual in the past or relied on antiquated, industrial-automation setups but have now been upgraded with state-of-the-art hardware and software. Companies that introduce this use case to upgrade their existing setups often do so to add flexibility and agility in the operations process so that specific process steps can be changed in the future. This becomes important because companies are increasingly interested in aligning their manufacturing and operations processes to ever-changing customer demands. **Automation devices include flow meters, thermocouples, pressure meters, valve status, vessel fill level meters, etc**. Many industries require the use of these devices including, pharma, chemical, oil and gas, mining, semiconductor manufacturing, etc. Batteryless wireless cellular solutions can provide flexibility by reducing the cost of change and adaption. Similar to asset condition monitoring, the average throughput is low but lower latency and higher data rates from RedCap and wakeup receivers are necessary.

29 – Facebook

We agree that the main goal should be embracing new use cases, the enhancing of power saving remains an important part in Rel. 18.

30 – Apple Poland Sp. z.o.o.

Apple

Our view is that the goal of Redcap evolution in Rel-18 is highly depending on how to manage the objective 2.2/2.3 and objective 2.4.

For objective 2.2 and 2.3, the main target use cases are industrial sensor and video surveillance, which have been included in Rel-17 WID as target use case and not new cases.

On the 'energy harvested from the environment' in objective 2.2, our understanding is that it still targets to industrial sensor and IOT devices from use case perspective and talks about power consumption performance optimization that requires new protocol and physical channel design.

There is a new use case pending on whether objective 2.4 is included in Rel-18 enhanced Redcap or not.

31 – Qualcomm Incorporated

For **justification part**, it is suggested to include the following:

The platform of NR RedCap devices should be further evolved in R18 towards the lower tier use cases in such a way to gradually expand its addressable market while leveraging R17 design. R18 eRedCap mainly targets low-tier sensors and wearables whose capabilities are between those specified for R17 RedCap devices and LTE LPWA devices.

Our **overall views on Rel-18 RedCap evolution** are shown below:

- Start with SI for Rel-18 RedCap Evolution
  - Focusing on UE BW reduction down to 5 MHz [RAN1 is leading]
  - Corresponding WI will follow within Rel-18 time frame
  - Enhanced DRX (>10.24s) becomes a part of Rel-18 RedCap (in WI phase)
- Separate SI for WUS/WUR [RAN1 is leading]
- Deprioritize energy harvesting and lower UE power class in Rel-18

32 – Verizon UK Ltd

Agree with Ercisson etc. The UE energy efficiency enhancement can be the main goal. For further UE cost reduction, the benefit and impact of reduced UE BW should be examed carefully.

33 – Sony Europe B.V.

The moderator's text discusses a potential work item description. We think that a fair amount of study will be required before things can be specified. While we are not advocating a study item, we think that some of the objectives will need to start with "study and if found feasible….".

Our preference is that Redcap evolution considers new use cases requiring low energy consumption.

We think there is limited scope to significantly further reduce the cost / complexity of Redcap devices.

We think there is little need to further extend the coverage of Redcap. eMTC and NB-IoT are the 3GPP technologies that address the LPWA market.

34 – Telstra Corporation Limited

Also agree with Ericsson, focus on improved energy efficiencies and cost reduction. Making strong improvements here will allow more use cases to be supported rather than introducing yet another non-BC category (5MHz), creating more fragementation and reduced economies of scale.

2.2 RedCap power saving / energy efficiency enhancements

The RWS discussion in Sep. concluded on the following [RP-212221]:

- **Enhanced DRX in RRC_INACTIVE (>10.24s) (*if not completed in R17*)**
- **Identify use cases and study corresponding protocol enhancements to support operation on intermittently available energy harvested from the environment**
  - **Note that how the devices harvest and store energy is outside the scope of 3GPP**

Please provide your views on the above 2 potential WID objectives. Please comment on the involved WGs and whether an objective is anticipated to have SA/CT impact.

Feedback Form 2: Views on RedCap power saving / energy efficiency enhancements

1 – vivo Communication Technology

In addition to the two objectives above, we think serving cell RRM relaxation should also be supported in Rel-18. In previous releases, only neighbor cell RRM relaxation was specified, this limits the potential of power saving gain, as the serving and neighbor cell measurement for a frequency are typically measured at the same or very close time occasion, relaxing neighbor cell measurement alone does not really reduce the UE activities for measurements. While it is true that eDRX can also achieve the serving cell RRM relaxation, but the increased latency would not be acceptable for many of the use cases. It should be noted that serving cell RRM relaxation has been specified in LTE eMTC/NB-IOT, there is no feasibility issue or good reason to not have the same functionality in NR. Regarding the involved WGs, we think RAN2 and RAN4 should be involved.

2 – Nokia France

We agree with the first objective. In our understanding, it is now clear that the enhanced DRX will not be completed in R17, so the part in parentheses can be removed.

For the intermittently-available energy case, this would be a study and would be better considered separately, e.g. as part of the passive IoT discussion.

RAN2 would be the main WG for both aspects.

3 – Guangdong OPPO Mobile Telecom.

We should give more details on how we study and what will be the results of investigating on intermittently available energy. The area is quite promising. From our understanding the RWS also have some consensus on RedCap enhancement base on intermittently available energy.

We think we should at least develop some evaluation assumption of the intermittently available energy and

the related characteristic on the energy source. And then identify the possible impact to the RedCap UE. In the end, we are looking for the identification of specification impact to let RedCap UE works well under that case. Thus. Seems the Bullets in the WID should have 3 points covered.

1 Study on evaluation methodology and assumption based on the intermittently available energy.

2 Specify for RedCap UE when the corresponding protocol enhancements identified.

No problem for the eDRX of over 10.24s.

4 – Futurewei Technologies

It may be premature to discuss the enhanced DRX objective because RAN2 has several meetings remaining. If the enhanced DRX in Rel-17 is not completed, we can use an exception or handle as the topic in TEI18 rather than the R18 WID. In addition, we should not introduce objectives into Rel-18 for solutions from the RedCap Rel-17 SI but not pursued.

As for studying devices operating with intermittently available energy, this objective does not belong in Rel-18 RedCap WID. It can be considered as passive IoT study since the subject appears to be a better fit.

5 – Sierra Wireless

Support Vivo's suggestion to include serving cell RRM relaxation for semi-static UEs.

If eDRX is not completed in Rel17, prefer to finish this in the Rel18 WI vs Rel 18 TEI.

The currently proposed study objectives on energy harvesting are still too general to start an efficiently run 3GPP RAN study. This might be better taken first by SA1. The proposed study objective do appear to overlap with discussion in "Passive IoT" discussion so it would be good to get clarification on that. If it agreed to be study, this seems like a very large study and thus Sierra feels it would be better taken within a separate study e.g.., the "Passive IoT" SI.

6 – CATT

Both bullets should be RAN2 led.

For the 1st bullet, we are fine with it. This may be updated in 2022Q1 since RAN2 still has some meetings left for Rel-17.

For the 2nd bullet, we are open to study, while the use cases should be clarified. Our suggestion is targeting at one or two most typical cases (e.g. polar energy) to construct a reasonable scope.

7 – Spreadtrum Communications

We share the similar justification view as vivo, so we support to include serving cell RRM relaxation for semi-static UEs.

8 – Xiaomi Communications

Xiaomi

We are OK with the eDRX part if it is not completed in Rel-17. Let's wait for RAN2's final progress.

As for studying devices operating with intermittently available energy, this area is new and promising. But on the other hand, this topic does not have similar grade of maturity compared with other topics in eRedCap and the relationship with eRedCap is not so clear to us. Thus, we prefer not to inlcude it in the eRedCap. We are open to set it as a separate SI or include it in other project.

9 – Samsung Electronics Polska

Enhanced DRX in RRC_inactive is left over from Rel-17, and if not completed in Rel-17, it shall be in the scope of Rel-18, for power saving purpose.

For energy harvesting, the target uses are not clear, and it is not clear on the potential impact in 3GPP. If this is for the case that UE (assuming a stationary UE) might be out of battery for some time. There is no issue for those kind of UEs to be served by current NR network.

10 – Intel Corporation (UK) Ltd

[Intel]

First, we note that a considerable contribution to device power savings can be materialize with further reduction of the max UE BW for lower-end RedCap devices (compared to Rel-17). Introduction of lower UE power classes (e.g., 20 dBm) helps further. These are currently covered under "Further RedCap complexity/cost reduction".

Enhanced DRX in RRC_INACTIVE (>10.24s) (if not completed in R17), SA2 already confirmed not support it in Rel-17. It is unlikely to be supported in R17 although there is no confirmation in RAN2. To support this in Rel-18, the coordination with CT1 and SA2 is needed, i.e., RAN2 can work on it only if CT1/SA2 confirm to support it in Rel-18. Otherwise, the same situation could happen in Rel-18.

In our view, support of devices that rely on intermittently available energy harvested from the environment for cellular communication needs careful study based on a "ground-up" approach, where we first need to study and understand the target use-cases, performance requirements, and the associated practical constraints. For instance, processing capabilities of such devices for L1 and higher layer processing, feasible UE power classes for such devices and their UL coverage, achievable QoS metrics and RRM functionalities that may be supported by such devices, and similar fundamental questions need to be addressed first. Just pursuing enhancements to protocol stack to support intermittent connectivity is not sufficient to enable practical support of such devices in real networks, especially if these are expected to be devices without batteries. On the other hand, for devices with battery and energy storage capability, the distinction compared to devices relying on conventional battery charging needs further clarifications. For instance, it is not immediately clear if these devices would operate as regular NR RedCap devices when power is available (e.g., in terms of Tx power, BW, data rates, etc.).

In short, it would be helpful to better understand the targeted use-cases and relationship, if any, to some of the targets of "passive IoT" use-cases before committing to a study in Rel-18.

11 – Sequans Communications

We don't see enough benefit to include serving cell relaxation in Rel 18, considering the fact that REDCAP UEs are not LPWAs. This topic can be deprioritized in our view. We agree with Nokia that energy harvasting UEs should be considered part of the study item on passive IoT.

12 – NTT DOCOMO INC.

We are fine with both bullets, while 1st one can be updated based on RAN2 outcome.

Regarding the leading WG, both bullets should be led by RAN2.

13 – Lenovo (Beijing) Ltd

We are fine with the first bullet.

For the 2nd bullet, we think before "study corresponding protocol enhancements", a study phase on the modeling of intermittently harvested energy is needed.

14 – Telia Company AB

We are fine with the 1st bullet. 2nd bullet needs more clarifications and studies and possibly combined with Passive IoT work and studies.

15 – Panasonic Corporation

We think the second point of " Identify use cases and study corresponding protocol enhancements to support operation on intermittently available energy harvested from the environment " should be handled in " 2.4 Study on low power wake-up receiver / signal" or "RAN94e-R18Prep-28 Passive IoT" as it is more like study topics.

16 – LG Electronics Inc.

For the first objective, according to SA2 LS (R2-2109378) to RAN2 to be discussed in RAN2 November meeting (RAN2#116), SA2 did not agree to support Enhanced DRX extension beyond 10.24s in RRC_INACTIVE in Rel-17 and instead will study potential solutions in Rel-18. In our view, without SA2 progress, RAN2 cannot continue the discussion in Rel-18. Then, we think the first objective on the Enhanced DRX may not fit Rel-18 RedCap SI/WI.

Regarding RRM relaxation, as we understand it, it has already been discussed but not included in the list due to lack of consensus. We still do not support serving cell RRM relaxation.

For the second bullet, we think the topic related to the energy harvesting is more relevant for LPWA and/or passive IoT. So, we think whether to study it for Rel-18 should be discussed separately, e.g., in the context of passive IoT, not in Rel-18 RedCap.

17 – China Mobile Com. Corporation

What is the potential spec impact of energy harvesting and the relationship with RedCap is still unclear. Does this belong the use cases justified for RedCap, and what do we expect from the study? Without a clear expect for this technology, it is hard for us to make a efficient 3GPP study.

We are ok with eDRX part(RAN2).

18 – DENSO CORPORATION

We support the 1st objective, i.e. the leftover eDRX aspects. The 2nd objective is too generic and conceptual and so it is difficult to envisage what RAN should do... As already commented, it might be relevant to passive IoT.

19 – VODAFONE Group Plc

It is clear that SA2/CT working groups will not do R17 work on eDRX for RRC Inactive. Hence this should be in Rel 18 (but it could be just TEI-18 or alignment with the SA2/CTx work)

The intermittent operation from the use of harvested energy is interesting, but is probably either more linked to 'passive IoT' (for very low low harvesting powers), or, could align with the system solutions for R17 IoT NTN discontinuous coverage concepts (for higher harvesting powers/significant energy storage).

20 – Ericsson LM

In our view, both objectives listed should be included in the eRedCap WI. The objective related to protocol enhancements to support operation on intermittently available energy harvested from the environment can start with a study phase.

Suggested objective with involved WGs and potential SA/CT impact:

- Extended DRX longer than 10.24s in RRC_INACTIVE [RAN2, RAN3, RAN4, SA2, CT1]
- Study, and if found beneficial, specify protocol enhancements to support operation on intermittently available energy harvested from the environment
  - Identify use cases and study corresponding protocol enhancements [RAN2, RAN1, RAN4]
  - How the devices harvest and store energy is outside the scope of this work item.

21 – CEWiT

We are ok to discuss eDRX as Rel18 WI, if not completed in Rel 17.

Study is needed to support devices that rely on intermittently available harvested energy with RAN1 as leading WG, as it requires alteration in RAN 1 processes to make efficient use of available energy along with fulfillment of the desired task in an optimal way.

Red-Cap use cases such as stationary devices like industrial wireless sensors, video surveillance and wearables are some of the target use cases that can rely on harvested energy, if the device is lacking of battery charging.

22 – MediaTek Inc.

eDRX: It is quite clear that eDRX > 10.24s in Inactive mode will not be done in Rel-17. As SA2 and CT1 involvement is needed for this feature, this cannot be a TEI as suggested by some companies above.

Energy harvesting: This objective should not be part of RedCap discussions. The objective is too generic and the target use-case is unclear. It may be better placed in the context of Passive IoT, and additionally requires a ground-up approach as suggested by Intel, before moving into specifics such as protocol enhancements.

23 – InterDigital Communications

We support the objectives. It is important to support energy harvesting devices in NR. Our concern is the potential work load and whether there will be bandwidth to study it. It may be better to study it as a separate SI under passive IoT.

24 – Huawei Tech.(UK) Co.. Ltd

By the end of Rel-17, NR already supports many features to enhance UE power saving for both RRC connected mode and idle mode. Assuming RedCap UE already supports those features, maintaining a battery life of one week is challenging, and mainly limited by stand-by current and reception, taking wearables as an example. Thus we believe RedCap UE power saving in Rel-18 should focus on lp-WUS/WUR which might bring significant gain rather than other small enhancements.

For the first bullet of DRX, technically we are fine with it from RAN perspective however it is our understanding the main reason it might not be completed in R17 is that SA/CT have different views. Thus it is unclear at this time whether such situation would be continue in Rel-18. Moreover, we would prefer to look at all potential Rel-17 leftovers together later, e.g. December.

For the second bullet of energy harvesting, we believe it shall be discussed in Passive IoT thread.

25 – China Unicom

We think RAN2 would be the main WG for RedCap enhanced DRX if it is not completed in Rel-17.

As for study energy harvested devices, we suggest to further clarify its target uase cases to see if it should be considered part of the study item on passive IoT.

26 – ZTE Corporation

Enhanced DRX in RRC_INACTIVE (>10.24s) could be considered for power saving. However, it is noted that SA2 already confirmed that it is not supported it in Rel-17. Therefore, longer DRX support should be confirmed together with SA2 and CT1 in Rel-18.

For the energy harvesting from environment, we believe that this would be considered comprehensively in the potential passive IoT item in the future. For RedCap UEs, it is not clear whether relying on energy harvesting is realistic based on the current power consumption requirements for RedCap UEs. Therefore, it is not preferred in the RedCap WI scope.

27 – Fraunhofer IIS

Energy harvesting devices (with or without battery) might have limitations regarding number of consecutive TX or RX timeslots. We support studying protocol enhancements to address this issue.

28 – Everactive

Light, heat, and vibration are the primary and most common sources of harvested energy. Use cases where these will be intermittent is very application-specific. Operating from outdoor light is subject to the day/night cycles, and some weather dependency such as snow cover. Indoor light provides less power, and may cycle with lights being on during working hours. Heat and vibration are often generated from the object a batteryless sensor is attached to. Therefore these sources will cycle with the operating state of that object. For example, steam traps only generate heat when the steam is on.

Areas to focus on with respect to protocol enhancements:

- Minimizing the energy required for a device to reconnect to the network after power loss. With intermittent energy, devices may lose their memory frequently when power is lost. Writing memory to flash is not a viable option because of the high power required to write to flash. This study item should include networking protocols leveraging the memory of the network equipment as well as new capabilities from low-power wakeup receivers to reduce the power used to reconnect to the network with no prior knowledge of the last connection.
- Ultra-low power (ULP) receivers should be considered for offloading routine and frequent network-level synchronization tasks, beyond simple device wakeup. This study item should evaluate what networking tasks can be efficiently offloaded to an ULP receiver to save power.
- Startup time and time-to-acquisition of a signal are critical metrics that can define the power floor of a device. This should study methods to reduce startup time of electronics, and the time for synchronization, as well as the time to turn off and enter a sleep state.

29 – Apple Poland Sp. z.o.o.

We support the 1st objective if it can not be completed in Rel-17.

On the 2nd objective, it is important to make use cases clear, which directly determines the work item it fits in. Our current assessment is that ‘harvested energy’ targets extreme low power consumption and

customized for very specific use cases. It is a brand-new topic and requires a lot of investigation. The study phase needs to involve the new design of physical channel and protocol to achieve extremely low power consumption. Therefore, 'harvested energy' design is more appropriate to be included in 'passive IoT' study item.

30 – Qualcomm Incorporated

It is clear that eDRX (>10.24s) in RRC_INACTIVE will not be completed in R17 so we support completing the work by including this topic inside the R18 RedCap evolution work item. One note is that this work is mainly RAN2 task but it may require works or feedbacks from SA2/CT1 as well.

Based on previous R18 email discussions, topics related to energy harvesting are premature to be included in Rel-18 as we do not have clear views on use cases, spec impacts, and even justifications. We suggest deprioritizing this in Rel-18 eRedCap.

31 – Sony Europe B.V.

We support the conclusion from the September RWS discussion.

Support for operation on intermittently available harvested energy is important. This topic may require an initial study phase. The energy harvesting UE may not be able to complete a transmission during a signalling exchange in CONNECTED mode. It should be possible to pause or suspend / resume that signalling exchange while the UE harvests energy. This aspect should be led by RAN2 with RAN1 as a secondary group.

Enhanced DRX should be led by RAN2.

2.3 Further RedCap complexity / cost reduction

The RWS discussion in Sep. concluded on the following [RP-212221]:

- **Study further reduced UE bandwidth of 5MHz, especially considering**
  - **expected UE complexity/cost reduction based on Rel-17 evaluation methodology**
  - **network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact**
  - **other solutions for reducing the UE peak data rates**
- **Support for lower UE power class**
  - **Considering NW impact, e.g. coverage aspects**

Please provide your views on the above 2 potential WID objectives. Please comment on the involved WGs and whether an objective is anticipated to have SA/CT impact.

Feedback Form 3: Views on further RedCap complexity / cost reduction

1 – vivo Communication Technology

We support the two objectives as proposed above.

In addition, we think "UE processing timeline relaxation for both data and CSI" can also be included for study and potentially support, as it can bring clear UE complexity reduction benefit, and power consumption can also be reduced if the UE processing can be slower. The involved WGs including RAN1, RAN4.

2 – Nokia France

Further reduced UE bandwidth is important for addressing new IIoT use cases and expanding the market addressable by RedCap. From the email discussion prior to RAN#93e, we saw that the majority of companies see a strong need for this, and we do not believe that further study is needed; enough is already known to be able to proceed directly to a WI objective. RAN1 would be the primary group, but there would also be RAN2/4 impacts.

3 – Guangdong OPPO Mobile Telecom.

It seems the low Power class UE should have some study to justify the necessary for RedCap UE. We should not say directly supported.

The narrow bandwidth is already proven to have better cost reduction. We agree it can be directly into the WI phase, considering it may take more time for standardization as we done in the R17.

4 – Futurewei Technologies

The study item should be RAN1 led primarily with RAN2 providing inputs for reducing peak data rates.

In Rel-17, the study item developed a methodology to evaluate complexity reduction techniques. While the objective "… Rel-17 evaluation methodology" recognizes that, the objective should explicitly exclude any changes to the evaluation methodology. For the second bullet, we should consider whether to constrain the studies based on the use cases, e.g., 5 MHz device coexistence with non-RedCap devices or only RedCap devices, or dedicated bandwidth. Such constraints are important to avoid the difficulties the WGs are encountering right now in Rel-17 with BW reduction and BWP operation.

The support for lower power class should be RAN4-led. The efforts can consider that LTE MTC/NB-IoT devices can be either power class 3 (23 dBm), class 5 (20 dBm), or class 5 (14 dBm), but all these need not be supported for RedCap in Rel-18. Any effort on coverage enhancement should be limited. If coverage enhancement is needed, we should first try to use all the existing R15/16/17 coverage enhancement methods before developing any new methods.

5 – Sierra Wireless

Agree that the reduced 5MHz UE bandwidth must be studied before it is agreed to be specified – there are way too many potential issues with this proposal. For example, supporting the Redcap 20MHz BW has shown to be more controversial and challenging than anticipated in RAN1.

However, in general, we would rather see a more general study objective "study UE complexity reduction methods" where 5MHz is listed as one of the techniques to be studied with other potential method for complexity reduction list. Given that some of the other methods have much less specification impact e.g. lower TBS, lower processing time, lower scaling factor, they should not be excluded.

No strong view on the lower power class. But if TUs are tight in RAN4 (which is likely) we would be OK to drop this as there isn't an urgent market demand for lower power class RedCap devices.

6 – CATT

Study on 5MHz should be RAN1 led.

Study phase is necessary to figure out the trade-off between the additional cost saving and network impact (apparently large), which is lack of justification. Meanwhile, other solutions for reducing the UE peak data rates should not be precluded, e.g. reducing the TBS.

Lower UE power class should be RAN4 led.

We should clarify that this does NOT require any coverage enhancement in addition to Rel-17. Low power class RedCap UE should only be deployed where the coverage is not an issue. NO promising method is foreseen to compensate huge coverage gap (tens of dB) with the same user perception rate and power cost.

7 – Spreadtrum Communications

For the objective of further reduced UE bandwidth of 5MHz

- As many companies mentioned in the previous discussion, further reduced UE bandwidth to 5MHz will translate into lower peak data rate, which then means lower memory requirements. Then the cost evaluation on the memory can be considered in R18.
- How to understand "compatibility with Rel-17", is it means compatibility with the capabilities of Rel-17 RedCap.
- For "other solutions for reducing the UE peak data rates", what's the baseline of this, 5MHz RedCap in Rel-18 or 20MHz RedCap in Rel-17? In other words, if 5MHz is introduced in Rel-18, should we continue pursue other solutions for reducing the UE peak data rates for 20Mhz RedCap UE□

For the objective of lower UE power class

- We are fine with this objective, but prefer clearer targets on the number of power classes and the target values which need to be introduced for Rel.18 RedCap. In addition, RAN4 should be included for this objective.

For other cost complexity reduction or related features

- Considering potentially more new use cases for Rel.18 RedCap, "UE processing timeline relaxation" and "HARQ related relaxation" should be included since they are benefit to the UE complexity/cost reduction and/or power saving.
- Due to reduced Rx number, the DL coverage is declined, therefore, coverage recovery for DL can also be included as an optimization feature in Rel.18.

8 – Xiaomi Communications

We are OK with these two proposals. Again, for the support of 5MHz, we prefer to set a study phase first and then decide whether to specify it based on the study result. As a baseline, the evaluation methodoly defined in R17 can be reused.

9 – Samsung Electronics Polska

We don't support 5MHz UE bandwidth. As analyzed in our paper (RP-211795), there is only 1% 3% of cost saving, while on the other hand, the spec change, impact on network, co-existence with other UE types are quite large.

On the other hand, the SI for RedCap in Rel-17 took LTE Cat 1bis as minimal data rate, and we agreed to not extend RedCap to LPWA use cases. However, single UE type is the outcome of Rel-17 SI. We don't see any new justification to support 5MHz BW in Rel-18. Moreover, the price to support 5MHz UE in Rel-18 is much more than in Rel-17, because co-existence with non-Redcap and Rel-17 RedCap UE shall be considered. For example, in IDLE/inactive mode, the network needs to consider more UE types (non-RedCap, 20MHz RedCap, 5MHz Redcap) to choose a configuration of initial BWP.

Considering the unclear use cases, impact on the network, specification effort, and limited cost saving, we don't support this further RedCap complexity/cost reduction in the scope of Rel-18.

10 – Intel Corporation (UK) Ltd

[Intel]

We do not think a study is necessary to decide whether to introduce RedCap UEs with 5 MHz max UE BW. At least for the case of 15 kHz SCS (limited to FR1), WGs can start with normative specification work, while potential support of other configurations can be studied further. The benefits to cost/complexity can be estimated already, and instead, it would be more appropriate to study and identify additional cost/complexity reduction mechanisms that would be commensurate with the reduction in max UE BW to 5 MHz. Consideration of "other solutions for reducing the UE peak data rates" is not necessary since just reducing UE peak data rates, without other meaningful simplification of lower-layer features (e.g., optimizing peak rate scaling factors, etc.), do not contribute meaningfully to device cost/complexity reduction on their own.

Thus, Rel-18 should start with introduction of 5 MHz RedCap UEs, and at least the following cost/complexity reduction techniques should be considered for 5 MHz RedCap UEs:

- Relaxed minimum UE processing times (for shared channels and CSI feedback)
- Limitations to max TBS
- Reducing max number of HARQ processes in DL/UL
- Lower UE power class

With introduction of 5 MHz RedCap UEs, some enhancements to ensure coexistence with other UEs and to mitigate the adverse impact to system spectral efficiency and coverage with such UEs in the system would be in order. These include, but not limited to:

- Efficient coexistence with other (e.g., Rel-17) RedCap and non-RedCap UEs
- Spectral efficiency improvements to compensate for reduced capabilities on BW and Rx antennas, e.g., via efficient frequency hopping/resource hopping schemes, reduced PDCCH load in the system, etc.
- Possible coverage enhancement schemes.

On responsible WGs, for this set of objectives, RAN1 should be the leading WG with RAN2/RAN4 as secondary WGs.

11 – NTT DOCOMO INC.

We are fine with both bullets in general.

Regarding the compatibility with Rel-17 in the 1st bullet, we don't think it is necessary for "reduced cost/-complexity" devices from previous releases. Even for Rel-17 RedCap UEs, they are not backward compatible with 100 MHz BW mandatory for non-RedCap UEs as Rel-17 RedCap UE-specific initial access procedure is being specified in RAN1. According to Rel-17 RedCap WID, SSB has to be reused but others do not (it only says "L1 changes minimized"). We agree that coexistence with both non-RedCap UEs and Rel-17 RedCap UEs should be ensured, but it is not equivalent to ensuring compatibility with Rel-17. It is fair to say "Rel-15 SSB bandwidth is reused and L1 changes minimized" as Rel-17 RedCap WID.

Regarding other complexity reduction techniques such as reduced number of HARQ processes and relaxed UE processing times, they were not adopted to Rel-17 RedCap UEs because of "relatively" smaller cost

reduction gain compared to other adopted complexity reduction techniques, and Rel-17 RedCap does not target low-end use cases. For Rel-18, the main goal is to further embrace new use cases, especially requiring low-cost devices (and low energy consumption). In that sense, any complexity reduction techniques which are beneficial for low-end use cases should be supported as long as the cost reduction gain is justified with reasonable NW impact. Therefore, we think they should be included.

Regarding the leading WG, both bullets should be led by RAN1 as primary WG and RAN2/RAN4 as secondary WGs.

12 – Sequans Communications

As we understand, reduced UE BW of 5MHz is being considered as a separate study item for UEs in dedicated spectrum. We should avoid duplicating work.
Besides, we don't believe there is sufficient cost reduction to justify specification efforts. We are also concerned about backward compatibility and coexistance requirements that will arise from such specification.

In our view, exiting IIoT use cases can be addressed by other existing technologies and REDCAP should focus on bandwidth hungry applications which would be better served by larger BW (e.g. 40MHz)

13 – Lenovo (Beijing) Ltd

We support both bullets.

For 5MHz maximum UE BW, we are fine to have a (short) study phase on the further UE complexity/cost reduction.

For the lower UE power class, it might be good to have a conclusion on what is the power class Rel.18 will target, which might need RAN4 inputs. Based on that, the network impact, e.g., coverage aspects can be considered.

14 – Panasonic Corporation

Our thinking is to the reduction of UE RF bandwidth of 5 MHz has the issue on the compatibility with Rel-17 network UEs. In addition, the boundary with e-MTC are unclear. It could require new SIBs only for this, which is more overhead. Instead of RF bandwidth of 5 MHz, if the cost reduction is intended, the reduction of limited assignment of PRBs or the limitation of HARQ or TB size should be targeted for the cost reduction for peak rate reduction.

For lower UE power class, as far as to be supported around up to 32 repetitions of Rel.17, we are ok. If it requires more the repetition, we are not so sure.

15 – LG Electronics Inc.

We are fine with the two objectives for further cost/complexity reduction. For the UE bandwidth of 5MHz, RAN1 should be the leading WG.

16 – China Mobile Com. Corporation

We do not support further UE bandwidth reduction.

Without additional coverage extension for RedCap, and also considering the higher cost of NR devices, it is unlikely to replace LTE-M or NB by RedCap. So the intention of RedCap design should be use cases that cannot be satisfied by LPWA rather than overlapped use cases. And we share similar view with Samsung, a lot of discussion during R17 is made to make sure only one RedCap UE type is defined, and then it is strange that R18 introduce another RedCap UE type. 5MHz UE cannot reuse the initial access procedure, and cannot share broadcast SI or paging with legacy UEs. Considering the lack of compatibility with R17

RedCap and non-RedCap designs, the possible workload for redesign a new system, the coexistence problems, and the coverage loss due to less available CCE in CORESET, we can not support further reducing UE bandwidth.

As to the cost reduction, both Samsung and Ericsson in pre-RAN#93 email discussion have mentioned that the cost saving is limited. And what's more, redesigning a new narrow band system leads to market fragmentation and not always contribute to low cost, but there is no doubt that it will involve large scale network upgrade and large effort for coexistence management.

We are open to solutions that can further reduce UE complexity based on backward compatibility, such as processing timeline relaxation or peak date rate reduction(RAN1, RAN2). And lower UE power class lead by RAN4 can also be studied as long as the UE coverage experience is guaranteed, for example, only limited to indoor case where coverage is not limited.

17 – VODAFONE Group Plc

Any 5 MHz variant of RedCap will reduce the economies of scale for the 20 MHz Redcap variant. Hence it is essential that any work on 5MHz is a study, and any study's results are analysed and only then is a decision made on whether or not to specify it.

Other methods for complexity reduction could be analysed (reduced number of HARQ processes, type B HD-FDD), but, again, we need to be vary careful of the impact of different product variants on Redcap's economies of scale.

18 – Ericsson LM

In principle, we are fine with the two objectives listed. RAN1, RAN4 and RAN2 would be the involved WGs.

UE BW reduction:

Regarding the further , from our initial analysis, e.g., Observations 3 to 6 in R1-2108824, different reduced UE BW options can be considered. It is found that the baseband BW reduction is preferable to RF BW reduction due to similar gains in cost reduction but minimal (and not maximal) specification impact. Thus, if it is to be considered, there should first be a study on different solution options, expected complexity/cost reduction based on Rel-17 evaluation methodology, NW impacts, and coexistence with Rel-17 RedCap and non-RedCap UEs.

Suggested addition to the objective:

- Different BW reduction options such as both RF and BB BW or only BB BW for data channels can be considered.

It is important to agree on some fundamental design principle before the study starts, e.g., any enhancements should

- Build on Rel-17 RedCap framework and avoid fundamental changes to the basic RedCap UE type defined in Rel-17
- Ensure compatibility with Rel-17 network, i.e., Rel-18 RedCap UEs should be able to fall back to Rel-17 behavior in order to access a Rel-17 RedCap network
- Not be restricted to only limited deployment scenario, e.g., it should not be limited only to 15 kHz SCS.

We suggest that the sub-bullet 'other solutions for reducing the UE peak data rates' is updated to "alternative solutions for reducing the UE peak data rates" in order to clarify that it is not considered as additional solution in addition to reduced UE RF BW. Note that other complexity reduction techniques already ruled out in Rel-17 SI phase due to unjustified gain (e.g., # HARQ processes, UE processing time) should not be re-considered again.

UE power class:

Regarding lower UE power class, the coverage aspect may be considered in connection with a new lower UE power class level. However, it should be emphasized that existing coverage enhancement mechanisms from Rel-15/16/17 should be considered before considering any introduction of new mechanisms.

19 – CEWiT

We support the study on reduced bandwidth for cost and complexity reduction in Red cap UEs. Importance to be given to initial access aspects with reduced bandwidth and coexistence with non Red Cap UEs

20 – MediaTek Inc.

BW reduction

It is evident from the responses above and from earlier discussions that the introduction of a 5MHz Red-Cap device is contentious. Before considering pursuing such a direction, a study is necessary to determine if the cost and complexity reductions are justifiable and if the specification and deployment impacts are reasonable. We need to be careful with further reduced BW operation as the specification complexities can be quite significant as can be seen in the ongoing Rel-17 discussions on RedCap BWP operation. Such a study should also investigate other means to reduce device cost/complexity without significant specification changes. These can include reducing UE peak data rates as well as UE processing timelines, which should be seen as alternative solutions to BW reduction.

Lower UE power class

It is quite clear from earlier discussions that operators will not accept an objective on lower UE power class without including coverage compensation. Having looked at the impact of coverage compensation for these power classes, it is quite clear that this is no longer a 'low hanging fruit' to pursue. We are ok to drop this objective from the WI.

21 – InterDigital Communications

We support the objectives. Reduced BW is important to enable NR to support more IoT oriented scenarios.

22 – Huawei Tech.(UK) Co.. Ltd

We share the views that a study phase seems unnecessary for 5 MHz UE bandwidth. The concerns from some operators represent a design constraint which can be reflected in normative WID text, just as was done for Rel-17 RedCap.

A lot of low data rate IoT use cases are quite cost-sensitive and this is the main reason that NR does not have competitive lower cost UE than LTE to help industries select 5G-NR. Sometimes, even though NR is better than LTE UE in terms of power saving, customers still hesitate to pay for it since the UE complexity/cost is the most important factor if LTE also suits. It is essential that RedCap evolution enables a new NR UE which has lower cost than LTE Cat1/1bis for the corresponding IoT markets. Different to LTE, NR's framework can support various bandwidths from Rel-15 onwards. NR also has a very flexible air interface with a forward-compatible design, and already supports a wide range of channel bandwidths down to 5 MHz. We believe it is the right time to reshape the market with a 5 MHz NR UE, and this is not a market

fragmentation to Rel-17 RedCap since Rel-17 cannot address this market due to higher complexity/cost than LTE Cat1/1bis.

Second, for the above bullets, it is unclear what is the meaning of 'compatibility with Rel-17' and why it is needed. Looking back for Rel-17 RedCap WID, there is no such objective to say "compatibility with Rel-16/Rel-15" and obviously Rel-17 RedCap is not compatible with Rel-15/Rel-16. Thus, we think it should be deleted to follow the same principle as Rel-17.

Overall, we think the corresponding bullets could be written as follows and RAN1 should be the lead working group. There should be no involvement for SA/CT.

− ***Complexity reduction***

○ *Specify further reduced UE bandwidth of 5 MHz together with peak data reduction*

Note: Strive to minimize impact on the network and specification.

For lower power class, we don't see the urgency, and this should be lower priority than 5 MHz UE. If it is supported, we prefer to accept the consequence is coverage loss compared to normal power class, rather than setting a target to compensate the coverage loss.

23 – ZTE Corporation

In FR1, 20MHz bandwidth for RedCap actually can provide quite a large peak data rate, up to 170Mbps for DL. There is still some room for peak data rate reduction and cost/complexity reduction. For the SCS=15KHz, SSB reception is still compatible. However, for the larger subcarrier spacing case, the SSB reception may need further evaluation. Therefore, we are OK to have a SI to further confirm the spec impact, and also together with the coexistence issue, cost/complexity reduction gain, etc.

Considering there exists the indoor coverage scenarios, the lower power class UE also can be considered for RedCap. However, it is not expected that the further coverage enhancement for lower power class UE is also considered in Rel-18, since the NW impacts e.g., NW capability, are not expected.

24 – ZTE Corporation

Low-power wake up signal is beneficial for power saving, which is quite attractive especially for RedCap UE. However, besides RedCap UE, the low-power wake up signal should also be used for other kind of UEs. Therefore, it should be viewed as a generic technique and discussed in a separate SI.

Additionally, to complete the evaluation for low-power wake up signal, the following also should be considered:

- Detection performance, e.g., false wake-up rate, missing detection rate, synchronization performance
- Inter-cell interference.
- Traffic model impacts on the performance.
- Cost increase by introducing additional hardware.

25 – Fraunhofer IIS

Fraunhofer A lower UE power class could potentially reduce the hardware requirements of RedCap UEs. This feature would be primarily beneficial for small cells or industrial campus networks where coverage is less of an issue.

For further reduction of the UE bandwidth, we would like to note that it is important that RAN is clear about the exact aim of the bandwidth reduction; Is it just considered as feature to reduce complexity of RedCap devices in general or does it aim at new market opportunities for RedCap (e.g. like train control systems with narrow available bandwidth)? Or both?

The recommended spectrum for GSM-R in Europe (CEPT) has a bandwidth of 4 MHz. We would like to discuss with companies whether 4 MHz would be a suitable lower bound for RedCap devices.

26 – Everactive

Lower UE power class is important for managing the power consumption, in particular on a device powered by harvested energy. There should also be a mechanism for the UE to put a limit on the transmit power class, in cases when stored energy is very low and high power class can not be supported (because it would deplete all energy).

27 – Apple Poland Sp. z.o.o.

Apple

We support the 1st objective. We share the view that the benefit is clear in terms of cost reduction based in the cost analysis framework established in Rel-17 and support to start from a WI objective by changing 'study' to 'specify'. This should be RAN1-led, RAN2/RAN4-second

In addition, 'UE processing timeline relaxation for both data and CSI' should be added as separate WI objective to reduce power consumption for low-end Redcap devices. This should be RAN1-led, RAN2/RAN4-second.

28 – Qualcomm Incorporated

Further UE BW reduction down to 5MHz is expected to provide sufficient cost saving gains with relatively limited system/network impacts. And as commented in section 2.1, UE BW reduction can expand the NR market towards even lower tier use cases. At least, we should start the study item at the beginning of Rel-18 to study the benefits and potential impacts of 5MHz operation more precisely and corresponding work item should follow within Rel-18 time frame. RAN1 is a leading WG and RAN2/4 impacts are expected.

In current objectives, the bullet addressing potential impacts should be further clarified as network and UE impacts overlap with other impacts.

Study further reduced UE bandwidth of 5MHz, especially considering

- **expected UE complexity/cost reduction based on Rel-17 evaluation methodology**
- **network impact, ~~compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs,~~ UE impact, specification impact**
- **other solutions for reducing the UE peak data rates**

Support for lower UE power class should be deprioritized while we focus on the study of UE BW reduction during the study item phase.

29 – Sony Europe B.V.

These enhancements are not a priority for us, given the potentially limited available TU. We would also like to avoid market fragmentation from having different categories of Redcap device.

30 – Telstra Corporation Limited

Both reduced BW and lower power classes are clearly problematic and should be down-prioritised. However they could be studied if spare TU's somehow appear

2.4 Study on low power wake-up receiver / signal

The RWS discussion in Sep. concluded on the following [RP-212221]:

- **Study low power wake-up receiver / wake-up signal (WUR/WUS)**
  - ***The study should target ultra-low power WUS/WUR required by RedCap use cases. The specified solutions shall not be limited to RedCap UEs only.***
  - ***As opposed to the work on UE power savings in previous releases, this study will not require existing signals to be used as WUS. Solutions should give justifiable gains compared to the existing Rel-16/17 UE power saving enhancements.***
  - **Objectives:**
    - **Study use cases, evaluation methodology & KPIs, and compatibility with other UE power saving solutions**
    - **Study and evaluate low-power wake-up receiver architectures**
    - **Study and evaluate wake-up signal designs to support wake-up receivers**
    - **Study and evaluate protocol changes needed to support wake-up receivers**
    - **Study potential system impact, such as network and other UE's power consumption, coexistence with R17 RedCap and non-RedCap UEs, network coverage**

Please provide your views on the above objectives. Please comment on the involved WGs and whether an objective is anticipated to have SA/CT impact.

Based on the Sep. outcome, the moderator proposes that this area targets a full-release Study Item with RAN1 as the primary lead WG and RAN4 secondary. It is the moderator's understanding that such study could even investigate non-OFDM waveforms as WUS.

Feedback Form 4: Views on the Study on low power WUR/WUS

1 – vivo Communication Technology

1. On high level planning, we support the moderator proposal to target a full-release study item for low power WUR/WUS due to the fact that new receiver structure and new signal are likely to be studied to achieve the large power saving gain. And we have not identified any SA/CT impact in the study item

phase. Regarding the leading group, it is reasonable to have RAN1 as the primary WG and RAN4 as secondary, additionally, we think RAN2 may also be involved in the later phase of the study item to study the potential impact/interaction to the higher layer protocol, e.g. paging procedure, measurement procedure and mobility management, etc.

2. Regarding the 1st sub-bullet, we propose the following revision to align the text as previously endorsed in RP-212608

The study should primarily target ultra-low power WUS/WUR required by RedCap use cases. The study/specified solutions shall not be limited to RedCap UEs only.

3. Regarding the use cases objective, it is our understanding that the study is not limited to stationary devices only and what mobility scenario would be prioritized can be discussed during the SI. Hopefully companies have the same understanding. And the responsible group for the use case objective should be RAN1

4. Add responsible group RAN1 and RAN4 to the objective of receiver architecture study.

5. For the study of wake-up signal design, the responsible group should be RAN1.

6. For the study of protocol changes, the responsible group for this protocol changes study should be RAN1 and RAN2.

7. For the last objective, we would like a clarification on the evaluation of "**other UE's power consumption**", is the intention to consider the potential false alarm issue if the wake-up signal is designed as group specific?

2 – Nokia France

If there is sufficient capacity for this in Rel-18, then we agree with the Moderator's proposal to target a full-release SI with RAN1 as lead and RAN4 secondary. RAN2 would also most likely need to be involved.

3 – Guangdong OPPO Mobile Telecom.

OPPO

The non-back ward compatible WUS signal is general assumption for WUS. We did not a lot enhancement based on NR channel for WUS. Now, only much more different signal procedure can meet the lower power consumption target.

The RedCap UE is not necessarily the only use case.

4 – Futurewei Technologies

As stated, the WUR/WUS is a study objective using targets developed in the power savings work item. Since the objectives involve evaluation of signal designs and architectures, RAN1 should lead the study efforts on all items. For protocols, RAN2 should lead the study efforts.

Because the WUR / WUS can be applied to all UEs, not just RedCap UEs, our preference is still a general focus SI with RedCap included as a use case, with a common or easily accommodated solution for RedCap.

5 – Sierra Wireless

Agree with the proposal. However, this looks like it will consume a lot of TUs so we should think about ways to descope. Also since all UEs should be supported, a separate SI could be better choice as TU budgets would be easier to manage.

SI should be led by RAN1 and RAN4 and RAN2 secondary.

6 – CATT

Considering that the low power WUS/WUR is not limited to RedCap UE, a separate study item is preferred. RedCap can be part of the justification in the scope.

Agree with moderator that sufficient study should be ensured for low power WUS/WUR. A full release study is reasonable. RAN2 should also be an involved secondary WG since higher layer protocal is likely to be modified (e.g. for paging).

7 – Xiaomi Communications

Xiaomi

we agree with the Moderator's proposal to target a full-release SI with RAN1. And support to set it as a separate SI.

8 – Samsung Electronics Polska

We suggest to discuss on the target traffic patterns, either listed in justification part, if can be agreed, or as part of the study, e.g., "study use cases **including the traffic**, …..".

We like to discuss on the **synchronization assumption** for this WUS detection, either listed in the objectives or add a discussion point of the scope.

Regarding on non-OFDM waveforms, we suggest to clarify whether it is in the scope or not during WID drafting phase, to avoid the debate in working group. Although non-OFDM waveforms may be a good candidate for WUS, we have some concerns on the TU and RAN 1 capacity to finish the study.

Besides, we like to clarify that sequence based WUS, e.g., WUS for NB-IoT/eMTC, or sequence-based WUS solution as discussed in Rel-17 , is also within the scope of this study. Based on the discussion in Rel-17, some companies believe sequence-based solution can provide significant power saving gain, especially for long DRX cycle.

Moreover, we think LP WUR can be used to all type of UEs. Therefore, we prefer a separate SI instead.

9 – Spreadtrum Communications

1. For the study target, we share the similar view as vivo. In our view, the LP-WUR can be also applied to non-RedCap UEs, since RedCap UEs and non-RedCap UEs have the similar requirements or characteristics in the idle/inactive mode while using the LP-WUR. We support vivo's revision.

2. For the "architectures" part, we think we should address the feasibility of the architectures, including performance (MDR/FAR usually as metric in power saving) and cost. In our view, if we use the front-end based receiver, the front-end may need to be optimized to meet the performance requirements which in turn raise the cost. The architectures can be studied by RAN4 and RAN1 both. Therefore, we suggest "Study and evaluate low-power wake-up receiver architectures with performance requirements, power consumption and cost."

3. For the "wake-up signal design", we think the WUR related PHY signal/channel and procedure should be addressed. Therefore, we suggest "Study and evaluate PHY signal/channel and procedure designs to support wake-up receivers".

4. For the "protocol changes", as mentioned by vivo, the higher layers behaviors should be studied, e.g. measurement relaxation, mobility issue for WUR. Therefore, we suggest "Study and evaluate higher layers changes needed to support wake-up receivers".

10 – Intel Corporation (UK) Ltd

[Intel]

A separate SI, as suggested by the moderator, is appropriate in our view. The listed objectives sound reasonable as well.

Two additional points to note regarding the scope of the study:

- The study itself should consider both RedCap and non-RedCap. We should not study only for RedCap UEs and expect that the solution can be applied to non-RedCap UEs as is. While a unified solution is most desirable and expected, different adaptations can be expected between non-RedCap and RedCap UEs (including 5 MHz UEs, assuming their introduction in Rel-18).
- The study should be limited to no-to-low mobility scenarios.

RAN1 should be the leading responsible WG for this SI, with RAN2/4 as secondary WGs.

11 – NTT DOCOMO INC.

We are supportive of the overall structure to target a full-release study item for low power WUR/WUS.

For ”compatibility with other UE power saving solutions”, we suggest clarifying the intended solutions, such as those specified in Rel-16/17 power saving WIs (WUS and PEI).

Regarding the leading WG, this study should be led by RAN1 as primary WG and RAN2 as secondary WG.

12 – Sequans Communications

We agree to have a separate SI for low power WUR/WUS, rather than limiting the specification to REDCAP UEs

13 – Lenovo (Beijing) Ltd

We are fine to study low power WUR/WUS, and we are fine to have the study in RedCap, although finally the solutions can be used for non-RedCap UEs as well. In the objectives, it might be good to clarify the lower power WUR/WUS is targeted for which UE state (IDLE/INACTIVE/CONNECTED).

14 – Panasonic Corporation

We think the above is reasonable, but it could be different time schedule compared with the other topics. Therefore, to separate work item or to merge with the discussion with ”RAN94e-R18Prep-28 Passive IoT” would be more reasonable.

15 – LG Electronics Inc.

We share view the Moderator that this area targets a full-release Study Item with RAN1 as the primary lead WG. But, as we expect this study to take a lot of efforts and time, and also the scope of the study doesn’t have to stay within the context of RedCap, we think this low-power WUR/WUS, once there is enough consensus, should be treated as a *separate* full-release SI, rather than as part of the Rel-18 RedCap SI/WI.

16 – China Mobile Com. Corporation

we are generally fine with the objectives of WUR/WUS. We agree with other companies that the study has a large scope and it is applicable to all kinds of UEs, so a separate SI lead by RAN1 is needed, RAN2 can be secondary WG.

17 – VODAFONE Group Plc

We support work in this area. We see that the main devices that would benefit are Redcap devices, but, the solution would be applicable to all devices. As this study is really independent of the Redcap 5 MHz study, having a standalone SI seems logical.

18 – Ericsson LM

In our view, the objective listed in Sept. discussion looks good. RAN1, RAN2, and RAN4 would be the involved WGs.

A few things to emphasize further:

- Low power WUS/WUR should be targeting IoT use cases (smartphones already addressed in Rel-17 PEI)
- It is preferred to agree on some fundamental design principle before the study starts, e.g., that new WUS should maintain orthogonality of OFDM signal, and that unlike Rel-17 PEI the WUS is not PDCCH-based to enable lower power WUR.
- The study objective should consider all RRC states, i.e., RRC*IDLE, RRC*INACTIVE, and RRC_CONNECTED.
- KPIs and evaluation should include, e.g., balance/tradeoff between coverage vs. power consumption and false alarm probability vs. power consumption.
- Macro coverage could be considered as a requirement of the study.

19 – CEWiT

We agree with objective 2.4 and share similar view with vivo Communication Technology. For the point 7 in vivo's comment, in our understanding "**the impact on other UE's power consumption**" includes potential false alarm issue and any process done by active UE in trying to decode the broadcasted WUS from the connected BS.

We agree with the Moderator's proposal to target a full-release SI with RAN1 as lead and RAN4 as secondary. The investigation on non-OFDM waveforms as WUS comes under study of wake-up signal design, hence no need for explicit representation.

20 – MediaTek Inc.

We agree with the rapporteur's suggestion, i.e. if LP-WUR is to be investigated in Rel-18, it has to be an independent full-release study item. RAN1 can be the lead WG, along with RAN2 and RAN4 involvement.

21 – InterDigital Communications

We agree with the proposal; objectives look reasonable. Since the WUS does not need to be based on existing signals and/or waveforms, a study phase is required.

22 – ZTE Corporation

Sorry for the wrong place. The additional reply in section 2.3 should be copied here.

Low-power wake up signal is beneficial for power saving, which is quite attractive especially for RedCap UE. However, besides RedCap UE, the low-power wake up signal should also be used for other kind of UEs. Therefore, it should be viewed as a generic technique and discussed in a separate SI.

Additionally, to complete the evaluation for low-power wake up signal, the following also should be considered:

- Detection performance, e.g., false wake-up rate, missing detection rate, synchronization performance.
- Inter-cell interference.
- Traffic model impacts on the performance.
- Cost increase by introducing additional hardware.

23 – Huawei Tech.(UK) Co.. Ltd

- We also think the study on low power WUR/WUS should be a separate SI. The low power WUR/WUS should be a general solution for different UE types, e.g. eMBB UEs, RedCap UEs etc. Therefore, we would like to propose the following modification:

The study should target ultra-low power WUS/WUR required by ~~RedCap use cases~~ ***e.g. eMBB and RedCap use cases.*** *~~The specified solutions shall not be limited to RedCap UEs only.~~*

- For "***this study will not require existing signals to be used as WUS***", we think it may help to say that existing signals are also not from the beginning precluded:

As opposed to the work on UE power savings in previous releases, this study will not require ***and not preclude*** *existing signals to be used as WUS.*

- The last bullet is a bit vague on network side description, suggest to make it clear to distinguish the UE and network side.

Study potential system impact, such as network and other UE's power consumption, coexistence with ***~~R17~~*** *RedCap and non-RedCap UEs, network* ***impact e.g.*** *coverage****, overhead, etc.***

- For "**Study and evaluate wake-up signal designs to support wake-up receivers**", in our view to enable wake-up receivers, the necessary functionalities that can be carried by the signal, e.g. for UE synchronization, should also be studied. We also agree with others that the procedures should also be included. Therefore we suggest the following modification:

Study and evaluate wake-up signal designs, ***and functionalities carried by the signal and related procedures*** *to support wake-up receivers*

- On moderator's understanding of "this area targets a full-release Study Item with RAN1 as the primary lead WG and RAN4 secondary" in the last paragraph, since the current objectives include "**Study and evaluate protocol changes needed to support wake-up receivers**", we think RAN2 should also be involved.

- On moderator's understanding of "non-OFDM" in the last description part, we are not sure about the exact meaning for non-OFDM waveform. For example, if an OOK/ASK signal generated based on CP-OFDM signals (like WiFi), is it non-OFDM waveform or not? Better to clarify why moderator mentions this and what is the common understanding. From a system coexistence perspective, we think CP-OFDM for WUS could be maintained.

We share the similar view as some other companies that this study should **not** be limited to low mobility/stationary devices. During the study, we should investigate how to support mobility.

24 – Fraunhofer IIS

Fraunhofer We support a study of energy harvesting as part of RedCap. Energy harvesting is extremely beneficial for industrial sensors in particular. Results of the study on WUR/WUS should be usable by non-RedCap devices as well.

25 – Everactive

Everactive agrees with the overall list of objectives outlined here.

The use of the ULP receiver should be broadened from simply "wakeup". The message transmitted to an ULP receiver could include a full packet structure, with synchronization, payload, error correction, and security. We should think of this as a stand-alone receiver that can operate without any support from the main communication radio.

We propose the following additions:

- Selectivity requirements placed on the ULP receiver should also be considered. This is driven by the proximity in frequency of adjacent channels or sub-carriers, and the relative strength of those signals.
- This study item should consider the timing requirements and synchronization of the signal for the ULP receiver. The accuracy requirement (in ppm) of a local crystal oscillator is inversely proportional to power consumption, and should not be so precise that this LO then dominates the power of the device.
- Investigate how an ULP receiver could be used to reduce the power of positioning to address the asset tracking use case.

26 – Apple Poland Sp. z.o.o.

We support the moderator's proposal to have a full-release study item for LP WUR, because this is a brand-new topic and requires a lot of investigation on the new signal/receiver design and power evaluations etc. It is reasonable to be a RAN1-led item, with RAN4 and RAN2 as secondary WGs. We do not see any SA/CT impact at this point.

Regarding "The study should target ultra-low power WUS/WUR required by RedCap use cases", our view is that the study should consider both RedCap and non-RedCap UEs, and investigate the applicability in different use cases.

UE power consumption evaluation should be included as one of the objectives (even though it is obvious).

For evaluation methodology & KPIs, it would be good to mention that we reuse the methodology in TS 38.840 when applicable.

It is not clear what "compatibility with other UE power saving solutions" intends to cover.

27 – Qualcomm Incorporated

We support having a full-release study item for low power wake-up receiver/signal which would be a separate SI from Rel-18 RedCap evolution. In the study item, we need to study the applicability of WUS to different UE types including Redcap, non-Redcap, etc. In doing this, different UE types and associated use cases, performance requirements, possible WUR architecture and WUS design options all need to be jointly considered/studied. This means that the study item should not prematurely target identifying a unified solution for all use cases/device types. We think the design requirements for WUR/WUS for stationary ultra low power/low cost IoT device could be different from that for eMBB with high mobility.

We suggest following modifications on the objectives:

- Study evaluation methodology & KPIs for low power WUR/S [RAN1, 4]
- Study use cases, performance requirements, different device types, WUR architecture/WUS design options jointly. [RAN1, 4]
- Study and evaluate low-power wake-up receiver architectures [RAN1, 4]

- Study and evaluate wake-up signal designs to support wake-up receivers [RAN1]
- Study and evaluate PHY/MAC protocol changes needed to support wake-up receivers covering both idle mode/connected mode [RAN1, 2]
- Study potential system impact, such as network and other UE's power consumption, coexistence with R17 UEs, network coverage, compatibility with other UE power saving solutions [RAN1]
- Study and evaluate performance of WUR/S design including comparison w.r.t existing solutions such as R17 PEI in idle mode and R16 WUS for connected mode [RAN1]

28 – Sony Europe B.V.

We support this proposal. The ultra low power WUR / WUS feature should not be limited to Redcap UEs, but should be generally applicable, as stated in the proposal.

We support that this work may require a full-release study item. RAN1 would be the primary lead WG with RAN4 as a secondary WG. There would also need to be some RAN2 involvement when handling protocol changes.

29 – Telstra Corporation Limited

We also support the proposal, in particular comments from Ericsson & Vodafone.

2.5 Initial Round summary and moderator recommendation for further discussion

2.5.1 RedCap justification and background

Most companies agreed that the RedCap evolution should target lower UE power consumption and lower UE complexity/cost. This should enable new use cases but also improve the existing ones. Most companies wanted to go as low in UE capabilities as LTE Cat1/1bis and avoid an overlap with eMTC/NB-IOT solutions. It was commented that the justification can be based on the justification of Rel-17 RedCap, which primarily targeted industrial / sensor, smart city / video surveillance, and wearable use cases. **The moderator proposes to continue discussing the justification of a RedCap evolution WI and invites for concrete text proposals in the intermediate round. See section 3.1 for more details.**

Most companies agreed that the lead WG should be RAN1 with RAN2 secondary. Other WGs maybe involved as well depending on the exact objectives.

Many companies agreed that the RedCap evolution can be a Work Item directly but it was also argued that some of the objectives (i.e. reduced UE BW and energy harvesting) should better be handled in a (separate) SI instead of a study phase inside a RedCap WI.

Most companies agreed that a low-power wake-up signal/receiver should be studied separately.

2.5.2 Power saving / energy efficiency enhancements

The Rel-18 eDRX enhancements were widely supported and seems to be stable. One company thought that the proposal can still be specified in Rel-17. The main concern was on the involvement of SA2 and CT1, which is needed to complete the specifications. **The moderator proposes to note the need for SA/CT**

involvement & commitment and (t)ask the RAN/SA/CT leadership to consider it in their alignment.

Many comments were posted on the proposed enhancements for energy harvesting. Most companies found it interesting and important but many proposed to study it outside of the RedCap WI as it would require a more general study. Many saw a relation of energy harvesting with the discussion thread [RAN94e-R18Prep-28 - Passive IoT]. However, as area 28 is ”for the purpose of better understanding” [RP-212608], it may result in a situation where enhancements related to energy harvesting will be out of Rel-18. **The moderator proposes to continue shaping the corresponding objectives and decide on its final home after the Rel-18 areas 05 and 28 get more stable, i.e. at the RAN#94e. See section 3.2 for more details.**

2.5.3 Complexity / cost reduction

Regarding the reduction of UE bandwidth, the discussion reiterated the known and extreme positions of companies either not wanting to reduce the UE bandwidth to 5MHz at all or to start a WI directly. Hence, the moderator believes that the current study proposal is a good middle ground and proposes to continue the discussion on the proposed study objectives. The main question is whether we go for a SI+WI or a WI with a study phase. On a more detailed technical level it was commented that the description should be clearer on alternative solutions to a reduction on RF. **The moderator proposes to continue shaping the corresponding study objectives and whether it should become a Study Item or a study phase.**

Introducing a lower UE power class was of lower priority for some companies. And it was preferred by some companies to state the exact power level. It seemed common understanding that the introduction of a new power class would not result in work on coverage extension but that the new power class would only be used in non-coverage-limited scenarios such as indoors. **The moderator proposes to continue shaping the corresponding objective. See section 3.3 for more details.**

2.5.4 Study on low-power wake-up signal / receiver

Most companies agreed that a low-power wake-up signal/receiver should be studied separately and that the SI should cover the entire Rel-18.

Most companies agreed with the proposed structure of SI objectives in general, incl. the primary (RAN1) and secondary WG (RAN4) and other WGs (RAN2) being involved. Most companies also agreed that the primary target should be RedCap/IoT use cases. However, a few companies wanted to add eMBB use cases with equal priority but it was also commented that this would likely result in multiple different, application-specific WUS/WUR designs. **To avoid fragmentation and to control the workload, the moderator proposes to continue focusing the SI primarily on IoT use cases. In the intermediate round, the moderator proposes to continue shaping the SI objectives and to work on the justification. See section 3.4 for more details.**

3 Intermediate Round

3.1 RedCap justification

Based on the initial round summary in section 2.5.1, please provide concrete text proposals for the justification part of a RedCap Evolution WI.

Feedback Form 5: Comments on the justification of a RedCap Evolution Work Item

1 – China Mobile Com. Corporation

Use cases of R17 RedCap focus on Industrial wireless sensors of connected industries,Video surveillance of smart city, Wearables. During the R17 SI and WI, cost/complexity reduction has been studied and specified. For R18 study, the design can be further enhanced to better satisfy the three use cases, especially for long battery life, and cost/complexity reduction if the gain is justified. And more use cases that require further cost/complexity reduction and power saving / energy efficiency enhancements can also be considered to construct a rich ecosystem. However it should be noticed that LTE-M or NB will still be there for a long time, without additional coverage extension for RedCap, and also considering the higher cost of NR devices, it is unlikely to replace LTE-M or NB by RedCap. So the intention of RedCap design should be use cases that cannot be satisfied by LPWA rather than overlapped use cases.

2 – Nokia France

In line with CMCC's explanation above, we suggest a full text proposal for the justification section of a RedCap Evolution WID:

Rel-17 introduced support for reduced capability NR devices, enabling the advanced features and spectral efficiency of NR to be available for devices that do not require the full high data rate capabilities of NR. Such devices include those for video surveillance, industrial sensors and wearables.

The Rel-17 "RedCap" devices have a number of simplifications to reduce cost and complexity, including a reduced maximum bandwidth (20 MHz for FR1 and 100 MHz for FR2), potentially reduced number of Rx branches, and HD-FDD operation. Signalling is also defined to enable the network to be aware of RedCap devices and their capabilities and to control their access to the network.

Considering the outcome of the Rel-17 work, a market gap exists between the capabilities of the Rel-17 RedCap devices and the existing LPWA technologies of eMTC and NB-IoT, roughly corresponding to the peak data rates of LTE Cat-1bis devices, and targeting use cases such as low-end surveillance cameras, industrial/medical sensors and wearables. Additionally, reduced power consumption is important to consider.

For these use cases, further reductions in device cost, complexity and power consumption are needed.

This evolution should build on the Rel-17 "RedCap" ecosystem, including principles of network awareness of device capabilities.

3 – FirstNet

Rel-18 RedCap devices embedded in a First Responder Personal Protection Equipment (PPE) shall be individually identifiable with its wearer with at least 1-week long battery life effective for at least 10 mile signal transmission from the receiving unit or same range as that of a non-RedCap UE.

4 – Sierra Wireless

Our suggested justification text proposal:

Rel-17 introduced support for reduced capability (RedCap) NR devices, enabling the advanced features and spectral efficiency of NR to be available for devices which do not need to meet the Rel 15/16 minimum UE requirements. Targeted use cases included: video surveillance, industrial sensors, and wearables.

The Rel-17 "RedCap" devices have a number of simplifications to reduce cost and complexity, including a reduced maximum bandwidth (20 MHz for FR1 and 100 MHz for FR2), potentially reduced modulation,

potentially reduced number of Rx branches, and potentially HD-FDD operation. Signaling was also defined to enable the network to be aware of RedCap devices and their capabilities and to efficiently control their access to the network.

To help better address the video surveillance, industrial sensors, and wearables market, improvements in power consumption and reduction of cost are justified while considering economies of scale, backward compatibility, network awareness of device capabilities, and spectral efficiency.

5 – Intel Corporation (UK) Ltd

[Intel]

For justification part on the introduction of 5MHz RedCap, we suggest the following (from our input to previous round).

While offering potential reduction in device cost/complexity and power consumption compared to eMBB or URLLC/IIoT use-cases, Rel-17 NR RedCap offers a considerable over-design in terms of device cost/-complexity or power consumption for IoT use cases with relaxed requirements on QoS (data rates, latency, reliability) but with higher sensitivity to cost/complexity and power consumption.

Thus, the primary motivation for evolution of RedCap in Rel-18 is to address new and existing use-cases with lower device cost/complexity and power consumption to cater to use-cases with significantly reduced data rate requirements (e.g., peak rates of a few Mbps) compared to Rel-17 RedCap (peak rates 80+ Mbps). Such evolution can pave a path for eventual migration of LTE-based solutions for low-to-mid-tier cellular IoT use cases, e.g., wireless sensors, low-end wearables, surveillance and alarm systems, tracking devices with mobility support, etc., from Cat 1, Cat 1bis to NR-based solutions.

6 – Spreadtrum Communications

Our text proposal for the justification part:

The 3GPP Rel-17 RedCap is an important step to further expand 5G NR market. The use cases include wearables, industrial wireless sensors, and video surveillance, while the capability/supported peak data rate of Rel-17 RedCap is based on the requirements of wearables which is obviously overdesigned.

Considering the industrial transformation and digitalization, the explosive growth in vertical/industrial market can be expected in the near future. As vertical use cases are usually sensitive on the cost and the power consumption, these two KPIs should be motivation to achieve large scale effect for Re1-18 RedCap. Rel-17 industrial wireless sensors and the new use cases or applications for vertical/industrial scenario should be Rel-18 RedCap design target to further reduce the supported peak data rate (hence the cost) and the power consumption.

The following categories of vertical use cases can be considered for Rel-18 RedCap.

- One important objective of RedCap is to enable factory automation, in addition to industrial sensors introduced in Release 17, it is desirable to control these machines, machine tools or packaging machines. As described in TS 22.104, the industrial controller is also a relatively low-end services with the requirement of small device form factors. The peak date rate of this case can be very small (e.g., less than 2 Mbps) but the reliability requirements are very high.
- Smart Grid services today rely upon a range of telecommunications services, which are delivered through a blend of private networks and commercial PLMN network. The use cases of distributed energy storage, advanced metering, distributed feeder automation in TR 22.867 potentially are the new demand for RedCap. The characteristic for these use cases is that the data rate requirements is very low, and the UL traffic is larger than DL.

For potential new use case specific requirements:

- Industrial controller: KPI is to be confirmed in Study phase
- Distributed energy storage: KPI is to be confirmed in Study phase
- Advanced metering: KPI is to be confirmed in Study phase
- Distributed feeder automation: KPI is to be confirmed in Study phase

7 – Guangdong OPPO Mobile Telecom.

We think the RedCap enhancement should be also from the 3 basic use cases for Rel-17. In the justification, it could mention the Rel-17 RedCap use cases.

Rel-18 RedCap should further fully support the video surveillance, wireless sensor network, and wearable devices. The further enhanced power efficiency, lower complexity and lower cost are considered as the main directions of enhancement. Impact of the normal UE's performance, network coverage and backward compatibility should be well considered and balanced.

In addition the major use cases, the RedCap enhancement should also be well considered and applicable for other cases, e.g. eMBB.

8 – Qualcomm Incorporated

For general justification of RedCap evolution, we suggest capturing the following text proposal

————- text proposal ————-

Along with Rel-15/16 NR designs which mainly focused on eMBB and URLLC, reduced capability (RedCap) device was newly introduced in Rel-17 to efficiently support mid-range use cases including video surveillance, industrial sensors, and wearables by enabling reduced bandwidth, reduced number of antennas, and half-duplex FDD operations.

The platform of NR RedCap devices should be further evolved in Rel-18 towards even lower tier use cases in such a way to gradually expand its addressable market while leveraging Rel-17 design. Rel-18 RedCap evolution mainly targets low-tier sensors and wearables whose capabilities are between those specified for R17 RedCap devices and LTE LPWA devices.

The potential use cases for Rel-18 RedCap evolution are including but not limited to:

- Low-end wearables
- Asset tracking/monitoring devices
- Low-end wireless sensors

————————————————

In addition to the general justification, we also suggest including sidelink support for RedCap evolution. In September email discussions, a good number of companies supported inclusion of RedCap sidelink in Rel-18. But it was not correctly captured in the latest summary of either eRedCap or Sidelink threads possibly because of the assumption that nothing is needed to support sidelink for RedCap devices. However, we believe that this is not the right way to support sidelink in RedCap, and there are some critical enhancements which have to be employed to realize sidelink features in RedCap devices as given below.

Rel-17 NR lays the foundation for the support of connected industries using UEs with reduced capabilities and a small form factor. An important subset of use cases, e.g., data collection using sensors in a wide-area IOT network, however, is required to meet larger range and more stringent battery life requirements compared to those supportable by the direct UE-to-network communication. Extending SL relay to support redcap remote/relay UEs therefore is crucial to address the requirements of connected industries. Hence, in our view, the following enhancements are also of high priority and can be easily supported without much additional standards work. These should be considered in Rel.18:

- Sidelink for remote/relay RedCap UEs:
  - SL RedCap capability definition, identification, and negotiation
  - Relay discovery and (re)selection enhancements to consider RedCap capabilities
  - RedCap Remote UE Access control
- Additional power saving enhancements:
  - Support of eDRX/ SL DRX adjustment under SL relay (if not supported in Rel-17)

9 – NTT DOCOMO INC.

Aligned with Nokia and Intel that:

Rel-17 introduced support for reduced capability NR devices, enabling the advanced features and spectral efficiency of NR to be available for devices that do not require the full high data rate capabilities of NR. Such devices include those for video surveillance, industrial sensors and wearables.

The Rel-17 "RedCap" devices have a number of simplifications to reduce cost and complexity, including a reduced maximum bandwidth (20 MHz for FR1 and 100 MHz for FR2), potentially reduced number of Rx branches, HD-FDD operation, and potential reduction of maximum modulation order for FR1 DL. Signalling is also defined to enable the network to be aware of RedCap devices and their capabilities and to control their access to the network.

Considering the outcome of the Rel-17 work, a market gap exists between the capabilities of the Rel-17 RedCap devices and the existing LPWA technologies of eMTC and NB-IoT, roughly corresponding to the peak data rates of LTE Cat1/Cat1bis devices, and targeting use cases such as low-end surveillance cameras, industrial/medical sensors and wearables. Additionally, reduced power consumption is important to consider.

For these use cases, further reductions in device cost, complexity and power consumption are needed.

This evolution should build on the Rel-17 "RedCap" ecosystem, including principles of network awareness of device capabilities. Such evolution can pave a path for eventual migration of LTE-based solutions for low-to-mid-tier cellular IoT use cases from LTE Cat1/Cat1bis to NR-based solutions.

10 – Ericsson LM

We agree with the moderator that the justification can partly be based on the justification of Rel-17 RedCap, and further elaborated on further expanding the addressable use cases, especially those with relatively low cost, low energy consumption, and low data rate requirements.

Please find below the text proposal for the justification part (an updated version of our RAN#93 contribution (RP-212425 New WID on Enhanced RedCap) based on the moderator summary of the initial round discussion.).

Justification

5G aims to accelerate industrial transformation and digitalization, which improve flexibility, enhance productivity and efficiency, reduce maintenance cost, and improve operational safety. Industrial sensors play

an important role for realizing such a vision. Not only widely used in industrial automation and digitalization use cases, industrial sensors are also widely used in the general environmental monitoring use cases such as monitoring of critical infrastructure (e.g., buildings, bridges, water dams, etc.) or monitoring for natural disasters (e.g., wild fire, flood, tsunami, earthquake, etc.).

Another emerging new class of new 5G use cases is the smart city vertical, which covers data collection and processing to more efficiently monitor and control city resources, and to provide services to city residents. Especially, the deployment of surveillance cameras is an essential part of the smart city but also of factories and industries.

Furthermore, there have been increasing interests in wearables use cases such as smart watches, eHealth related devices, and medical monitoring devices. These use cases call for different design considerations and have different requirements in terms of form factor, UE complexity and energy efficiency, compared to eMBB devices.

The support of industrial sensors, video surveillance, and wearables were the motivations behind Rel-17 RedCap. Through the Rel-17 NR RedCap work item, 3GPP has established a framework for enabling reduced capability NR devices suitable for a range of use cases, including the industrial sensors, video surveillance, and wearables use cases mentioned above, with requirements on low UE complexity and sometimes also on low UE power consumption.

Now when the foundation has been laid in Rel-17, some enhancements can be considered to enable as efficient support as possible for the mentioned use cases and to widen the range of use cases that can be addressed without fundamental changes to the basic RedCap UE type defined in Rel-17.

Many industrial sensors use cases require a deployment of a massive number of sensors. Replacing the battery of each of these sensors might be prohibitively difficult or undesirable. In certain use cases, it might be difficult to access or even exactly locate the sensors after they have been deployed. Thus, for these use cases, a key enabler is to allow the sensors to sustain decades of operation without ever needing battery replacement. Furthermore, many of the sensor use cases operate in environments where it is possible to harvest ambient energy for operation. The harvested ambient energy may be, for example, vibrational energy, photovoltaic energy, thermal-electric generated energy.

Some of these considerations are also applicable to video surveillance and medical wearable use cases. For example, a video surveillance camera deployed outdoors may harvest solar energy. A medical wearable device may be able to harvest energy through vibration and it may be desirable that the patients do not need to replace battery themselves (i.e., battery lasts between office visits).

To further expand the market for RedCap use cases with relatively low cost, low energy consumption, and low data rate requirements, e.g., industrial wireless sensor network use cases, some further cost and complexity reduction enhancements can be considered. The enhancements can aim at supporting lower UE peak data rate and energy consumption compared to Rel-17, while ensuring Rel-17 compatibility.

To further expand the RedCap use cases, the following enhancements can be considered:

- **Improved UE power saving/energy efficiency**: An improved UE energy efficiency will help improve battery lives and may even enable battery-less operation in some cases, which may be a highly attractive property, e.g., for many sensor applications.
    - **Enable devices to operate on harvested energy**: In scenarios where the surrounding environment provides an opportunity to harvest energy, e.g., from vibrations, it may be possible to enable battery-less operation, e.g., for use cases where battery-driven operation is not feasible. To facilitate this, some protocol enhancements to support operation on intermittently available energy with potential variations of the amount of harvested energy and traffic can be studied.

- **Other UE power saving enhancements**: To support very low UE energy consumption, other UE power saving enhancements such as enhanced DRX longer than 10.24s in RRC_INACTIVE and cross-slot scheduling for paging can be considered.

- **UE cost/complexity reduction**: Further UE complexity/cost reduction without fundamental changes to the Rel-17 basic RedCap UE type may be motivated to enable the uptake of RedCap UE in low-end use cases.
  - **Study further reduced UE bandwidth**: There exist different solutions to support use cases requiring low cost and low peak data rates. One approach is based on further reducing maximum supported UE bandwidth, e.g., to 5MHz in FR1. There are trade-offs between expected cost/-complexity reduction, specification impacts, and network impacts, especially the compatibility with Rel-17, and coexistence of RedCap and non-RedCap UEs. It is not clear if the additional cost saving gain is justified and thus a study phase is needed. Other alternative solutions for lowering peak data rate such as reduced UE baseband BW for data channels, scaling factor for peak data rate, and TBS restriction can also be part of the study.
  - **Support for lower UE power class**: To support use cases requiring low cost and low energy consumption, 23 dBm UE power class may not always be suitable. Moreover, to facilitate devices operating on energy harvested from the ambient environment, definition of one or more lower UE power classes can be considered. When considering lower UE power class, some non-coverage-limited scenarios such as indoor can be assumed. If coverage recovery is needed, the existing coverage enhancement techniques in Rel-15/16/17 and possibly UL-cell edge data rate reduction may also be considered.

These enhancements can be introduced while maintaining the integrity of the RedCap ecosystem and maximizing the benefit of economies of scale. These enhancements can be introduced by having new firmware/-software running on the same baseband platform as Rel-17 RedCap.

This WI aims to specify enhancements applicable to the RedCap UE type and framework defined in Rel-17. Compatibility with Rel-17 network should be ensured, i.e., Rel-18 RedCap UEs should be able to fall back to Rel-17 behaviour in order to access a Rel-17 RedCap network.

11 – ZTE Corporation

Aligned with Nokia and CMCC, our suggested justification text proposal is shown as follows:

The Rel-17 “RedCap” devices have a number of simplifications to reduce cost and complexity, including a reduced maximum bandwidth (20 MHz for FR1 and 100 MHz for FR2), potentially reduced number of Rx branches, and HD-FDD operation. Signalling is also defined to enable the network to be aware of RedCap devices and their capabilities and to control their access to the network.

Rel-17 introduced support for reduced capability NR devices, enabling the advanced features and spectral efficiency of NR to be available for devices that do not require the full high data rate capabilities of NR. Such devices include those for video surveillance, industrial sensors and wearables. Moreover, the Rel-17 RedCap design for the data rate, complexity/cost and power consumption is beyond the requirements of industrial sensor and economic video surveillance, of which the data rate is no more than 5Mbps.

In Rel-18, main goal of the RedCap evolution is to further embrace low rate use cases, e.g., industrial sensor, and economic video surveillance or any other new use cases, to fulfill the market gap between the capabilities of the Rel-17 RedCap devices, e.g. wearables and high end video surveillance, and the existing LPWA.

- the target data rate for these use cases could range from 1M 10Mbps.

These use cases that require further cost/complexity reduction and power saving / energy efficiency enhancements can also be considered to construct a rich ecosystem.

12 – Samsung Electronics Polska

For power saving, eDRX can be a WI directly, led by RAN 2, as leftover of Rel-17. If all the rest of RedCap needs SI phase. We support to make this part separately as TEI.

For energy harvesting, the discussion can be combined to passive IoT. We don't think it is RedCap specific technique.

For further RedCap complexity reduction, clear justification/use case should be provided, including the target data rate. We expect something more than Rel-17, otherwise, it is not clear to us on starting another study item with the same justification/use cases. This should be a study item other than a SI phase in a WI. Some more discussion on whether/how to support further low cost RedCap is required based on the outcome of study item.

For LP WUS part, we think it can be a separated SI.

If there is no room for other objectives for Redcap, e.g., potential leftover from Rel-17 on separate BWP operation, we suggest this eRedCap to be a study item other than a work item with study phase.

13 – Sequans Communications

We agree with the lines of the text proposal suggested by Spreadtrum Communications. It is not clear to us the need to rush and replace existing 3GPP based technologies and to further fragment the market. Rel. 17 REDCAP compatible enhancements should be exhausted before further fragmentation is considered. Care should be taken not to impact the scale-dependent viability of Rel. 17 REDCAP solution.

14 – Huawei Tech.(UK) Co.. Ltd

The key justification for Rel-18 RedCap work is to facilitate all low-tier IoT use cases (other than LPWA) being enabled to transfer to or connect to 5G NR, by providing NR support between existing LPWA UEs and the capabilities of Rel-17 RedCap UEs. This motivates a particular focus on further reduction of NR UE complexity/cost, and power consumption. This will be achieved by enabling a new NR UE which is comparable in those terms to LTE Cat 1/1bis, with a peak data rate of approximately a few Mbps.

15 – Everactive

16 – Sony Europe B.V.

Without providing concrete text, we would like the justification to include focus on:

- Power consumption reduction of Redcap devices
- The need to eliminate (or reduce) the maintenance burden of dealing with battery operated devices. This has OPEX and sustainability benefits
- The desire for further complexity reduction, targeting an NR device with capabilities similar to LTE Cat1
- This project is not attempting to create another LPWA solution (that need is satisfied by eMTC and NB-IoT)

17 – Fraunhofer IIS

Fraunhofer We are fine with the general proposals by other companies and would also like to include the sidelink support for RedCap as mentioned by Qualcomm. This is vital for ensuring the support of new use cases for vertical markets, e.g., wearables and industrial sensors.

18 – Lenovo (Beijing) Ltd

One objective of RedCap in Rel.18 is further cost reduction for devices like industrial sensors, low-end wirable and economic videos, etc., which require much lower data rate (an example is that as defined in TR 22.832 and TS 22.104, the reference bit rate is less than 2 Mbps for all wireless sensors, while Rel.17 RedCap supports up to 150Mbps reference bit rate), while cost reduction is significant for wide deployment of such devices. Further cost/complexity breakdown specific for the low-end RedCap devices therefore needs to be studied.

Another objective is further power consumption, which is vital for RedCap devices that require ultra-long battery life. It is also noted for some RedCap devices, like battery-less sensors that harvest energy from environment, it is expected that even harsher requirement on the power consumption is needed.

3.2 RedCap power saving / energy efficiency enhancements

Please provide feedback on the objectives as updated after the initial round feedback:

Power saving/energy efficiency enhancements

- **Enhanced DRX in RRC_INACTIVE (>10.24s) [RAN2, RAN3, RAN4]**
  - ***Note that this objective requires SA2, CT1 involvement***
- **Enhanced support for energy harvesting from the environment (*TBD: whether this objective is part of a RedCap Item or part of area 28 "Passive IoT"*)**
  - **Identify use cases, incl. models of corresponding energy sources [RAN1, RAN2]**
  - **Study corresponding protocol enhancements to support operation on intermittently available energy harvested from the environment, e.g. efficient UE reconnect after power loss, reduced start-up and synchronization times [RAN2, RAN4]**
  - ***Note that how devices harvest and store energy is outside the scope of 3GPP***

Feedback Form 6: Comments on the objectives related to power saving

1 – China Mobile Com. Corporation

Fine with eDRX part.

For the energy harvesting one, the objectives are still unclear for us to start a new study.

- Firstly, the framework of energy harvesting should be based on NR framework and waveform. If not, it should be not be part of RedCap, may be part of [RAN94e-R18Prep-28 - Passive IoT]. With NR framework, the use cases study may also include definition of service traffic model, UE type, however, the UE type definition should not reopen bandwidth discussion.

- Secondly, for the protocol enhancement example, such as efficient UE reconnect after power loss, what is the intention for spec impact? Currently, UE can already provide its preferred RRC state such as idle, inactive when it is released from RRC connected. In our understanding, UE can report its preference for RRC inactive before it run out of power, and then it can recover fast when enough energy is harvested. What additionally can be done for this?

  And the definition of start-up time is also not clear, whether the reduced start-up and synchronization times can be realized by UE implementation? What is expected for network?

The above questions need to be answered first before we go to a study phase for energy harvesting.

2 – VODAFONE Group Plc

Agree with enhanced eDRX in RRC_INACTIVE. On the second part of the proposal, we believe that SA and CT should also be involved in the corresponding protocol enhancements

3 – Nokia France

The first bullet (Enhanced DRX) is OK as is.

The second bullet would only be a study (wherever it ends up), so it would be helpful to insert "Study" at the beginning of the main bullet: "Study enhanced support for …". CMCC also raises some good questions.

4 – Futurewei Technologies

For the enhanced-DRX objective, we should not put enhanced DRX in Rel-18 right now. We can assess the situation in December to see whether e.g., an exception can be used.

For energy harvesting, the study should be in Passive IoT and not here.

5 – MediaTek Inc.

eDRX

Ok with this draft objective

Energy harvesting

It should not be TBD whether this is part of RedCap. As several companies have commented in the first round (and above), this objective is orthogonal to the RedCap usecases and it should not be part of this discussion. The rapporteur has indicated that if this goes to the Passive IoT discussion, then it might not happen in Rel-18. However it is important that proposals are discussed in the correct forum based on their individual merit, and not be piggy-backed onto other discussions to improve their chances of being agreed.

6 – Sierra Wireless

The first bullet (Enhanced DRX) is agreeable.

Agree with CMCC questions and comments. Whether Energy harvesting is included here or Passive IoT does depend on the type of specification modification we are considering for study. If we only consider methods to efficiently "pause" e.g. a RRC connection or have more time between RRC messages and data messages to allow an energy harvesting to harvest energy, then I think it could be include here but the objective needs to be narrower. With that in mind may I suggest we just focus on the 2nd bullet with the following text proposal:

Study corresponding protocol enhancements to support UEs with intermittent operation e.g., longer timeouts, efficient UE reconnect, early identification, reduced start-up and synchronization times [RAN2, RAN1, RAN4]

- **Identify use cases, incl. models of intermittent operation corresponding energy harvesting [RAN1, RAN2]**
- **Note that how devices harvest and store energy is outside the scope of 3GPP**

7 – vivo Communication Technology

For serving cell RRM relaxation, there were four companies supported to include it in Rel-18 scope, while one company was against (since it was discussed in Rel-17 but not intoduced). However, as commented by multiple companies, there is no technical feasibility issue for serving cell RRM relaxation given LTE already support this feature. Therefore, we still woud like to include the serving cell RRM relaxation in Rel-18 scope, to make it simpler, we can accept to consider IDLE/INACTIVE mode only as a compromise.

We are fine with the current objectives on eDRX and energy harvesting.

8 – Intel Corporation (UK) Ltd

[Intel]

We are fine with the objective on eDRx enhancements. It would be good to get early confirmation from SA2/CT1 on whether they will support it in Rel-18 in order to avoid the same situation from Rel-17 happening again in Rel-18.

However, as elaborated already, on energy harvesting, we do not agree on having this objective as part of RedCap evolution. This would only distract the focus of the Rel-18 WI on RedCap while questions on basic justification remain unanswered. If at all, this can be considered as part of the discussion on "Passive IoT".

9 – Spreadtrum Communications

We are generally fine with the current objectives, in addition, as we commented in the first round, we still propose that serving cell RRM relaxation for semi-static UEs should be included.

10 – Guangdong OPPO Mobile Telecom.

We think the scope have too much on the power harvesting, and this apparently out of RedCap scope. Also see many other companies have the question.

We suggest to remove "**Enhanced support for energy harvesting from the environment (*TBD: whether this objective is part of a RedCap Item or part of area 28 "Passive IoT"*)** "

The following sub-bullet can be changed into:

"Identify power models of intermittent operation by energy harvesting [RAN1]"

If we start to define use cases it will fall into the area 28 and will also have SA involvement.

We expect this power model will be a quick study and more study should based on this. But how to harvesting and use case will take too much time.

The eRX is fine.

11 – Apple Poland Sp. z.o.o.

- The 1st objective is part of Rel-17 Redcap WI and being discussed in RAN2. Whether to include it into Rel-18 eRedcap WI is naturally subject to the progress of RAN2 in Rel-17 timeframe. Therefore, the conditional sentence '(if not completed in R17)' proposed by moderator should be added for 1st objective.

- On the 2nd objective, we observe that majority companies' preference is to handle it in either 'passive IoT' study item or a separate project since even the use cases are far from clear at this moment. This should be the outcome of the email thread. We do not see any justification to keep the 2nd objective and therefore prefer to remove the entire 2nd objective from Rel-18 enhanced Redcap WI.

12 – Qualcomm Incorporated

For eDRX (>10.24s) in RRC_INACTIVE, we are fine to have it under RedCap evolution. As RAN work is directly dependent on SA2 agreements, it is desirable to wait for SA2 design before making progress in RAN WGs. And we do not support this item as Rel-18 TEI since it has cross-WG impacts.

We see that topics related to energy harvesting are premature to be included in Rel-18 as we do not have clear views on use cases, spec impacts, and even justifications. We suggest deprioritizing energy harvesting in Rel-18 eRedCap.

13 – NTT DOCOMO INC.

We are fine with both objectives. Regarding the appropriate place for 2nd objective, we also think this can be discussed separately from RedCap items, and are fine to be included in Passive IoT.

14 – Ericsson LM

On Rel-18 eDRX enhancement (>10.24s in RRC_INACTIVE), we agree with the moderator proposal regarding the need for SA/CT involvement & commitment.

The updated objectives look fine to us. For the second bullet, it could perhaps be useful to further clarify that the study can focus on energy harvesting from the environment rather than harvesting from the RF signal. Any protocol enhancements would be based on the existing NR framework. In our view, one example of the aspects which can be considered is to make the gNB aware of that the UE is operating on harvested energy.

15 – Sequans Communications

We agree with Sierra Wireless proposal for study of energy harvasting UEs. We can consider discussing this topic either within eREDCAP or Passive IoT

16 – CEWiT

We are ok with the eDRX part.

Regarding enhancements related to energy harvesting:

For efficient use of available energy along with the fulfillment of the desired task in an optimal way, enhancement for L1 processes is necessary. Hence we suggest including the following sub-bullet

- Study L1 layer enhancement and processes to support efficient use of intermittently available energy harvested from the environment [RAN1]

Regarding the inclusion of energy harvesting objective in RedCap:

Red-Cap use cases such as stationary devices like industrial wireless sensors, video surveillance, and wearables can rely on harvested energy along with conventional batteries. Hence this Objective can be included

here. Else energy harvesting topic can be taken as a separate SI involving the use cases in both RedCap and passive IoT

17 – Transsion Holdings

eDRX

We are OK to this objective.

energy harvesting

It is more related to the 28 passive IOT, and it may be discussed in the passive IOT part.

18 – CATT

We are fine with eDRX>10.24s for RRC_INACTIVE and agree with Intel that early confirmation from SA2/CT1 is desirable to avoid the same situation as in Rel-17.

For the energy harvesting, we also think it should not be part of eRedCap in Rel-18. In addition, it seems quite difficult for RAN1 and RAN2 to identify the use cases and models.

19 – InterDigital Communications

We are fine with these objectives.

20 – ZTE Corporation

We are fine with the DRX part. For the energy harvesting, more clarification is needed.

- To avoid the duplicated discussion and obtain overall comprehension on this issue, we believe that this would be considered in the potential passive IoT item in the future. It is possible that the discussion for RedCap is not compatible with the discussion for passive IoT.
- If the energy harvesting and data transmission can independently/simultaneously work for a device type, we do not think any spec change is needed. If another type of device can only do energy harvesting or data transmission at one moment, due to the long time of energy harvesting, we understand that the communication after energy harvesting is similar to current shutdown and restart, and also no spec change is needed. Therefore, the motivation and necessity of spec change by e.g., efficient UE reconnect after power loss, reduced start-up and synchronization times, for energy harvesting need clarification.
- In order to define the use case and requirement more accurately, we think that we should first discuss it in SA1 rather than RAN1.

21 – Panasonic Corporation

On energy harvesting, our view is it should be in the passive IOT context. We are ok with eDRX.

22 – China Unicom

We are fine with the current objectives on eDRX. However, energy harvesting is more related to passive IoT.

23 – Samsung Electronics Polska

We support the eDRX part, which can directly go to WI phase. If the rest of RedCap scope requires study phase, we support VODAFONE's suggestion, i.e. to make a TEI instead.

For energy harvesting, it is not clear how this related to RedCap UE, which mainly focuses on complexity reduction. Moreover, the use cases, models are not clear so far, as well as the potential protocol impact. This should be better to fit in the discussion of passive IoT instead.

24 – ROBERT BOSCH GmbH

We support eDRX in RRC_INACTIVE.

We prefer energy harvesting remains in passive IoT discussion.

25 – LG Electronics Inc.

We can accept the first bullet on the eDRX with the SA/CT involvement.

For the second bullet, we don't see enough justification on studying the enhanced support for energy harvesting from the environment under Rel-18 RedCap when most of the companies think it is more relevant for LPWA or passive IoT which is not the target use case of the RedCap. So, we still think whether to study it for Rel-18 should be discussed separately, e.g., in the context of passive IoT, not in Rel-18 RedCap.

26 – Philips International B.V.

We agree with the proposed objectives. In particular, for the 2nd bullet point about energy harvesting/passive IoT devices we think that a SI or at least a study phase is required before the WI takes place.

27 – Huawei Tech.(UK) Co.. Ltd

For the first bullet of eDRX, it's technically from a RAN-only perspective. However, it is our understanding the main reason it is not completed in R17 is that SA/CT have different views. Thus it is unclear at this time whether such situation would be continue in Rel-18.

What is missing in the current moderator proposal is a place to look at all potential Rel-17 leftovers together at the appropriate time, i.e. in December. Thus, what is produced this week needs to include a placeholder for such a consideration, which would certainly also include eDRX.

For the second bullet of energy harvesting, we believe it shall be discussed in Passive IoT thread and especially for the new part stated as models of corresponding energy sources. We also noticed that in that thread there already be discussion about use cases and scenarios where devices are battery-less.

28 – Sony Europe B.V.

Support these objectives

29 – Everactive

30 – Fraunhofer IIS

Fraunhofer We support this proposal. We think that energy harvesting should be part of a RedCap item as the technique of energy harvesting is much more mature than the other topics discussed in passive IoT.

31 – Lenovo (Beijing) Ltd

We are basically fine with the moderator's proposal. The study of the first sub-bullet of the second bullet, "Identify use cases, incl. models of corresponding energy sources [RAN1, RAN2]" can be either in RedCap or passive IoT. And then protocol enhancement for RedCap and passive IoT can be separately discussed in the respective AI (if agreed) based on the modeling.

3.3 Further RedCap complexity / cost reduction

Please provide feedback on the objectives as updated after the initial round feedback and on your preference of Study Item vs. study phase for the proposal to reduce the UE bandwidth:

Complexity/cost reduction

- **Study further reduced UE bandwidth of 5MHz, especially considering**
  - **expected UE complexity/cost reduction based on Rel-17 evaluation methodology**
  - **network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact**
  - **other alternative solutions for reducing the UE peak data rate**
- **Support for lower UE power class**
  - **Focus on non-coverage-limited scenarios, e.g., indoor industrial**

Feedback Form 7: Comments on the objectives related to complexity reduction

1 – China Mobile Com. Corporation

It is hard to reach a common understanding about the cost reduction with 5MHz. As some companies pointed that the cost saving is limited, while some others insist to include this as one objective. Since the proposed objective is still based on Rel-17 evaluation methodology, we don't think the study will reach a consistent understanding about the cost saving gain. Also considering the market fragmentation of design a new narrow band system, large scale network upgrade and large effort for coexistence management, we are not convinced to do such a study.

2 – Nokia France

We still believe that the further reduced UE bandwidth should be a normative objective. However, for the sake of progress we can compromise on a study phase within the WI: "Study, and if agreed, specify further reduced …"

For the support for a lower UE power class, it should be clarified that this is for RAN4.

3 – VODAFONE Group Plc

As commented on the previous round, any 5 MHz variant of RedCap will reduce the economies of scale for the 20 MHz Redcap variant, thus we prefer to have it as a study item without committing to perform any normative work until results are obtained. In this sense, all sub-bullets in the moderators proposal seem reasonable to be included in the SI

4 – Futurewei Technologies

For the reduced UE bandwidth objective, we are OK with either a study phase (if there are other work contents) or a study item.

Several companies provided comments about the compatibility bullet. Our observation with Rel-17 was that there was considerable debate how RedCap UEs operate when the initial BWP for non-RedCap UEs exceeded the maximum bandwidth of RedCap UEs.

For Rel-18 and 5 MHz RedCap UEs, it is important to understand how the 5 MHz RedCap UEs are to be deployed. Possibilities include that 5MHz RedCap UEs: are not expected to be deployed with Rel-17 RedCap or non-RedCap UEs; are not expected to be deployed with non-RedCap UEs but may be deployed in Rel-17 separate initial BWPs (if defined). This clarification of deployment targets is needed.

For lower UE power class, it is a lower priority so we are OK not to include this objective. However, if the objective were agreed, a sub-bullet should list which power class is included.

5 – MediaTek Inc.

5MHz bandwidth

This should only be a SI, if pursued, without committing to a WI (as suggested by Vodafone) unless the SI indicates clear benefits with the introduction of a 5MHz RedCap UE. This study should include a look into alternative ways to reduce device cost, and we therefore suggest the following change:

- **Study further reduced UE bandwidth of 5MHz, especially considering**
  - **expected UE complexity/cost reduction based on Rel-17 evaluation methodology**
  - **network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact**
  - **other alternative solutions to reduce device cost such as reducing the UE peak data rate and relaxing the UE processing timeline**

Lower Power Class

There was limited support for this objective in the initial round and a number of objections. In the interest of time, we are ok to down-prioritise this objective.

6 – Sierra Wireless

We do not agree with the proposal as only 5MHz is being studied as a complexity reduction technique.

As mentioned before, we would rather see a more general study objective "study UE complexity reduction methods" where 5MHz is listed as one of the techniques to be studied with other potential method for complexity reduction list. Given that some of the other methods have much less specification impact e.g. lower TBS, lower processing time, lower scaling factor, they should not be excluded.

Thus if only 5MHz is studied, then we do not want a study at all and certainly not a WI objective.

7 – vivo Communication Technology

There are a numer of companies (8 companies from our reading of the initial round comments) supported "processsing time relaxation for data and CSI" in the initial round of discussion, we think it is fair to keep the door open for it. We support the MTK's suggested revision as below

other alternative solutions to reduce device cost such as reducing the UE peak data rate and relaxing the UE processing timeline

For lower power class, we think it should be included in Rel-18 with equal priority as other objectives, since it provide clear cost and power efficiency improvement for the devices. Given the clarification that no additional coverage compensation will be considered, the spec impact will not be large, mainly RAN4 work. It should also be noted that LTE support lower power class (power class 5: 20dBm/power class 6: 14dBm), therefore no good reason to not allow this feature in NR. If the power class is to be clarified, we suggest to consider both 20dBm and 14dBm as in LTE.

8 – SoftBank Corp.

While we are OK to go with study phase for 5MHz BW, we would emphasize that UE cost reduction with big impact to the network side makes no sense.

9 – Intel Corporation (UK) Ltd

[Intel]

At the risk of repeating ourselves, we do not see a need for a study for the introduction of 5 MHz RedCap UEs. All the considerations listed in this round can be addressed as part of the normative work itself.

More so, a separate study item would be totally unwarranted for this purpose. If at all, we can consider a study phase in parallel to investigate the possibility of supporting SCS other than 15 kHz, while normative work on 5 MHz RedCap UEs for 15 kHz SCS can proceed as part of the Rel-18 WI on eRedCap.

We also support spelling out relaxations to minimum UE processing times for PDSCH/PUSCH and CSI feedback as well as mechanisms like max TBS restrictions. **However, these should NOT be identified as "other alternative solutions" but instead as supplementary to max UE BW reduction.**

10 – Spreadtrum Communications

For complexity/cost reduction, we prefer to have a study phase instead of a study item. We had a study item for RedCap in R17, and some fundamental conclusions were made and captured in the TR 38.375. In addition, the most important/complexity part for cost/complexity reduction is the evaluation, as we have already established a basic evaluation methodology in R17, any update for evaluation methodology can be considered as optimization issue and can be quickly done in the R18 study phase. Therefore, a study item is not necessary.

Regarding the update for evaluation methodology, we porpose that the complexity/cost evaluation for the higher layer related components could be added, e.g., L2 buffer, memory, etc. It worth noticing that RAN2 had discussed some cost/complexity reduction features in R17, without the evaluation methodology for the higher layer related components, some features were not well discussed. In addition, some RAN1 related features may bring additional cost benefits to the higher layer related components, the current evaluation methodology seems missing this part.

In addition to 5MHz, the "UE processing timeline relaxation" and "HARQ related relaxation" can still be considered in R18 phase. First of all, this two features are benefit to the UE complexity reduction and/or power saving. Second, even with R17 evaluation methodology, the cost benefits of this two features are considerable, if we jointly consider the higher layer related components, the cost benefit will be much higher.

In the end, coverage recovery for some DL channels due to RX reduction has been identified by some companies in R16 RedCap SI evaluation, but was not specified in WI. The absolute metric to identify the

channels to be coverage recovered can be revisited, as some companies had mentioned the absolute metric is practical in some scenarios. Therefore, coverage recovery can be specified for R18 RedCap.

11 – Guangdong OPPO Mobile Telecom.

We would prefer to support 5MHz, not study. However, it seems some views in other side. A middle ground is fine.

Then, the low power class should also be studied. Similar as MTK, we share the view that the benefit is not clear. We suggest to also make it study first and treated same as for 5MHz.

12 – Apple Poland Sp. z.o.o.

We are generally ok with the 1st objective. However, we believe it is important to further relax the UE processing time in addition to the UE peak data rate reduction as captured in the 3rd bullet. Therefore, the following was proposed :

- **Study further reduced UE bandwidth of 5MHz, especially considering**
- **expected UE complexity/cost reduction based on Rel-17 evaluation methodology**
- **network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact**
- **other alternative solutions for reducing the UE peak data rate and relaxing UE processing time.**

We are also ok to spell processing time relaxation as a separate objective in parallel with '5MHz' objective.

13 – Qualcomm Incorporated

We are fine with either study item or study phase for the 5MHz UE bandwidth.

As raised by some companies, we are also concerned about "compatibility with Rel-17". We generally say it is backward compatible if any newly introduced features do not give impacts to legacy UEs, which is the case for 5MHz eRedCap device. However, we should not force that Rel-18 device has to be compatible with Rel-17 NW. We all know that Rel-17 RedCap is not compatible with Rel-16 NW. In the same bullet, we also have "network impact", meaning that network impact needs to be minimized. It is clearly redundant having both "network impact" and "compatibility with Rel-17". "Compatibility with Rel-17" should be removed.

Support for lower UE power class should be deprioritized while we focus on the study of UE BW reduction during the study (item) phase.

14 – NTT DOCOMO INC.

Regarding the 1st objective, we prefer a study phase in the WI. Therefore, we also suggest modifying to "Study, and if agreed, specify further reduced…".

Regarding the compatibility with Rel-17 in the 1st objective, as commented in the initial round, we don't think it is necessary for "reduced cost/complexity" devices from previous releases. Therefore, It is fair to say "Rel-15 SSB bandwidth is reused and L1 changes minimized" as Rel-17 RedCap WID.

Regarding other complexity reduction techniques such as reduced number of HARQ processes and relaxed UE processing times, they should be included as commented in the initial round.

15 – Xiaomi Communications

1. For the 5MHz part, we think it is necessary to study it to know the performance and impact better. Then based on the study result, let's decide whether to specify it or not . As for the evaluation methodology, the R17 evaluation methodology can be the baseline.

2. For the low power class, it is benefical to the power saving which also aligns with the main goal of the RedCap evolution.

16 – CEWiT

We are fine with either study phase or study item. Study on supported SCS and coexistence issues with non Red Cap UEs and Rel. 17 Red Cap UEs to be considered carefully.

17 – Ericsson LM

With most of the objectives discussed under this thread containing a study phase, it is preferred to have an study item first with a follow-up work item. Objectives not requiring study can be added in the work item directly.

Regarding the study objectives, we prefer to agree on some fundamental design principle before the study starts, e.g., that any enhancements should

- Build on Rel-17 RedCap framework and avoid fundamental changes to the basic RedCap UE type defined in Rel-17 to avoid further market fragmentation
- Ensure compatibility with Rel-17 network, i.e., Rel-18 RedCap UEs should be able to fall back to Rel□17 behavior in order to access a Rel-17 RedCap network. For example, no new early indication framework should be required and instead the Rel-17 solution is reused.
- Not be restricted to only limited deployment scenario, e.g., it should not be limited only to 15 kHz SCS.

Regarding lower UE power class, in our view, it is reasonable to introduce a new lower UE power class to support use cases requiring low cost and low energy consumption as the 23 dBm UE power class may not always be suitable. Moreover, to facilitate devices operating on energy harvested from the ambient environment, definition of one or more lower UE power classes can be considered. We agree with the moderator proposal that a new power class would not result in work on coverage extension and that non-coverage-limited scenarios can be assumed. If coverage recovery due to lower UE power class is really needed, the existing coverage enhancement techniques in Rel-15/16/17 and possibly UL-cell edge data rate reduction can be considered.

18 – Sequans Communications

We agree with CMCC and MTK that benefits of 5MHz BW in cost reduction are not clearly suficcient to justify specification effort. We can support a SI without commitment to WI. We are ok with MTK proposal for the objectives.

More over we agree that the focus of this topic should be on other complexity reduction techniques that can bring more significant cost reduction such as relaxed UE processing times, as suggested by many companies

19 – Transsion Holdings

5MHz bandwidth:

We should start the research phase of 5MHz BW first. The reason is:

1. Reducing the bandwidth to 5MHz will limit the redcap market

2. If the maximum bandwidth is limited to 5MHz, it is necessary to evaluate the impact of initial access for services with SCS greater than 15KHz on the specification.

The other method to reduce complexity and cost should not be excluded e.g. lower TBS, relaxed UE processing time.

Lower power class

NR can consider the power class used in NB-IOT, like 20dBm.

20 – CATT

We are not convinced to support 5MHz UE bandwidth, but would be fine with the study as proposed by moderator as a compromise. To start the normative work for 5MHz UE bandwidth directly is not acceptable to us.

In addition, other solutions for reducing the UE peak data rates should not be precluded, e.g. reducing the TBS, smaller scaling factors etc..

For lower power class, we would like to clarify that there is no RAN1 impact.

21 – InterDigital Communications

We are generally fine with the objectives. We do no think compatibility with Rel-17 is necessary. As some other companies mentioned, ”other alternative solutions” does not need to be a sub-bullet of reduced BW; it may be a complementary solution.

22 – ZTE Corporation

As analyzed before, for SSB reception with 15KHz, the bandwidth is 3.6MHz, which means 5MHz UE can receive the 15KHz SSB without any impact. Moreover, compared with current RedCap UE, more than 10% cost reduction can be expected for 5MHz UE. Therefore, we prefer 5MHz as the WI and also are generally fine the text proposal here as the med round.

In order to avoid the duplicated discussion of further coverage enhancement, a Note can be added for the support of lower UE power class, as follows

- Focus on non-coverage-limited scenarios, e.g., indoor industrial
- Note: further coverage enhancement is not pursued.

23 – Samsung Electronics Polska

For complexity/cost reduction part, we share similar view as CMCC, Vodafone and others. That we are not convinced to have 5MHz RedCap. Without justified new use cases, it would be a repeat of Rel-17 study item for cost reduction/low peak data rate support. We see no reason to have different conclusion or recommendation than Rel-17 SI.

If SI is the best outcome we can have in the end, we shall same view as Vodafone, MTK, if pursued, it shall not committing to a WI.

For the objective of SI, other than the listed impact, “DL coverage”, “support of massive number of UEs”, should be included as well. Moreover, “network impact” can be changed into “network impact including network efficiency/capacity”.

We suggest to keep the last bullet as current as "**other alternative solutions for reducing the UE peak data rate**" without adding examples, to make it more open. In our understanding, any other solutions for reducing UE data rate can be proposed and discussed in the SI.

24 – ROBERT BOSCH GmbH

We support 5MHz UE to be WI directly.

We also support low power class UEs.

25 – LG Electronics Inc.

For the first bullet, we agree with the Moderator's view that the current study proposal is a good middle ground b/w the two extremes. For details, we are fine with the first two sub-bullets, but share the view with the Moderator that the description should be clearer on the third sub-bullet. After the intermediate round, if it is still not clear, or if there is no consensus, then we think the third sub-bullet should be removed. For the support for lower UE power class, we think the clarification in the sub-bullet should be kept.

26 – Philips International B.V.

We agree with the proposed objectives. We think a study phase followed by a work item phase should be the most convenient.

27 – Huawei Tech.(UK) Co.. Ltd

First, we believe that 5 MHz UE is not market fragmentation of R17 20 MHz RedCap UE since they are targeting different tiers of IoT use cases. Given that LTE already has such UEs (e.g. LTE-Cat1/1bis) much cheaper than R17 RedCap, clearly those markets do not currently belong to – and cannot be addressed by – R17 RedCap but would be suitable for a 5MHz NR UE. Secondly, the concerns to network complexity from some operators represent a design constraint which can be reflected in normative WID text, just as was done for Rel-17 RedCap.

Again, same as other companies, it is unclear for us why compatibility with Rel-17 is needed.

To make progress between the groups of companies, we could compromise on a short study phase for network impact part with suggest the following updates:

Complexity/cost reduction

- *Study **and specify** further reduced UE bandwidth of 5MHz, especially considering*
  - ~~***expected UE complexity/cost reduction based on Rel-17 evaluation methodology***~~
  - ***Study and specification work should take into account** network impact, ~~**compatibility with Rel-17,**~~ coexistence ~~**of**~~ with RedCap and non-RedCap UEs, UE impact, specification impact*
  - *Other ~~**alternative**~~**additional** solutions for reducing the UE peak data rate*

28 – Huawei Tech.(UK) Co.. Ltd

Since the studied solutions are not limited to RedCap, it would make sense to say that the study itself is not limited to IoT, otherwise there can be confusion:

- *The study should primarily target ultra-low power WUS/WUR required by IoT **and eMBB** use cases. The studied solutions should not be limited to RedCap UEs only*

As in previous rounds, the bullet below would benefit from being clearer that the study is open to new and to existing signals. Moderator's current wording is prone to causing long discussions in WGs otherwise:

- *As opposed to the work on UE power savings in previous releases, this study will not require* ***(and not preclude)*** *existing signals to be used as WUS. Solutions should ... ...*

For WUS designs, to enable wake-up receivers, the necessary functionalities that can be carried by the signal, e.g. for UE synchronization, should also be studied. We suggest the following modification:

- *Study and evaluate wake-up signal designs****, and functionalities carried by the signal*** *to support wake-up receivers*

On the second bullet, we do not agree with the statement that coexistence should be restricted to only Rel-17, since there may be a Rel-18 RedCap UE also. This wording needs to be changed as shown.

Overhead also needs to be noted in the list to study.

- *Study potential system impact, such as* ***overhead,*** *network and other UE's power consumption, coexistence with* ***~~R17~~RedCap and non-RedCap*** *UEs, network coverage, and compatibility with other UE power saving solutions [RAN1, RAN2]*

29 – Sony Europe B.V.

Given that other companies are supportive of 5MHz bandwidth Redcap UEs, we can support these objectives.

We are OK with an initial study phase on support of 5MHz bandwidth Redcap devices. We suspect that either a study item or study phase would lead to the same outcome: that there would be normative work on this objective later in Rel-18.

30 – Everactive

31 – Fraunhofer IIS

Fraunhofer We agree with the proposed objective in general.

Given the feedback from other companies so far regarding the justification, reducing the bandwidth (<= 5MHz) is a possible solution to enable new verticals in introducing 5G/RedCap for their communication networks.

32 – Lenovo (Beijing) Ltd

We are basically fine with the moderator's proposal. For the second sub-bullet of the first bullet, "network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact", we prefer to remove "network impact, UE impact, specification impact". These impacts result from "compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs" in our understanding.

Besides, the 3rd subbullet of the first bullet is not clear enough. Prefer to remove it or it should be a separate bullet with clarifications.

3.4 Study Item on low power wake-up receiver / signal

Please provide feedback on the SI objectives and justification as updated after the initial round feedback:

Study Item on low power wake-up receiver / wake-up signal (WUR/WUS)

- ***The study should primarily target ultra-low power WUS/WUR required by IoT use cases. The studied solutions should not be limited to RedCap UEs only.***
- ***As opposed to the work on UE power savings in previous releases, this study will not require existing signals to be used as WUS. Solutions should give justifiable gains compared to the existing Rel-16/17 UE power saving enhancements. Aspects such as UE power consumption, detection performance, coverage, UE complexity, should be covered by the evaluation.***
- **Objectives:**
  - **Study use cases, evaluation methodology & KPIs [RAN1, RAN4]**
  - **Study and evaluate low-power wake-up receiver architectures [RAN1, RAN4]**
  - **Study and evaluate wake-up signal designs to support wake-up receivers [RAN1, RAN4]**
  - **Study and evaluate L1/L2 protocol changes needed to support wake-up receivers [RAN2, RAN1]**
  - **Study potential system impact, such as network and other UE's power consumption, coexistence with R17 UEs, network coverage, and compatibility with other UE power saving solutions [RAN1, RAN2]**

Please provide concrete text proposals for the justification part of the SI on WUS/WUR.

Feedback Form 8: Comments on the proposed Study Item on low power wake-up receiver / signal

1 – Nokia France The sentence "*The studied solutions should not be limited to RedCap UEs only*" is not necessary for the study; this would become relevant in a possible future work item, where a non-RedCap UE might be able to indicate WUS capability, but there shouldn't be any reason why the design of the WUS itself would need to be different for a non-RedCap UE, Indeed, it is better to avoid fragmentation by having a common design, which would be set by the requirements and capabilities of the RedCap UEs.
2 – VODAFONE Group Plc We support having a separate WUR/WUS study item and we are fine to target IoT use cases in NR for workload management reasons. The potential system impact needs coordination with SA
3 – Futurewei Technologies Ok with the moderator's proposal.
4 – Sierra Wireless Agree with the proposal.
5 – vivo Communication Technology The moderator proposal looks fine for us in general. One minor comment, we think the 1st objective on use case, EVM&KPIs can be done in RAN1 without the strong need for RAN4 involvement. We suggest to remove RAN4 for this objective.

Study use cases, evaluation methodology & KPIs [RAN1~~, RAN4~~]

and RAN4 invovlment will be needed for the next objective when we evaluate the receiver architecture and corresponding sensitivities.

6 – SoftBank Corp.

We are OK with the moderator's proposal. We are still not sure if it is really feasible for the network to handle different kinds of power saving techniques, but we hope can be clarified during the study.

7 – Intel Corporation (UK) Ltd

[Intel]

We are almost fine with the proposed SI and objectives.

We would like to clarify that, at this stage, the following objective is not enforcing same solutions across RedCap and non-RedCap, etc. While a common design may certainly be desirable, the study should NOT be constrained from the beginning.

The study should primarily target ultra-low power WUS/WUR required by IoT use cases. The studied solutions should not be limited to RedCap UEs only.

8 – Spreadtrum Communications

For the 2nd architectures bullet, we still propose to focus on the feasibility study **including reception performance, power saving gain and complexity/cost**, as it is very important for introducing a new separate receiver at UE side.

For the 4th L1/L2 protocol changes bullet, we suggest to change to "**L1 procedure and L2 protocol changes**".

9 – Guangdong OPPO Mobile Telecom.

The moderator's proposal is OK. The justification we suggested has also mentioned the enhancement does not limited to RedCap use case. This part is also reflecting it.

10 – Apple Poland Sp. z.o.o.

- We would like to suggest removing "The study should primarily target ultra-low power WUS/WUR required by IoT use cases. The studied solutions should not be limited to RedCap UEs only." More than 10 companies suggested that both RedCap and non-RedCap UEs should be considered for the SI, and we don't think we need to give priority to certain use cases at this point. This should be the outcome of the study instead. We can replace it with something like "The study should cover both RedCap and non-RedCap UEs."
- On the coexistence study, we believe it is more accurate to say "coexistence with legacy UEs" or "coexistence with UEs that do not support LP WUR", instead of 'coexistence with Rel-17 UEs' in the last sub-objective.
- It is unclear to us how it may affect other UE's power consumption. Does it refer to the UEs that do not support LP WUR or other UEs that also support LP WUR? It would be helpful to make it clear in the next round moderator proposal.
- We asked for clarification on "compatibility with other UE power saving solutions" in the 1st round. Does it mean whether LP WUR can be used together with the existing UE power saving features? Is it considered as a requirement? At least we see LP WUR as a potential replacement of PEI in R17. In

our view, what is important is not the compatibility, but the power saving gain that can be provided by LP WUR (either used alone or used together with existing solutions if possible). Hence, we propose to delete the words 'and compatibility with other UE power saving solutions'

11 – Qualcomm Incorporated

We are generally fine with moderator's proposal with following modification.

- The study should primarily target ultra-low power WUS/WUR required by IoT use cases. The studied solutions should not be limited to RedCap UEs only.

- As opposed to the work on UE power savings in previous releases, this study will not require existing signals to be used as WUS. Solutions should give justifiable gains compared to the existing Rel-16/17 UE power saving enhancements. **~~Aspects such as UE power consumption, detection performance, coverage, UE complexity, should be covered by the evaluation.~~**
- Objectives:
  - Study use cases, evaluation methodology & KPIs [RAN1, RAN4]
  - Study and evaluate low-power wake-up receiver architectures [RAN1, RAN4]
  - Study and evaluate wake-up signal designs to support wake-up receivers [RAN1, RAN4]
  - Study and evaluate L1/L2 protocol changes needed to support wake-up receivers [RAN2, RAN1]
  - Study potential system impact, such as network and other UE's power consumption, coexistence with R17 UEs, network coverage, and compatibility with other UE power saving solutions [RAN1, RAN2]
  - **Study feasibility in terms of UE power consumption, detection performance, coverage, UE complexity (receiver architecture) [RAN1]**
  - **Study and evaluate L1/L2 protocol changes needed to support wake-up receivers [RAN1, RAN2]**

12 – NTT DOCOMO INC.

We are supportive of the moderator's proposal.

For the 5th objective on "compatibility with other UE power saving solutions", as we mentioned in the initial round, we suggest clarifying the intended solutions, such as those specified in Rel-16/17 power saving WIs (WUS and PEI).

As mentioned by vivo, we also suggest removing RAN4 from the 1st objective since evaluation methodology & KPIs should be considered by RAN1.

13 – Xiaomi Communications

Generally, we support the proposal. We also support firstly study the potential application in IoT use cases.

And there is a small comment on the last bullet. We think the coexistence study should not be limited to the R17 UEs. We suggest to modify it as **coexistence with other ~~R17~~ UEs**

14 – Ericsson LM

The updated objectives look fine to us. It can perhaps be further emphasized that the study objective should consider all RRC states, i.e., RRC*IDLE, RRC*INACTIVE, and RRC_CONNECTED. For more clarity of the scope, some more details could also be added, e.g., under the 3rd and 4th bullets of the objectives:

- False paging probability and UE grouping [RAN1]
- Changes to paging procedure [RAN2)

Some TP for Justification:

- **Enable ultra-low-power UE wake-up radio**: A very energy efficient ultra-low-power UE wake-up radio may be highly attractive for use cases where a very long battery life is important, especially when combined with low-latency requirements in downlink. A wake-up signal, detectable by a low power wake-up radio, for waking up the main receiver to allow for an extremely low energy consumption in sleep mode, and possibly some extensions to the paging protocol to fully realize the potential gains can be considered.

15 – Transsion Holdings

We are fine with the SI and objectives.

16 – Sequans Communications

We are ok with the moderator's proposal, but still believe this topic should be subject of a separate study item, not part of eREDCAP work item

17 – CEWiT

We agree with the objectives

18 – CATT

Please find our proposal as follows.

Study the low-power active device and passive device for the wakeup receiver

- Study the characteristic and the receiver sensitivity of low-power active device and passive device for the wakeup receiver
- Define the power model and evaluation methodology for the low-power active device and passive device used for wakeup receiver
- Investigate NR system design and operation of integrating the low-power wakeup receiver in achieving the UE power saving
  - Coverage and operational frequency of low-power wakeup receiver
  - Enhancement of NR physical layer and protocol layer with the use of low-power wakeup receiver.

19 – InterDigital Communications

We are fine with the objectives.

20 – Panasonic Corporation

We are ok with the proposal.

21 – ZTE Corporation

Resource occupation for low power WUS, especially for always-on WUS, would impact NW capacity and cause the resource fragmentation. Therefore, at least the NW capacity should be considered in the evaluation. And the following modification for the second bullet is suggested:

- Aspects such as UE power consumption, detection performance, coverage, UE complexity, and **NW capacity impact** should be covered by the evaluation.

Additionally, for the low power WUS support, there may also exist the RAN3 impacts, e.g., the CN and gNB may need to be aware of whether the terminal support the LP-WUS, which may impact the paging strategy.

22 – China Unicom

We are fine with moderator's proposal.

23 – Samsung Electronics Polska

This can be a separated SI for a whole release study, if TU is sufficient.

We think it is better to clarify that whether this WUS is mainly used for IDLE/inactive status, other than connected status, or it is can be applicable for all the status. We prefer to focus on idle/inactive first in the SI, so that the discussion in WG can be concentrated.

It is better to clarify the type of UEs in objective part other that justification part.

The benchmark of study and evaluation can be mentioned, which should be corresponding existing Rel-16/17 power saving solutions, other than Rel-15 behavior in order to avoid to introduce duplicated features for same purpose.

24 – ROBERT BOSCH GmbH

We are fine with the proposal.

25 – Philips International B.V.

We agree with the proposed text by the moderator. We also agree with executing this work as a full SI. As for the justification for WUS/WUR, we think that such signals can really reduce the energy consumption, enabling ultra-low power IoT, and also reduce the latency of those devices that, otherwise, would be in PSM mode.

26 – LG Electronics Inc.

We agree in general with the Moderator's assessment on the current situation. The SI objectives themselves seem to be reasonable, but we think this study should be treated as a *separate* full-release SI, rather than as part of the Rel-18 RedCap SI/WI, *if enough consensus is achieved* on studying the low power WUR/WUS in Rel-18.

27 – Huawei Tech.(UK) Co.. Ltd

Since the studied solutions are not limited to RedCap, it would make sense to say that the study itself is not limited to IoT, otherwise there can be confusion:

- *The study should primarily target ultra-low power WUS/WUR required by IoT* ***and eMBB*** *use cases. The studied solutions should not be limited to RedCap UEs only*

As in previous rounds, the bullet below would benefit from being clearer that the study is open to new and to existing signals. Moderator's current wording is prone to causing long discussions in WGs otherwise:

- *As opposed to the work on UE power savings in previous releases, this study will not require* ***(and not preclude)*** *existing signals to be used as WUS. Solutions should ... ...*

For WUS designs, to enable wake-up receivers, the necessary functionalities that can be carried by the signal, e.g. for UE synchronization, should also be studied. We suggest the following modification:

- *Study and evaluate wake-up signal designs****, and functionalities carried by the signal*** *to support wake-up receivers*

On the second bullet, we do not agree with the statement that coexistence should be restricted to only Rel-17, since there may be a Rel-18 RedCap UE also. This wording needs to be changed as shown.

Overhead also needs to be noted in the list to study.

- *Study potential system impact, such as* ***overhead,*** *network and other UE's power consumption, coexistence with* ***~~R17~~RedCap and non-RedCap*** *UEs, network coverage, and compatibility with other UE power saving solutions [RAN1, RAN2]*

28 – Sony Europe B.V.

We support the objectives. The last bullet in the objectives should refer to "UEs'" rather than "UE's".

The objectives should include mention of RRC modes in which the low power WUR/WUS would be applicable. For example: "study and evaluate the usage of low power wake up receivers in RRC IDLE, INACTIVE and CONNECTED states [RAN2, RAN1]"

The justification revolves around further power consumption reduction and supporting a UE that is able to receive mobile terminated signalling / data with lower latency.

29 – Everactive

30 – Fraunhofer IIS

Fraunhofer We are fine with the proposed text as motivation for study on low-power WUS/WUR. If RedCap also supports SL, the discussion shall also consider WUS/WUR for SL communication.

31 – MediaTek Inc.

The meaning of 'IoT use cases' as listed in the justification section is not clear in the context of NR. Furthermore, if studying 'usecases' is meant to be an SI objective, this SI becomes too open-ended for RAN WGs to investigate (this is more SA work than RAN). We therefore suggest listing out usecases, similar to what we did for RedCap in Rel-17. This will ensure that we have a clear scope for RAN WGs to study. It would also be useful to have some targets included for the LP-WUR power consumption.

For now, we suggest the following update:

- ***The study should primarily target ultra-low power WUS/WUR required by power-sensitive small form-factor devices such as sensors and wearables.***
- ***As opposed to the work on UE power savings in previous releases, this study will not require existing signals to be used as WUS. Solutions should give justifiable gains compared to the existing Rel-16/17 UE power saving enhancements. Aspects such as UE power consumption, detection performance, coverage, UE complexity, should be covered by the evaluation.***
- **Objectives:**
  - **Study ~~use cases,~~ evaluation methodology & KPIs [RAN1, RAN4]**
  - **Study and evaluate low-power wake-up receiver architectures [RAN1, RAN4]**
  - **Study and evaluate wake-up signal designs to support wake-up receivers [RAN1, RAN4]**
  - **Study and evaluate L1/L2 protocol changes needed to support wake-up receivers [RAN2, RAN1]**
  - **Study potential system impact, such as network and other UE's power consumption, co-existence with R17 UEs, network coverage, and compatibility with other UE power saving solutions [RAN1, RAN2]**

32 – Lenovo (Beijing) Ltd

We are basically fine with the moderator's proposal. For the first bullet, we are fine to have IoT use case as the main target and the solutions are not limited to RedCap UEs. For the third bullet, we still think the target RRC states should be listed in the objectives, given that we have wake-up signals developed for different RRC states in legacy.

3.5 Intermediate Round Summary

3.5.1 RedCap justification

All companies agreed to summarize the Rel-17 RedCap capabilities. Some wanted to state that Rel-17 RedCap was "overdesigned" for IoT.

All companies wanted to highlight that Rel-18 is an evolution into lower-tier devices (lower complexity and power consumption) targeting the known use cases but also expanding into new use cases. Rel-18 RedCap should address the range down to (but excluding) LPWA. Some companies explicitly mentioned LTE Cat1/1bis and some mentioned concrete/vague target data rates. The desire for compatibility and the risk of fragmentation was mentioned as well as the desire to let the RedCap eco system grow.

2 companies wanted to add sidelink into the RedCap scope.

3.5.2 RedCap power saving / enrgy efficiency enhancements

Most companies agreed to the eDRX enhancements. 2 companies wanted to wait until the end of Rel-17 before agreeing on the objective.

The objective on Energy Harvesting is controversial and many prefer to study it outside the RedCap scope, e.g., in area 28.

Some companies brought back the proposal of "serving cell RRM measurement relaxations", which was not pursued after the Sep. discussion as it was controversial.

3.5.3 RedCap complexity / cost reduction

Companies again highlighted their support as well as their concerns with a 5MHz UE BW. Many stressed that this should be a study item without an unconditional commitment to normative work.

The lower UE power class was not opposed but it was not high priority for anyone.

3.5.4 Study on low-power wake-up signal / receiver

The objectives are rather stable and widely supported. Detailed changes to the exact wording were proposed. Some companies proposed to add eMBB use cases in addition to IoT.

3.5.5 Moderators Way Forward

The RedCap WI/SI structure was discussed in all sections. The moderator's conclusion from section 3.5.2 is that the objective on energy harvesting should not be part of RedCap but studied separately (e.g. in area 28).

The moderator's conclusion in section 3.5.3 is to work on further complexity/cost reduction techniques in an initial (6 month) study item followed by a Rel-18 WI. This is because 1) approving a WI directly seems very controversial and 2) the major part of the remaining work is actually "to study". The objectives on eDRX and potentially on the lower UE power class should be added to the follow-up RedCap Evolution WI.

The moderator's conclusion in section 3.5.4 is to continue shaping the remaining details of the draft SID on WUS/WUR.

4 Final Round

Based on the above discussion, the moderator has prepared 2 drafts of the initial SID (studying reduced RedCap UE bandwidth) and the follow-up WID (on RedCap evolution), which can be found in the RAN#94 drafts folder. We will use the final round to collect feedback and comments on those 2 draft SID & WID.

Based on the above discussion, the moderator has prepared anothe draft SID on WUS/WUR, which can also be found in the RAN#94 drafts folder. We will use the final round to collect feedback and comments on that draft SID as well.

4.1 Initial Study Item on reduced RedCap UE bandwidth

In the final round, please feedback and comment on the draft SID.

Feedback Form 9: Comments on the draft Study Item on reduced RedCap UE bandwidth

1 – vivo Communication Technology

Thanks for the efforts from Moderator. We have one to the draft SID.

It is not very clear what is exactly included in the last sub-bullet by saying "other alternative solutions for

reducing device complexity/cost". Acccording to the discussion, there are quite strong support for other solutions for peak data rate reduction, and relaxing UE processing timeline, therefore it is suggested to spell out these alternative solutions as examples, Proposed changes as below.

- other alternative solutions for reducing device complexity/cost, **e.g. reducing the UE peak data rate and relaxing UE processing timeline, etc.**

Other parts of the SID including the time plan are agreeable to us. .

2 – vivo Communication Technology

Some more thinking on Energy harvesting study: Although energy harvesting has been removed from RedCap study due to the overlap with Passive IoT discussion, however, we think there could be a way to define a boundary between these two discussions.

In RedCap study, the focus will be the exisitng Rel-17 and new Rel-18 RedCap devices, these devices clearly has much higher capabilty than eMTC/NB-IOT, therefore the study of energy harvesting in RedCap shall focus on the feasbility on using harvest energy (fully or partially together with a small capacity battery) to support some use cases with battery constraint for the device together with some other energy saving features, e.g. eDRX, and low power WUR/WUS. And if there is feasbility, to study some specification enhancement. In this study, any foundamental change of PHY design will not be considerd.

Passive IoT is however targeting foundamentally new device types with ultra-low cost and ultra-low power cconsumption and with much lower capability than eMTC/NB-IOT. It likely require new air interface and higher layer protocal design to achieve the goal. For these new type of devices, energy harvesting will be an essential feature that should be considered from the begining of the study.

While we are fine to continue discussing energy harvesting under Passive IoT context, there might be a risk that the potential usage of harvested energy for traditional RedCap devices (i.e. Rel-17/18 RedCap) will not eventually be studied as Passive IOT study will likely focus on new device types and new air interface design.

3 – Futurewei Technologies

We are generally ok with the SID proposal. Some modifications are needed.

In the justification, we have three comments.

- The first three paragraphs are redundant with the fourth paragraph and do not provide justification for the study item. We suggest that the first three paragraphs be removed.

- In the fifth paragraph, a revision suggestion is "enhancements can be considered ~~to enable as efficient support as possible for the mentioned use cases and also~~ to expand RedCap into a new range of use cases." In our understanding, efficiency is not the only consideration of the study.

- In the last paragraph, the word "work" should be "study".

With the objectives, a minor edit for the third sub-bullet, remove "other" as it is redundant.

4 – Everactive

We support Vivo's comment and justification for keeping EH in eRedCap as a use case in general (not just for the UE bandwidth reduction SID).

5 – Sierra Wireless

It is unfortunate that a focused SI looking only at 5MHz BW for cost reduction is the best compromised we have. The justification does not add any NEW use cases beyond those considered in Rel 17 so this Rel 18 study will be a repeat of Rel-17 study thus we see no reason the conclusion and recommendations will be different than Rel-17 SI. However, if proponents still want this, here are some specific comments on the objectives:

I assume everyone agrees FR2 is out of scope but we should be clear:

Study further reduced UE bandwidth of 5MHz in FR1, especially considering [RAN1]

It would also be good to clarify that studied 5MHz solutions should consider support for all FR1 network configuration e.g. SCS and the study shall not overlap with LPWA thus these two Notes should be added to the end of the objective section:

Note:

· **The SI shall not consider solutions which overlap with existing LPWA solutions (e.g. NB-IOT/eMTC).**

· **This SI shall consider all FR1 frequency ranges, SCS configurations, and applicable duplex modes unless otherwise specified.**

6 – CATT

Although companies' initial evaluations only show small cost reducion from 5MHz based on Rel-17 Red-Cap, a study item seems to be the best middle ground we can reach for now.

The current scope is generally fine to us. We have concern in the dropped schemes for cost reduction in Rel-17 RedCap SI and prefer not to include them.

Agree with Futurewei's modification on 'work' to 'study' to make it more precise.

Also agree with Sierra wireless's suggestions on adding 'FR1'.

7 – Intel Corporation (UK) Ltd

Intel

We do not see a justification for a separate SI. As commented before, RAN WGs can move with normative work on 5 MHz UEs based on what we know already. The only elements worthy of study would be exact combination of additional complexity reduction features that may be specified for 5 MHz UEs, and can be carried out via a short study phase as part of the WI as is rather typical procedure.

Moreover, even if there is a study phase on any of the elements, splitting into a separate SI would be procedurally inefficient while bringing no material benefits. As can be seen from the draft WID, there is currently no objective for RAN1, and thus, normative work, along with any associated studies for introduction of 5MHz UEs can be carried out as part of the eRedCap WI.

Further, on the objectives themselves from the draft SID, we should consider other solutions for device cost/complexity reduction as additional/supplementary to max UE BW reduction, and not as "alternatives".

Thus, as a compromise, we suggest including the related objectives as part of the WID for eRedCap as below, with an initial study phase:

- *Study **and specify** further reduced UE bandwidth of 5MHz **in FR1**, ~~**especially**~~ considering [RAN1]*
  - *expected UE complexity/cost reduction based on Rel-17 evaluation methodology*
  - *network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact*

- ~~*other alternative*~~ *solutions* ***in addition to reduced UE bandwidth of 5MHz*** *for reducing device complexity/cost* ***including at least:***
  - ***relaxed minimum UE processing times for PDSCH/PUSCH and CSI feedback***
  - ***limitations to max TBS***
  - ***type B HD-FDD***

8 – Spreadtrum Communications

For the justification part, we have two comments.

1. Regarding the second last paragraph, the target capability/market for Rel.18 RedCap is still unclear, as the capability gap between LPWA and Rel-17 RedCap is very large. Actually, the R17 RedCap is tilted to wearable use cases, no doubt the overdesigned capability can cover the low-end use cases (sensors, low end video), while these kind of devices are more sensitive to the cost in the market. As mentioned by many companies, R18 RedCap should go as low in UE capabilities as LTE Cat1/1bis, i.e., reduce the supported peak data rate to around 10Mbps, to match the requirements of low-end use cases. We think this is the right way to clarify what is the key target for R18 RedCap. Therefore, we have the following wording suggestion for the second last paragraph:

- *"Rel-18 RedCap should provide NR support for low-tier devices between existing LPWA UEs and the capabilities of Rel-17 RedCap UEs,* ***and closer to LPWA. The supported peak data rate for Rel-18 RedCap targets to 10Mbps.*** *The Rel-18 RedCap should not overlap with existing LPWA solutions"*

In short,

- Rel-18 RedCap is mainly specified for the low-end use cases with around 10Mbps peak data rate requirements, e.g, 5M bandwidth, which is not necessary to compatible with Rel-17 network mentioned by a lot of companies.
- For higher date rate requirements, e.g, >10Mbps, market can use Rel-17 RedCap with additional Rel-18 enhanced features (power efficiency, other cost/complexity reduction, etc.) to achieve better efficiency and/or better balance between performance and cost. These evolution devices will compatible with Rel-17 network.

2. For the second paragraph, in addition to the smart city, the emerged new class of new 5G use cases should include the smart grid as well. First of all, SA1 had already studied some smart grid related use cases with the detailed description and requirements in TR 22.867. According to the TR 22.867, many smart grid use cases are well matched to RedCap's capabilities. Second, there are huge low-end devices demands for smart grid market (we notice there is a potential RAN4 Rel-18 item for regional smart grid.). Therefore, smart grid use case is suggested to be added in the second paragraph:

- *"Another emerging new class of new 5G use cases is the smart city vertical, which ... but also of factories and industries.* ***In addition to smart city vertical, smart grid vertical is another important 5G use cases such as distributed energy storage, advanced metering, distributed feeder automation in TR 22.867."***

For the objective part, we have two comments.

1. For the evaluation methodology, as we commented in the intermediate round, we think that the complexity/cost evaluation for the higher layer related components (e.g., L2 buffer, memory, etc.) should not be precluded in Rel-18. We suggest adding one sub-bullet:

- *expected UE complexity/cost reduction based on Rel-17 evaluation methodology*
    - ***including the complexity/cost evaluation for the higher layer related components***

2. For the last bullet (i.e., other alternative solutions), we share the similar view with vivo that it is suggested to spell out these additional solutions as examples, and we think reducing the UE peak data rate, relaxing UE processing timeline, HARQ relaxation can be added. Additionally, from our perspective, the Rel.18 RedCap is mainly focused on low-end use cases, these kind of devices are more sensitive to the cost, complexity and the power consumption, therefore, these features are important.

- other **additional** ~~alternative~~ solutions for reducing device complexity/cost, **e.g. reducing the UE peak data rate and relaxing UE processing timeline, etc.**

9 – Apple Poland Sp. z.o.o.

On 5MHz bandwidth reduction objective, we understand that a study item maybe something agreeable at this moment. On the other hand, the NR cost reduction analysis framework has been well established in Rel-17 and the potential benefit of 5MHZ BW reduction is clearly predicable for companies. Spending six months to study is simply to defer the unavoidable debating to half a year later.

There are at least 8 companies proposing to add 'UE processing time relaxation' in the intermediate round. This should be reflected in the new SID objective section. We therefore proposed the following:

- other alternative solutions for reducing device complexity/cost, **e.g. reducing the UE peak data rate and relaxing UE processing timeline, etc.**

We support to remove the energy harvest to passive IOT due to brand-new design and unclear use case.

10 – Qualcomm Incorporated

We are generally fine with the justification parts.

In the objective section, as we mentioned in the 2nd round discussions, we are concerned about "compatibility with Rel-17". We generally say a newly introduced feature is backward compatible if it does not give impacts to legacy UEs, which is the case for 5MHz eRedCap device. However, we should not force that Rel-18 device has to be compatible with Rel-17 NW. We all know that Rel-17 RedCap is not compatible with Rel-16 NW. In the same bullet, we also have "network impact", meaning that network impact needs to be minimized. It is clearly redundant having both "network impact" and "compatibility with Rel-17". "Compatibility with Rel-17" should be removed.

For the evaluation methodology, we agree to use Rel-17 evaluation methodology as a staring point. However, if the BW is further reduced and overall complexity decreases, fundamental architectural change could happen for the implementation of a device and we may need to consider additional factors for the complexity/cost evaluation.

As suggested by a number of companies, we are also supportive of including the UE processing time relaxation.

Our suggested objectives are:

To further reduce the complexity/cost of RedCap devices, the following should be studied:

- Study further reduced UE bandwidth of 5MHz, especially considering [RAN1]
- expected UE complexity/cost reduction based on Rel-17 evaluation methodology **as a starting point**
- network impact, ~~**compatibility with Rel-17,**~~ coexistence of RedCap and non-RedCap UEs, UE impact, specification impact

- other alternative solutions for reducing device complexity/cost
- **UE processing time relaxation**

11 – Nokia France

In principle we agree with all the comments from Intel, although we do accept that a SI or study phase may be the best compromise we can reach at this stage.

Hence, we would suggest just taking their clarifying points:

- *Study further reduced UE bandwidth of 5MHz* ***in FR1****,* ~~***especially***~~ *considering [RAN1]*
  - *expected UE complexity/cost reduction based on Rel-17 evaluation methodology*
  - *network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact*
  - ~~***other alternative***~~ *solutions* ***in addition to reduced UE bandwidth of 5MHz*** *for reducing device complexity/cost* ***including at least:***
    - ***relaxed minimum UE processing times for PDSCH/PUSCH and CSI feedback***
    - ***limitations to max TBS***
    - ***type B HD-FDD***

We also agree with the first bullet proposed by Sierra Wireless, except that we do observe that the justification section already states ”Rel-18 RedCap should not overlap with existing LPWA solutions” so it seems clear already.

12 – Ericsson LM

We agree with the moderator as well as companies’ feedback that Rel-18 RedCap can start with a study item without committing to any normative work until the outcome of the SI is obtained.

Therefore, we are supportive of the draft SID in general. Some comments on the details:

Regarding the main bullet “Study further reduced UE bandwidth of 5MHz”, a more general formulation should be used, e.g., the same formulation as in the draft SID, i.e., “Study further reduced UE cost / complexity”, to acknowledge that also alternative techniques such as BB-only BW reduction or other forms of peak rate reduction are also in the SI scope.

Regarding the sub-bullet “other alternative solutions for reducing device complexity/cost”, and the word “other” should be removed, and we furthermore suggest updating to “alternative solutions for reducing device complexity/cost and/or peak data rate”. There was some other suggestion to add examples under this sub-bullet. In our view, it is not necessary as any other solutions for reducing device complexity/cost and/or peak data rate can be proposed and discussed in the SI.

Regarding the potential study on support for operation on intermittently available energy harvested from the environment, we see a quite clear distinction from the original scope of the proposed discussion in area 28, i.e., ‘Passive IoT’ and RedCap addresses different UE segments (below and above LTE-M/NB-IoT, respectively) and use cases. Therefore, we prefer that such energy-harvesting study would be RedCap-specific and included in the Rel-18 RedCap SI/WI.

With a potential scope including alternative solutions other than reduced UE BW, the SI name should be updated to a more general title to reflect this, e.g., “New SID on further RedCap UE complexity reduction” or “New SID on enhanced support of reduced capability NR devices”.

13 – NTT DOCOMO INC.

Same comment as initial/intermediate rounds: Regarding the compatibility with Rel-17 in the objective, we don't think it is necessary for "reduced cost/complexity" devices from previous releases. Therefore, it is fair to say "Rel-15 SSB bandwidth is reused and L1 changes minimized" as Rel-17 RedCap WID.

Since it is study item on further reduction of the complexity/cost of RedCap devices now, other complexity/cost reduction techniques such as reduced number of HARQ processes and relaxed UE processing times should be included for further study as individual bullet (not as a sub-bullet of 5MHz BW study). Also, the title of SID should be revised from "Study on RedCap UE bandwidth reduction" to "Study on complexity/cost reduction of RedCap UE".

14 – Samsung Electronics Polska

We still have concerns on the SI for 5MHz, since we do not see any "new" use cases comparing with Rel-17 and do not expect "new" outcome than Rel-17 SI. However, we understand that this discussion only for objectives drafting, and further discussion will happen in the coming RAN meeting.

For the objective of SI, we suggest the following updates:

- Study further reduced UE bandwidth of 5MHz, especially considering [RAN1]
- expected UE complexity/cost reduction based on Rel-17 evaluation methodology
- network impact **(including at least spectral efficiency, capacity, coverage, scheduling flexibility)**, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact
- other alternative solutions for reducing device complexity/cost

Again, we suggest to keep the last bullet as current as "**other alternative solutions for reducing the UE peak data rate**" without adding examples, to make it more open. In our understanding, any other solutions for reducing UE data rate can be proposed and discussed in the SI.

15 – VODAFONE Group Plc

We propose the following update for the objective as the main text and first bullet seem redundant, and the last sub-bullet does not pertain to the main bullet

To further reduce the complexity/cost of RedCap devices, the following should be studied:

- ~~Study~~ **F**urther reduced UE bandwidth of 5MHz, especially considering [RAN1]
  - expected UE complexity/cost reduction based on Rel-17 evaluation methodology
  - network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact
- **Other alternative solutions for reducing device complexity/cost**

Examples for alternative solutions can be added as subbullets as suggested by Nokia

16 – CEPRI

We propose to include Smart grid use cases from TR 22.867 into Rel-18 RedCap justification, and we share the same view with Spreadtrum on the use case part. Thanks.

17 – Guangdong OPPO Mobile Telecom.

Regarding the separation 5MHz to a Single SI, we would like to merge it back to the RedCap SI/WI. One reason is the importance of that part to the whole RedCap.

Further, it seems the current separation will make the RedCap WI became a none-RAN1-centric Item. Then, the separated WI would not be RAN1 leading.

Regarding the lower power-class, it is unclear how to down prioritize it, if it is the only one primarily for RAN4. And, we are still prefer study it first to see it will be supported. It is also reflect some companies views earlier that we did not conclude the low power class for RedCap UE. Bullet modified as:

”Study further if lower UE power class can be supported for RedCap UE [RAN1][RAN4]”

Regarding the energy harvesting, please note that we are not against to assuming intermittent power source in the study. We just don’t see RedCap SI can study how to harvesting. But, we are either fine for not mention it at all, or only mention the power assumption in the study.

18 – ZTE Corporation

We are generally fine with FL’s text in the Study Item on reduced RedCap UE bandwidth. A clarification for last sub-bullet objective ‘other alternative solutions for reducing device complexity/cost’ is needed. Since this sub-bullet is parallel with the other sub-bullets for 5MHz evaluation, any solution, e.g., HARQ process reduction and reducing the UE peak data rate, should be considered within the 5MHz study item. If there are any other candidate technologies for reducing the complexity/cost of RedCap devices and out of the scope of 5MHz study item, they should be additionally listed and discussed.

Additionally, the target data rate for the mentioned use cases in Rel-18 should be further clarified in the justification part, which can help us better understand the goal of reducing complexity. An example is shown as following:

- Rel-18 RedCap should provide NR support for low-tier devices between existing LPWA UEs and the capabilities of Rel-17 RedCap UEs. **The target data rate for these use cases could range from 1M 10Mbps and** Rel-18 RedCap should not overlap with existing LPWA solutions.

19 – LG Electronics Inc.

We suggest some minor changes on the second sub-bullet of the SI objectives as follows:

- Study further reduced UE bandwidth of 5MHz, especially considering [RAN1]
  - expected UE complexity/cost reduction based on Rel-17 evaluation methodology
  - network/**UE** impact, compatibility with Rel-17 **RedCap UEs**, coexistence of RedCap and non-RedCap UEs, ~~**UE impact,**~~ specification impact
  - other alternative solutions for reducing device complexity/cost

20 – Lenovo (Beijing) Ltd

We don't think this study needs 6-month long. It could be shorter one with e.g., 3 months. The focus should be the cost/complexity gain that further reduced UE BW (and other solutions) can provide, which is expected to be evaluated quickly based on Rel.17 methodologies.

Besides, the third sub-bullet "other alternative solutions for reducing device complexity/cost" is not that clear, better to list some candidate solutions as examples.

21 – InterDigital Communications

We think that the "other alternatives" part seems a little confusing and the intention is not clear. We should clarify as:

- *solutions* ***in addition to reduced UE bandwidth of 5MHz*** *for reducing device complexity/cost* ***including***
  - ***relaxed minimum UE processing times for PDSCH/PUSCH and CSI feedback***
  - ***limitations to max TBS***
  - ***type B HD-FDD***

22 – China Mobile Com. Corporation

It is true that companies may have different understandings about the UE cost reduction and the network impact. As in the R17 RedCap study, the SSB issue has exposed the difficulty of compromise between different positions. It is difficult for us to foresee the network impact brought by the further introduction of 5MHz, large upgrade requirement or large overhead, and also different companies have give different cost saving evaluation results, either large or small. We are still not convinced for the study of 5MHz and can not support the study of it.

23 – CEWiT

We agree with the moderator's proposal

24 – Huawei Tech.(UK) Co.. Ltd

It seems that RAN will need to have further discussion on whether and why to separate the SID from being a study phase of a WID, which would seem to be less project management effort and to more reflect the well-understood nature of RedCap cost, etc. evaluations.

We do think the number of concerns raised about "compatibility with Rel-17" wording need to respected in the final update, however. New, reduced, BW UEs are not expected to be compatible with legacy systems, any more than Rel-16 RedCap UEs are compatible with wider bandwidth NR cells. These words are clearly not correct, and if the moderator has a concern on deleting them, we would appreciate an explanation of why.

In a SID, saying "alternative solutions" may be workable, because it will serve to prove the benefit of 5 MHz BW UEs. But in a WI, RAN should not set up a competition like this, and it would be appropriate to say "additional solutions". This latter would also be a fairer reflection of the rounds of discussion in this week.

25 – Philips International B.V.

We agree with Vodafone.

26 – MediaTek Inc.

The draft objectives need to be updated (as below) to clarify that 'alternative' in this context refers to alternatives to UE bandwidth reduction, and to list out the alternatives identified thus far.

- *Study further reduced UE bandwidth of 5MHz, especially considering [RAN1]*
  - *expected UE complexity/cost reduction based on Rel-17 evaluation methodology*
  - *network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact*
  - *~~other~~ alternative solutions to UE bandwidth reduction to reduce device complexity/cost, e.g. peak data-rate reduction and UE processing time relaxation*

27 – Verizon UK Ltd

We agree with the moderator and feedback from Ericsson etc that Rel-18 RedCap can start with a study item without committing to any normative work until the outcome of the SI is obtained. This is an eco-system impacting item that worths a careful study and the study outcome matters.

28 – Sony Europe B.V.

We are generally supportive of the proposed study item text. We have the following comments:

On this paragraph:

"Rel-18 RedCap should provide NR support for low-tier devices between existing LPWA UEs and the capabilities of Rel-17 RedCap UEs. But Rel-18 RedCap should not overlap with existing LPWA solutions."

We would rather refer to "between NB-IoT and eMTC Cat-M1 UEs". Although complexity is an important aspect of LPWA UEs, we think it is not the defining aspect. Rather, low power and good coverage are the defining aspects. Hence the "tier" should be compared with the complexity of a device rather than its LPWA-ishness. The final sentence of "not overlap with existing LPWA solutions" is good. Redcap-lowBW is not aiming to push the boundaries of low-power/high coverage.

These enhancements should be introduced while maintaining the integrity of the RedCap ecosystem and maximizing the benefit of economies of scale. The work aims at enhancements applicable to the RedCap UE type and framework defined in Rel-17.

Should "work" be "study"?

29 – Fraunhofer IIS

Fraunhofer Regarding energy harvesting, we have similar views as Vivo, Everactive and Ericsson. We prefer a study of energy harvesting as part of the Rel-18 RedCap SI/WI.

In addition, we agree with Sierra Wireless that the current SID misses the chance to include new use cases in the justification to motivate the study further.

4.2 Follow-up Work Item on RedCap evolution

In the final round, please feedback and comment on the draft WID.

Feedback Form 10: Comments on the draft Work Item on RedCap evolution

1 – vivo Communication Technology

The WID looks good to us. The impacted specifications may be reviewed later when the preceding SI is concluded.

2 – Futurewei Technologies

In the justification, we have one comment.

- As mentioned in the SID, the first three paragraphs are redundant with the fourth paragraph and do not provide justification for the work item. We suggest that the first three paragraph be removed.

For the objectives:

- For e-DRX bullet, a clarification about the involvement of SA2/CT1. If normative work cannot proceed with those WGs, perhaps a statement saying "work on this objective is pending agreement from SA2/CT1".
- The further reduced UE cost / complexity bullet should be removed. We should add this bullet based on the outcome of the study.
- The lower UE power class bullet should be promoted to a standalone RAN4 bullet
- At the end, the 4 separate notes bullets should be removed. The LPWA note is covered by the sub-bullet for the lower power class objective. The coexistence bullet should be based on the outcome of the SI. The last two bullets are needed for a RedCap UE.

3 – Everactive

4 – Sierra Wireless

The WID looks good to us.

5 – CATT

Generally fine with the WID.

We think it is reasonable that only *RAN4* is involved in lower power class item, since it focus on non-coverage-limited scenario, where no coverage compensation work is required in *RAN1*. But the mark 'lower priority' is ambiguous (as always) and suggest to remove it. The trade-off should be acceptable if defining a new power class is the only burden.

6 – Intel Corporation (UK) Ltd

Intel

As mentioned in response to previous question (feedback form #9), the objective of specifying 5MHz RedCap UEs should be included as part of the WID for eRedCap. Towards this, the following objectives are suggested below to be added to the WID (same as in feedback form #9).

- *Study **and specify** further reduced UE bandwidth of 5MHz **in FR1**, ~~**especially**~~ considering [RAN1]*
  - *expected UE complexity/cost reduction based on Rel-17 evaluation methodology*
  - *network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact*
  - *~~**other alternative**~~ solutions **in addition to reduced UE bandwidth of 5MHz** for reducing device complexity/cost **including at least:***
    - ***relaxed minimum UE processing times for PDSCH/PUSCH and CSI feedback***
    - ***limitations to max TBS***
    - ***type B HD-FDD***

Even from a procedural/work planning perspective, as it stands right now, there is not a single RAN1-led objective in the WID and it would be rather strange to have the WI as RAN1-led.

Also, as a minor comment, in the following, instead of "DRX" we should say "extended DRX" to avoid any confusion.

- *Enhanced **extended** DRX in RRC_INACTIVE (>10.24s) [RAN2, RAN3, RAN4]*

7 – Spreadtrum Communications

Similar comments as for 4.1, we have the same suggestions for the justification part.

8 – Qualcomm Incorporated

Current objectives look generally fine but some of notes are misleading or not actually needed. This WI highly depends on the outcome of the study item, so we do not need any unnecessary restrictions or detailed guideline inside the WID. We will anyway update the WID after the competition of the corresponding study item. We can put more details at that time rather than putting restrictions now.

As we commented in the 2nd round discussion, we believe that sidelink support for eRedCap should be discussed further as it can support an important market with minimum work. We need to understand that SL relay is not supported for RedCap devices due to the lack of capability indication. We suggest having a placeholder for SL support for RedCap devices in WID at least for the support of different category of UEs with SL Relay.

Our suggested objectives are:

Power saving/energy efficiency enhancements

- Enhanced DRX in RRC_INACTIVE (>10.24s) [RAN2, RAN3, RAN4]
  - *Note that this objective requires SA2, CT1 involvement*

Complexity/cost reduction

- Further reduced UE cost / complexity
  - *TBD: based on SI outcome*
- Support for lower UE power class [RAN4] (*lower priority*)
  - Focus on non-coverage-limited scenarios, e.g., indoor industrial

Sidelink support for RedCap devices

- Support for different category of UEs with SL Relay.

Notes:

- The work defined as part of this WI is not to overlap with LPWA use cases.
- Coexistence with non-RedCap UEs and Rel-17 RedCap UEs should be ~~ensured~~ considered.
- This WI focuses on SA mode and single connectivity with operation in a single band at a time.
- ~~This WI considers all frequency ranges and all applicable duplex modes unless otherwise specified.~~

9 – Nokia France

The draft WID looks good.

Two comments at the end of the Justification section:

- it should be left open for the WI to decide the detail of whether a second UE type is defined or not, and
- it should be made clear that the Rel-17 principles of network awareness of UE capabilities are to be applied also in Rel-18.

To reflect these, we propose: ”The WI aims to specify enhancements applicable to the RedCap UE ~~type and~~ framework defined in Rel-17, including principles of network awareness of device capabilities.

Thanks.

10 – Ericsson LM

The draft WID looks fine to us.

On lower UE power class, with RAN 4 being the only involved WG in the current proposal, it could be added that coverage recovery is not in the scope

11 – NTT DOCOMO INC.

We are fine with the draft WID.

12 – Samsung Electronics Polska

Regarding on eDRX part, it can be treated as TEI-18. The issue has been discussed in Rel-17 in RAN 2. SA2 already sent LS to RAN 2 that SA 2 will study potential solutions in Rel-18. More important, eDRX has nothing to do with the aspects in RedCap SI. Therefore, we think it is quite suitable for a TEI-18, other than waiting for RedCap SI.

For the cost reduction part, we should not promise a WID without knowing the outcome of SI. Therefore, we do not agree with the WID.

13 – TELECOM ITALIA S.p.A.

The performance part of the work item is as usual very vague.

If I well remember there was a RAN recommendation to clearly state the objectives in the performance part for all Work Items, in order to allow better estimation of RAN4 workload

14 – CEPRI

We propose to include Smart grid use cases from TR 22.867 into Rel-18 RedCap justification, and we share the same view with Spreadtrum on the use case part. Thanks.

15 – VODAFONE Group Plc

We are OK with the draft WID

16 – Guangdong OPPO Mobile Telecom.

We comment in the last section, the separated WI would not be RAN1 leading.

We prefer a combined one, BW + Power efficiency, with some item have study phase.

Low power class also need some study.

”Study further if lower UE power class can be supported for RedCap UE [RAN1][RAN4]”

17 – ZTE Corporation

Regarding the justification part, similar comment as section 4.1, the target data rate should be clarified. The following modification is suggested.

- Rel-18 RedCap should provide NR support for low-tier devices between existing LPWA UEs and the capabilities of Rel-17 RedCap UEs **targeting 1 10Mbps peak data rate for these use cases,** but it should not overlap with existing LPWA solutions.

For the support for lower UE power class in the objective part, we think there may exist the RAN2 impacts, e.g., UE capability definition. Therefore, RAN2 also should be involved in, as follows

- Support for lower UE power class [RAN4**, RAN2**] (*lower priority*)

18 – Lenovo (Beijing) Ltd

We are fine with this draft WID

19 – InterDigital Communications

We are ok with the WID.

20 – China Mobile Com. Corporation

We are generally fine with the objectives except the Further reduced UE cost / complexity part. As expressed in section 4.1, we can not support a study for further reduce bandwidth to 5MHz. And we are open to other compatible cost/complexity reduction solutions such as reducing the UE peak data rate and relaxing the UE processing timeline

21 – CEWiT

We are fine with the WID.

22 – Huawei Tech.(UK) Co.. Ltd

Our comments to 4.1 apply jointly here.

In the justification -

- It is important to clarify the "aim" statement in the Justification of SID/WID, because in enabling the pathway of low-tier IoT into RedCap, the aim is not only lower than Rel-17 NR RedCap, but also attractive compared to LTE Cat 1/1bis:

  "*The enhancements aim at supporting lower UE complexity/cost and energy consumption compared to Rel-17* ***and LTE Cat 1/1bis***."
- The "applicable to the RedCap UE type defined in Rel-17" is problematic since 5 MHz will be a new UE. But the general framework of Rel-17 should be ok:

  The WI aims to specify enhancements applicable to the ~~RedCap UE type and~~ framework defined in Rel-17.

We agree with others that the notes copied from the Rel-17 WID need to be reconsidered before assuming all apply to Rel-18, especially if there is a WID following SID or study phase.

23 – Philips International B.V.

WID looks good for now to us but it will need to be reviewed once the SID concludes

24 – MediaTek Inc.

Rather than qualifying lower UE power class as a 'lower priority' objective, it's best to remove this objective altogether from the WI as Rel-18 should only focus on what's important.

25 – Sony Europe B.V.

The justification section of the WI provides a motivation to avoid battery replacement, but there are no corresponding objectives (longer DRX cycles just prolong the time between battery replacement, rather than eliminating). We agree that avoiding battery replacement is an important aspect of Redcap (and an important aspect of reducing OPEX). We thus think that there should be an energy harvesting objective in the WID, as per the proposal in section 2.2. We are also open to energy harvesting being discussed under passive-IOT in discussion-28, but are concerned that companies are considering eRFID in discussion-28, rather than eRedcap.

In the second to last paragraph in the justification, we would prefer that we do not compare the "tier" of eRedcap to LPWA UEs, but rather to NB-IoT / eMTC Cat-M1 UEs. We agree that eRedcap should not overlap with existing LPWA solutions (eRedcap is not about achieving the low power consumption and coverage of LPWA solutions).

26 – Fraunhofer IIS

Fraunhofer We are fine with the WID in general. Regarding SL for RedCap, we propose the following text based on the proposal from Qualcomm.

Sidelink support for RedCap devices

- Support for power saving techniques, e.g. DRX, etc.

- Support for different category of UEs with SL Relay.

4.3 Study Item on low-power wake-up signal / receiver

In the final round, please feedback and comment on the draft SID.

Feedback Form 11: Comments on the draft Study Item on low-power wake-up signal / receiver

1 – vivo Communication Technology

The draft SID on low-power WUR/WUS looks stable, while we have some suggested small revisions

- 1. The SID seems irrelavant to covarege enhance SI/WI, so propose to delete them in section 2.3
- 2. Justification part: the seperate WUR should be capable for continuous monitoring the WUS with low power, but it does not always have to do that, It will be dependent on detailed design.
- 3. Justification part: It might be good to mention, at least some example on how the low complexity and low power wake-up receiver will look like, we suggest to mention envelop detector as one example.
- 4. Objective part: we need to mention wearable as well as it is very important use case which requires long battery life and low wake-up latency. It is also important to mention that ”the studied solutions should not be limited to IoT use cases only.” as there are strong interest to also considere other use cases from companies feedback.
- 5. Objective part: Regarding RRC state, our priority is IDLE/INACTIVE, but we think CONNECTED mode does not have to be excluded now. Maybe we can delete ”in all RRC state” for now if it is controversial, and discuss the targeted RRC state and priority within the study item, e.g. during the use case discussion.

  An revised version which reflects the above suggestions for your consideration can be found as below: https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_94e/Inbox/Drafts/%5BRAN94e-R18Prep-05%5D/draft%21xxxx%20New%20SID%20on%20WUS%20WUR_vivo.docx

2 – Futurewei Technologies

We are general ok with the draft SID proposal. Some small modifications are needed.

In section 2.3 of the SID, it is unclear why coverage enhancement and RedCap are mentioned in the table. As such, those four rows should be removed.

In section 3, the term “work” in “Both out-band and in-band operation work for ultra-low power wake-up receiver is useful” is unclear. Should the term be “study”?

Also in section 3, while we understand the purpose, the term “separate / auxiliary receiver” implies an architecture. Can the term “wake-up receiver” be used.

In the objective, the statement “(in all RRC states)” in fourth sub-bullet should be clarified. The considered RRC states should be based on the outcome of identifying the use cases in the first sub-bullet.

3 – Sierra Wireless

Support this SI.

A few minor comments on the objective section:

The 1st sentence in the objective section is not needed as it is well covered in the justification section and as Vivo mentions may limit use case to IoT only:

The study should primarily target ultra-low power WUS/WUR required by IoT use cases, e.g. power-sensitive, delay-critical, small form-factor devices such as industrial sensors or controllers.

Since a WUR is an type of lower power RX implement, it will not be specified, thus the objective should be changed:

- **Study and evaluate L1 procedures and L2 protocol changes needed to support the detection of wake-up signals ~~wake-up receivers~~ (in all RRC states) [RAN2, RAN1]**

To save TUs, I think we do not need to consider the RRC connected mode so this objective could be changed.

- **Study and evaluate L1 procedures and L2 protocol changes needed to support wake-up receivers (in ~~all~~ RRC idle/inactive states) [RAN2, RAN1]**

4 – Everactive

On ULP receiver architectures - we would prefer to leave this out of a justification, and keep this part of the study phase. ULP receivers do not necessarily require an envelop-detector architecture. For examples of ULP receivers, you could refer to the survey and spreadsheet at this link: https://wics.engin.umich.edu/ultra-low-power-radio-survey/

5 – CATT

Thanks for the moderator's great effort. We are generally fine with the SID. Some additional comments:

1. 'Receiver sensitivity' is a critical KPI to the low power WUR/WUS, and we suggest to include it in the 1st bullet as an example.

2. 'Power model' is essential for power saving estimation, and we also suggest to include it in the 1st bullet as an example.

3. Agree with moderator that both out-band and in-band WUR are attractive to consider. The impact/cost on intergrating the out-band/in-band WUR in current NR receiver will be different and should be studied. Better to include it in the objectives explicitly for guidance.

In summary, we propose the following minor modification:

- **Identify use cases, evaluation methodology & KPIs, e.g. receiver sensitivity, power modle [RAN1]**
- **Study and evaluate low-power wake-up receiver architectures [RAN1, RAN4]**
  - **The low-power wake-up receiver is assumed to be intergrated as the front end device of NR receiver, and can be in-band or out-band**
- ...(the unchage part is omitted)

6 – Intel Corporation (UK) Ltd

Intel

We are mostly fine with the objectives with the following exception.

The following statement is not required as part of objectives.

"The study should primarily target ultra-low power WUS/WUR required by IoT use cases, e.g. power-sensitive, delay-critical, small form-factor devices such as industrial sensors or controllers."

Primary reason being that it is not objectively enforceable at RAN WG levels, and would be likely to only cause confusion at WG level. For instance, there can be "eMBB UEs" used for IoT use-cases for which ultra-low power WUR may still be relevant. Also, from a technical perspective, a separate ultra-low power WUR need not be limited to "small form-factor devices" only.

If at all, we can consider capturing the following modified text **but within the justification section**:

*"The study **~~should~~ is** primarily **~~target~~ motivated by** ultra-low power WUS/WUR required by IoT use cases, e.g. power-sensitive, delay-critical, small form-factor devices such as industrial sensors or controllers."*

7 – Apple Poland Sp. z.o.o.

We are generally fine with the draft SID with a few comments below:

On 'use cases' (first paragraph of 'objective of SI' section)

- As we commented earlier, we do not see the need to prioritize the IoT use cases from the beginning.
- Low latency is certainly one potential benefit of LP WUS. However, even without low latency requirements, LP WUS should still provide significant power saving due to the low power consumption of WUR compared to that of idle UE today. So the use cases should not be limited to low latency only.

We therefore suggest the following changes on the SID draft:

'The study on ~~should primarily target~~ ultra-low power WUS/WUR should cover both ~~required by~~ IoT use cases and generic non-IoT use cases. The IoT use cases include e.g. power-sensitive~~, delay-critical,~~ and small form-factor devices such as industrial sensors, ~~or~~ controllers or wearables, with or without low latency requirements.'

On the last objective:

We asked clarification questions on "other UEs' power consumption" and "compatibility with other UE power saving solutions", which haven't been addressed so far. We would suggest removing these two for now unless the intention is clearly explained:

'Study potential system impact, such as network and ~~other UEs' power consumption,~~ coexistence with legacy UEs, network coverage~~, and compatibility with other UE power saving solutions~~ [RAN1, RAN2]'

8 – Qualcomm Incorporated

We agree with other companies on use case. We think the scope should not be limited to IoT use case. Given that the LP WUR/WUS could benefit other use cases requiring lower latency and lower power consumption, those other use cases, e.g., eMBB, should be also included. The justification part also needs to be modified accordingly. We suggest following modification in objective description.

The study should ~~primarily~~ target ultra-low power WUS/WUR required by IoT use cases, (e.g. power-sensitive, delay-critical, small form-factor devices such as industrial sensors or controllers) and eMBB use cases.

We are fine with "all RRC states". We can remove the parenthesis in 4th objective.

- **Study and evaluate L1 procedures and L2 protocol changes needed to support low power wake-up signals/receivers ~~(~~in all RRC states~~)~~**

9 – Spreadtrum Communications

For the justification part.

- For the "continuously monitoring", we share the similar view as vivo that LP-WUR is capable of it but may not do this all the time. So, we suggest removing "**continuously**".

For the objective part.

- The fourth bullet. For RRC state, we think it is too early to decide which RRC state should be focused on or supported. So, we suggest removing "**in all RRC state**" currently.
- The fifth bullet. For interaction b/w the separate LP-WUR and the main receiver , we share the similar view as Everactive that the main receiver may need to maintain local timing to avoid the power consumption of re-sync. We think it may also mentioned by other companies as the feasibility of architecture in term of power consumption. If the transition power is too high, the power saving gain will be largely reduced. Like the transition power mentioned above, the transition time should be also considered, especially for RRC connected mode. So, we suggest adding "latency" in the network impact. Indeed, we suspect whether we list the sufficient network impact already, thus we suggest changing "such as" to "e.g.". Therefore, we suggest changing the whole part of network impact as "**e.g.** network and other UEs' power consumption, coexistence with legacy UEs, network coverage, **latency, power consumption of the main receiver,** and compatibility with other UE power saving solutions".

Other views

- For CATT's suggestion "**The low-power wake-up receiver is assumed to be intergrated as the front end device of NR receiver**", we don't think the LP-WUR can be integrated as the front end of the main receiver. The separate LP-WUR means the separate front-end and modem. We don't know which part of the front end can be integrated into NR receiver. As we always commented, we should pay attention to the complexity/cost of architecture of LP-WUR, and also the low complexity/cost front-end of LP-WUR is important.

10 – Nokia France

The SID looks OK.

We do not agree that specific examples of implementation solution should be mentioned in the justification section as suggested by Vivo; that should be left to the study itself.

11 – CEWiT

We are generally fine with the draft SID.

Regarding use cases, we share a similar view with other companies that the scope should not be limited to IoT and eMBB should be included.

12 – Ericsson LM

The draft SID looks fine to us.

In our view, it is not necessary to add examples of specific receiver architecture in the justification text as they can be proposed and discussed in the SI.

We agree with Vivo's intended clarification in the justification that WUR mustn't necessarily be used with continuous monitoring of the DL.

The sentence "Both out-band and in-band operation work for ultra-low power wake-up receiver is useful" in the last paragraph of the justification seems a bit unclear. We generally don't agree with the benefits of 'out-band operation' listed and propose to remove it.

13 – NTT DOCOMO INC.

For the 5th objective on "compatibility with other UE power saving solutions", as we mentioned in the initial round and intermediate round, we suggest clarifying the intention, such as studying whether or not ultra-low power WUS/WUR can be used together with the existing UE power saving features, e.g. WUS, PEI.

If there is no clarification about that, we are also fine to delete "and compatibility with other UE power saving solutions".

14 – Samsung Electronics Polska

First of all, we also have interest to expand the use case to other type of UEs, e.g., eMBB UEs. Therefore, we suggest to modify the objective as:

The study should primarily target ultra-low power WUS/WUR required by IoT use cases, e.g. power-sensitive, delay-critical, small form-factor devices such as industrial sensors or controllers.

Other use cases or UE types are not precluded.

- Identify **traffic characteristic of the target** use cases, evaluation methodology & KPIs [RAN1]

Besides, we think it is important to focus the study on the WUS/WUR first, taking into account on the potential system impact. Then, based on the potential design of WUS/WUR, we can discuss on the L1 procedures and L2 protocol changes. Therefore, we suggest to either delete the following bullet, and update it in later RAN based on the outcome.

- ~~***Study and evaluate L1 procedures and L2 protocol changes needed to support wake-up receivers (in all RRC states) [RAN2, RAN1]***~~

Or, this part can be started in second phase, which can be clearly noted in the SID to give clear guidance of WG.

15 – TELECOM ITALIA S.p.A.

We share the concern raised by T-Mobile US by mail (see below)

The introduction in the objective section of the WUS SID states "As opposed to the work on UE power savings in previous releases, this study will not require existing signals to be used as WUS". This is concerning because it implies that the solution(s) identified in the SID don't have to be backward compatible. T-Mobile USA is concerned the farther REDCAP drifts from the NR specification the less synergy there is with NR and the greater the ecosystem challenges. To address T-Mobile USA proposes to add a bullet to the objectives that states "All WUS solutions identified shall be fully backward compatible"

16 – VODAFONE Group Plc

The draft SID looks OK to us, we're fine to restrict to NR IoT use cases for workload management reasons as commented in the previous round.

17 – ZTE Corporation

1. For the description, 'A dedicated carrier for wake-up signal purpose only may cause low resource efficiency and inflexible for operator to deploy', the word 'only' is not appropriate here since the network capacity issue or any other potential issue also may be caused. Therefore, a minor modification is suggested

- 'A dedicated carrier for wake-up signal purpose ~~only~~ may cause low resource efficiency and **inflexibility** for operator to deploy',

2. For the first paragraph of Objective of SI, it is mentioned that IoT use cases are delay-critical. However, according to the Rel-17 RedCap WID, the typical uses case, including Industrial wireless sensors, Video surveillance and Wearables, have the latency requirement 5 500ms and they are not so delay critical. Therefore, it can be removed and the modification can be

- 'The study should primarily target ultra-low power WUS/WUR required by IoT use cases, e.g. power-sensitive~~, **delay-critical**~~, small form-factor devices'

3. Resource occupation for low power WUS, especially for always-on WUS, would impact NW capacity and cause the resource fragmentation. Therefore, the NW capacity also should be considered in the evaluation.

- Study potential system impact, such as network and other UEs' power consumption, coexistence with legacy UEs, network coverage, **network capacity** and compatibility with other UE power saving solutions [RAN1, RAN2]

18 – Guangdong OPPO Mobile Telecom.

We are general fine with this separation on WUS from RedCap.

Since this design may have wide spec impact. Some of the bullet may not be that limited. The RAN2 spec impact does not limited to L2. It can be "Study and evaluate L1 procedures and higher layer protocol changes ...".

19 – LG Electronics Inc.

We think one of the most important part of this study, if agreed, is to evaluate the performance gap b/w the existing solutions and the low-power WUR/WUS.

It was captured somehow in the introductory remarks under 4.1 Objective of SI, but we prefer it to be explicitly listed as one of the SI objectives with some minor modification as suggested below.

We included Rel-15 because the DRX which is one of target for comparison has been supported since Rel-15.

So, we would like to add the following as one of the SI objectives:

- **Evaluate the gains of identified solutions compared to the existing Rel-15/16/17 UE power saving schemes**

20 – InterDigital Communications

We support the SID. We also think that study should not be limited to IoT use case only. We are fine with all RRC states.

21 – Lenovo (Beijing) Ltd

We are fine with this draft SID

22 – China Mobile Com. Corporation

We are generally fine with the draft SID.

23 – Huawei Tech.(UK) Co.. Ltd

In the justification part, it is not clear on the understanding of 'reliable energy source'. These are sources with lesser capacity, but not lesser reliability. Thus we suggest the following modification:

Energy efficiency is even more critical for some UEs ~~***without a reliable energy source***~~*, e.g., UEs using small rechargeable and single coin cell batteries.*

For the first paragraph of the objective part:

1) In the first sentence of the objectives, it is rather detailed on examples, which are not the key points of the SI. The key point of the SI is when a device is power-sensitive, and for this purpose in the SID we need mention only that. The other examples can be dealt with if demanded in WGs, thanks to the first objective for identifying use cases.

There also some other concerns with specifics of the currently-listed examples, which can be dealt with most easily by simplifying the opening:

2) Regarding the 'delay-critical', it is not clear to us what baseline is considered for the delay. We think waking-up the main receiver by a WUR may also need large latency considering the main receiver could be switched off for extremely low power.

3) We don't see a need to mention the size of the device, e.g. 'small form-factor', and it is not clear on how it would impact the power enhancement study.

The study should ~~***primarily***~~ *target ultra-low power WUS/WUR required by* ~~***IoT use cases, e.g.***~~ *power-sensitive*~~***, delay-critical, small form-factor***~~ *devices* ~~***such as industrial sensors or controllers***~~*.*

For the second paragraph of the objective part, we understand the intention is to have justifiable gains over the various power saving mechanisms that exist in NR, from Rel-15, i.e. not only those introduced in Rel-16/17 work.

...Solutions should give justifiable gains compared to the existing ~~*Rel-16/17 UE*~~ *power saving mechanisms*~~*enhancements*~~*. ...*

For the 4th objective, according to the first and intermediate round discussion, most companies seems to focus on the power saving for RRC_IDLE/INACTIVE state UEs, similarly as the moderator described in the justification part. We suggest it is better to let WGs consider which RRC states are suitable for solutions, before mandating them all from SID-level:

- ***Study and evaluate L1 procedures and L2 protocol changes needed to support wake-up receivers ~~(in all RRC states)~~ [RAN2, RAN1]***

Thanks for the update on coexistence with different releases of UEs. However, the lp-WUR/WUS also needs to consider Rel-18, and the word "legacy" misses this:

Study potential system impact, such as network and other UEs' power consumption, coexistence with ~~legacy~~other UEs, network coverage, and compatibility with other UE power saving solutions [RAN1, RAN2]

24 – Philips International B.V.

We agree with Sierra Wireless. In addition, we suggest to move the second paragraph to a NOTE below the objectives.

25 – Verizon UK Ltd

OK with SID. We also think that study should not be limited to IoT use case only.

26 – Sony Europe B.V.

We support the justification and objectives.

We have the following comments:

- In the second paragraph of the justification, presumably "changing" should read "charging"
- In the fourth paragraph of the justification, we should talk about "a separate receiver which **has the ability to** continuously **monitor** wake-up signal with ultra-low power consumption". Although the WUR is expected to have low power consumption, it is not expected to have zero power consumption, hence it would be beneficial if the WUR doesn't have to be continuously active.
- In the objectives, we agree that WUS / WUR should be considered for all RRC states (connected, idle and inactive)

27 – MediaTek Inc.

The term 'IoT usecases' should be replaced by a list of qualities required by these use cases to clarify the target of this SI. In addition, 'delay-critical' should be removed unless the delay target is quantified. The following changes are suggested:

The study should primarily target ultra-low power WUS/WUR required by ~~IoT use cases, e.g.~~ power-sensitive, ~~delay-critical~~, small form-factor devices such as industrial sensors, controllers and wearables.

The design criteria for the LP-WUS signal should be clear from the objectives with well-defined requirements. We suggest targeting an order of magnitude reduction in power consumption when compared to

NR. The study should consider all aspects of LP-wakeup receiver operation including the need for frequent SSB reception today e.g. for mobility. Therefore we suggest the following change:

As opposed to the work on UE power savings in previous releases, this study will not require existing signals to be used as WUS. Solutions should give justifiable gains compared to the existing Rel-16/17 UE power saving enhancements. The target power consumption for LP-WUR operation should be an order of magnitude (1/10th) lesser than what can be achieved with RRC Idle mode operation in NR today. The requirements for frequent SSB reception needs to reconsidered to achieve this low power target. Aspects such as UE power consumption, detection performance, coverage, UE complexity, should be covered by the evaluation.

As the use-cases are already listed out in the paragraphs above, there's no need to further investigate use-cases as part of this SI and an objective can result in a very open-ended SI. It is also important to remove 'all RRC states' from the objectives as it is even unclear if LP-WUR operation can be mapped to any specific RRC state. This would instead be a part of this study, where we look at the overall protocol impact.

- ***Identify ~~use cases,~~ evaluation methodology & KPIs [RAN1]***
- ***Study and evaluate low-power wake-up receiver architectures [RAN1, RAN4]***
- ***Study and evaluate wake-up signal designs to support wake-up receivers [RAN1, RAN4]***
- ***Study and evaluate L1 procedures and ~~L2 protocol changes~~ overall protocol impact needed to support wake-up receivers ~~(in all RRC states)~~ [RAN1, RAN2]***

28 – Fraunhofer IIS

Fraunhofer the justification part of the SID we propose to not preempt possible outcome of the SID. Therefore we would like to remove the following sentence:

Both out-band and in-band operation work for ultra-low power wake-up receiver is useful. ~~A dedicated carrier for wake-up signal purpose only may cause low resource efficiency and inflexible for operator to deploy.~~ To support the scenario where wake-up signal and legacy system are deployed in one carrier, the coexistence of wake-up signal and legacy signal/channel needs to be considered.

4.4 Final Round summary

Based on the above discussion and below conclusions, the moderator has updated the 2 SIDs and the WID in the RAN#94e drafts inbox. The documents will be submitted to RAN#94e in RP-212705 (WID on RedCap evolution), RP-212732 (SID on further RedCap UE complexity / cost reduction), and RP-212733 (SID on WUS/WUR).

4.4.1 Initial Study Item on further RedCap UE complexity / cost reduction

The main discussion point was the relation of the proposed RF bandwidth reduction to 5MHz with other solutions, e.g. peak data rate reduction, UE processing timelines, etc. One question was whether they are exclusive or can complement each other. Another question was which solutions are explicitly captured in the SID. The moderator's understanding is that the studied/selected solutions can complement each other and that any (reasonable) proposal to reduce cost/complexity can be studied. The moderator has tried to clarify this issue through a re-structuring of the list of potential solutions.

A couple of companies asked to removed the notion of "compatibility with Rel-17" with the argument that this is not mandated/required. While the moderator agrees that it is not required, he would like to highlight that the SID only says "compatibility with Rel-17 ... should be considered". As moderator, I am very hesitant to remove that part, as this consideration/question seems to be the single most important aspect of the SI. The SI conclusion will then tell us whether the follow-up WI will require such compatibility or not.

A couple of companies wanted to add the study on protocol enhancements for Energy Harvesting back. Although it seems correct that area 28 is not addressing the existing NR/LTE RATs, the moderator assumes that the majority of companies still don't agree to add it back (as stated in the Intermediate Round). However, Energy Harvesting could be mentioned as a new Rel-18 use case.

A couple of comments addressed the justification part, especially the relation of Rel-18 RedCap and LPWA. To further clarify the desire for non-overlapping technical solutions a target peak data rate of 10Mbps has now been added.

4.4.2 Follow-up Work Item on RedCap evolution

There were comments on the justification part, which has now been adapted to the justification part of the preceding SI.

There were comments on the bottom notes, which will need to be addressed based on the SI conclusions.

Companies commented that the editorial note on "low priority" for the lower UE power class doesn't add value and the moderator agrees that we rather decide at plenary to keep/remove the corresponding objectives. As there was no strong objection, the corresponding objective has been kept.

4.4.3 Study Item on low-power wake-up signal / receiver

Some companies continued to propose to expand the SI scope also to eMBB use cases with equal priority. The moderator expects this to be a rather large increase in scope, i.e., multiplying the evaluation work and potentially leading to multiple different wake-up signal designs. Hence, the moderator believes that onboarding more use-cases with equal priority can only be discussed together with the Rel-18 time budget during RAN#94e. Instead, the moderator would like to note that the current formulation "The study should primarily target..." already allows to consider other use cases on secondary basis. This has now been further highlighted by adding Samsung's proposal "Other use cases are not precluded".

The applicable RRC states were discussed. The moderator acknowledges that there might be benefits in any RRC state and thinks that this aspect can be further discussed when identifying the most promising use cases for WUS/WUR.

The justification of "in-band / out-band wake-up signals" were discussed and the moderator acknowledges that it is not entirely clear 1) what those terms mean and 2) what the pros & cons might be. Hence it was removed from the justification but can be looked at when identifying the most promising use cases for WUS/WUR.

5 Moderator's final proposal

- Approve the SID on "Study on further RedCap UE complexity / cost reduction" (RP-212732) at RAN#94e

- Allocate TUs for the follow-up WI on “RedCap evolution” in the Rel-18 time budget
- Approve the updated WID on “RedCap evolution” after the completion of the initial Study Item on “further RedCap UE complexity / cost reduction” (RP-212705) at RAN#97 (Sep. ’22)

- Approve the SID on “Study on low-power wake-up signal / receiver” (RP-212733) at RAN#94