**3GPP TSG RAN WG1 #110bis-e R1-22XXXX**

**e-Meeting, October 10th – 19th, 2022**

**Agenda item: 9.5.2.3**

**Source: Moderator (CMCC)**

**Title: Summary for low power high accuracy positioning**

**Document for:** **Discussion and Decision**

**Introduction**

In the latest approved/revised Rel-18 SID on study on expanded and improved NR positioning [1], an objective to evaluate and study the low power high accuracy requirement provided by SA1 was justified as follows.

|  |
| --- |
| * + Study the requirements on LPHAP as developed by SA1 and evaluate whether existing RAN functionality can support these power consumption and positioning requirements. Based on the evaluation, and, if found beneficial, study potential enhancements to help address any limitations [RAN2, RAN1]     - Study is limited to a single representative use case (use case 6 as defined TS 22.104). The choice of selected use case can be reviewed at the start of the study.     - Study is limited to enhancements to RRC\_INACTIVE and/or RRC\_IDLE state |

This contribution provides a summary of the submitted contributions, issues for discussions and outcomes in RAN1#110bis-e meeting.

**Collection of proposals for online / email approval**

## 2.1 Proposals for online session

TBD

## 2.2 Proposals for email approval

TBD

**Remaining issues of evaluation methodology**

***Background:*** This agenda item aims to evaluate whether current RAN functionalities can meet the LPHAP requirement on battery life, and also potential enhancements to maximize the battery life. To better align the power consumption results for different evaluation cases from different companies and properly identify the performance gap and make conclusions, the evaluation methodology and power consumption models should be defined.

In RAN1#110 meeting, all remaining issues on the evaluation assumption were resolved except the power model of ultra-deep sleep.

## 3.1 Power model of ultra-deep sleep state

***Background:*** In RAN1#110 meeting, it was agreed to consider ultra-deep sleep state for the purpose of LPHAP evaluation. Two options of the power consumption model of the ultra-deep sleep state were proposed for further study, along with all the values in the power model:

|  |
| --- |
| Agreement  For the purpose of LPHAP evaluation, an ultra-deep sleep state is considered. The following options of the power consumption model of the ultra-deep sleep state can be further discussed:   * Option 1:   + The relative power unit: 0.015   + Additional transition energy: 2000   + Total transition time: 400ms * Option 2:   + The relative power unit: 0.01   + Additional transition energy: 450;   + Total transition time: 25ms   + FFS: restrictions in processing associated with option 2 after the UE comes out of ultra-deep sleep state * Notes: the values above can be further discussed   Agreement  For option 1 in the agreement above, the value of additional transition energy is changed to “a value between 2000 and 20000”. FFS which value. |

During the discussion in the last meeting, companies supporting each option have the following understanding:

* Option 1: Considers the evaluation assumption of “Power Saving State” in the study of NB-IoT as a starting point, where a UE consumes less power than that in RRC\_IDLE state by shutting down most of its power supplies to maintain a very low current, and accurate time/frequency synchronization with the network is not guaranteed.
* Option 2: Assumes a UWB-like LPHAP UE with limited communication functionalities and dedicated positioning capabilities, which can quickly wake up from an ultra-deep sleep mode to perform positioning operation only and hence has an optimized value for transition energy and time.

3.1.1 Summary of inputs

Based on the submitted contributions in this meeting, 11 companies (HW/Hisilicon, vivo, Nokia/NSB, CATT, Intel, ZTE, xiaomi, CMCC, Samsung, Qualcomm, Ericsson) discuss the power model of ultra-deep sleep state and/or adopt some of the models to provide evaluation results of battery life:

* **Issue #1: Whether down-selection of the two options is pursued**
  + 1 company (HW/Hisilicon) proposes to adopt both options as they refer to different wake-up states:
    - For Option 1, it is assumed that UE would be capable of the legacy “communication” service and the UE is expected to be ready to perform regular operations for communication when leaving from the sleeping mode, such as cell access, data transmission/reception, etc.
    - For Option 2, it is assumed that UE is implemented dominantly for positioning purpose so UE is only expected to be ready for positioning operation only when leaving from the sleeping mode.
  + 7 company (vivo, Nokia/NSB, Intel, ZTE, CMCC, Samsung, Qualcomm) mention in their contributions to adopt either one of them, due to the reason that, e.g., to avoid over-complicating the evaluations.
* **Issue #2: Option 1 vs Option 2**
  + Supporting Option 1: 10 companies (HW/Hisilicon, vivo, Nokia/NSB, CATT, Intel, xiaomi, CMCC, Samsung, Qualcomm, Ericsson), in which,
    - 4 companies (vivo, Intel, Samsung, Qualcomm) explicitly propose to adopt Option 1 and show concerns on Option 2:
      * More justification is required on the feasibility and applicability of ultra-deep sleep option 2 in practical applications, as in the ultra-deep sleep, most of the hardware components are expected to be turned off which implies longer transition time.
      * No accurate synchronization is maintained in the ultra-deep sleep state, and it is not practical for a UE to wake up from ultra-deep sleep to only perform positioning functionalities without processing SSBs.
      * Option 2 assumes specialized device(s) with only positioning capabilities beyond the already defined devices (e.g. regular device or Redcap device), which is not in the study scope.
    - 3 companies (CATT, xiaomi, Ericsson) simply use Option 1 in their evaluations.
  + Supporting Option 2: 3 companies (HW/Hisilicon, ZTE, CMCC), in which,
    - Option 1 refers to the evaluation assumption of power saving states for NB-IoT, which shares different UE capabilities and bandwidth with that of the LPHAP device. It is not reasonable to take the assumptions for NB-IoT as a starting point.
    - Option 2 assumes a dedicated UE dominantly for positioning purpose, which is only expected to be ready for positioning operation when leaving from the sleeping mode.
* **Issue #3: Values of ultra-deep sleep state Option 1**
  + Additional transition energy
    - 3 companies (Intel, ZTE, CMCC) oppose to reuse the value of 20000 as defined in the study of NB-IoT, the rational include:
      * NB-IoT power model has only 2 sleep states (light sleep and deep sleep for idle state), and LPHAP has 4 sleep states (ultra-deep, deep, light, micro-sleeps). Assumption on which hardware components are turned off for the sleep state with normalized power value 1 are not the same in the two UEs.
      * NB-IoT needs looser synchronization, much less support bandwidth, and lower UE capability than NR UE.
      * From the evaluations, assuming 20000 as additional transition energy is no way to meet the target requirement of battery life of 6~12 months for baseline LPHAP device. Please refer to the summary of results in Section 4.2.
    - The proposed additional transition energy is summarized below

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Values | 2000 | 5000 | 20000 | 10000 |
| Source | CATT, Intel, xiaomi, CMCC, Samsung | vivo | Qualcomm | HW/Hisilicon |

* + Relative power unit: 1 company (HW/Hisilicon) prefers to align the relative power unit of the two options to 0.01.
* **Issue #4: Values of ultra-deep sleep state Option 2**
  + 2 companies (ZTE, CMCC) propose different values on Option 2:
    - Additional transition energy: ZTE proposes 480; CMCC proposes [800].
    - Transition time: CMCC proposes [50]ms.

3.1.2 Round 1 discussion

***FL comments:*** Though only a few companies are supportive of Option 2 of the power model of the ultra-deep sleep state, seems that most companies do not realize the assumptions on Option 2 (e.g., a dedicated device with dominantly positioning capabilities and limited communication requirements), or do not think this kind of device type is in the study scope, or are not convinced by the processing restrictions (e.g., go strict to process positioning without get synchronized). FL suggest to have a round of discussion on Option 2 to let companies understand each other before going straight to Option 1.

In addition, regarding the values of the additional transition energy of Option 1, majority of companies admit the drawbacks of reuse 20000 as defined for NB-IoT. For values other than 20000, 2000 that proposed by 5 companies is taken as a starting point.

Therefore, the following proposal is formulated:

**[High] Proposal 3.1 (I)**

* For the power consumption model of the ultra-deep sleep type, down-select from the following two alternatives:
  + Alt. 1: Adopt the following option (modified option 1 from RAN1#110 meeting)
    - The relative power unit: 0.015
    - Additional transition energy: 2000;
    - Total transition time: 400ms
  + Alt. 2: Adopt the following options for different wake-up states
    - Option 1:
      * The relative power unit: 0.015
      * Additional transition energy: 2000;
      * Total transition time: 400ms
    - Option 2 (an optimized wake-up state):
      * The relative power unit: 0.01
      * Additional transition energy: 480;
      * Total transition time: 25ms

|  |  |  |
| --- | --- | --- |
| **Company** | **Alt.** | **Comments** |
| Qualcomm | 1 with 20000 and NOT 2000 | Sorry for the confusion in the paper. Our view is to use 20000. We don’t agree with the arguments above on using 2000. The reasoning of 2 states vs 4 states, we don’t think that makes a difference. It hasn’t been discussed what synchronization is needed for NR UE for an ultra-deep sleep state. There hasn’t been any related discussion in the Power Saving subagenda.  The fact that with 20K we don’t meet the requirements should not be an argument. It is enough to show gains and that the gap closes to motivate an enhancement. These models are either way very simplistic, and it is the reason there is also the implementation factor that can go up to “4”. |
|  |  |  |
|  |  |  |

## 3.2 Other considerations

3.2.1 Summary of inputs

In [6/Nokia, NSB], it is proposed to add the following note to the conclusion on positioning accuracy made at RAN1#109-e meeting:

**Proposal 1:** Add the following note to the conclusion made at RAN1#109.

* Note: This does not imply anything about if the Rel-16/17 positioning technique can achieve the target horizontal positioning accuracy requirement based on the baseline assumption for power consumption evaluation of LPHAP.

The intention is that the baseline assumption on the power model of the DL PRS measurement considers 4 TRPs in the LPHAP evaluation; while in Rel-17 InF scenario for evaluation of positioning accuracy, UE needs to measure 18 TRPs. Hence, it may have risk of achieving the target requirement of accuracy with the baseline assumptions of LPHAP evaluation.

***FL comments:*** Though the baseline assumption on the power model of the DL PRS measurement is not aligned with that in the accuracy evaluation in Rel-17 InF scenario with 18 TRPs, my suggestion is not to add this note. We can consider the LPHAP baseline assumption as TDMed measuring 18 TRPs across 5 I-DRX cycles (within 1 I-DRX cycle, 4 TRPs are measured), where with the baseline assumption of I-DRX cycle = 1.28s, we have 5 cycles = 6.4s. In addition, we also agreed that the UE mobility is up to 3km/h, then with a duration of 6.4s, the UE moves about 5.3m, which is trivial, and the overall environment and configuration can be considered as the same.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

**Evaluation results**

## 4.1 Rel-17 RRC\_INACTIVE state positioning

4.1.1 Summary of inputs

From reviewing submitted contributions in this meeting, 12 (HW/Hisilicon, Spreadtrum, vivo, Nokia/NSB, CATT, Sony, xiaomi, CMCC, Samsung, LGE, Qualcomm, Ericsson) out of 20 companies provide evaluations for baseline Rel-17 RRC\_INACTIVE state positioning. The results for each positioning method are summarized below.

Note: Without otherwise noted, “High SINR” refers to the case that no intra-/inter-frequency RRM is considered, and “Low SINR” refers to the case that multiple SSB bursts are used for synchronization, intra-frequency, and inter-frequency RRM.

**Table 1: Summary for results of UE-assisted DL positioning**

|  |  |  |  |
| --- | --- | --- | --- |
| Source | Evaluation case description | Target requirement are met – Yes/No | |
| 6 months | 12 months |
| HW, Hisilicon [2] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  Cell access procedures per 10.24s | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR, CG-SDT for reporting;  Cell access procedures per 10.24s | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  Cell access procedures per 10.24s | K = 1, Type A: NO | K = 1, Type A: NO |
| Spreadtrum [4] | I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| vivo [5] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, RA-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR, RA-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR, RA-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR, RA-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| Nokia,NSB [6] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| CATT [8] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| Sony [10] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| xiaomi [12] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| CMCC [13] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, RA-SDT for reporting; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR, RA-SDT for reporting; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| Samsung [16] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR, RA-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, Low SINR, RA-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR, RA-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| LGE [18] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; CG-SDT for reporting;  Gap between paging and PRS is minimized; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; CG-SDT for reporting;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR; RA-SDT for reporting;  Gap between paging and PRS is minimized; No inter-frequency RRM; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR; RA-SDT for reporting;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR; CG-SDT for reporting;  Gap between paging and PRS is minimized; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR; CG-SDT for reporting;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR; RA-SDT for reporting;  Gap between paging and PRS is minimized; No inter-frequency RRM; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR; RA-SDT for reporting;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| Qualcomm [20] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; CG-SDT for reporting; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR; CG-SDT for reporting; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR; CG-SDT for reporting; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Ericsson [21] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  8 TRP receptions; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 10.24, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  8 TRP receptions; | K = 1, Type A: NO | K = 1, Type A: NO |

**Table 2: Summary for results of UE-based DL positioning**

|  |  |  |  |
| --- | --- | --- | --- |
| Source | Evaluation case description | Target requirement are met – Yes/No | |
| 6 months | 12 months |
| HW, Hisilicon [2] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  Cell access procedures per 10.24s | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR;  Cell access procedures per 10.24s | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  Cell access procedures per 10.24s | K = 1, Type A: NO | K = 1, Type A: NO |
| Spreadtrum [4] | I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| vivo [5] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| Nokia,NSB [6] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| CATT [8] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| xiaomi [12] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| CMCC [13] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| LGE [18] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  Gap between paging and PRS is minimized; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR;  Gap between paging and PRS is minimized; No inter-frequency RRM; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  Gap between paging and PRS is minimized; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR;  Gap between paging and PRS is minimized; No inter-frequency RRM; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| Qualcomm [20] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |

**Table 3: Summary for results of UL positioning**

|  |  |  |  |
| --- | --- | --- | --- |
| Source | Evaluation case description | Target requirement are met – Yes/No | |
| 6 months | 12 months |
| HW, Hisilicon [2] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  Cell access procedures per 10.24s | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR;  Cell access procedures per 10.24s | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  Cell access procedures per 10.24s | K = 1, Type A: NO | K = 1, Type A: NO |
| Spreadtrum [4] | I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| vivo [5] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| Nokia,NSB [6] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| CATT [8] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| xiaomi [12] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| CMCC [13] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  No SRS (re)configuration; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR;  No SRS (re)configuration; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  RA-SDT for SRS (re)configuration per power cycle; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR;  RA-SDT for SRS (re)configuration per power cycle; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| Samsung [16] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, Low SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| LGE [18] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  Gap between paging and PRS is minimized; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR;  Gap between paging and PRS is minimized; No inter-frequency RRM; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, Low SINR;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  Gap between paging and PRS is minimized; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR;  Gap between paging and PRS is minimized; No inter-frequency RRM; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, Low SINR;  Gap between paging and PRS is minimized; BWP switching; | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: YES | K = 0.5, Type A: NO  K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 0.5, Type B: NO  K = 1, Type B: NO  K = 2, Type B: NO  K = 4, Type B: NO |
| Qualcomm [20] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  No SRS (re)configuration; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR;  No SRS (re)configuration; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  No SRS (re)configuration; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR;  RA-SDT for SRS (re)configuration per power cycle; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR;  RA-SDT for SRS (re)configuration per power cycle; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR;  RA-SDT for SRS (re)configuration per power cycle; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| Ericsson [21] | I-DRX= 10.24, 1 RS per 1 I-DRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |

**Table 4: Summary for results of DL+UL positioning**

|  |  |  |  |
| --- | --- | --- | --- |
| Source | Evaluation case description | Target requirement are met – Yes/No | |
| 6 months | 12 months |
| Qualcomm [20] | I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  No SRS (re)configuration; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR, CG-SDT for reporting;  No SRS (re)configuration; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  No SRS (re)configuration; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| I-DRX= 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  RA-SDT for SRS (re)configuration per power cycle; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 1.28s, 1 RS per 8 I-DRX, High SINR, CG-SDT for reporting;  RA-SDT for SRS (re)configuration per power cycle; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |
| I-DRX= 10.24s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  RA-SDT for SRS (re)configuration per power cycle; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |

To sum up, evaluation results on Rel-17 positioning for UEs in RRC\_INACTIVE state are provided by 12 sources (HW/Hisilicon, Spreadtrum, vivo, Nokia/NSB, CATT, Sony, xiaomi, CMCC, Samsung, LGE, Qualcomm, Ericsson) out of 20 sources, and the following is observed:

* For UE-assisted DL positioning with LPHAP Type A device (12 sources in total):
  + Target requirement of 6 months: **YES: 0; NO: 12** [HW/Hisilicon (K = 1); Spreadtrum (K = 1,2,4); vivo (K = 1); Nokia/NSB (K = 1,4); CATT (K = 1); Sony (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4); Samsung (K = 1); LGE (K = 0.5,1,2,4); Qualcomm (K = 1,4); Ericsson (K = 1)];
  + Target requirement of 12 months: **YES: 0; NO: 12** [HW/Hisilicon (K = 1); Spreadtrum (K = 1,2,4); vivo (K = 1); Nokia/NSB (K = 1,4); CATT (K = 1); Sony (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4); Samsung (K = 1); LGE (K = 0.5,1,2,4); Qualcomm (K = 1,4); Ericsson (K = 1)];
* For UE-based DL positioning with LPHAP Type A device (9 sources in total):
  + Target requirement of 6 months: **YES: 0; NO: 9** [HW/Hisilicon (K = 1); Spreadtrum (K = 1,2,4); vivo (K = 1); Nokia/NSB (K = 1,4); CATT (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4); LGE (K = 0.5,1,2,4); Qualcomm (K = 1,4)];
  + Target requirement of 12 months: **YES: 0; NO: 9** [HW/Hisilicon (K = 1); Spreadtrum (K = 1,2,4); vivo (K = 1); Nokia/NSB (K = 1,4); CATT (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4); LGE (K = 0.5,1,2,4); Qualcomm (K = 1,4)];
* For UL positioning with LPHAP Type A device (11 sources in total):
  + Target requirement of 6 months: **YES: 0; NO: 11** [HW/Hisilicon (K = 1); Spreadtrum (K = 1,2,4); vivo (K = 1); Nokia/NSB (K = 1,4); CATT (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4); Samsung (K = 1); LGE (K = 0.5,1,2,4); Qualcomm (K = 1,4); Ericsson (K = 1)];
  + Target requirement of 12 months: **YES: 0; NO: 11** [HW/Hisilicon (K = 1); Spreadtrum (K = 1,2,4); vivo (K = 1); Nokia/NSB (K = 1,4); CATT (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4); Samsung (K = 1); LGE (K = 0.5,1,2,4); Qualcomm (K = 1,4); Ericsson (K = 1)];
* For DL+UL positioning with LPHAP Type A device (1 source in total):
  + Target requirement of 6 months: **YES: 0; NO: 1** [Qualcomm (K = 1,4)];
  + Target requirement of 12 months: **YES 0; NO: 1** [Qualcomm (K = 1,4)];
* For UE-assisted DL positioning with LPHAP Type B device (7 sources in total):
  + Target requirement of 6 months: **YES: 5** [Spreadtrum (K = 4); Nokia/NSB (K = 4); CMCC (K = 4); LGE (K = 2,4); Qualcomm (K = 4)]; **NO: 7** [Spreadtrum (K = 1,2); vivo (K = 1); Nokia/NSB (K = 1); Sony (K = 1); CMCC (K = 1,2); LGE (K = 0.5,1); Qualcomm (K = 1)];
  + Target requirement of 12 months: **YES: 2** [LGE (K = 4); Qualcomm (K = 4)]; **NO: 7** [Spreadtrum (K = 1,2,4); vivo (K = 1); Nokia (K = 1,4); Sony (K = 1); CMCC (K = 1,2,4); LGE (K = 0.5,1,2); Qualcomm (K = 1)];
* For UE-based DL positioning with LPHAP Type B device (6 sources in total):
  + Target requirement of 6 months: **YES: 5** [Spreadtrum (K = 4); Nokia/NSB (K = 4); CMCC (K = 4); LGE (K = 2,4); Qualcomm (K = 4)]; **NO: 6** [Spreadtrum (K = 1,2); vivo (K = 1); Nokia/NSB (K = 1); CMCC (K = 1,2); LGE (K = 0.5,1); Qualcomm (K = 1)];
  + Target requirement of 12 months: **YES: 2** [LGE (K = 4); Qualcomm (K = 4)]; **NO: 6** [Spreadtrum (K = 1,2,4); vivo (K = 1); Nokia/NSB (K = 1,4); CMCC (K = 1,2,4); LGE (K = 0.5,1,2); Qualcomm (K = 1)];
* For UL positioning with LPHAP Type B device (6 sources in total):
  + Target requirement of 6 months: **YES: 5** [Spreadtrum (K = 4); Nokia/NSB (K = 4); CMCC (K = 4); LGE (K = 2,4); Qualcomm (K = 4); **NO: 6** [Spreadtrum (K = 1,2); vivo (K = 1); Nokia/NSB (K =1); CMCC (K = 1,2); LGE (K = 0.5,1); Qualcomm (K = 1)];
  + Target requirement of 12 months: **YES: 2** [LGE (K = 4); Qualcomm (K = 4)]; **NO: 6** Spreadtrum (K = 1,2,4); vivo (K = 1); Nokia (K = 1,4); CMCC (K = 1,2,4); LGE (K = 0.5,1,2); Qualcomm (K = 1)];
* For DL+UL positioning with LPHAP Type B device (1 source in total):
  + Target requirement of 6 months: **YES: 1** [Qualcomm (K = 4)]; **NO: 1** [Qualcomm (K = 1)];
  + Target requirement of 12 months: **YES: 1** [Qualcomm (K = 4)]; **NO: 1** [Qualcomm (K = 1)];

Based on the submitted evaluation results, we can safely conclude that the existing RAN functionality cannot meet the target requirement with baseline evaluation assumptions and devices, and it is necessary to study enhancements to improve the battery life.

4.1.2 Round 1 discussion

From the inputs, the following initial observations can be made:

**[High] Proposal 4.1-1 (I)**

Capture the following in TR as an observation:

* For the evaluation on the battery life of the baseline LPHAP Type A device:
  + Based on the results provided by all sources, the target requirement of 6~12 months is not achieved by the existing Rel-17 positioning for UEs in RRC\_INACTIVE state;
  + For UE-assisted DL positioning, results are provided by 12 sources (HW/Hisilicon, Spreadtrum, vivo, Nokia/NSB, CATT, Sony, xiaomi, CMCC, Samsung, LGE, Qualcomm, Ericsson) out of 20 sources, and the following is observed:
    - The target requirement of 6 months is achieved by 0 source, and is not achieved by 12 sources even with the most power efficient case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, CG-SDT for measurement reporting, and implementation factor K = 4.
    - The target requirement of 12 months is achieved by 0 source, and is not achieved by 12 sources even with the most power efficient case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, CG-SDT for measurement reporting, and implementation factor K = 4.
  + For UE-based DL positioning, results are provided by 9 sources (HW/Hisilicon, Spreadtrum, vivo, Nokia/NSB, CATT, xiaomi, CMCC, LGE, Qualcomm) out of 20 sources, and the following is observed:
    - The target requirement of 6 months is achieved by 0 source, and is not achieved by 9 sources even with the most power efficient case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, and implementation factor K = 4.
    - The target requirement of 12 months is achieved by 0 source, and is not achieved by 9 sources even with the most power efficient case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, and implementation factor K = 4.
  + For UL positioning, results are provided by 11 sources (HW/Hisilicon, Spreadtrum, vivo, Nokia/NSB, CATT, xiaomi, CMCC, Samsung, LGE, Qualcomm, Ericsson) out of 20 sources, and the following is observed:
    - The target requirement of 6 months is achieved by 0 source, and is not achieved by 11 sources even with the most power efficient case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, no SRS (re)configuration, and implementation factor K = 4.
    - The target requirement of 12 months is achieved by 0 source, and is not achieved by 11 sources even with the most power efficient case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, no SRS (re)configuration, and implementation factor K = 4.
  + For DL+UL positioning, results are provided by 1 source (Qualcomm) out of 20 sources, and the following is observed:
    - The target requirement of 6 months is achieved by 0 source, and is not achieved by 1 source even with the most power efficient case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, no SRS (re)configuration, and implementation factor K = 4.
    - The target requirement of 12 months is achieved by 0 source, and is not achieved by 1 source even with the most power efficient case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, no SRS (re)configuration, and implementation factor K = 4.
* For the evaluation on the battery life of the optional LPHAP Type B device:
  + Based on the results provided by a majority of sources, the target requirement of 6~12 months is not achieved by the existing Rel-17 positioning for UEs in RRC\_INACTIVE state;
  + For UE-assisted DL positioning, results are provided by 7 sources (Spreadtrum, vivo, Nokia/NSB, Sony, CMCC, LGE, Qualcomm) out of 20 sources, and the following is observed:
    - The target requirement of 6 months is achieved by 4 sources with the implementation factor K = 4 and by 1 source with the implementation factor K >= 2, and is not achieved by 6 sources with the implementation factor K < 4 and by 1 source with the implementation factor K < 2;
    - The target requirement of 12 months is achieved by 2 sources with the case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, CG-SDT for reporting and implementation factor K = 4, and is not achieved by 7 sources with the implementation factor K < 4.
  + For UE-based DL positioning, results are provided by 6 sources (Spreadtrum, vivo, Nokia/NSB, CMCC, LGE, Qualcomm) out of 20 sources, and the following is observed:
    - The target requirement of 6 months is achieved by 4 sources with the implementation factor K = 4 and by 1 source with the implementation factor K >= 2 , and is not achieved by 5 sources with the implementation factor K < 4 and by 1 source with the implementation factor K < 2;
    - The target requirement of 12 months is achieved by 2 sources with the case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, and implementation factor K = 4, and is not achieved by 6 sources with the implementation factor K < 4.
  + For UL positioning, results are provided by 6 sources (Spreadtrum, vivo, Nokia/NSB, CMCC, LGE, Qualcomm) out of 20 sources, and the following is observed:
    - The target requirement of 6 months is achieved by 4 sources with the implementation factor K = 4 and by 1 source with the implementation factor K >= 2, and is not achieved by 5 sources with the implementation factor K < 4 and by 1 source with the implementation factor K < 2;
    - The target requirement of 12 months is achieved by 1 source with the case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, no SRS (re)configuration, and implementation factor K = 4, and is not achieved by 6 sources with the implementation factor K < 4.
  + For DL+UL positioning, results are provided by 1 source (Qualcomm) out of 20 sources, and the following is observed:
    - The target requirement of 6 months is achieved by 1 source with implementation factor K = 4, and is not achieved by 1 source with implementation factor K < 4;
    - The target requirement of 12 months is achieved by 1 source with the case that I-DRX cycle of 10.24s, 1 RS per 1 I-DRX cycle, high SINR, no SRS (re)configuration, and implementation factor K = 4, and is not achieved by 1 source with implementation factor K < 4.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

**[High] Proposal 4.1-2 (I)**

Capture the following in TR:

* From evaluations for the baseline LPHAP device, RAN1 acknowledges that the existing Rel-17 positioning for UEs in RRC\_INACTIVE state cannot satisfy the target battery life developed by LPHAP use case 6, potential enhancements to meet the target battery life should be pursued in Rel-18.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

**[High] Question 4.1**

* In RAN2#119-e meeting, the following agreement was made that RAN2 will wait for RAN1’s conclusion on whether the existing RAN functionality can satisfy the requirement:

RAN2 shall wait for RAN1 conclusions from evaluations on UE power consumption with respect to baseline functionality and whether enhancements are needed. RAN2 will study potential areas for higher layer enhancements that may result in reduction of UE power consumption.

* Do your think that RAN1 should send LS to RAN2 with observations and agreements that are going to be made on existing RAN functionality in this meeting?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / No** | **Comments** |
|  |  |  |
|  |  |  |
|  |  |  |

## 4.2 Rel-18 potential enhancements

4.2.1 Summary of inputs

From reviewing submitted contributions in this meeting, 12 (HW/Hisilicon, Spreadtrum, vivo, Nokia/NSB, CATT, Sony, xiaomi, CMCC, Samsung, LGE, Qualcomm, Ericsson) out of 20 companies provide evaluations for Rel-18 potential enhancements to maximize the battery life. The results are summarized below.

**Table 5: Summary for results of Rel-18 potential enhancements**

|  |  |  |  |
| --- | --- | --- | --- |
| Source | Evaluation case description | Target requirement are met – Yes/No | |
| 6 months | 12 months |
| Enhancements | eDRX | | |
| Nokia, NSB [6] | UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, Low SINR, CG-SDT for reporting;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, Low SINR;  BWP switching | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| CATT [8] | UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| xiaomi [12] | UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| Samsung [16] | UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR; | K = 1, Type A: NO | K = 1, Type A: NO |
| Enhancements | ultra-deep sleep state | | |
| HW, Hisilicon [2] | Option 1 (10000); UE-assisted DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Cell access procedures per 10.24s;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (10000); UE-based DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR;  Cell access procedures per 10.24s;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (10000); UL positioning;  eDRX= 10.24, 1 RS per 1 eDRX, High SINR;  Cell access procedures per 10.24s;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 2 (450); UE-based DL positioning;  eDRX= 10.24, 1 RS per 1 eDRX, High SINR;  No paging reception;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 2 (450); UL positioning;  eDRX= 10.24, 1 RS per 1 eDRX, High SINR;  No paging reception;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| vivo [5] | Option 1 (20000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (20000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (20000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (20000); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (20000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (20000); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (15000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (15000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (15000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (15000); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (15000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (15000); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (10000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (10000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (10000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (10000); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (10000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (10000); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (5000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (5000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (5000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (5000); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (5000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 1 (5000); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 2 (450); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: YES |
| Option 2 (450); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES  K = 1, Type B: YES | K = 1, Type A: YES  K = 1, Type B: YES |
| Option 2 (450); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES  K = 1, Type B: YES | K = 1, Type A: YES  K = 1, Type B: YES |
| Option 2 (450); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES  K = 1, Type B: YES | K = 1, Type A: YES  K = 1, Type B: YES |
| Option 2 (450); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES  K = 1, Type B: YES | K = 1, Type A: YES  K = 1, Type B: YES |
| Option 2 (450); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES  K = 1, Type B: YES | K = 1, Type A: YES  K = 1, Type B: YES |
| CATT [8] | Option 1 (2000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: YES | K = 1, Type A: NO |
| Intel [9] | Option 1 (20000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (20000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (20000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (20000); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (20000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (20000); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| ZTE [11] | Option 1 (20000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (20000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (20000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (20000); DL+UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 1, Type B: YES | K = 1, Type A: NO  K = 1, Type B: NO |
| Option 1 (20000); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type B: YES | K = 1, Type B: NO |
| Option 1 (20000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type B: YES | K = 1, Type B: NO |
| Option 1 (20000); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type B: YES | K = 1, Type B: NO |
| Option 1 (20000); DL+UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type B: YES | K = 1, Type B: NO |
| Option 2 (450); UE-assisted DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 2 (450); UE-based DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 2 (450); UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 2 (450); DL+UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 2 (480); UE-assisted DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 2 (480); UE-based DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 2 (480); UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 2 (480); DL+UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR, CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| xiaomi [12] | Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 2 (450); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: YES |
| Option 2 (450); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: YES |
| Option 2 (450); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: YES |
| CMCC [13] | Option 1 (20000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  No optimization on gaps between paging/PRS/SRS/reporting in PTW; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (20000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  No optimization on gaps between paging/PRS/SRS/reporting in PTW; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (20000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  No optimization on gaps between paging/PRS/SRS/reporting in PTW; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  No optimization on gaps between paging/PRS/SRS/reporting in PTW; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  No optimization on gaps between paging/PRS/SRS/reporting in PTW; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 2 (450); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  No optimization on gaps between paging/PRS/SRS/reporting in PTW; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 2 (450); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  No optimization on gaps between paging/PRS/SRS/reporting in PTW; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 2 (450); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  No optimization on gaps between paging/PRS/SRS/reporting in PTW; | K = 1, Type A: NO | K = 1, Type A: NO |
| Samsung [16] | Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO | K = 1, Type A: NO |
| Qualcomm [20] | Option 1 (20000); UE-assisted DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); UE-based DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); DL+UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); DL+UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); UE-assisted DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: YES  K = 1, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); UE-based DL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: YES  K = 1, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: YES  K = 1, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Option 1 (20000); DL+UL positioning;  eDRX= 30.72s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: YES  K = 1, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| Ericsson [21] | Option 1 (2000); UE-assisted DL positioning;  DRX = 1.28s, 1 RS per 8 DRX, High SINR; CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  DRX = 10.24s, 1 RS per 1 DRX, High SINR; CG-SDT for reporting; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  DRX = 10.24s, 1 RS per 1 DRX, High SINR; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  DRX = 30.72s, 1 RS per 1 DRX, High SINR; | K = 1, Type A: YES | K = 1, Type A: YES |
| Enhancements | SRS mobility enhancements | | |
| HW, Hisilicon [2] | Option 2 (450); UL positioning;  eDRX= 10.24, 1 RS per 1 eDRX, High SINR;  No paging reception; | K = 1, Type A: YES | K = 1, Type A: YES |
| Enhancements | Minimizing the gaps between paging/PRS/SRS/reporting | | |
| Sony [10] | UE-assisted DL positioning;  I-DRX = 1.28s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  Sleep states in TR 38.840 | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| UE-assisted DL positioning;  I-DRX = 1.28s, 1 RS per 8 I-DRX, High SINR, CG-SDT for reporting;  Sleep states in TR 38.840 | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| UE-assisted DL positioning;  I-DRX = 10.24s, 1 RS per 1 I-DRX, High SINR, CG-SDT for reporting;  Sleep states in TR 38.840 | K = 1, Type A: NO  K = 1, Type B: NO | K = 1, Type A: NO  K = 1, Type B: NO |
| CMCC [13] | Option 1 (20000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES |
| Option 1 (20000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES |
| Option 1 (20000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 2, Type B: YES  K = 4, Type B: YES |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting; | K = 1, Type A: NO  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: NO  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES |
| Option 1 (2000); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: YES  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: YES  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES |
| Option 2 (450); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting; | K = 1, Type A: YES  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES | K = 1, Type A: NO  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES |
| Option 2 (450); UE-based DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: YES  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES | K = 1, Type A: YES  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES |
| Option 2 (450); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; | K = 1, Type A: YES  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES | K = 1, Type A: YES  K = 2, Type A: YES  K = 4, Type A: YES  K = 1, Type B: YES  K = 2, Type B: YES  K = 4, Type B: YES |
| Enhancements | Paging or PEI triggered positioning operation | | |
| Samsung [16] | Option 1 (2000); UE-assisted DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Paging triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  PEI triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting;  Paging triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting;  PEI triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Paging triggered positioning operation; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  PEI triggered positioning operation; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting;  Paging triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UE-assisted DL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting;  PEI triggered positioning operation; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Paging triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  PEI triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting;  Paging triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 10.24s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting;  PEI triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  Paging triggered positioning operation; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, High SINR; CG-SDT for reporting;  PEI triggered positioning operation; | K = 1, Type A: NO | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting;  Paging triggered positioning operation; | K = 1, Type A: YES | K = 1, Type A: NO |
| Option 1 (2000); UL positioning;  eDRX= 20.48s, 1 RS per 1 eDRX, Low SINR; RA-SDT for reporting;  PEI triggered positioning operation; | K = 1, Type A: YES | K = 1, Type A: NO |
| Enhancements | TRS-based synchronization | | |
| HW, Hisilicon [2] | Option 2 (450); UL positioning;  eDRX= 10.24, 1 RS per 1 eDRX, High SINR;  No paging reception; SRS mobility enhancements; | K = 1, Type A: YES | K = 1, Type A: YES |
| Enhancements | SDT for SRS pre-configuration with minimum delay | | |
| Qualcomm [20] | UL positioning;  eDRX = 10.24, 1 RS per 1 eDRX, High SINR;  Sleep states in TR38.840; Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES |
| DL+UL positioning;  eDRX = 10.24, 1 RS per 1 eDRX, High SINR;  Sleep states in TR38.840; Gaps between PRS/SRS/paging/reporting is minimized; | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: YES | K = 1, Type A: NO  K = 4, Type A: NO  K = 1, Type B: NO  K = 4, Type B: NO |

To sum up, the following aspects on enhancements are identified:

***Ultra-deep sleep state***

Evaluations results on different options/values of the power model of the ultra-deep sleep state are provided by 10 sources (HW/Hisilicon, vivo, CATT, Intel, ZTE, xiaomi, CMCC, Samsung, Qualcomm, Ericsson) out of 20 sources. To be specific,

* For Option 1 of the power model of the ultra-deep sleep state:
  + Results with additional transition energy of 20000 are presented by 5 sources (vivo, Intel, ZTE, CMCC, Qualcomm) out of 20 sources, and the following is observed:
    - For UE-assisted DL positioning with LPHAP Type A device (5 sources in total):
      * Target requirement of 6 months: **YES: 1** [Qualcomm (K = 4)]; **NO: 5** [vivo (K = 1); Intel (K = 1); ZTE (K = 1); CMCC (K = 1,2,4); Qualcomm (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 5** [vivo (K = 1); Intel (K = 1); ZTE (K = 1); CMCC (K = 1,2,4); Qualcomm (K = 1,4)];
    - For UE-based DL positioning with LPHAP Type A device (5 sources in total):
      * Target requirement of 6 months: **YES: 1** [Qualcomm (K = 4)]; **NO: 5** [vivo (K = 1); Intel (K = 1); ZTE (K = 1); CMCC (K = 1,2,4); Qualcomm (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 5** [vivo (K = 1); Intel (K = 1); ZTE (K = 1); CMCC (K = 1,2,4); Qualcomm (K = 1,4)];
    - For UL positioning with LPHAP Type A device (5 sources in total):
      * Target requirement of 6 months: **YES: 1** [Qualcomm (K = 4)]; **NO: 5** [vivo (K = 1); Intel (K = 1); ZTE (K = 1); CMCC (K = 1,2,4); Qualcomm (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 5** [vivo (K = 1); Intel (K = 1); ZTE (K = 1); CMCC (K = 1,2,4); QC (K = 1,4)];
    - For DL+UL positioning with LPHAP Type A device (2 sources in total):
      * Target requirement of 6 months: **YES: 1** [Qualcomm (K = 4)]; **NO: 2** [ZTE (K = 1); Qualcomm (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 2** [ZTE (K = 1); Qualcomm (K = 1,4)];
    - For UE-assisted DL positioning with LPHAP Type B device (4 sources in total):
      * Target requirement of 6 months: **YES: 4** [vivo (K = 1); ZTE (K = 1); CMCC (K = 1,2,4); Qualcomm (K = 1,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 2** [CMCC (K = 2,4); QC (K = 4)]; **NO: 4** [vivo (K = 1); ZTE (K = 1); CMCC (K = 1); QC (K = 1)];
    - For UE-based DL positioning with LPHAP Type B device (4 sources in total):
      * Target requirement of 6 months: **YES: 4** [vivo (K = 1); ZTE (K = 1); CMCC (K = 1,2,4); Qualcomm (K = 1,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 2** [CMCC (K = 2,4); Qualcomm (K = 4)]; **NO: 4** [vivo (K = 1); ZTE (K = 1); CMCC (K = 1); Qualcomm (K = 1)];
    - For UL positioning with LPHAP Type B device (4 sources in total):
      * Target requirement of 6 months: **YES: 4** [vivo (K = 1); ZTE (K = 1); CMCC (K = 1,2,4); Qualcomm (K = 1,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 2** [CMCC (K = 2,4); Qualcomm (K = 4)]; **NO: 4** [vivo (K = 1); ZTE (K = 1); CMCC (K = 1); Qualcomm (K = 1)];
    - For DL+UL positioning with LPHAP Type B device (2 sources in total):
      * Target requirement of 6 months: **YES: 2** [ZTE (K = 1); Qualcomm (K = 1,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [Qualcomm (K = 4)]; **NO: 2** [ZTE (K = 1); Qualcomm (K = 1)];
  + Results with additional transition energy of 2000 are presented by 6 sources (CATT, Intel, xiaomi, CMCC, Samsung, Ericsson) out of 20 sources, and the following is observed:
    - For UE-assisted DL positioning with LPHAP Type A device (5 sources in total):
      * Target requirement of 6 months: **YES: 4** [Intel (K = 1); xiaomi (K = 1); CMCC (K = 2,4); Samsung (K = 1)]; **NO: 2** [CMCC (K = 1); Ericsson (K = 1)];
      * Target requirement of 12 months: **YES: 1** [CMCC (K = 4)]; **NO: 5** [Intel (K = 1); xiaomi (K = 1); CMCC (K = 1,2); Samsung (K = 1); Ericsson (K = 1)];
    - For UE-based DL positioning with LPHAP Type A device (4 sources in total):
      * Target requirement of 6 months: **YES: 4** [CATT (K = 1); Intel (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [CMCC (K = 2,4)]; **NO: 4** [CATT (K = 1); Intel (K = 1); xiaomi (K = 1); CMCC (K = 1)];
    - For UL positioning with LPHAP Type A device (5 sources in total):
      * Target requirement of 6 months: **YES: 5** [Intel (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4); Samsung (K = 1); Ericsson (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 2** [CMCC (K = 2,4); Ericsson (K = 1)]; **NO: 4** [Intel (K = 1); xiaomi (K = 1); CMCC (K = 1); Samsung (K = 1)];
    - For UE-assisted DL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [CMCC (K = 1,2,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [CMCC (K = 1,2,4)]; **NO: 0**;
    - For UE-based DL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [CMCC (K = 1,2,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [CMCC (K = 1,2,4)]; **NO: 0**;
    - For UL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [CMCC (K = 1,2,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [CMCC (K = 1,2,4)]; **NO: 0**;
  + Results with additional transition energy of 15000 are presented by 1 source (vivo) out of 20 sources, and the following is observed:
    - For UE-assisted DL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 0; NO: 1** [vivo (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 1** [vivo (K = 1)];
    - For UE-based DL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 0; NO: 1** [vivo (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 1** [vivo (K = 1)];
    - For UL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 0; NO: 1** [vivo (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 1** [vivo (K = 1)];
    - For UE-assisted DL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
    - For UE-based DL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
    - For UL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
  + Results with additional transition energy of 10000 are presented by 2 sources (HW/Hisilicon, vivo) out of 20 sources, and the following is observed:
    - For UE-assisted DL positioning with LPHAP Type A device (2 sources in total):
      * Target requirement of 6 months: **YES: 0; NO: 2** [HW/Hisilicon (K = 1); vivo (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 2** [HW/Hisilicon (K = 1); vivo (K = 1)];
    - For UE-based DL positioning with LPHAP Type A device (2 sources in total):
      * Target requirement of 6 months: **YES: 0; NO: 2** [HW/Hisilicon (K = 1); vivo (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 2** [HW/Hisilicon (K = 1); vivo (K = 1)];
    - For UL positioning with LPHAP Type A device (2 sources in total):
      * Target requirement of 6 months: **YES: 0; NO: 2** [HW/Hisilicon (K = 1); vivo (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 2** [HW/Hisilicon (K = 1); vivo (K = 1)];
    - For UE-assisted DL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
    - For UE-based DL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
    - For UL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
  + Results with additional transition energy of 5000 are presented by 1 source (vivo) out of 20 sources, and the following is observed:
    - For UE-assisted DL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 0; NO: 1** [vivo (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 1** [vivo (K = 1)];
    - For UE-based DL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 0; NO: 1** [vivo (K = 1)];
    - For UL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 0; NO: 1** [vivo (K = 1)];
    - For UE-assisted DL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
    - For UE-based DL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
    - For UL positioning with LPHAP Type B device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [vivo (K = 1)]; **NO: 0**;
* For Option 2 of the power model of the ultra-deep sleep state,
  + Results with additional transition energy of 450 are presented by 5 sources (HW/Hisilicon, vivo, ZTE, xiaomi, CMCC) out of 20 sources, and the following is observed:
    - For UE-assisted DL positioning with LPHAP Type A device (4 sources in total):
      * Target requirement of 6 months: **YES: 4** [vivo (K = 1); ZTE (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 3** [vivo (K = 1); xiaomi (K = 1); CMCC (K = 2,4)]; **NO: 2** [ZTE (K = 1); CMCC (K = 1)];
    - For UE-based DL positioning with LPHAP Type A device (5 sources in total):
      * Target requirement of 6 months: **YES: 5** [HW/Hisilicon (K = 1); vivo (K = 1); ZTE (K =1); xiaomi (K = 1); CMCC (K = 1,2,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 3** [vivo (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4)]; **NO: 2** [HW/Hisilicon (K = 1); ZTE (K = 1)];
    - For UL positioning with LPHAP Type A device (5 sources in total):
      * Target requirement of 6 months: **YES: 4** [vivo (K = 1); ZTE (K = 1); xiaomi (K = 1); CMCC (K = 1,2,4)]; **NO: 1** [HW/Hisilicon (K = 1)];
      * Target requirement of 12 months: **YES: 3** [vivo (K = 1); xiaomi (K=1); CMCC (K = 1,2,4)]; **NO: 2** [HW/Hisilicon (K = 1); ZTE (K = 1)];
    - For DL+UL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [ZTE (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [ZTE (K = 1)]; **NO: 0**;
    - For UE-assisted DL positioning with LPHAP Type B device (2 sources in total):
      * Target requirement of 6 months: **YES: 2** [vivo (K = 1); CMCC (K = 1,2,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 2** [vivo (K = 1); CMCC (K = 1,2,4)]; **NO: 0**;
    - For UE-based DL positioning with LPHAP Type B device (2 sources in total):
      * Target requirement of 6 months: **YES: 2** [vivo (K = 1); CMCC (K = 1,2,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 2** [vivo (K = 1); CMCC (K = 1,2,4)]; **NO: 0**;
    - For UL positioning with LPHAP Type B device (2 sources in total):
      * Target requirement of 6 months: **YES: 2** [vivo (K = 1); CMCC (K = 1,2,4)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 2** [vivo (K = 1); CMCC (K = 1,2,4)]; **NO: 0**;
  + Results with additional transition energy of 480 are presented by 1 source (ZTE) out of 20 sources, and the following is observed:
    - For UE-assisted DL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 0; NO: 1** [ZTE (K = 1)];
      * Target requirement of 12 months: **YES: 0; NO: 1** [ZTE (K = 1)];
    - For UE-based DL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [ZTE (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 1** [ZTE (K = 1)]; **NO: 0**;
    - For UL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [ZTE (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 0; NO: 1** [ZTE (K = 1)];
    - For DL+UL positioning with LPHAP Type A device (1 source in total):
      * Target requirement of 6 months: **YES: 1** [ZTE (K = 1)]; **NO: 0**;
      * Target requirement of 12 months: **YES: 0; NO: 1** [ZTE (K = 1)];

***Extended DRX cycle***

Evaluation results of extended DRX cycle (with and without ultra-deep sleep state) are provided by 11 sources (HW/Hisilicon, vivo, Nokia/NSB, CATT, Intel, ZTE, xiaomi, CMCC, Samsung, Qualcomm, Ericsson) out of 20 sources, the following is observed:

* Results with extended DRX cycle without consideration of ultra-deep sleep state are provided by 4 sources (Nokia/NSB, CATT, xiaomi, Samsung) out of 20 sources, and power saving gain based on slot-averaged relative power unit with respect to that with the baseline DRX cycle of 1.28s is acquired;
* Results with extended DRX cycle and ultra-deep sleep state are provided by 10 sources (HW/Hisilicon, vivo, CATT, Intel, ZTE, xiaomi, CMCC, Samsung, Qualcomm, Ericsson) out of 20 sources, the target requirement of battery life of 6~12 months can be met.

***Minimized gaps between PRS/SRS/paging/reporting***

Evaluation results of minimized gaps between PRS/SRS/paging/reporting are provided by 9 sources (HW/Hisilicon, vivo, Intel, ZTE, xiaomi, Samsung, Qualcomm) out of 20 sources, the following is observed:

* Results with and without optimization of gaps between PRS/SRS/paging/reporting are provided by 2 sources (Sony, CMCC) out of 20 sources, and power saving gain based on slot-averaged relative power unit of the minimized gaps with respect to that without minimized gaps is acquired, in which
  + Results in [13/CMCC] show that without minimized gaps between PRS/SRS/paging/reporting, the target requirement of battery life of 6~12 months cannot be met; while with minimized gaps between PRS/SRS/paging/reporting, the target requirement of battery life of 6~12 months can be met.
* In addition, results in [2/HW, Hisilicon], [5/vivo], [9/Intel], [11/ZTE], [12/xiaomi], [16/Samsung], [20/Qualcomm] imply that the gaps between PRS/SRS/paging/reporting are optimized, and the target requirement of battery life of 6~12 months can be met.

***SRS enhancement***

Evaluation results of SRS (re)configuration enhancement are provided by 11 sources (HW/Hisilicon, vivo, Nokia/NSB, CATT, Intel, ZTE, xiaomi, CMCC, Samsung, Qualcomm, Ericsson) out of 20 sources, the following is observed:

* Results with and without are provided by 3 sources (HW/Hisilicon, CMCC, Qualcomm) out of 20 sources, in which,
  + Results in [13/CMCC] and [20/Qualcomm] show that the power consumption significantly increases considering UE (re)entering RRC\_CONNECTED state to obtain SRS (re)configuration in every power cycle;
  + Results in [2/HW, Hisilicon] show that without SRS (re)configuration enhancement, the target requirement of battery life of 6~12 months cannot be met; while with SRS (re)configuration enhancement, the target requirement of battery life of 6~12 months can be met.
* In addition, results in [5/vivo], [6/Nokia, NSB], [8/CATT], [9/Intel], [11/ZTE], [12/xiaomi], [13/CMCC], [16/Samsung], [20/Qualcomm], [21/Ericsson] imply SRS (re)configuration enhancement in the enhanced cases, and the target requirement of battery life of 6~12 months can be met.

***No paging reception***

Evaluation results without paging reception are provided by 1 source (HW,Hisilicon) out of 20 sources, and the following is observed:

* Without requirement of paging reception, UE may implement ultra-deep sleep Option 2 to wake-up to perform positioning only, and the target requirement of battery life of 6~12 months can be met.

***Paging or PEI triggered positioning***

Evaluation results of paging or PEI triggered positioning are provided by 1 source (Samsung) out of 20 sources, and the following is observed:

* Paging and PEI triggered positioning are beneficial in improving the battery life, and the target requirement of battery life of 6~12 months can be met.

***SDT with minimum delay for SRS (pre)configuration***

Evaluation results of SDT procedure with minimum delay for SRS (pre)configuration are provided by 1 source (Qualcomm) out of 20 sources, and the following is observed:

* Reducing the latencies involved in the legacy SDT procedure may significantly reduce the power consumption, and the target requirement of battery life of 6~12 months can be met.

4.2.2 Round 1 discussion

***FL comments:*** From the inputs, several aspects on enhancements are identified, and the target battery life of 6~12 months can be met together with some options of the ultra-deep sleep state, but as the power model of the ultra-deep sleep state is still under discussion in this meeting, the observations on potential enhancements should wait until we have consensus on the ultra-deep sleep.

Alternatively, a work flow in Rel-17 study item stage can be followed. First, we can conclude in this meeting the performance benefits on the identified enhancements so that it can encourage interested companies to provide additional evaluations with the agreed ultra-deep sleep state. Then, in the next meeting, final observations will be made to be captured in the TR.

**[High] Question 4.2**

* Do you think that it is necessary to make some intermediate conclusions on performane benefits of the identified enhancements in this meeting (as what we have done in Rel-17 study item), to encourage interested companies to provide additional evaluations so that the discussions in the next meeting would be faciliated? See below some of the examples of the conclusions:
* *Example #1 of proposed conclusion:* 
  + Evaluations show that extending DRX cycles provide power saving gains with respect to that with the baseline DRX cycle of 1.28s and is beneficial to improve the battery life;
  + Note: Additional evaluations need to be performed before deciding whether and how to capture the above in the TR
* *Example #2 of proposed conclusion:* 
  + Evaluations show that UE (re)entering RRC\_CONNECTED state to obtain SRS (re)configuration significantly increases power consumption;
  + Initial results also show that assuming SRS (re)configuration enhancement is beneficial to improve battery life;
  + Note: Additional evaluations need to be performed before deciding whether and how to capture the above in the TR

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / No** | **Comments** |
|  |  |  |
|  |  |  |
|  |  |  |

**Potential enhancements**

***Background:*** As clarified by the objective, potential enhancements will be studied if found necessary based on evaluations. In this section, the potential enhancements on positioning in RRC\_INACTIVE and/or RRC\_IDLE states are summarized.

## 5.1 Clarification on study scope

5.1.1 Summary of inputs

As described in the SID [1], the study scope of the potential enhancements is limited to enhancements to RRC\_INACTIVE and/or RRC\_IDLE state. In [13/Samsung], it is mentioned that further clarifications on the study scope of whether positioning for RRC\_IDLE state is within the scope is required. As the clarification should be made by RAN2, it is proposed that RAN1 to wait for RAN2’s clarification on the scope.

***FL comments:*** This issue was raised at the online session in the last RAN1 meeting, and it was clarified that at the study item phase, enhancements in both RRC\_INACTIVE and RRC\_IDLE state are within the study scope, and the “OR” in the objective may imply that one or the other is included/recommendated in the normative work.

## 5.2 SRS enhancements for UL/DL+UL positioning

***Background:*** In Rel-17 positioning, UL SRS for positioning transmissions in RRC\_INACTIVE state was specified. The UE keeps using the SRS configuration obtained via RRCRelease unless validity criteria fails (e.g., upon cell re-selection, TA invalidation, etc.).

5.2.1 Summary of inputs

Based on the submitted contributions in this meeting, 10 companies (HW/Hisilicon, vivo, Nokia/NSB, CATT, Intel, ZTE, xiaomi, CMCC, Qualcomm, Ericsson) discuss the enhancements on SRS for positioning to support UE mobility in RRC\_INACTIVE state, such that the UE does not need to frequently enter RRC\_CONNECTED state to update the SRS (re)configurations and hence the power consumption is reduced.

* In [2/HW/Hisilicon], [5/vivo], [6/Nokia, NSB], [12/xiaomi], [13/CMCC], and [21/Ericsson], enhancements on SRS (pre)configurations applicable to multiple cells (a positioning area) are proposed. In addition, [8/CATT], [7/Intel], [11/ZTE], [12/xiaomi], and [20/Qualcomm] propose to study solutions to prevent the UE from (re)entering RRC\_CONNECTED mode to update the SRS configuration when it moves to a new cell.
* Furthermore, [5/vivo], [8/CATT], [12/Xiaomi] and [20/Qualcomm] discuss activation/request enhancements of SRS configuration, e.g., allows the NW to activate and/or the UE to request SRS configuration by paging or RACH procedure, etc.
* A solution to enable SRS beam sweeping is proposed in [5/vivo] to address the validation failure of spatial relation info.

5.2.2 Round 1 discussion

***FL comments:*** The frequent power state transition to enter RRC\_CONNECTED mode to update SRS configurations in RRC\_INACTIVE state and the corresponding power consumption is harmful to meet the expected battery life. From the inputs, companies are interested in support of SRS enhancements for UL/DL+UL positioning. Therefore, the following proposal is formulated:

**[High] Proposal 5.1 (I)**

* For UL and DL+UL positioning for UEs in RRC\_INACTIVE and/or RRC\_IDLE state, the enhancements on SRS for positioning will be studied in order to avoid UE (re)entering RRC\_CONNECTED mode to obtain SRS (re)configuration if validation criteria fails, including at least the following:
  + The (pre-)configuration of SRS for positioning. FFS details, e.g., signaling and procedure, whether/how it is applicable to an area across multiple cells;
  + SRS for positioning activation/request procedure(s), e.g., NW activation of SRS via paging, UE request to obtain/update SRS via RACH-based procedure;
    - FFS: Events of invalidity of SRS configuration to trigger the UE request procedure.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## 5.3 Enhancements on DRX/paging

5.3.1 Summary of inputs

From reviewing the submitted contributions in this meeting, 12 companies (HW/Hisilicon, Quectel, vivo, CATT, Intel, Sony, ZTE, xiaomi, CMCC, Lenovo, Samsung, NTT DOCOMO) provide their views on DRX and/or paging related considerations/enhancements.

* In [2/HW,Hisilicon], [5/vivo], [9/Intel], [12/xiaomi], and [13/CMCC], benefits/enhancements of a DRX cycle longer than 10.24s in RRC\_INACTIVE state to help reduce the power consumption are acknowledged/proposed. Corresponding UE behaviors and coordination among positioning nodes (e.g., to allow the LMF to recommend appropriate SRS configuration to the gNB according to the eDRX configuration) are suggested for further study in [6/vivo]. In [11/ZTE], however, it is opposed to consider eDRX enhancements under positioning agenda item.
* 3 companies (HW/Hisilicon, CATT, CMCC) acknowledge the benefits of reduced/no paging reception to further acquire power saving gain. Specifically, in [2/HW, Hisilicon], it is suggested to revisit the necessity of paging reception, considering that the LPHAP device as a device with little mobile terminated service requirement. Similarly, CATT considers to stop paging monitoring for MT-LR.
* Moreover, 10 companies (Quectel, vivo, Sony, ZTE, xiaomi, CMCC, Lenovo, Samsung, LGE, NTT DOCOMO) discuss solutions regarding paging reception , PRS measurement and/or SRS transmission, which allows a UE to wake-up once to perform all necessary operations and reduces the power consumption by extending the sleep duration. 4 companies (vivo, Sony, CMCC, NTT DOCOMO) generally propose to align the PRS measurement and/or SRS transmission with paging monitoring. Specific solutions are proposed by [11/ZTE], [16/Samsung] and [18/LGE], where ZTE and Samsung propose to study paging/PEI triggered positioning operation, and the solution is to define a time window in [18/LGE]. Furthermore, [5/vivo] and [14/Lenovo] propose to allow the LMF to be aware of the DRX configuration of a positioning UE for the adaptation of the PRS/SRS configuration.

5.3.2 Round 1 discussion

***FL comments***: Based on the evaluations and analysis provided by companies, enhancements on DRX and/or paging are critical to maximize the battery life to meet the target requirement developed by SA1. Therefore, the following proposal is formulated:

**[High] Proposal 5.2 (I)**

* For the purpose of reducing power consumption for LPHAP, study at least the following enhancements with respect to DRX and/or paging reception:
  + Extending DRX cycle larger than 10.24s in RRC\_INACTIVE state
  + UE suspends monitoring the paging occasions
    - FFS details and applicable conditions, e.g., device type, deferred MT-LR, positioning methods, etc.
  + Time domain adaptation on paging reception, PRS measurement and/or SRS transmission
    - FFS details on how to achieve the adaptation, e.g., paging and/or PEI-triggered positioning, defining time window to restrict UE behavior on PRS measurement and/or SRS transmission, coordination among positioning nodes (LMF, gNB) to align the configurations of DRX, PRS and/or SRS, etc.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## 5.4 DL Positioning in RRC\_IDLE state

5.4.1 Summary of inputs

From reviewing the contributions in this meeting, 8 companies (vivo, CATT, Intel, Sony, CMCC, Lenovo, Sharp, Qualcomm) provide views on the study of DL positioning in RRC\_IDLE state.

* 4 companies (vivo, CMCC, Lenovo, Qualcomm) propose that at least DL PRS measurement in RRC\_IDLE state should be supported.
* 4 companies (CATT, Intel, Sony, Sharp) propose to study DL positioning in RRC\_IDLE state, in which [8/CATT] mentions that support of measurements/location estimates reporting in RRC\_IDLE state should be considered.

5.4.2 Round 1 discussion

***FL comments:*** In Rel-17 SI, the following agreements were achieved in RAN1#103-e meeting:

|  |
| --- |
| Agreement:  Capture the following in the TR:  From a physical layer perspective, it is feasible for a UE to perform DL positioning measurement in RRC\_IDLE state.   * Note: This does not imply that measurements have to be reported in RRC\_IDLE state.   Conclusion:  It is up to RAN2 to decide whether to support the enhancements of NR positioning reporting of DL positioning measurements and/or positioning estimates for RRC\_IDLE UEs. |

Based on the agreement made in Rel-17 and companies’ proposals, we can try one step further to support DL PRS measurement in RRC\_IDLE state.

Therefore, the following proposal is formulated:

**[High] Proposal 5.3 (I)**

* From RAN1’s perspective, supportive of DL positioning measurements by UEs in RRC\_IDLE state is recommended for normative work.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## 5.5 Enhancements on PRS/SRS configuration and PHY layer procedure

5.5.1 Summary of inputs

Based on the submitted contributions in this meeting, 5 companies (ZTE, Nokia/NSB, LGE, Qualcomm, NTT DOCOMO) provide their considerations on PRS and/or SRS configuration and physical layer procedure:

* In [11/ZTE], support of more compact and flexible PRS resource pattern is proposed to save power;
* In [6/Nokia, NSB] and [18/LGE], it suggests to consider the impact of BWP switching on power consumption when SRS outside of initial UL BWP is configured in RRC\_INACTIVE state.
* In [6/Nokia, NSB], it is proposed to study how to reduce UE positioning activities (e.g., PRS reception in DL positioning, or SRS-pos transmission in UL positioning) on demand.
* In [20/Qualcomm], it is proposed to study PRS/SRS configuration restrictions and corresponding new UE capabilities for enabling reduced power consumption for RTT positioning, e.g., same centre frequency of PRS and SRS is requested to avoid extra retuning, to configure PRS and SRS close in time, to have PRS and SRS on different bands.
* In [18/LGE] and [19/DCM], enhancements on priority of PRS and/or SRS is discussed in terms of positioning accuracy and latency. In addition, [18/LGE] considers the enhancement on OPLC of SRS to achieve power saving gain and accuracy requirement.

5.5.2 Round 1 discussion

***FL comments:*** Multiple companies are interested in enhancements regarding PRS and/or SRS configurations and related PHY layer procedures. As the solutions are quite diverse, the following high-level proposal is formulated based on the inputs:

**[Medium] Proposal 5.4 (I)**

* For the purpose of reducing power consumption for LPHAP, study enhancements with respect to PRS and/or SRS configurations and corresponding physical layer procedures and UE capabilities:
  + The study can include PRS and/or SRS resource pattern (e.g. 1-symbol PRS, comb size > 12), PRS and/or SRS configuration restrictions in time and frequency domain, priority of PRS and/or SRS, OPLC of SRS, etc.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## 5.6 PRACH-based UL positioning

5.6.1 Summary of inputs

From reviewing the submitted contributions in this meeting, 3 companies (Quectel, InterDigital, Sharp) propose to study whether/how PRACH can be used for UL positioning in RRC\_INACTIVE and/or RRC\_IDLE state.

5.6.2 Round 1 discussion

***FL comments:*** UL E-CID is enhanced in Rel-17 TEI work, where PRACH preamble can be used to determine the start of a subframe. To extend the PRACH-based UL positioning to UEs in RRC\_INACTIVE and/or RRC\_IDLE state, whether the sub-meter positioning accuracy can be met should be considered as well.

**[Medium] Proposal 5.5 (I)**

* For purpose of reducing power consumption for LPHAP, study the enhancements on extending PRACH-based UL positioning for UEs in RRC\_INACTIVE state and/or RRC\_IDLE state:
  + FFS: whether the positioning accuracy of the PRACH-based UL positioning can meet the sub-meter requirements.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## 5.7 Enhancements on assistance data and/or measurement reporting

5.7.1 Summary of inputs

From reviewing the contributions in this meeting, enhancements on assistance data delivery and/or measurement reporting to save power are discussed by 2 companies (Nokia/NSB, OPPO):

* In [6/Nokia, NSB], it is proposed to study optimization on the measurement reporting and assistance data delivery, e.g., skip some measurement reports, partial updates or reports of PRS assistance data or measurements of UEs in RRC\_INACTIVE mode.
* In [9/OPPO], it is proposed to study whether to introduce more candidate values for the reporting interval for the UE power saving.

5.7.2 Round 1 discussion

***FL comments:*** The enhancements on AD and/or measurement reporting seems trivial when compared to other enhancements. In this sense, FL suggests to treat it as low priority for now, interested companies can further provide evaluations and discussion on this issue in the next meeting.

**[Low] Proposal 5.6 (I)**

* For purpose of reducing power consumption for LPHAP, study enhancements on assistance data delivery and/or measurement reporting for UEs in RRC\_INACTIVE state:
  + The study can include partial update of assistance data and/or measurements, introducing more candidate values for reporting interval.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## 5.8 TRS-based synchronization

5.8.1 Summary of inputs

From reviewing the submitted contributions in this meeting, results of using TRS to serve time/frequency synchronization for UL positioning are evaluated in [2/HW, Hisilicon]. In the evaluation, the TRS for synchronization is configured adjacent to SRS occasions. It shows that the power consumption is further reduced. Based on the evaluations, it is proposed to further study the configuration of TRS for synchronization before the SRS transmission for LPHAP in RRC\_INACTIVE state.

5.8.2 Round 1 discussion

***FL comments:*** The enhancement on TRS-based synchronization in RRC\_INACTIVE seems trivial when compared to other enhancements and only 1 company provide views on it. In this sense, FL suggests to treat it as low priority for now, interested companies can further investigate on this issue in the next meeting.

**[Low] Proposal 5.7 (I)**

* For the purpose of reducing power consumption, study the configuration of TRS for synchronization in adjacent to the SRS for positioning transmission in RRC\_INACTIVE state.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## 5.9 Enhancements on network-initiated DL message transmission

***Background:*** In Rel-17 positioning, RAN2 agreed that the NW can send DL LCS, LPP message and RRC message to the UE if the UE initiates data transmission using UL SDT beforehand. Otherwise, if the UE does not initiate UL SDT, the NW shall rely on the legacy operation, i.e., transit the UE to RRC\_CONNECTED mode.

5.9.1 Summary of inputs

From reviewing the contributions in this meeting, 2 companies (ZTE, InterDigital) propose to study and support of network-initiated DL LCS/LPP message transmission via MT-SDT in RRC\_INACTIVE states.

5.9.2 Round 1 discussion

***FL comments:*** As the support of MT-SDT for UEs in RRC\_INACTIVE state is to be studied in RAN2 in Rel-18 SDT agenda item, RAN1 should wait for the progress of RAN2.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## 5.10 Ultra-deep sleep

5.10.1 Summary of inputs

From reviewing the contributions in this meeting, 2 companies (HW/Hisilicon, xiaomi) propose to support ultra-deep sleep state in LPHAP. To be specific, in [2/HW, Hisilicon], it is proposed to study the specification impact to support the ultra-deep sleep option 2.

5.10.2 Round 1 discussion

***FL comments:*** To FL’s understanding, whether specification impact should be considered depends on which power model of the ultra-deep sleep state is considered. If option 1 is used, no particular specification impact seems necessary. In this meeting, we should first try to reach consensus on the two options of the power model of the ultra-deep sleep state. If option 2 is agreed, the specification impact can be further investigated.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## 5.11 Decoupling of communication and positioning BW

5.11.1 Summary of inputs

From reviewing the contributions in this meeting, in [2/HW, Hisilicon], it is proposed to study the decoupling of bandwidth of communication and positioning for LPHAP, such that a LPHAP UE is able to satisfy high accuracy positioning services, meanwhile, the communication functionality is limited to reduce power consumption and cost.

5.11.2 Round 1 discussion

***FL comments***: To my understanding, from potential enhancements perspective, the specification impact seems too early for this stage to consider. Nevertheless, such LPHAP device type with decoupled communication and positioning BW would be a promising implementation in the industry, and it is also related to several issues, e.g., power model of ultra-deep sleep state, enhancements on eDRX and paging reception, etc. From this perspective, FL suggests companies to keep this in mind when discussing evaluation assumptions and potential enhancements.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

**References**

1. RP-213588, Revised SID on Study on expanded and improved NR positioning, 3GPP TSG RAN Meeting #94e.
2. R1-2208456 Evaluation and solutions for LPHAP Huawei, HiSilicon
3. R1-2208517 Discussion on Low Power High Accuracy Positioning Quectel
4. R1-2208559 Discussion on evaluation on LPHAP Spreadtrum Communications
5. R1-2208651 Discussion on Low Power High Accuracy Positioning vivo
6. R1-2208737 Views on LPHAP Nokia, Nokia Shanghai Bell
7. R1-2208802 Discussion on Low Power High Accuracy Positioning OPPO
8. R1-2210242 Discussion on Low Power High Accuracy Positioning CATT

Revision of R1-2208984

1. R1-2209060 On Low Power High Accuracy Positioning Intel Corporation
2. R1-2209107 Discussion on Low Power High Accuracy Positioning Sony
3. R1-2209216 Discussion on low power high accuracy positioning ZTE
4. R1-2209294 Discussion on Low Power High Accuracy Positioning xiaomi
5. R1-2209344 Discussion on low power high accuracy positioning CMCC
6. R1-2209396 LPHAP considerations Lenovo
7. R1-2209490 Discussions on Low Power High Accuracy Positioning (LPHAP) techniques InterDigital, Inc.
8. R1-2209739 Discussion on LPHAP Samsung
9. R1-2209786 Views on low power high accuracy positioning Sharp
10. R1-2209806 Discussion on LPHAP in idle/inactive state LG Electronics
11. R1-2209910 Discussion on Low Power High Accuracy Positioning NTT DOCOMO, INC.
12. R1-2209993 Requirements, Evaluations, Potential Enhancements for Low Power High Accuracy Positioning Qualcomm Incorporated
13. R1-2210178 Evaluations for Low Power High Accuracy Positioning Ericsson

**Appendix A: Summary of contributions**

A.1 Remaining issues on evaluation methodology

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| Huawei, HiSilicon [2] | ***Observation 2: Without the requirement of receiving paging, UE may implement ultra-deep sleep Option 2 for the purpose of waking up to do positioning only.***  ***Proposal 1: On the ultra-deep sleep model***   * ***Adopt a single value of 0.01 power unit per slot for both options*** * ***Both Options can be adopted in the evaluation, where***   + ***Option 2 applies to the case when UE wakes up to only perform positioning transmission or measurement***   + ***Option 1 applies to the case when UE wakes up to perform communication, including receiving paging, initiating SDT, or accessing a cell*** * ***The transition energy of Option 1 takes the value of 10000.*** |
| vivo [5] | ***Proposal 2:***   * ***For ultra-deep sleep option1, support 5000 power units as ultra-deep sleep transition power.*** |
| Nokia/NSB [6] | **Proposal 1:** Add the following note to the conclusion made at RAN1#109.   * Note: This does not imply anything about if the Rel-16/17 positioning technique can achieve the target horizontal positioning accuracy requirement based on the baseline assumption for power consumption evaluation of LPHAP.   **Proposal 2:** RAN1 considers option 1 for the evaluation of the battery life of the LPHAP device with a modification of the transition energy from 2000 to 20000. |
| OPPO [7] | ***Proposal 1: For the study/evaluation of LPHAP, additional target positioning requirements is suggested as***   * ***End-to-end latency for position estimation of UE (< 1 s).***   ***Proposal 2: If RAN1 evaluation is needed for LPHAP, support to reuse the evaluation assumptions of FR1 InF-DH scenario captured in TR 38.857.***  ***Proposal 3: For evaluating the power consumption of LPHAP, suggest to take the power consumption model of [5] as the starting point and further consider the following power states***   * ***For positioning methods based on DL PRS***   + ***Deep sleep***   + ***PRS reception and processing***   + ***UL transmission for positioning reporting*** * ***For positioning methods based on UL SRS resources for positioning***   + ***Deep sleep***   + ***SRS*** ***transmission*** * ***For positioning methods based on both DL PRS and UL SRS resources for positioning***   + ***Deep sleep***   + ***PRS reception and processing***   + ***UL transmission for positioning reporting***   + ***SRS*** ***transmission***     - ***Note: SRS transmission and UL transmission for positioning reporting may be merged into one state*** |
| Intel [9] | **Observation 1: The LPHAP device characteristics for Option 2 in the ultra-deep sleep power model is unclear and transition time of 25ms seems rather too low given relative time is scaled down by factor of 100.**  **Observation 4: NB-IOT power model may not be directly applicable to NR LPHAP model for the following reasons**   * **UE capabilities, operating BWs etc. can be different for NB-IOT and NR LPHAP** * **Group of HW components that can be turned ON/OFF in different sleep states appear to be quite different for NB-IOT and NR LPHAP devices. NB-IoT only defined two sleep states, whereas NR LPHAP model consists of four sleep states.** * **Power states with normalized relative power value of 1 have different characteristics for NB-IOT and NR LPHAP**   + **Light sleep with relative power 1 in NB IOT model can still assume synchronization and accurate timing is maintained**   + **Deep sleep in LPHAP has relative power 1 and it may not observe accurate timing and synchronization**   **Proposal 1: Support Option 1 with additional transition energy 2000 for the ultra-deep sleep state for power consumption evaluation of LPHAP devices.** |
| ZTE [11] | ***Proposal 2: For the power consumption model in ultra-deep sleep state, option 2 is revised as:***   * + - ***The relative power unit: 0.01***     - ***Additional transition energy: 480;***     - ***Total transition time: 25ms*** |
| CMCC [13] | **Proposal 1: For option 1 of ultra-deep sleep state, consider the following power consumption model:**   * **The relative power unit: 0.015** * **Additional transition energy: 2000** * **Total transition time: 400ms**   **Proposal 2: For option 2 of ultra-deep sleep state, consider the following power consumption model:**   * **The relative power unit: 0.01** * **Additional transition energy: 800** * **Total transition time: 50ms**   **Proposal 3: For the power consumption model of the ultra-deep sleep state, RAN1 strives to down-select between the following two options:**   * + **Option 1:**     - **The relative power unit: 0.015**     - **Additional transition energy: 2000**     - **Total transition time: 400ms**   + **Option 2:**     - **The relative power unit: 0.01**     - **Additional transition energy: [800]**     - **Total transition time: [50]ms** |
| Samsung [16] | **Proposal 2: Support Option 1 for ultra deep sleep study:**   * **Option 1:**   + **The relative power unit: 0.015**   + **Additional transition energy: 2000**   + **Total transition time: 400ms** |

A.2 Evaluations

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| Huawei, HiSilicon [2] | ***Observation 1: Rel-17 baseline UL and DL positioning in RRC\_INACTIVE state can approximately achieve 300 – 500 hours battery life, which cannot meet the LPHAP requirements.***   * ***Even with K factor taking the value 4, it still cannot meet the battery life requirement of 6 months.***   ***Observation 3:***   * ***With ultra-deep sleep Option 1***   + ***DL and UL positioning cannot meet the requirement of 6 months*** * ***By further removing paging reception and adopting ultra-deep sleep Option 2***   + ***DL UE-based positioning can meet the requirement of 6 months*** * ***By further enhancing SRS mobility***   + ***UL positioning can meet the requirement of one year*** |
| Spreadtrum [4] | ***Observation 1: When implementation factor K is less than 4, the battery life of LPHAP device Type A and Type B cannot meet the requirement of 6 months.***  ***Observation 2: When implementation factor K is equal to 4, the battery life of LPHAP device Type B can meet the requirement of 6 months.***  ***Observation 3: The battery life of LPHAP device Type A and Type B cannot meet the requirement of 12 months with any values of implementation factor K.*** |
| vivo [5] | ***Observation 1:***   * ***For LPHAP power consumption evaluation, when I-DRX cycle is 1.28s, the evaluation results of baseline cases are as follows*** * ***the battery life for type A and type B LPHAP devices is 0.44 and 2.48 months for baseline case of UE-based DL positioning under high SINR*** * ***the battery life for type A and type B LPHAP devices is 0.36 and 2.02 months for baseline case of UE-assisted DL positioning under high SINR with CG-SDT*** * ***the battery life for type A and type B LPHAP devices is 0.46 and 2.58 months for baseline case of UL positioning under high SINR*** * ***For LPHAP power consumption evaluation, when I-DRX cycle is 10.24s, the evaluation results of baseline cases are as follows*** * ***the battery life for type A and type B LPHAP devices is 0.68 and 3.84 months for baseline case of UE-based DL positioning under high SINR*** * ***the battery life for type A and type B LPHAP devices is 0.65 and 3.68 months for baseline case of UE-assisted DL positioning under high SINR with CG-SDT*** * ***the battery life for type A and type B LPHAP devices is 0.68 and 3.87 months for baseline case of UL positioning under high SINR***   ***Observation 2:***   * ***Regardless of I-DRX cycle is selected as 1.28s or 10.24s, the power consumption in inactive state for the cases of existing RAN functionality cannot meet the requirement of 6 months for type A and type B LPHAP devices with implementation factor of 1.*** * ***e.g., even for the lowest power consumption in the case of UL positioning under high SINR and with 10.24s IDRX cycle, the battery life gaps are 5.32 and 2.13 months for type A and type B LPHAP devices respectively, compared to 6 months requirement.***   ***Observation 3:***   * ***For DL positioning in inactive state, UE-based positioning is more power efficient than UE-assisted DL positioning***.   ***Observation 4:***   * ***For UE-assisted DL positioning, CG-SDT report is more power efficient than RA-SDT report.***   ***Observation 5:***   * ***In inactive state, positioning with good channel conditions (such as high SINR) consumes less power than that with bad channel condition.***   ***Observation 6:***   * ***With some enhanced assumptions of ultra-deep sleep and eDRX configuration, the power consumption for baseline cases can meet the battery life requirement of 6 months and 12 months.*** * ***For type A LPHAP device, baseline cases with ultra-deep sleep option 1 with transition power of 5000 and 30.72s eDRX cycle can reach 6 months battery life, while other baseline cases with larger ultra-deep sleep transition power and/or shorter eDRX cycle are hard to reach the 6 months battery life.*** * ***For type A LPHAP device, baseline cases with ultra-deep sleep option 2 and eDRX cycle of 20.48s/30.72s can basically reach the battery life of 12 months.*** * ***For type B LPHAP device, baseline cases with all kinds of enhanced assumptions can achieve 6 months battery life and most of baseline cases with enhanced assumptions can achieve 12 months battery life.***   ***Observation 7:***   * ***For ultra-deep sleep option 1, as the ultra-deep sleep transition power decreases, the UE power consumption decreases, and it is easier to achieve target battery life.*** * ***For type A LPHAP device, in the case of UE-based DL positioning with 30.72s eDRX cycle, the sub-cases with 20000/15000/10000/5000 transition power can reach battery life of 2.04/2.64/3.71/6.26 months respectively.*** * ***For type B LPHAP device, in the case of UE-based DL positioning with 30.72s eDRX cycle, the sub-cases with 20000/15000/10000/5000 transition power can also reach battery life of 11.05/14.83/20.56/35.22 months respectively.***   ***Observation 8:***   * ***For ultra-deep sleep option 1, ultra-deep sleep transition power occupies the largest proportion of the total power consumption.*** * ***Ultra-deep sleep transition power of 20000 occupies more than 90% of the total power consumption, and even the transition power of 5000 occupies about 70% of the total power consumption***   ***Observation 9:***   * ***More justifications may be needed to verify the feasibility and applicability for the assumption of option 2 ultra-deep sleep.***   ***Observation 10:***   * ***At least for ultra-deep sleep option 1, disabling paging monitoring does not bring significant power gain.***   ***Observation 11:***   * ***At least for ultra-deep sleep option 1, as the DRX cycle decreases, the gain of power consumption of ultra-deep sleep compared to regular deep sleep becomes smaller.***   ***Observation 12:***   * ***Ultra-deep sleep is more suitable for DRX with large period, especially for eDRX cycle>10.24s.*** |
| Nokia/NSB [6] | **Observation 1:** For DL-only UE-based positioning with low SINR assumption, average power consumption per slot is 2.470, 1.184, 1.092, and 1.061, respectively for DRX cycle of 1.28 s, 10.24 s, 20.48 s, and 30.72 s.  **Observation 2:** For DL-only UE-assisted positioning with low SINR assumption, the average power consumption per slot is 3.246, 1.281, 1.140, and 1.094, respectively for DRX cycle of 1.28 s, 10.24 s, 20.48 s, and 30.72 s.  **Observation 3:** For DL-only UE-based positioning with high SINR assumption, the average power consumption per slot is 1.639, 1.080, 1.040, and 1.027, respectively for DRX cycle of 1.28 s, 10.24 s, 20.48 s, and 30.72 s.  **Observation 4:** For DL-only UE-assisted positioning with high SINR assumption, the average power per slot is 2.064, 1.133, 1.066, and 1.044, respectively for DRX cycle of 1.28 s, 10.24 s, 20.48 s, and 30.72 s.  **Observation 5:** For UL-only UE-assisted positioning with low SINR assumption, the average power per slot is 2.696, 1.212, 1.106, and 1.071, respectively for DRX cycle of 1.28 s, 10.24 s, 20.48 s, and 30.72 s.  **Observation 6:** For UL-only UE-assisted positioning with high SINR assumption, the average power per slot is 1.674, 1.084, 1.042, and 1.028, respectively for DRX cycle of 1.28 s, 10.24 s, 20.48 s, and 30.72 s.  **Observation 7:** The evaluated battery life time for two different types of LPHAP device (unit: days) is as follows:   1. I-DRX cycle with 1.28 s  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Type-A LPHAP device | | Type B LPHAP device | | | K=1 | K=4 | K=1 | K=4 | | DL-only UE-based | Low SINR | 8.99 | 35.98 | 50.60 | 202.42 | | High SINR | 13.55 | 54.23 | 76.26 | 305.06 | | DL-only UE-assisted | Low SINR | 6.84 | 27.38 | 38.51 | 154.03 | | High SINR | 10.76 | 43.06 | 60.56 | 242.24 | | UL-only | Low SINR | 8.24 | 32.97 | 46.36 | 185.45 | | High SINR | 13.27 | 53.09 | 74.67 | 298.68 |  1. I-DRX cycle with 10.24 s  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Type-A LPHAP device | | Type B LPHAP device | | | K=1 | K=4 | K=1 | K=4 | | DL-only UE-based | Low SINR | 18.76 | 75.07 | 105.57 | 422.29 | | High SINR | 20.57 | 82.30 | 115.74 | 462.96 | | DL-only UE-assisted | Low SINR | 17.34 | 69.39 | 97.58 | 390.32 | | High SINR | 19.61 | 78.45 | 110.32 | 441.30 | | UL-only | Low SINR | 18.33 | 73.34 | 103.13 | 412.54 | | High SINR | 20.50 | 82.00 | 115.31 | 461.25 |  1. eDRX cycle with 20.48 s  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Type-A LPHAP device | | Type B LPHAP device | | | K=1 | K=4 | K=1 | K=4 | | DL-only UE-based | Low SINR | 20.35 | 81.40 | 114.46 | 457.87 | | High SINR | 21.36 | 85.47 | 120.19 | 480.76 | | DL-only UE-assisted | Low SINR | 19.49 | 77.97 | 109.65 | 438.59 | | High SINR | 20.84 | 83.38 | 117.26 | 469.04 | | UL-only | Low SINR | 20.09 | 80.36 | 113.01 | 452.07 | | High SINR | 21.32 | 85.30 | 119.96 | 479.84 |  1. eDRX cycle with 30.72 s  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Type-A LPHAP device | | Type B LPHAP device | | | K=1 | K=4 | K=1 | K=4 | | DL-only UE-based | Low SINR | 20.94 | 83.77 | 117.81 | 471.25 | | High SINR | 21.63 | 86.55 | 121.71 | 486.85 | | DL-only UE-assisted | Low SINR | 20.31 | 81.25 | 114.26 | 457.03 | | High SINR | 21.28 | 85.14 | 119.73 | 478.92 | | UL-only | Low SINR | 20.74 | 82.99 | 116.71 | 466.85 | | High SINR | 21.61 | 86.46 | 121.59 | 486.38 |   **Observation 8**: Type-A LPHAP device can’t achieve the target requirement for battery life without further enhancement beyond just e-DRX.  **Observation 9**: The gains from e-DRX of 20.48 s and 30.72 s are marginal compared with the existing I-DRX configurations.  **Observation 10**: Type-B LPHAP device can’t achieve the target requirement for battery life with the baseline *K* value of 1.  **Observation 11**: In order to achieve the LPHAP battery life requirement, enhancement of Rel-17 functionality is necessary. |
| CATT [8] | **Observation 1: The UE-based DL positioning with eDRX (eDRX cycles with 30.72 sec) and ultra-deep sleep could meet the target requirement of 6 months, where battery life is 7.71 months.**  **Observation 2: The major power consumption is caused by sleep state.** |
| Intel [9] | **Observation 2: For the baseline evaluation scenario of type A LPHAP device, assuming transition energy 2000 in Option 1 of the ultra-deep sleep power model meets the 6 months battery life requirement when 20.48s and 30.72s DRX cycles are assumed for the three positioning methods.**  **Observation 3: For the baseline evaluation scenario of type A LPHAP device, assuming transition energy 20000 in Option 1 of the ultra-deep sleep power model does not meet the 6 months battery life requirement when 20.48s and 30.72s DRX cycles are assumed for the three positioning methods.** |
| Sony [10] | [Observation 1 – The battery life of the LPHAP device is limited to 4 – 12 days for the studied scenarios and with C2 =800 mhA, much significantly lower than the long 6 – 12 months battery life requirements. The battery life of LPHA device increases linearly when increasing its battery capacity to 4500 mAh.](#_Toc115347992)  [Observation 2 – Looking at the power consumption break-down, it is observed that the dominant source of energy cost is different depending on the I-DRX periodicity and positioning occasion periodicity](#_Toc115347993)  [Observation 3 - Aligning the DRX on duration and DL assisted PRS procedure provide power saving gain.](#_Toc115347994)  [Observation 4 – When aligning the DRX on duration and DL assisted PRS procedure, the power saving gain is higher for the scenarios where the DRX cycle are short and DL positioning and paging have the same periodicity.](#_Toc115347995) |
| ZTE [11] | ***Observation 1: The maximum additional transition energy suggested in option 1 accounts for a very large portion in a eDRX cycle, which is too large to meet the battery lift requirement.***  ***Observation 2: The additional transition energy of ultra-deep sleep should be greater than that of deep sleep.***  ***Observation 3: The battery life requirement of LPHAP device cannot be satisfied in some evaluation cases, e.g. with too large transition energy for ultra-deep sleep mode, or with too short DRX cycle, or with too small C2.***  ***Observation 4: The power consumption of LPHAP device is lower when PRS is configured close to SSB and PO.***  ***Observation 5: The evaluated battery life of option 1 can meet the requirement only when the DRX cycle is configured larger than 10.24s with device Type B.***  ***Observation 6: The requirement of battery life for LPHAP device can be satisfied in most cases while adopting option 2 and revised option 2 with 10.24s DRX cycle for device Type A.***  ***Observation 7: Smaller additional transition energy of ultra-deep sleep increases the battery life of LPHAP device.***  ***Observation 8: Longer DRX cycle configuration can improve the battery life of LPHAP device.***  ***Observation 9: The number of transition times resulting in the power consumption accounts for very large proportion in the total power for LPHAP device.***  ***Observation 10: Support of 1-symbol PRS can further reduce the power consumption of PRS measurement.*** |
| xiaomi [12] | ***Observation 1: For UE-based DL positioning***   * ***Case ID#4 with 1 eDRX cycle (20.48s) and Ultra sleep state (Option 2) can meet the target requirement 12 months.*** * ***Case ID#5 with 1 eDRX cycle (20.48s) and Ultra sleep state (Option 1 with 2000 as additional transmission energy) can almost meet the target requirement 6 months.*** * ***Case ID#6 with 1 eDRX cycle (30.72s) and Ultra sleep state (Option 1 with 2000 as additional transmission energy) can meet the target requirement 6 months.***   + ***If the value of additional transmission energy changed to more than 3000, it will not be able to meet the target requirement 6 months.***   ***Observation 2: For UE-assisted DL positioning***   * ***Case ID#10 with 1 eDRX cycle (20.48s) and Ultra sleep state (Option 2) can meet the target requirement 12 months.*** * ***Case ID#11 with 1 eDRX cycle (20.48s) and Ultra sleep state (Option 1 with 2000 as additional transmission energy) can almost meet the target requirement 6 months.*** * ***Case ID#12 with 1 eDRX cycle (30.72s) and Ultra sleep state (Option 1 with 2000 as additional transmission energy) can meet the target requirement 6 months.***   + ***If the value of additional transmission energy changed to more than 3000, it will not be able to meet the target requirement 6 months.***   ***Observation 3: For UL positioning***   * ***Case ID#16 with 1 eDRX cycle (20.48s) and Ultra sleep state (Option 2) can meet the target requirement 12 months.*** * ***Case ID#17 with 1 eDRX cycle (20.48s) and Ultra sleep state (Option 1 with 2000 as additional transmission energy) can almost meet the target requirement 6 months.*** * ***Case ID#18 with 1 eDRX cycle (30.72s) and Ultra sleep state (Option 1 with 2000 as additional transmission energy) can meet the target requirement 6 months.***   + ***If the value of additional transmission energy changed to more than 3000, it will not be able to meet the target requirement 6 months.*** |
| CMCC [13] | **Observation 1: With baseline evaluation assumptions, none of the existing Rel-17 RRC\_INACTIVE state positioning functionalities meets the target requirement of 6~12 months battery life.**  **Observation 2: For UL positioning, frequent (re)configuration for UL SRS significantly increases the power consumption:**   * **The slot-averaged relative power unit increases from 1.85 to 4.11 for a power cycle of 1.28s;** * **The slot-averaged relative power unit increases from 1.51 to 1.79 for a power cycle of 10.24s.**   **Observation 3: By extending the DRX cycle and RS periodicity, the power consumption significantly reduced, as the UE is able to go into a deeper sleep state and stays asleep as much as possible.**  **Observation 4: Minimizing the gap between paging reception, DL PRS/UL SRS occasion, and measurement reporting helps reduce the power consumption, as the UE reduces the number of transitions from active to ultra-deep sleep and stays asleep as much as possible**  **Observation 5: For option 1 of ultra-deep sleep state with additional transition power 20000:**   * **None of the UE-assisted DL positioning, UE-based DL positioning and UL positioning techniques meets the battery life of 6 nor 12 months for LPHAP Type A device.** * **The battery life of 6 and 12 months can be met with UE-assisted DL positioning, UE-based DL positioning and UL positioning for LPHAP Type B device.**   **Observation 5: For option 1 of ultra-deep sleep state with additional transition power 2000:**   * **The battery life of 6 and 12 months can be met with UE-assisted DL positioning, UE-based DL positioning and UL positioning for LPHAP Type A device.** * **The battery life of 6 and 12 months can be met with UE-assisted DL positioning, UE-based DL positioning and UL positioning for LPHAP Type B device.**   **Observation 6: For option 2 of ultra-deep sleep state:**   * **The battery life of 6 and 12 months can be met with UE-assisted DL positioning, UE-based DL positioning and UL positioning for LPHAP Type A device.** * **The battery life of 6 and 12 months can be met with UE-assisted DL positioning, UE-based DL positioning and UL positioning for LPHAP Type B device.** |
| Samsung [16] | ***Observation 1: For Type A LPHAP device with implementation factor K=1:***   * ***For a same evaluated configuration case, DL positioning consumes more power than UL positioning.*** * ***For all evaluated configuration cases in both DL and UL positioning, deep sleep cannot achieve the target battery life of 6 to 12 months.*** * ***For all evaluated configuration cases in both DL and UL positioning, ultra deep sleep can improve the battery life.***    + ***Especially, the improvement is significant for long DRX cycle (e.g., Case 3 and 4 in the evaluations).***   + ***For eDRX cycle (e.g., Case 4 in the evaluations), the target battery life of 6 to 12 months can be achieved for high SNR scenario.*** * ***For all evaluated configuration in both DL and UL positioning with low SNR scenario (or bad synchronization), the target battery life of 6 to 12 months still cannot be achieved.***   ***Observation 2: For Type A LPHAP device with implementation factor K=1:***   * ***Paging and PEI triggered positioning are beneficial in improving the battery life.***    + ***Especially for low SNR scenario, PEI triggered positioning can remarkably improve the battery life and achieve the target of 6 months.*** |
| LGE [18] | ***Observation #1: Type A LPHAP device (i.e. C2=800mAh) cannot meet the target battery life.***  ***Observation #2: Type B LPHAP device (i.e. C2=4500mAh) cannot meet the target battery life in most of cases. Meanwhile when 10.24s I-DRX cycle and K≥2 are assumed, there are some cases that can meet the target requirement for battery life.*** |
| Qualcomm [20] | ***Observation 1: Reducing the latencies involved in the legacy SDT procedure may significantly reduce the power consumption.***  ***Observation 2: Time-domain proximity of the PRS/SRS/Paging/Reporting-Opportunity reduces the power consumption by ensuring the UE stays in sleep mode longer times and reducing the need of sleep mode switches.***  ***Observation 3: Increasing I-DRX and/or SRS periodicities would reduce the power consumption while keeping the latency-related QoS within the required targets (e.g. 20.48, 30.72 SRS periodicities and/or I-DRX).***  ***Observation 4: If the location is needed at the UE, the smallest Power consumption is achieved for UE-based DL Positioning***  ***Observation 5: If the location is needed at the network, the smallest Power consumption is achieved for UL-only Positioning***  ***Observation 6: Positioning-related (re-)configuration(s) (e.g. SDT) increase significantly the power.*** |
| Ericsson [21] | Observation 1: For the baseline of K=1 and Type A LPHAP UE with C2=800mAh, the average PU consumption target is 0.0608  Observation 2: With 8 TRP measured per DRX, it is possible to completely sound the indoor factory deployment in 3 10.24s DRX cycles, and still be within the reporting periodicity budget of use case 6 (30 secs).  Observation 3: Knowledge of the DRX pattern configured to the UE by the LMF is beneficial in order to optimize the assistance data.  Observation 4: Short SRS is sufficient to provide UL coverage in InF cases  Observation 5 : The proposed ultra deep sleep option 1 profile, together with 10.24s DRX cycle with a single SRS transmission per DRX, fulfill the power requirements for 6 months battery life  Observation 6 : The proposed ultra deep sleep option 1 profile, together with 30.72s DRX cycle with a single SRS transmission per DRX, fulfill the power requirements for 12 months battery life  Observation 7: SDT procedure for synching of the UL SRS may introduce addition power consumption that need to be taken into account if needed frequently.  Observation 8: The configuration of SRS in multiple cell to allow SRS mobility for RRC\_INACTIVE UE is not efficient from the resource utilization perspective. |

A.3 Potential enhancements

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| Huawei, HiSilicon [2] | ***Proposal 2: RAN1 should further study the impact to support ultra-deep sleep Option 2, where UE ramping up from ultra-deep sleep is only for positioning transmission or measurement.***  ***Proposal 3: RAN1 acknowledges the benefit of DRX enhancement (e.g. no paging reception or eDRX in RRC\_INACTIVE state) to reduce the power consumption for LPHAP.***  ***Proposal 4: RAN1 should further study decoupling bandwidth between communication and positioning for LPHAP.***   * ***Note: decoupling bandwidth between communication and positioning includes at least a larger positioning bandwidth (PRS and/or SRS) than the communication bandwidth.***   ***Proposal 5: RAN1 should further study the configuration of SRS that is applicable to an area consisting of multiple cells, where the SRS configuration is not released as long as the cell UE is camping on belongs to the area.***  ***Proposal 6: RAN1 should further study the configuration of TRS for synchronization before the SRS transmission.*** |
| Quectel [3] | ***Proposal 1:***   * The procedure of low power positioning should consider the impact of Paging Early Indication for UE in RRC\_IDLE/RRC\_INACTIVE mode   ***Proposal 2:***   * For power saving and latency reduction for RRC\_IDLE/INACTIVE UEs, positioning with PRACH preamble should be studied from the perspectives of TA granularity, PRACH SCS and length and DL synchronization accuracy.   ***Proposal 3:***   * The power consumption of SRS transmission and higher accuracy DL positioning method should be evaluated. |
| vivo [5] | ***Proposal 1:***   * ***Power saving enhancements should be supported for LPHAP to meet the power consumption requirement.***   ***Proposal 3:***   * ***In idle/inactive state, the issues/solutions for LPHAP with eDRX mechanism should be considered to maximize the battery life, including*** * ***Potential UE behavior when eDRX is configured*** * ***Positioning related issues for eDRX cycle beyond 10.24s in inactive state*** * ***eDRX/positioning related coordination between positioning nodes***   ***Proposal 4:***   * ***The following solutions related to inactive DRX can be considered for LPHAP, including*** * ***LMF requesting inactive DRX configurations (e.g. DRX cycle, etc.) from the cells including UE serving cell and neighboring cells that may be reselected can be considered for LPHAP*** * ***PRS measurement/SRS transmission in the vicinity of paging monitoring***   ***Proposal 5:***   * ***Mobility for SRS transmission inactive state can be considered for LPHAP, including*** * ***Pre-configured SRS*** * ***UE initiated SRS configuration update request*** * ***SRS beam sweeping enabling***   ***Proposal 6:***   * ***Introduce longer candidate values for SRS periodicity, e.g., 15360, 20480, 30720ms.***   ***Proposal 7:***   * ***Support the following enhancements related to idle state positioning*** * ***DL-PRS measurement in idle state*** * ***Reporting of DL-PRS measurement and/or location estimate performed in idle state when the UE is in inactive/connected state.*** |
| Nokia/NSB [6] | **Proposal 3:** RAN1 should consider overall enhancement including positioning measurement behavior, positioning measurement reporting, procedure for RS configuration/reconfiguration.  **Proposal 4**: RAN1 to study allowing UE to skip some measurement reports (e.g., when measurement results are similar).  **Proposal 5:** For purpose of the power consumption reduction, RAN1 investigates the impact of the partial measurement reporting functionality and identifies the necessary physical layer procedure.  **Proposal 6:** RAN1 to study partial updates of PRS AD for UEs in RRC\_INACTIVE mode to reduce overhead and power consumption.  **Proposal 7**: RAN1 to study methods to reduce frequent configuration or update of UL SRS for positioning, e.g., by configuring common UL SRS for positioning within a positioning area.  **Proposal 8**: RAN1 to study how to avoid frequent BWP switching to transmit SRS resource outside of UL BWP.  **Proposal 9**: RAN1 to study how to reduce UE positioning activities (e.g., PRS reception in DL positioning, or SRS-pos transmission in UL positioning) on demand. |
| OPPO [7] | ***Proposal 4: Study whether or not to introduce more candidate values for the reporting interval for the UE power saving.*** |
| CATT [8] | **Proposal 1: For DL positioning, enhancement to support measurement reporting in RRC\_IDLE state should be considered for LPHAP in Rel-18.**  **Proposal 2: For UL positioning, the mechansim of SRS-Pos configuration for UE in RRC\_INACTIVE/RRC\_IDLE state should be enhanced especially for the case when UE moves out of the original gNB in Rel-18.**  **Proposal 3: The following SRS-Pos configuration method for UL positioning should be considered:**   * **Introducing a new RACH procedure for UE to obtain the SRS-Pos configuration information.**   **Proposal 4: UE could stop monitoring the Paging Occasions (POs) during the deferred MT-LR period.** |
| Intel [9] | **Proposal 2: RAN1 recommends to support eDRX values of 20.48s and 30.72s in RRC INACTIVE state.**  **Proposal 3: Investigate UL positioning enhancement mechanisms such as how SRS configuration can be updated without entering RRC connected mode in new cell.**  **Proposal 4: RAN1 conducts feasibility study on whether DL positioning measurement reporting and UL SRS transmission can be supported from physical layer perspective**   * **Consider at least pre-configured UL resource for UL transmissions in Idle mode.** |
| Sony [10] | Proposal 1 – Consider aligning the DRX on duration and DL assisted PRS procedure. Further discuss the details (e.g., by RAN2).  Proposal 2 – RAN1 to consider other/additional power saving mechanisms to reduce the total power consumption of LPHAP devices. |
| ZTE [11] | ***Proposal 1: eDRX cycle with > 10.24s should not be discussed in positioning agenda.***  ***Proposal 3: To reduce transition times, UE should either receive both PO and PRS or receive nothing.***  ***Proposal 4: Support the following enhancement for PRS configuration:***   * + - ***Support 1-symble PRS/SRS***     - ***Support the comb size {24, 48}***   ***Proposal 5: Rel-18 should further enhance the UE mobility in RRC\_INACTIVE/RRC\_IDLE to reduce the power consumption for UL positioning, e.g. reduce SRS reconfiguration.***  ***Proposal 6: Support MT-LR for positioning via MT-SDT in RRC\_INACTIVE in Rel-18.*** |
| xiaomi [12] | ***Proposal 1: Support to define Ultra-deep sleep state for LPHAP device.***  ***Proposal 2: eDRX cycle with 20.48s and 30.72s can be configured to archive the target battery life for LPHAP device.***  ***Proposal 3: Study SRS transmission or PRS measurement in PO indicated not necessary to wake up by DCI format 2\_7.***  ***Proposal 4: The positioning SRS con be configured per cell group for UE power consumption reduction.***  ***Proposal 5: Study SRS configuration request by random access.*** |
| CMCC [13] | **Proposal 4: Enhancements on power saving solutions should be studied for low power and high accuracy positionings.**  **Proposal 5: From RAN1 perspective, support of DL measurement for UEs in RRC\_IDLE state.**  **Proposal 6: The following DRX related enhancements should be considered:**   * **Introduction of the eDRX mode in LPHAP** * **Reduce the number of PDCCH monitoring occasions in RRC\_INACTIVE/IDLE state for LPHAP** * **Align the DRX pattern and the DL PRS / UL SRS occasions**   **Proposal 7: The following enhancement of SRS transmission in RRC\_INACTIVE state should be considered:**   * **SRS resources are (pre-)configured within an area in RRC\_INACTIVE state.** * **FFS: How to define this area.** |
| Lenovo [14] | ***Proposal 1: RAN1 to support positioning measurements in RRC\_IDLE state, which may be considered beneficial for LPHAP devices.***  ***Proposal 2: The serving gNB may provide/share the applicable UE’s DRX configuration with the LMF for adaptation of the PRS measurement configuration.***  ***Proposal 3: RAN1 to further study they type of DRX configuration to be shared with the LMF, e.g., C-DRX, I-DRX. RAN3 coordination may be required.*** |
| InterDigital [15] | **Proposal 1: Study achievable accuracy of IDLE mode positioning**  **Proposal 2: Study feasibility of IDLE mode positioning methods using PRACH and/or SRS for positioning** |
| Samsung [16] | **Proposal 1: RAN1 shall wait for RAN2’s clarification on the scope of the study. Especially, one of the following options shall be clarified:**   * **Option 1: The study investigates potential enhancement to positioning in RRC\_INATIVE state to support LPHAP.** * **Option 2: The study investigates supporting of positioning in RRC\_IDLE state and potential enhancement to support LPHAP.** * **Option 3: Option 1 + Option 2.**   **Proposal 3: To improve the battery life in low SNR scenario, it’s beneficial to study and support paging or PEI triggered positioning.** |
| Sharp [17] | **Proposal:** For LPHAP, the DL positioning in RRC\_IDLE state should be studied.  **Observation:** When studying PRACH-based UL positioning in RRC\_IDLE state, the difference of power consumption between the positioning in RRC\_INACTIVE state and the positioning in RRC\_IDLE should be the metric. |
| LGE [18] | ***Proposal #1:***   * Enhancements for power saving in RRC inactive state should be studied.   ***Observation #3:***   * For LPHAP, following issues should be considered from a time domain perspective:   + For higher accuracy, configuring the shorter periodicity and/or the larger repetition on PRS/SRS resources could be used, but it costs of UL/DL resources and UE power.   + The time domain window is not supported for inactive state UE in Rel-17.   ***Observation #4:***   * For LPHAP, following issues should be considered from a frequency domain perspective   + When separated BWP for positioning SRS is configured for UE in RRC inactive state, power consumption due to the BWP switching should be considered.   ***Observation #5:***   * If the SRS for positioning always has lower priority than other UL channels, not only performance in terms of accuracy cannot be guaranteed, but also the latency can be increased because of the drop and/or delaying of SRS transmission due to lower priority. |
| NTT DOCOMO [19] | **Proposal 1:**   * **To achieve the requirements of Rel-18 LPHAP (i.e., use case 6 defined in TS 22.104), high reception priority of DL-PRS in RRC\_INACTIVE state may be needed.** * **One possible solution is to reuse PPW for high priority reception of DL-PRS. In addition, RAN1 may need to discuss additional specification impacts.**   **Proposal 2:**   * **To achieve the requirements of Rel-18 LPHAP (i.e., use case 6 defined in TS 22.104), high transmission priority of SRS for positioning in RRC\_INACTIVE state may be needed.** * **One possible solution is to introduce transmission priority indicator between SRS for positioning and other DL/UL signals.**   **Proposal 3:**   * **RAN1 should study to align DRX configuration and paging occasion with PRS measurement or SRS transmission occasion.** * **Priority rules between DRX and PRS/SRS configuration may be needed if the alignment isn’t possible.** |
| Qualcomm [20] | ***Proposal 1: Support Positioning measurements in RRC Idle state.***  ***Proposal 2: For the purpose of reduced power consumption in RRC Inactive, the following can be beneficial:***   * ***Study ways of optimizing the SRS configuration/activation/request procedure(s) included in the UL/DL+UL RRC inactive positioning (e.g. SRS pre-configuration, RACH-based SRS request from the UE, paging-based SRS activation).*** * ***Study ways for SRS transmission continuation after cell change in RRC Inactive (e.g., continuity of the configured SRS across cell change).*** * ***Study PRS/SRS configuration restrictions & corresponding new UE capabilities for enabling reduced power consumption for RTT positioning.*** |

**Appendix B: Agreements in previous RAN1 meetings**

B.1 RAN1#109-e meeting

**Agreement**

Confirm that use case 6 defined in TS 22.104 is the single representative use case for the study of LPHAP.

**Agreement**

At least the relative power unit is adopted as the performance metric to evaluate the power consumption of the Rel-17 RRC\_INACTIVE state positioning and potential enhancements.

**Agreement**

A reference device (e.g., a mobile phone) with reference traffic type, reference battery capability, and reference battery life is defined for the purpose of identification of the performance gap that achieved by the Rel-17 RRC\_INACTIVE state positioning baseline and the target battery life of LPHAP use case 6.

**Agreement**

* Adopt the following parameters as the common evaluation parameters for the LPHAP evaluation:
  + Frequency range: FR1 (baseline); FR2 (optional)
  + SCS: 30kHz for FR1 (baseline); 120kHz for FR2 (optional)
  + BW of the DL PRS and UL SRS pos: 100MHz;
  + Single-sample measurement per position fix (baseline); 4-sample measurement per position fix (optional)
  + UE mobility: up to 3km/h
* Note: It is up to each company to provide detailed power model and evaluation results on power consumption in FR2.

**Agreement**

In the LPHAP evaluation, the power consumption of 5GC data traffic is not modelled. Only the power consumption of the traffic type related to LPHAP positioning (e.g., obtaining/updating SRS configurations, DL PRS measurement reporting, etc.) is considered.

* Note: This does not preclude the power consumption of paging monitoring in the baseline evaluation, but rather assumes that no power consumption of 5GC data traffic is considered during a power cycle.

**Agreement**

Adopt the following power consumption model common for the baseline evaluation of Rel-17 RRC\_INACTIVE state positioning.

|  |  |
| --- | --- |
| **Power State** | **Relative power** |
| PDCCH-only (PPDCCH) | 50Note |
| PDCCH + PDSCH (PPDCCH+PDSCH) | 120 |
| SSB proc. (PSSB) | 50 |
| UL | 250 (0 dBm)  700 (23 dBm) |
| (Optional) PRACH | [210] |
| (Optional) BWP switching | [50] |
| (Optional) Intra-frequency RRM measurement (Pintra) | [60] (synchronous case, N=8, measurement only; Pintra, meas-only)  [80] (combined search and measurement; Pintra, search+meas) |
| (Optional) Inter-frequency RRM measurement (Pinter) | [60] (measurement only per freq. layer; Pinter, meas-only)  [150] (neighbor cell search power per freq. layer; Pinter, search-only)  Micro sleep power assumed for switch in/out a freq. layer |
| Note: Power scaling to 20MHz reception bandwidth follows the rule in Section 8.1.3 of TR 38.840, i.e., max{reference power \* 0.4, 50}. | |

**Agreement**

Adopt the following power consumption model for UL SRS for positioning transmission.

|  |  |
| --- | --- |
| **Power State** | **Relative power** |
| SRS | 210 (baseline);  700 (optional) |

**Agreement**

* In Rel-18 low power and high accuracy positioning, adopt the following requirement:
  + Horizontal positioning accuracy < 1 m for 90% of UEs
  + Positioning interval / duty cycle of 15-30 s
  + UE battery life of 6 months – 1 year
* Note: Setting an exact value each from the set of positioning interval / duty cycle and UE battery life in the evaluation and identification of performance gap will be discussed separately when necessary.

**Conclusion**

* At least when the positioning accuracy is evaluated without jointly evaluating the associated power consumption, the target horizontal positioning accuracy requirement on LPHAP of <1m can be achieved by Rel-16/17 positioning techniques with a positioning bandwidth of at least 100MHz.
* The main aspect of RAN1 evaluation is on power consumption.
* Note: This does not preclude the case that the positioning accuracy can be revisited, if found necessary at later stage.

**Agreement**

* Study further at least the following models and parameter values of conversion between the relative power unit and the battery life to identify the performance gap:
  + Alt. 1: battery life is used as the metric to identify the gap
    - Example:
  + Alt. 2: relative power unit is adopted as the metric to identify the gap
    - Example:

in which

* C1 is the battery capacity of the reference device;
* T1 is the battery life of the reference device;
* P1 is the relative power unit obtained based on the reference traffic type;
* X is the percentage of the power consumed by the reference traffic type;
* C2 is the battery capacity of the LPHAP device;
* P2 is the evaluated relative power unit of the LPHAP device;
* P2\_req is the target relative power unit of the LPHAP device;
* T2\_req is the target battery life of the LPHAP device
* Examples of these parameters are provided as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **C1** | **T1** | **X** | **reference traffic type** | **C2** | **T2req** |
| [4500] mAh | [10] hours | [20] % | [FTP (model 3)] | [800] mAh | [12] months |

**Agreement**

Adopt the following periodicity of DL PRS / UL SRS for positioning in the baseline evaluation of Rel-17 RRC\_INACTIVE positioning:

* 1 DL PRS / UL SRS for positioning occasion per N I-DRX cycle(s);
  + Candidate values of N to evaluate is 1 and 8 for I-DRX cycle of 1.28s;
    - Note: Individual company may consider either one or both in the evaluation.
  + Candidate value of N to evaluate is 1 for I-DRX cycle of 10.24s.

**Agreement**

* The I-DRX configuration is included in the baseline evaluation of Rel-17 RRC\_INACTVIE positioning.
  + Note: This does not preclude the case where no I-DRX cycle nor paging is considered in the evaluation of potential solutions to maximize the battery life.
* Adopt the following I-DRX cycle to evaluate:
  + 1.28s (baseline); 10.24s (optional).

**Agreement**

* Adopt the power consumption model, additional transition energy and total transition time of the three sleep types (deep sleep, light sleep, and micro sleep) in TR38.840 as the evaluation baseline:
* FFS: whether/how an additional new ultra-deep sleep mode can be considered in the evaluation of potential solutions to maximize the battery life, including the determination of the relative power, additional transition energy and total transition time, if necessary.

**Agreement**

* Adopt the following reference configuration and assumption for DL PRS to define the power consumption model for DL PRS measurement:
  + 1 Number of PFL;
  + 8 DL PRS resources per slot are measured;
  + DL PRS instance of smaller than or equal to 1 slot duration;
* Adopt the following table as the power consumption model for DL PRS measurement (derived from Table 22 in TR38.840):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| N: Number of TRPs for DL PRS measurement | Synchronous case (baseline) | | Asynchronous case (optional) | |
| FR1 (baseline) | FR2  (optional) | FR1 | FR2 |
| N=4 (baseline) | 120 | 195 | 140 | 255 |
| N=8 (optional) | 150 | 225 | 170 | 285 |

**Agreement**

* For DL positioning, at least the following power components and parameter values are considered for the baseline evaluation of Rel-17 RRC\_INACTIVE positioning:
  + For the UE-assisted DL positioning,
* SSB proc. with 2 ms duration and the periodicity of I-DRX cycle;
* Paging with 2 ms duration, the periodicity of I-DRX cycle, and group paging rate of 10%;
* DL PRS measurement with 0.5 ms duration;
* CG-SDT with 1ms duration and the periodicity of positioning interval;
  + - * RRCRelsease after the CG-SDT can be optionally included with [1] ms duration;
* (Optional) BWP switching with [1] ms duration;
* (Optional) Intra-/inter-frequency RRM measurement in low SINR condition with [1] ms duration;
* (Optional) RA-SDT (e.g., including CORSET0 + SIB1, PRACH, RAR, Msg 3/4/5) in case of CG-SDT is unavailable;
  + For the UE-based DL positioning,
    - SSB proc. with 2 ms duration and the periodicity of I-DRX cycle;
    - Paging with 2 ms duration, the periodicity of I-DRX cycle, and group paging rate of 10%;
    - DL PRS measurement with 0.5 ms duration;
    - (Optional) BWP switching with [1] ms duration;
    - (Optional) Intra-/inter-frequency RRM measurement in low SINR condition with [1] ms duration;
* Note: The power component and parameter values for UE-assisted DL positioning is also applicable to the DL part of UE-assisted DL+UL positioning method.
* Note: Individual company may consider additional power components and different parameter values in bracket in the evaluation.
* Note: Companies are encouraged to provide the assumption on the timeline between different power consumption events in the evaluation of potential enhancements to reduce the transition times between different power states and to extend the sleeping time as much as possible.

**Agreement**

* For UL positioning, at least the following power components and parameter values are considered for the baseline evaluation of Rel-17 RRC\_INACTIVE positioning:
  + SSB proc. with 2 ms duration and the periodicity of I-DRX cycle;
  + Paging with 2 ms duration, the periodicity of I-DRX cycle, and group paging rate of 10%;
  + UL SRS for positioning transmission with 0.5 ms duration;
  + (Optional) BWP switching with [1] ms duration;
  + (Optional) Intra-/inter-frequency RRM measurement in low SINR condition with [1] ms duration;
* Note: The power component and parameter values for UL positioning is also applicable to the UL part of UE-assisted DL+UL positioning method.
* Note: Individual company may consider additional power components and different parameter values in bracket in the evaluation.
* Note: Companies are encouraged to provide the assumption on the timeline between different power consumption events in the evaluation of potential enhancements to reduce the transition times between different power states and to extend the sleeping time as much as possible.

B.2 RAN1#110 meeting

Agreement

In the LPHAP evaluation, adopt the following model to convert the relative power unit to the battery life:

* Alt. 1: battery life is used as the metric to identify the gap



* + K is an implementation factor, K = 1 (baseline); K = 0.5, 2, 4 (optional)
* Note: The definition of the notations will be captured in the updates of TR.
* Note: The voltage is assumed to be the same for the reference device and the LPHAP device.

Agreement

* In the LPHAP evaluation, adopt the following example parameter values in the conversion model to evaluate the battery life:
  + For the reference device in the conversion model:

|  |  |  |  |
| --- | --- | --- | --- |
| **C1 (mAh)** | **T1 (hour)** | **X** | **reference traffic type** |
| 4500 | 12 | 20% | FTP (model 3) |

* + For the LPHAP device, consider 2 typesin the conversion model:

|  |  |  |
| --- | --- | --- |
| **LPHAP device** | **C2 (mAh)** | **T2req (month)** |
| Type A (baseline) | 800 | 6~12 |
| Type B (optional) | 4500 | 6~12 |

* Note: As the reference device and LPHAP device characteristics, and therefore the parameter values of the model for determining battery life, is dependent on implementation factors, manufacturer, design options and cost options, it is up to individual company to evaluate the optional K values, and report the corresponding parameter values.

Agreement

In the LPHAP evaluation, adopt the example value of relative power unit of the reference device P1 = 50 to further align the battery life among companies.

Agreement

For the purpose of LPHAP evaluation, an ultra-deep sleep state is considered. The following options of the power consumption model of the ultra-deep sleep state can be further discussed:

* Option 1:
  + The relative power unit: 0.015
  + Additional transition energy: 2000
  + Total transition time: 400ms
* Option 2:
  + The relative power unit: 0.01
  + Additional transition energy: 450;
  + Total transition time: 25ms
  + FFS: restrictions in processing associated with option 2 after the UE comes out of ultra-deep sleep state
* Notes: the values above can be further discussed

Agreement

For option 1 in the agreement above, the value of additional transition energy is changed to “a value between 2000 and 20000”. FFS which value.

Agreement

* For the purpose of LPHAP evaluation, the following assumptions on eDRX configuration and/or paging reception can be optionally considered:
  + The eDRX cycle to evaluate: 20.48s; 30.72s;
  + For paging reception:
    - 1 paging occasion is included in one eDRX cycle
    - 10% paging rate
  + No paging reception can be optionally evaluated;
  + 1 DL PRS and/or UL SRS for positioning occasion per 1 eDRX cycle
    - Minimizing the gap between PRS measurement, SRS transmission and/or measurement reporting with paging monitoring in time domain can be evaluated.

Agreement

The tables to collect evaluation results from each source in section 3.3.2 of [R1-2207993](file:///C:\Users\cmcc\AppData\Local\Temp\360zip$Temp\Docs\R1-2207993.zip) are endorsed.

Agreement

Capture the following in TR as an observation:

* Evaluations of baseline Rel-17 RRC\_INACTIVE state positioning with the evaluation assumptions agreed for the study show that the power consumption on deep sleep state accounts for the highest proportion in the total power.

**Appendix C: Contact information**

The contact information of delegates in charge of LPHAP AI is summarized in the following table for your information.

|  |  |  |
| --- | --- | --- |
| **Company** | **Name** | **Email** |
| CMCC | Jingwen Zhang | zhangjingwen@chinamobile.com |
| vivo | Yuanyuan Wang | yuanyuan.wang.txyj@vivo.com |
| Huawei, HiSilicon | Jinhuan Xia | Jinhuan.xia@huawei.com |
| CATT | Ren Da | renda@catt.cn |
| Qualcomm | Alex Manolakos | amanolak@qti.qualcomm.com |
| OPPO | Zhihua Shi | szh@oppo.com |
| Xiaomi | Mingju Li | limingju@xiaomi.com |
| Samsung | Hongbo Si | hongbo.si@samsung.com |
| Lenovo | Alexander Golitschek | aelbwart@lenovo.com |
| Ericsson | Florent Munier | Florent.munier@ericsson.com |
| NTT DOCOMO | Masaya Okamura | masaya.okamura.ea@nttdocomo.com |
| Spreadtrum | Zhenzhu lei | reven.lei@unisoc.com |
| ZTE | Chuangxin Jiang | jiang.chuangxin1@zte.com.cn |
| InterDigital | Fumihiro Hasegawa | Fumihiro.hasegawa@InterDigital.com |