**3GPP TSG RAN WG1 #109e R1-22NNNNN**

**e-Meeting, May 9th – 20th, 2022**

**Source: Moderator (Ericsson)**

**Agenda item: 9.5.3**

**Title: Feature Lead Summary#1 for Positioning for RedCap UEs**

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

# Introduction

This document summarizes the proposals in [1]-[22] for the agenda item 9.5.3, and documents the discussion for the email discussion [109-e-R18-Pos-08] as per the following chairman decision

[109-e-R18-Pos-08] Email discussion on positioning for RedCap UEs by May 20 – Florent (Ericsson)

* Check points: May 16, May 20

# Summary of proposed discussion topics

The received contributions provide proposals on the following aspects:

* Use cases and target requirements for positioning for redcap UEs
* Scenarios, evaluation assumptions and simulation Parameters for redcap UEs
* Evaluation results for redcap UEs
* Enhancements for redcap UEs

# Use cases and target requirements for Redcap UEs

## Summary of proposals

Several companies have proposed to generally discuss use cases and performance targets [2][7][10][18][20] during this meeting. [3][9][11][12] proposes to re-use the use case and requirements from rel-17 support for commercial /IIOT use cases, and [9] [11] proposes to consider relaxing the IIOT requirement for redcap devices. [10] proposed to re-use rel16 commercial requirements as a starting point. The use case of wearables is mentioned by [4][11][14], and [14] proposes to target < 1 m horizontal, <3m vertical accuracy. [19] mentions IWSN for IIOT

Latency requirement are discussed in [18][10]. [22] proposes to involve RAN4 regarding the requirements for 1Rx branch.

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Proposal 1: Set the following target requirements for RedCap positioning:**** ***Horizontal positioning accuracy: <1m***
* ***Vertical positioning accuracy: <3m***
 |
| [2] | **Proposal 1**: RAN1 to discuss the performance targets for RedCap UEs.  |
| [3] | ***Proposal 1: The Rel-18 positioning accuracy requirement for RedCap UEs should be no higher than the Rel-17 positioning accuracy requirement for commercial and IIoT use cases, e.g., 1~3 meter (90% of UEs).*** |
| [4] | ***Proposal 1**** ***Select the use case of wearables as a single representative use case for RedCap positioning.***
* ***The following accuracy requirement can be considered for RedCap positioning.***
* ***Horizontal position accuracy of 2m for 90% of UEs.***
* ***Vertical position accuracy of 3m for 90% of UEs.***
 |
| [7] | Proposal 3: RAN1 needs to define the target positioning accuracy for RedCap UE. |
|  |  |
| [9] | **Proposal 2:** * **In commercial scenario, reusing the Rel-16/Rel-17 requirements for commercial scenario for RedCap positioning**
* **In industrial scenario, consider relaxing the requirements for RedCap positioning compared with the R17 IIoT requirement**
 |
| [10] | ***Observation 1: the positioning accuracy (or latency) requirements are not clear.******Proposal 1: RAN1 is to study the requirements on positioning accuracy for RedCap UEs.******Proposal 2: using positioning accuracy requirement for commercial use cases defined in R16 as starting point.***  |
| [11] | ***Proposal 1: Regarding the positioning support for RedCap UEs, support the following two categories of use cases:**** + ***Commercial use cases mainly for wearables***
	+ ***IIoT use cases mainly for industrial wireless sensors***

***Proposal 4: The requirements of positioning performance for RedCap UE should be lower than that of normal UEs.**** + ***FFS: the exact values of requirements***
 |
| [12] | **Proposal 3: For horizontal and vertical accuracy, reuse Rel. 17 targets (less than 1m and 0.2m for commercial and IIoT applications for horizontal accuracy and less than 3m and 1m for commercial and IIoT applications for vertical accuracy)** |
| [14] | **Proposal 1: The requirements of the RedCap UE positioning is defined as:*** + - **Horizontal position accuracy (< 1 m) for 90% of UEs**
		- **Vertical position accuracy (< 3 m) for 90% of UEs**
 |
| [18] | ***Proposal 1: RAN1 needs to define the potential indoor and outdoor use cases and positioning requirements for RedCap positioning*.** ***Proposal 2: RAN1 needs to study at least the vertical and horizontal positioning accuracy and availability requirements for the RedCap devices considering indoor and outdoor deployments.******Proposal 3: Study the end-to-end latency requirements for the RedCap devices.*** |
| [19] | **Proposal 1:** Among three Rel-17 RedCap use cases, the target for positioning should be IWSN for IIoT.**Proposal 2:** The use case of the RedCap positioning should be selected among the use cases categorized in TS22.104.**Observation:** Given that the positioning is applied for RedCap devices with IWSN use case, the positioning use case that overlaps with the RedCap IWSN would be use case #4 (Process automation: Sequence container (Intralogistics) in 22.104.**Proposal 3:** For RedCap IWSN, how the clarified requirements for positioning use case can be achievable should be studied. |
| [20] | * **RAN1 to decide on target positioning accuracy for RedCap use-cases for NR-based positioning, potentially considering availability of multiple complementary positioning methods to ascertain the need for enhancements for RedCap UEs with max UE BW of 20 MHz.**
 |
| [22] | ***Proposal 1: Send LS to RAN4 to ask them to include positioning requirements derived using simulation assumptions wherein 1 Rx is assumed at the UE.***  |

## First round of discussion

Considering the work plan, the ambition for this meeting is to agree on target requirements and use case for RedCap positioning. Based on the exisiting proposals and observation, it seem possible to begin the discussion from the rel17 targets for commercial and IIOT use cases as a starting point for evaluation. Further discussion is needed to consider additional, potentially more relaxed, requirements.

For convenience, rel17 requirements for commercial and IIOT is copied below:

|  |
| --- |
| Agreement:* In Rel-17 target positioning requirements for commercial use cases are defined as follows:
	+ Horizontal position accuracy (< 1 m) for 90% of UEs
	+ Vertical position accuracy (< 3 m) for 90% of UEs
	+ End-to-end latency for position estimation of UE (< 100 ms)
	+ Physical layer latency for position estimation of UE (< 10 ms)
* In Rel-17 target positioning requirements for IIoT use cases are defined as follows:
	+ Horizontal position accuracy (< 0.2 m) for 90% of UEs
	+ Vertical position accuracy (< 1 m) for 90% of UEs
	+ End-to-end latency for position estimation of UE (< 100ms, in the order of 10 ms is desired)
	+ Physical layer latency for position estimation of UE (<10ms)
* Note 1: Target positioning requirements may not necessarily be reached for all scenarios and deployments
* Note 2: For some scenarios the requirement for Horizontal position accuracy can be relaxed to < 0.5 m in IIoT use cases.
* Note 3: All positioning techniques may not achieve the target positioning requirements over all scenarios
 |

Proposal 3.2 For the study of positioning performance of RedCap UEs, the following accuracy requirements are used for performance evaluations:

* + IIOT: Horizontal position accuracy (< 0.2m) , vertical position accuracy (< 1 m) for [90%] of UEs
	+ Commercial: Horizontal position accuracy (< 1m), vertical position accuracy (< 3m) for 90% of UEs
	+ FFS: other requirements and use case
	+ FFS: whether latency requirements should be considered.

Companies are encouraged to comment on how to evolve the proposal in the table below, especially if further use cases and requirements should be considered.

**Proposal 3.2:**

|  |  |
| --- | --- |
| Company | comment |
|  |  |

# Evaluation assumptions for Redcap UEs

## Summary of proposals

For evaluation assumptions, several companies proposed different baselines to be used indoor and outdoor. For indoor, reusing the methodology for indoor factory scenario from rel17 (iiot scenario) and indoor office from rel16 (commercial scenarios) was proposed in [3][9][11][12][13]. [22] propose to consider InH for indoor. For outdoor Commercial scenario baseline (using UMi as channel model) is discussed in [9][11][12][22]

In addition to rel16 and rel17 simulation scenarios and methodology, [21][22] propose to introduce evaluation of 700MHz macro scenarios (Uma for [22], RMa for [21])

Several proposal mention specific parameters to be modified for redcap:

Bandwidth:

* + 20MHz in FR1 [1] [7][10][12][13][18][21][22]
	+ 5MHz in FR1: [2]
	+ 100 MHz in FR2 [7][12][18][22]
	+ Use of redcap initial BWP for PRS/ SRS [4]

Number of Rx branches for redcap devices:

* + 1RX branch [1][4][6][2][7][9][10][11][13]
	+ 2Rx branch[1][11]
	+ Note: redcap UEs only have 1 Tx branch

Different positioning methods have been mentioned, including DL AOD[12], UTDOA[1], DL TDOA[2] [3] [4] [7] [10] [11], E-CID[16] and multi-RTT.

Half duplex FDD is discussed in [4]

DRX impact is discussed in [4][15]

Recap reduced processing time[12]

Reference signals and their parameterization (e.g. PRS duration) are discussed in [16][17] [18]. From the FL perspective, it is proposed to leave it to proponent to detail the reference signal parameters in the evaluation, and leave RS details out of the methodology, as it was done during previous releases.

Based on the proposals, it is proposed to discuss the following:

* General consideration for the UE and gNB simulation parameters
* Channel models and evaluation scenarios
* Bandwidths to be evaluated
* Number of Tx and Rx branches to be evaluated
* Positioning methods
* Reference signals
* DRX/power consumption
* Rel17 reduced redcap processing time

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Observation 1: The use cases of RedCap UEs (e.g., sensors, wearables) would require a sub-meter (< 1m in horizontal) positioning accuracy considering the reduced capabilities:**** ***Bandwidth: 20MHz at FR1***
* ***Antenna setting: 1Tx&1Rx, 1Tx&2Rx***
 |
| [2] | **Proposal 2:** RAN1 to consider evaluation assumption parameters of Table 1 as a baseline for accuracy performance evaluation of RedCap UE. |
| [3] | ***Proposal 2: Suggest reusing Rel-17 Indoor Factory scenarios for the evaluation of the positioning performance of RedCap UEs.*** |
| [4] | ***Proposal 3**** ***For power saving, positioning impacted by CDRX should be considered for RedCap positioning, including:***
* ***PRS measurement behaviour inside/outside drx-onDurationTimer or DRX active time.***
* ***LMF awareness of DRX configurations and DRX state change(e.g., short-long DRX cycle transition due to drx-ShortCycleTimer, etc.).***
* ***Related signaling and procedure.***

***Proposal 4**** ***The following aspects can be considered for RedCap positioning, including:***
* ***Separated initial BWP support for PRS measurement and SRS transmission.***
* ***Priority/collison rules for DL PRS processing and SRS transmission when Half-duplex FDD is supported.***
* ***The impact of UE not supporting CA/DC.***
 |
| [6] | ***Proposal 1: Study the impact on the accuracy of the positioning with a bandwidth reduction and reduced Rx branches.*** |
| [7] | Proposal 1: Study the impact of RedCap UE maximum bandwidth and minimum number of Rx-branch to the positioning accuracy.Proposal 2: RAN1 needs to define the simulation assumptions suitable for RedCap UE. |
| [9] | **Proposal 1:** * **The baseline application scenario for RedCap positioning is the commercial scenario**
* **The industrial scenario can be considered for RedCap positioning as well**

**Proposal 3:** * **Reuse the evaluation methodology defined in 38.855 and 38.857 for the evaluation of RedCap positioning**
* **For assumption of RedCap devices**
	+ **Reduced bandwidth is assumed**
	+ **Both reduced Rx branch and normal Rx branch is assumed**
 |
| [10] | ***Proposal 3: RAN1 to study the impacts to measurements caused by reduced BW and antenna number.*** |
| [11] | ***Proposal 2: To evaluate positioning performance of RedCap UEs, support the following scenarios and evaluation assumptions:**** + ***For commercial use cases, select one or two of the following cases defined in Section 6.1 of TR 38.855***
		- ***Case 1: Indoor Office***
		- ***Case 2: UMi street canyon***
	+ ***For IIoT use cases, select one or two of the following cases defined in Section 6 of TR 38.857***
		- ***Case 3: InF-SH***
		- ***Case 4: InF-DH***
	+ ***FR1 is the first priority***
	+ ***For the detailed information of evaluation assumptions for each case, refer to TR 38.855 and TR 38.857.***
 |
| [12] | **Observation 1: The effect of reduced bandwidth for RedCap UEs should be investigated for both commercial and IIoT applications****Proposal 1: For system parameters for SLS evaluation of positioning accuracy, use the evaluation assumptions in TR 38.875 as the baseline****Proposal 2: For DL-based positioning methods, use 20MHz for FR1 and 50MHz or 100MHz for FR2 for PRS bandwidth.****Proposal 4: Study the effect of reduced UE processing time on the operation of the PRS processing window****Proposal 5: Study the effect of reduced UE bandwidth on latency for positioning** |
| [13] | ***Observation 1: Of the device capability differences between Rel-16 baseline UEs and RedCap UEs, only the maximum bandwidth and the number of Rx antenna branches affect the positioning performance.******Proposal 1: For the RedCap UE evaluation, set the bandwidth of the Redcap devices to 20 MHz and the Number of Rx antennas to 1.*** ***Proposal 2: RAN1 to set a common evaluation methodology and common evaluation parameters based on the parameters in 38.855*** [4]  ***and 38.857*** [3]***.*** * ***it is necessary to agree on the simulation assumptions for the configuration of the positioning reference signals***
 |
| [16] | ***Proposal 1:*** * The accuracy of DL positioning should be evaluated first for RedCap UEs in Rel-18.

***Proposal 2:*** * The followings are proposed for the evaluation of ECID of RedCap UEs:
	+ The number of gNBs for the position calculation of an outdoor UE should be evaluated in the urban scenario.
	+ The performance enhancement for NLoS scenario should be considered with ECID.

***Proposal 3:*** * When the requirements of positioning accuracy and latency are not high, PSS, SSS, PBCH DMRS should be used for positioning. The performance of positioning with PSS, SSS, PBCH DMRS should be evaluated.
 |
| [17] | ***Proposal #1:*** * Discuss which of the reduced feature among RedCap UE impacts the performance of positioning in terms of accuracy / latency / resource efficiency.

***Proposal #2:*** * Discuss whether and how to configure PRS resources for RedCap UEs.
 |
| [18] | ***Proposal 4: Evaluate RedCap positioning with reduced bandwidths e.g., 20MHz for FR1 and 100MHz for FR2 with reduced Rx antenna/RF chain of 1 for link budget evaluation.*** ***Proposal 5: Evaluate and study the positioning performance of RedCap devices with longer PRS symbol lengths, e.g., 12 to support RedCap devices.*** |
| [21] | ***Proposal 1 Evaluation scenarios for RedCap positioning include InF, IOO, UMi, UMa and RMa.******Proposal 2 Evaluate DL-TDOA and multi-RTT for RedCap positioning, with high priority.******Proposal 3 For performance evaluation of RedCap positioning,******• maximum UE bandwidth is 20MHz in FR1 and 100MHz in FR2,******• minimum antenna configurations are one Rx branch and one Tx branch in FR1 and (Mg, Ng, M, N, P) = (1, 1, 1, 2, 2) with PC7 in FR2,******• maximum antenna configurations are two Rx branches and two Tx branches in FR1 and (Mg, Ng, M, N, P) = (1, 1, 2, 2, 2) with PC3 in FR2, and******• minimum EIRP in FR2 is 17dBm for RedCap UEs with PC7 and 22.4dBm for RedCap UEs with PC3.******• Note: performance evaluation for RedCap UEs with PC3 in FR2 is optional.******Proposal 4 Carrier frequencies are 700MHz for RMa and 3.5GHz for other scenarios in FR1, and 28GHz in FR2.******Proposal 5 SCS can be 15kHz for RMa and 30kHz for other scenarios in FR1, and 120kHz in FR2.******Proposal 6 UE distribution in UMi and UMa is 80% indoor with the speed of 3km/h and 20% outdoor in cars with the speed of 30km/h.******Proposal 7 UE distribution in RMa is 50% indoor with the speed of 3km/h and 50% outdoor in cars with the speed of 120km/h.******Proposal 8 Use the simulation assumptions listed in Table 2 for performance evaluation in RMa.*** |
| [22] | ***Proposal 2: For TDD scenarios,*** * ***We propose to reuse NR Rel-16/17 Evaluation assumptions for InH, and UMI FR1 scenarios as agreed in RAN1 #94-Bis for 4 GHz and 2 GHz.***
	+ ***Support adding optionally to evaluate the UMI FR1 cases with DeltaTau modeling similar to the one introduced for InF scenarios.***
* ***For FR1 FDD scenario introduce a new Urban Macro at 700 MHz with 500m ISD according to the simulation assumptions shown below.***
* ***For FR2 TDD Redcap, reuse the NR Rel-16/17 FR2 simulation assumptions with 100 MHz PRS bandwidth.***
 |

## First round of discussion

### Channel models and evaluation scenarios

We propose to start the discussion by identifying which channel model and scenarios should be evaluated. Once the channels are agreed, we can proceed with the details regarding the deployment. Since a majority of companies mentioned that the previous releases scenarios can be reused for evaluation of RedCap UEs, we can start from these scenarios and see if modifications are needed.

**Question 4.2.1: which of the following scenarios can be evaluated for positioning performance of Redcap UEs (please also mark which case could be optional and which case should be mandatory/baseline). Please also state which modifications should be made to the scenarios, if any.**

**Outdoor:**

* **Case 1: UMi street canyon , as described in Table 6.1-1-4 of 38.855**
* **Case 2: Uma , as described in Table 6.1-1-6 of 38.855**
* **Case 3: Rma (FFS details of the scenario)**

**Indoor:**

* **Case 4: InF-SH and DH as described in Table 6.1-1 of 38.857**
* **Case 5: Indoor Open Office, as described in Table 6.1-1-3 of 38.855**

Companies are encouraged to provide their view on which channel model should be evaluated

**Question 4.2.1**

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| --- | --- |
| Company | comment |
|  |  |

### General consideration for the UE and gNB simulation parameters

Based on the received proposal, we can re-use some of the common scenario parameters from rel17 as proposed by many companies. The proposal below is based on table 6.1 in 38.857, with the UE antenna model removed from the table in order to discuss it separately. Some of the parameters are marked as TBD due to the dependency on agreed simulation bandwidth. 700MHz carrier is added as an FR1 scenario.

Proposal 4.2.2 For evaluation of positioning performance of redcap UEs, adopt the general parameters are detailed in the table below

* + TBD parameters are discussed separately

 Table 6-1: Common scenario parameters applicable for all scenarios for Redcap UEs evaluations

|  |  |  |
| --- | --- | --- |
|  | FR1 Specific Values | FR2 Specific Values  |
| Carrier frequency, GHz  | 3.5GHz, 700MHz Note 1 | 28GHz Note 1 |
| Bandwidth, MHz | TBD | TBD |
| Subcarrier spacing, kHz | 30KHz, 15KHz (for 700MHz carriers) | 120kHz |
| gNB model parameters  |  |  |
| gNB noise figure, dB | 5dB | 7dB |
| UE model parameters  |  |  |
| UE noise figure, dB | 9dB – Note 1 | 13dB – Note 1 |
| UE max. TX power, dBm | 23dBm – Note 1 | 23dBm – Note 1EIRP should not exceed 43 dBm. |
| UE antenna radiation pattern  | Omni, 0dBi | Antenna model according to Table 6.1.1-2 in TR 38.855 |
| PHY/link level abstraction | Explicit simulation of all links, individual parameters estimation is applied. Companies to provide description of applied algorithms for estimation of signal location parameters. |
| Network synchronization | The network synchronization error, per UE dropping, is defined as a truncated Gaussian distribution of (T1 ns) rms values between an eNB and a timing reference source which is assumed to have perfect timing, subject to a largest timing difference of T2 ns, where T2 = 2\*T1– That is, the range of timing errors is [-T2, T2]– T1: 0ns (perfectly synchronized), 50ns (Optional) |
| UE/gNB RX and TX timing error | (Optional) The UE/gNB RX and TX timing error, in FR1/FR2, can be modeled as a truncated Gaussian distribution with zero mean and standard deviation of T1 ns, with truncation of the distribution to the [-T2, T2] range, and with T2=2\*T1:- T1: X ns for gNB and Y ns for UE- X and Y are up to sources - Note: RX and TX timing errors are generated per panel independentlyApply the timing errors as follows: - For each UE drop, - For each panel (in case of multiple panels)- Draw a random sample for the Tx error according to [-2\*Y,2\*Y] and another random sample for the Rx error according to the same [-2\*Y,2\*Y] distribution. - For each gNB - For each panel (in case of multiple panels)- Draw a random sample for the Tx error according to [-2\*X,2\*X] and another random sample for the Rx error according to the same [-2\*X,2\*X] distribution. - Any additional Time varying aspects of the timing errors, if simulated, can be left up to each company to report.- For UE evaluation assumptions in FR2, it is assumed that the UE can receive or transmit at most from one panel at a time with a panel activation delay of 0ms. |
| Note 1: According to TR 38.802Note 2: According to TR 38.901 |

Companies are encouraged to provide their view the common scenario parameters , and if any, any additional common parameters to be added:

**Proposal 4.2.2**

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

### Bandwidths to be evaluated

Contributions have mentioned 5MHz and 20MHz bandwidth to be evaluated for FR1 and 100MHz for FR2. Companies are asked which of these bandwidth should be, if any, optional and which should be a mandatory evaluation:

**Question 4.2.3: which of the UE bandwidth configuration should be evaluated? (please also mark which case could be optional and which case should be mandatory/baseline)**

* + FR1, 20MHz
	+ FR1 5MHz
	+ FR2 100MHz
	+ other

Companies are encouraged to provide their view on which bandwidth should be evaluated, and if so, whether it should be mandatory/optional:

**Question 4.2.3**

|  |  |
| --- | --- |
| Company | comment |
|  |  |

### UE antenna configuration and Number of Tx and Rx branches to be evaluated

Based on the proposals, it is proposed to update the UE antenna configuration table from 38.855 to adapt it to Redcap UEs. The majority of proposals suggest using 1 Rx branch as a baseline, but some companies also propose to use 2Rx which we could have as optional. For the antenna configuration, some companies have mentioned either (Mg, Ng, M, N, P)= (1, 1, 1, 2, 2) (i.e. minimum antenna configuration), other also included (1, 1, 2, 2, 2). We propose to have the minimum configuration as baseline as a starting point.

Proposal 4.2.4-1 Adopt the following table for th UE model parameters

|  |  |  |
| --- | --- | --- |
|  | FR1 Specific Values | FR2 Specific Values  |
| UE model parameters  |  |  |
| UE antenna configuration | Panel model 1 – Note 1Mg = 1, Ng = 1, P = 2, dH = 0.5λ,(M, N, P, Mg, Ng) = (1, 2, 2, 1, 1) | **See proposal 4.2.4-2 below** |
| UE antenna radiation pattern  | Omni, 0dBi | Antenna model according to Table 6.1.1-2 in TR 38.855 |
| Number of UE branches | Baseline: 1Rx 1TxOptional: 2Rx 1 Tx |

Companies are encouraged to provide their view on the proposed UE model parameters below:

**Proposal 4.2.4-1**

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

Proposal 4.2.4-2 For the FR2 UE antenna configuration, select between the following options:

* **Option1: as in 38.355:**

**Multi-panel Configuration 1 and Panel Configuration a – Note 1**

**- Multi-panel Configuration 1: (Mg, Ng) = (1, 2); Θmg,ng=90°; Ω0,1=Ω0,0+180°; (dg,H, dg,V)=(0,0)**

**- Panel Configuration a:**

**- Each antenna array has shape dH=dV=0.5λ**

**- Config a: (M, N, P) = (2, 4, 2),**

**- the polarization angles are 0° and 90°**

**- The antenna elements of the same polarization of the same panel is virtualized into one TXRU**

* **Option 2:** (M, N, P, Mg, Ng) = (1, 2, 2, 1, 1) **as minimum antenna configuration (baseline) and** (M, N, P, Mg, Ng) = (2, 2, 2, 1, 1) **as optional configuration.**

Companies are encouraged to provide their view on the proposed FR2 UE configuration below:

**Proposal 4.2.4-2:**

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

### Positioning methods

All positioning methods used in previous releases have been mentioned in the contributions. It is proposed to leave to proponents to detail the positioning method used to evaluate RedCap UEs performances in their evaluations.

Proposal 4.2.5: For evaluation of RedCap UE positioning performances, all RAT based positioning methods can be considered. Sources should detail the chosen method(s) when presenting performance evaluations.

Companies are encouraged to provide their view on the proposal below:

**Proposal 4.2.5:**

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

### Reference signals

Some companies have proposed parameters for the reference signals. As in previous release, we propose to agree that the evaluation methodology does not define any baseline reference signals, and sources can detail the used reference signal parameters in their evaluation.

Proposal 4.2.6 The evaluation methodology for RedCap UEs positioning performance does not define any baseline reference signals. Sources should detail the chosen reference signal(s) when presenting performance evaluations.

Companies are encouraged to provide their view on the proposal below:

Proposal 4.2.6

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

### DRX/power consumption

A few companies have discussed power consumption and the impact of DRX on the performance. Since there are only a few contribution mentioning the issue, it is propose to first ask whether the issue should be discussed in RAN1 for this meeting.

**Question 4.2.7: should the evaluation of RedCap UE positioning performance include DRX and power consumption aspects?**

**Question 4.2.7**

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

### Rel17 reduced redcap processing time

One company mentioned the impact of redcap UE processing time in [12]. Since no other companies have raised the issue, we can start by asking whether to pursue the issue during the study:

**Question 4.2.8: should the evaluation of RedCap UE positioning performance include UE processing time aspects?**

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

# Evaluations and Enhancements for Redcap UEs

## Summary of proposals

Many observations have been raised by the contributions for the different positioning techniques. While it is too early to propose to capture any observation since the simulation assumptions have not been aligned, we can make progress by agreeing on a format to capture the results of the future evaluation.

Several enhancements have been proposed. Many contributions have proposed to handle the limited bandwidth of RedCap UEs by applying some form of frequency hopping [2][5][6][7][8][12][14][22]. In [8][22] phase difference AOD is discussed. [13] mention evaluating if changes to reference signal parameters can be enough to compensate the performance loss. [14] proposes to evaluate carrier phase positioning for redcap UEs. TRS and SSB based measurements are mentioned in [22].

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Observation 2: Compared with eMBB UE, the positioning accuracy for RedCap UE is seriously degraded due to the reduced bandwidth.******Observation 3: The performance for RedCap UE with existing positioning methods (>3m@90% with NLOS detection) cannot meet the sub-meter positioning accuracy requirement.******Proposal 2: Identify positioning solutions suitable for RedCap UEs to achieve high accuracy positioning, i.e., sub-meter positioning accuracy.*** |
| [2] | **Observation 1**: The horizatonal positioning accuracy performance of RedCap UEs is significantly degraded compare with normal NR UEs. **Proposal 3**: RAN1 to study more dynamic SRS transmissions for RedCap UEs. **Proposal 4**: RAN1 to investigate group based positioning schemes for RedCap UEs. **Proposal 5**: RAN1 to study the ability to receive wideband PRS signals with a narrow band receiver (e.g., over multiple 20 MHz chunks) and transmit wideband signal on a narrow band transmitter (e.g., frequency hopping over multiple 20 MHz chunks). Identifying any specification impact should be part of the study. **Observation 2**: RedCap UEs may have positioning measurement performance degradation due to power saving/reduced capability features it is implementing. **Proposal 6**: RAN1 to study methods for reducing the impact of reduced capability features (e.g., RRM measurement relaxation) on the positioning measurement accuracy of RedCap UEs.  |
| [3] | ***Observation 1: Simulation result shows that in InF-SH, the horizontal positioning error is 2.39 meter for 20MHz bandwidth for 90% of UEs, and 0.27 meter for 100MHz bandwidth for 90% of UEs.*** |
| [4] | ***Observation 1**** ***For DL-TDOA positioning, the potential performance target [2m 90%] can be achieved in InF-SH and InF-DH with bandwidth of 20MHz.***
* ***For UL-TDOA positioning, the potential performance target [2m 90%] can be achieved in InF-SH and InF-DH with bandwidth of 20MHz.***

***Observation 2**** ***For UL-AOA positioning, the performance of 20MHz bandwidth in SH is close to the potential performance target [2m 90%].***
* ***For DL-AOD positioning, the performance of 20MHz bandwidth in SH is close to the performance target [2m 90%].***

***Observation 4**** ***Accuracy requirement for RedCap positioning can be achieved under the bandwidth of 20MHz, based on current positioning techniques.***
* ***Rel-18 techniques of AI-based positioning and carrier phase positioning can also be applied to scenarios where bandwidth is limited for better accuracy.***

***Proposal 2**** ***For accuracy enhancement of RedCap positioning, support reusing existing positioning method and measurements with RedCap UEs as much as possible.***
 |
| [5] | ***Observation 1:*** *For FR1, the positioning performance is insufficient because of limited bandwidth.****Observation 2:*** *The random phase between hops will damage the positioning performance if it was not adjusted.****Observation 3:*** *PRS frequency hopping can improve positioning performance if the random phase between hops can be adjusted.****Proposal 1:*** *Consider at least SRS frequency hopping for positioning*.***Proposal 2:*** *To eliminate phase difference between hops, some methods should be researched*. |
| [6] | ***Proposal 2: For NR REDCAP UEs, study the PRS frequency hopping scheme and consider the time and frequency allocation for each hopping subband******Proposal 3: For NR REDCAP UEs, if frequency hopping is enable, study the muting mechanism for subbands.*** |
| [7] | Observation 2: Reducing the bandwidth for DL-PRS transmission also reduces the positioning accuracy.Proposal 4: Further study the positioning techniques to improve positioning accuracy of RedCap UE. |
| [8] | **Proposal 2-1**: Support DL-PRS transmission hopping**Proposal 2-2**: For DL-PRS transmission hopping, the partial overlapping in frequency domain between the BW before and after the hopping is preferred**Proposal 2-3**: The SRS transmission outside UL BWP may also be considered, especially for the positioning techniques of requiring DL and UL measurements**Proposal 3-1**: The phase difference based AOD needs to be justified to be better than the RSRP based AOD. Otherwise there is no need to define another solution for the angle based measurement, since there are quite a lot similarity between the RSRP based AOD and the phase difference based AOD**Proposal 3-2**: Move the discussion of the phase difference based AOD to AI 9.5.2.2 for carrier phase measurement |
| [10] | ***Observation 2: the reduced FFT size (in translated to reduced sampling rate) could obviously reduce the performance.******Observation 3: the reduced sequence length could obviously reduce performance at low SNR region.*** |
| [11] | ***Proposal 3: The support of positioning for RedCap UEs and any potential enhancement should not have large impact on the cost of RedCap UEs.***  |
| [12] | **Observation 2: In FR2, for DL-AoD, reduced BW from 400MHz to 100MHz leads to nearly 1m accuracy loss at CDF of 90% ile.****Proposal 6 : Study enhancements related to frequency hopping for DL-PRS, at least for DL-AoD, to improve positioning accuracy for RedCap UEs** |
| [13] | ***Proposal 3: RAN1 to investigate if modification of the reference signal parameters assumptions can compensate for performance loss based on a common set of evaluation parameters.*** |
| [14] | **Proposal 2: Further study enhancements of RedCap UE positioning:*** + - **SRS frequency hopping**
		- **Carrier phase positioning**
 |
| [15] | **Observation 1:** * **Applying existing timing-based positioning procedures and measurements to RedCap UEs will lead to degraded positioning performance compared with non-RedCap UEs due to reduced bandwidth.**

**Observation 2:** * **It may be better to evaluate each method and consider which methods are suitable for RedCap UEs with considering complexity of the method in addition to performance.**

**Proposal 1:** * **Once the evaluation results reveal performance degradation, RAN1 should work for the enhancement for positioning for RedCap UEs and determine the target performance level.**

**Proposal 2:** * **RAN1 should consider PRS frequency hopping and joint estimation as potential solutions to overcome the performance concern due to the bandwidth reduction.**

**Proposal 3:** * **For Rel-18 positioning for RedCap UEs with lower power consumption, it should be discussed the optimization feasibility of positioning in DRX state.**
 |
| [16] | ***Proposal 4:*** * To reduce the UE complexity, it is proposed for RedCap UE to report channel estimation to its serving gNB and the gNB implements the position estimation with the reported channel estimation.
 |
| [17] | ***Proposal #3:*** * Discuss time/frequency domain enhancement (e.g., BWP hopping/switching and burst transmission of SRS for positioning) to compensate performance degradation of RedCap UE
 |
| [18] | ***Observation 1: Redcap UEs are designed with the aim of lowering device cost through reduced complexity.******Observation 2: Significant degradation in the accuracy of the positioning is seen for 20 MHz PRS bandwidth in outdoor scenarios.*** |
| [20] | * **Study frequency hopping (FH) techniques for the UL-SRS and DL-PRS signal transmission to enhance the timing-based estimates of the DL-TDOA, UL-TDOA, and Multi-RTT positioning methods for the RedCap UEs.**
* **If enhancements are determined as necessary for 20 MHz RedCap UEs, study super resolution MUSIC-like methods for performance improvement of the DL-TDOA, UL-TDOA, and Multi-RTT positioning methods for RedCap UEs and the support of frequency hopping-based schemes to enable such algorithms.**
* **If enhancements are determined as necessary for 20 MHz RedCap UEs, study carrier phase measurements-based positioning techniques for positioning performance improvement for RedCap UEs.**
 |
| [22] | ***Observation 3: At the 80% percentile, for DL-TDOA, without network synchronization error, in 4 GHz UMI TDD, without Deltautau modelling, ,and 20 MHz UEs, the horizontal accuracy degrades from 11.3 meters to 12.2 meters due to reducing the number of Rx antennas from 2 to 1.*** ***Observation 4: At the 80% percentile, for DL-TDOA, without network synchronization error, in 28 GHz InF-SH TDD, and 100 MHz UEs, the horizontal accuracy degrades from 0.07 meters to 0.20 meters (case 4) due to reducing the number of Rx antennas from 2 to 1.*** ***Observation 5: In the 3GPP UMI 4 GHz Scenario, without DeltaTau modeling, Horizontal accuracy <10m is achievable with 20 MHz, 1 Rx with M-RTT and outlier rejection positioning engine for outdoor UEs.*** * ***Reducing the number of antennas from 2 Rx to 1 Rx, has smaller impact in the performance compared to reducing the bandwidth***
* ***M-RTT seems to be demonstrating better performance compared to DL-TDOA on the same scenario.***

***Observation 6: Reducing from (100 MHz, 2 Rx) to (20 MHz, 1 Rx), results in a horizontal performance degradation from the [1-3]m range to the [7-12]m range, with the reduction in Bandwidth playing the main role in this performance reduction******Observation 7: Reducing from (400 MHz, 2 Rx) to (100 MHz, 1 Rx), results in a horizontal performance degradation from the 0.0x m range to the 0.x0 m range, with the reduction in Bandwidth playing the main role in this performance reduction.******Proposal 3: Support Enhancements for Redcap devices, in both FR1 and FR2, to enable reaching a horizontal accuracy performance close to the NR Rel-17 positioning requirements at least in a subset of evaluation scenarios.*** ***Observation 8: Enabling receiver’s PRS hopping would allow sharing the legacy PRS across eMBB and Redcap devices.*** ***Proposal 4: Study inter & intra-slot repetition of a DL PRS resource for the purpose of enabling receive PRS hopping for both FR1 and FR2.******Proposal 5: Study inter & intra-slot repetition of a SRS resource for positioning for the purpose of enabling transmit SRS hopping for both FR1 and FR2.******Observation 9: The phase discontinuity introduced due to PRS frequency hopping results a in performance degradation which could be mitigated by using frequency hopping with overlapping tones.*** ***Proposal 6: Study PRS/SRS overlapping configuration for the purpose of enabling phase estimation across PRS hops both FR1 and FR2.******Observation 10: Enabling transmitter’s PRS hopping could improve the Tx power, and further improve the positioning accuracy.******Proposal 7: Study DL-PRS/ SRS resource configuration for the purpose of enabling transmitter PRS hopping.******Observation 11: Phase-Difference-based AoD may be a useful additional method for scenarios with unprecoded transmissions from gNB side (e.g. FDD cases).*** ***Proposal 8: For the purpose of Redcap positioning enhancements, study supporting Phase-Difference AoD.*** ***Proposal 9: For the purpose of Redcap positioning enhancements, study supporting Positioning measurements (RSTD, UE Rx-Tx, RSRPP) derived on SSB, TRS.******Proposal 10: For the purpose of Redcap positioning enhancements, study supporting M-RTT using SRS-MIMO.*** |

## First round of discussion

### Format for capture of the evaluations

Several companies have already provided results in their contributions. To capture the results in the SI TR, a common template should be used. It is proposed to re-use TR 38.857 template as a starting point and discuss what field in the template should be removed or added. The template is copied in appendix of this FL summary for convenience.

**Question 5.2.1: To capture the evaluation parameters and results of rel18 evaluations of positioning for RedCap UEs, the template used in TR 38.857 for the inclusion of simulation results can be reused. Please comment whether the template should be used as is or if any field should be removed or added**

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

### Candidates for enhancements of RedCap UE positioning performance

Since bandwidth hopping for PRS and SRS has been already mentioned by many companies, it is proposed to capture that it will be studied during the evaluation

Proposal 5.2.2 PRS and SRS Bandwidth hopping will be investigated in Rel-18 NR positioning for RedCap UEs.

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

Conclusions

References

1. R1-2203168, Discussion on RedCap positioning, Huawei, HiSilicon
2. R1-2203180, Initial Views on Positioning for RedCap UEs, Nokia, Nokia Shanghai Bell
3. R1-2203471, Discussion on positioning for RedCap UEs, CATT
4. R1-2203570, Discussion on positionig for RedCap Ues, vivo
5. R1-2203628, Discussion on Positioning for RedCap UE, ZTE
6. R1-2203696, Discussion on positioning support for RedCap UEs, NEC
7. R1-2203740, Discussion on positioning for RedCap UEs, Sony
8. R1-2203754, The potential solutions for RedCap UEs for positioning, MediaTek Inc.
9. R1-2203826, Initial views on the positioning for RedCap UEs, xiaomi
10. R1-2203915, Discussion on Positioning for RedCap Ues, Samsung
11. R1-2203968, Discussion on Positioning for RedCap Ues, OPPO
12. R1-2204157, Evaluation assumptions and potential solutions for positioning for RedCap UEs, InterDigital, Inc.
13. R1-2204254, Discussions on Positioning for RedCap UEs, Apple
14. R1-2204314, Discussion on RedCap positioning, CMCC
15. R1-2204388, Discussion on positioning for RedCap UEs, NTT DOCOMO, INC.
16. R1-2204425, Discussion on Positioning for RedCap UEs, Quectel
17. R1-2204526, Discussion on positioning support for RedCap Ues, LG Electronics
18. R1-2204563, Positioning for RedCap devices, Lenovo
19. R1-2204671, Views on positioning for RedCap UEs, Sharp
20. R1-2204808, On enhancements for NR positioning support of RedCap UEs, Intel Corporation
21. R1-2204954, Positioning for RedCap Ues, Ericsson
22. R1-2205042, Positioning for Reduced Capabilities UEs, Qualcomm Incorporated

Appendix: template for the capture of RedCap UE positioning performance evaluation.

Table 1: template for capture of the parameters used for performance evaluation

|  |  |
| --- | --- |
| Parameter | Source X, scenario, FRx] |
| Channel model (baseline, otherwise state any modifications) |  |
| Carrier frequency |  |
| Subcarrier spacing |  |
| Reference Signal Transmission Bandwidth |  |
| Reference Signal Physical Structure and Resource Allocation (RE pattern) (reference to figure in contribution) |  |
| Reference signal(type of sequence, number of ports, …) |  |
| Number of sites |  |
| Number of symbols used per occasion |  |
| number of occasions used per positioning estimate |  |
| Power-boosting level |  |
| Uplink power control (applied/not applied) |  |
| interference modelling (ideal muting, or other) |  |
| Description of Measurement Algorithm (e.g. super resolution, interference cancellation, ….) |  |
| Description of positioning technique / applied positioning algorithm (e.g. Least square, Taylor series, etc) |  |
| Network synchronization assumptions |  |
| UE/gNB Tx/Rx Calibration Error |  |
| Beam-related assumption (beam sweeping / alignment assumptions at the tx and rx sides) |  |
| Precoding assumptions (codebook, nrof antenna elements used, etc) |  |
| Additional notes, if any |  |

Table 2: template for capture of the evaluation results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | 50% | 67% | 80% | 90% |
| Evaluation #,scenario, FR#, technique  | Convex UEs or all UEs  |  |  |  |  |