RAN93e-R18Prep-10 - Version 0.0.4
RAN

1

3GPP TSG RAN#93e RP-211660

Electronic Meeting, 13-17 September 2021

Agenda Item: 9.0.1

Source: Email discussion moderator (Intel)

Title: Moderator's summary for discussion [RAN93e-R18Prep-10] Expanded and improved Positioning

Document for: Information and Decision

2 Introduction

This discussion covers the topic #10 "Expanded and improved Positioning" as identified in the outcome of the RAN Rel-18 Workshop [RWS-210659]

Deadlines, organisational details, and guidelines for the NWM discussion are provided by the RAN Chair in [RP-211639]. Please read these guidelines carefully before contributing to the discussion, in particular slides 4 and 5.

As stated in the guidelines, the starting point for discussion is the set of example areas identified at the workshop, and these are subject to further update/removal during the discussion For positioning the starting point is:

- 10. Expanded and improved Positioning, with the following example areas:
  - Sidelink positioning/ranging
  - Improved accuracy, integrity, and power efficiency
  - RedCap positioning

3 General

In this section companies are invited to provide high-level views on the topic of Expanded and Improved Positioning.

3.1 Initial Round comments

Feedback Form 1: General high level views (Initial Round)

1 – Apple France

For the set of example areas identified at the workshop, we think SL positioning should be prioritized. In our view and based on some of the contributions to R18-WS, improved accuracy is mainly about left-over enhancements from R17 SI, like contiguous SRS transmission across intra/inter band CCs. It was already discussed within R17 that such enhancements are subject to RAN4 study on feasibility and requirements.

2 – Guangdong OPPO Mobile Telecom.

In Rel-16, 3GPP introduced NR positioning with a comprehensive list of features. Rel-17 further enhance positioning for commercial and IIoT scenarios for better performance, low latency and all. In general, the current positioning framework is relatively complete for commercial and IIoT scenarios. Thus, Rel-18 positioning enhancement should focus on new scenarios/use cases (e.g., sidelink, RedCap UE, LPHAP).

Furthermore, since the background and procedure for Uu-based positioning and PC5-based positioning diverse a lot, it is suggested to do the two via independent item.

3 – Nokia Denmark

General observations:

The following are identified in terms of requirements (in roughly decreasing order of popularity):

- Ranging
- Low-power positioning
- Accuracy enhancements (down to cm-level)
- RAT-dependent positioning integrity
- Latency reduction

For ranging, the most identified technique by far is sidelink-based.

Low-power positioning is primarily targeted at RedCap devices but may also be applicable to other devices. Support for positioning in RRC_IDLE is the most identified technique here.

The main techniques proposed for accuracy enhancement in general (apart from sidelink assistance) are terrestrial carrier-phase positioning, PRS/SRS bandwidth aggregation, and the use of wide bandwidths at 60 GHz (which also implies the ability to transmit PRS in unlicensed spectrum, which is also seen as relevant for sidelink positioning).

4 – Intel Corporation (UK) Ltd

In our view positioning accuracy (measurement enhancements), integrity, increased efficiency, including power saving and low latency are important work directions for further enhancements of NR positioning technology. Technology should also evolve to support all RAT interfaces (Uu and PC5) and various spectrum allocation options.

5 – Huawei Tech.(UK) Co.. Ltd

Power efficiency while maintaining high accuracy should be the first priority for positioning enhancements in Rel-18. Power efficiency in positioning has never been addressed for NR and there are a number of use cases (e.g. from SA1 LPHAP) that are simply not feasible because of device power consumption. We would also like to generally clarify LPHAP vs. RedCap positioning. General Rel-18 enhancements for DL/UL positioning for power efficiency (SA1 LPHAP) may have different requirements from Redcap positioning. For example, LPHAP requires high accuracy as well as long battery life (e.g., few years). Redcap

positioning may be more focused on increasing positioning accuracy for UEs with low cost/complexity. Rather than discussing Redcap vs. non-Redcap framework, the discussion should start from identifying the use cases and the requirements. What UE type(s) would eventually be needed is not so urgent to discuss. SA1 has defined requirements for LPHAP, so those requirements are known and available. For RedCap positioning, it should first be clarified what the proposed targets are.

6 – MediaTek Inc.

1, The centi-meter accuracy needs to be pursued. The signal phase related measurement could be studied

2, The existing TEG framework for group delay mitigation may consume UE power significantly. Low power for higher accuracy needs to be pursued at least for UE

3, Both SL-assisted and SL-based for positioning are useful for positioning/ranging

7 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility

Generally, there seems to be a high level of interest among many companies for the 3 areas of improved positioning based on the outcome of the Rel-18 WS. Considering the potential workload and TU allocation, we broadly consider three high priority positioning areas for further discussion based on the vertical use cases and requirements including (1) SL positioning/ranging (2) Redcap Positioning (3) Low Power High Accuracy Positioning. On improved accuracy and integrity, our understanding is that these aspects have been carried over from the Rel-17 positioning discussions, while the power efficiency aspect can be commonly addressed under the umbrella topics of (1) SL positioning/ranging (2) Redcap Positioning (3) Low Power High Accuracy Positioning. We would also like to note that the SL positioning study would require a ground up design of which the feasibility needs to be determined in a new study item while a separate Rel-18 work item for Redcap positioning may also be considered. On LPHAP, relating to the IIoT tool tracking use cases further study may also needed on whether Uu or SL positioning can address this particular IIoT positioning requirement.

8 – Samsung R&D Institute UK

We think that further discussion is necessary whether the set of example areas need to be treated in a single study/work item or separated in multiple items. We think that including all areas in a single study/work item is not reasonable since it requires a huge amount of study/work. In addition, sidelink positioning may need to be studied first before the normative work since it was not studied before.

9 – ZTE Corporation

Basically, we agree Moderator's categorization. Furthermore, we suggest the scope on Rel-18 positioning should be controlled in a proper size. So we are not expecting too many items in Rel-18 normative work.

In addition, as most potential aspects listed in the subsequent sections need to be verified/justified by simulation results, we suggest starting Rel-18 positioning with a study phase.

10 – 5GAA

5GAA, as a 3GPP Market Representation Partner, believes that the topic "Expanded and improved Positioning" is related to the specific feature "Positioning enhancements" from 5GAA's input to the 3GPP RAN Workshop (see RWS-210360) in June 2021. For the 5GAA members, this feature was ranked level 1 (highest) out of 8 priority levels and the main motivation identified was:

- Advanced use cases require high level positioning accuracy and precision

- Advanced use cases include basic and advanced VRU protection, automated driving, teleoperated driving, dynamic intersection management, group start, etc.

As potential sub-topics and enhancements, we had identified:

- Introduce mechanisms to enhance the positioning accuracy, regardless of the network coverage scenarios, i.e. in-coverage, partial coverage and out-of-coverage.
- For in-coverage scenarios, support a combined Uu and sidelink positioning mode.
- Include positioning enhancements for vehicular Distributed Antenna Systems (DAS) UE.
- To support positioning in unlicensed spectrum, thus avoiding any impact to existing V2X deployments.

5GAA would be thankful, if 3GPP could consider the above in its further discussions on SI/WIs for Rel-18.

11 – China Mobile E-Commerce Co.

From the feedback from the market (e.g., automotive industry), Rel-18 positioning enhancements should further improve the accuracy and reliability of the RAT-dependent positioning under NLOS scenarios. In addition, the to-be-localized devices with stringent requirements of low cost and low power consumption should be further investigated. In this sense, the following enhancements should be studied (in order of priority):

- Improved accuracy, integrity, and power efficiency
- Redcap positioning
- Sidelink positioning/ranging

12 – FirstNet

The precision location of a first responder deep within GPS denied infrastructure has been an elusive goal of the fire safety and emergency personnel community for well over a decade. The objective is to pinpoint a location to within a few meters as quickly as possible. Thus, the NR positioning/ranging enhancements and solutions study should support:

o both higher horizontal and vertical accuracy,

o low latency, and

o network and device efficiency requirements, such as power consumption and complexity, for commercial use cases.

13 – Beijing Xiaomi Mobile Software

For Rel-18 positioning, we think sidelink positioning, ranging, Redcap positioning and solutions for improved accuracy should be considered. Regarding sidelink positioning and ranging, we see some differences between sidelink positioning and ranging, sidelink positioning is to acquire 2D/3D absolute/relative coordinates and ranging is to acquire one component of 2D/3D coordinates, e.g. direction, angle. So both term of sidelink positioning and ranging should be used and unified solutions for sidelink positioning and ranging can acquire either the whole 2D/3D coordinates or only one component of 2D/3D coordinates.

14 – vivo Mobile Communication Co.

Our preference in Rel-18 positioning is to put high priority on more advanced commercial needs that are not possible with current specified solutions, e.g., positioning for AR/VR devices with centi-meter level positioning (through unlicensed band in FR1 and FR2x), low power consumption for wearable devices, etc.

15 – CATT

Seven service-level performance goals are defined for 5G location services in TS 22.261, in terms of the accuracy (to 30 centimeter level), availability (to 99.9%) and latency (to 10 millisecond level). Although the target performance of Rel-17 NR Positioning Enhancements is much better than that defined for Rel-16, there is still a large gap with the requirements defined in TS 22.261. Thus, one of the main goal for Rel-18 is to further enhancements of the positioning accuracy in order to meet performance requirements defined in TS 22.261 for both absolute and relative positioning.

In Rel-18, the following areas should be taken into account:

- Sidelink positioning/ranging;
- Positioning accuracy improvement;
- RAT-dependent integrity;
- Low power high accuracy positioning;
- Redcap positioning.

16 – MediaTek Inc.

1, 3 network coverage conditions are considered to support

2, The signal phase related measurement could be further investigated with SL related positioning

17 – Sony Europe B.V.

Background

NR ePos in Rel-17 addresses IIoT use-cases with the following requirements:

- <0.2 m and <1 m for Horizontal and vertical accuracy
- <100ms end-to-end latency for position estimation

We need to continue the improve positioning, including positioning for some new use-cases/scenarios that may have specific requirements (e.g., accuracy, latency, power consumption).

Proposed topics:

1. Positioning for the following new use-cases/scenarios:

   - Positioning for RedCap UE.
   - Sidelink positioning, particularly supporting V2X Positioning (High priority). Ranging based service could be interesting but it is not high priority.

2. **Continue the evolution of NR positioning [e.g., NR FePOS] to address**

   - Features/enhancements which have not been addressed in Rel-17 SI, including left-over from Rel-17 WI (e.g, accuracy improvements, integrity, UE power consumption).

18 – CEWiT

Ubiquitous, higher accuracy and low power positioning (RAT based) for different verticals should be the target in Rel 18 for positioning enhancement. Sidelink positioning along with Uu link positioning will help to achieve ubiquitous positioning/ranging. Support on RRC-Idle positioning is important for low power positioning. Similarly, support of positioning in unlicensed band and remaining enhancements like PSR/SRS band aggregation for positioning should be considered in Rel 18. We prefer to study sidelink positioning separately from the other positioning topics which can be clubbed together as enhancement to 5G positioning.

3.2 Moderator summary at end of initial round

Thank you for providing general comments to the discussion. One observation that I would like to make is that the RAN chair's guidelines [RWS-210659] request that strong motivation/justifications are provided along with the proposal being made, but many of the comments made are of for nature 'XYZ should be included', 'XYZ is our priority', etc without explaining very much justification.

Also, a number of companies have started to express opinions about the WI/SI structure. At the moment the focus is more to identify the technical topics than to discuss WI/SI structure.

3.3 Intermediate Round

For the intermediate round, it is preferable to provide comments direct to one of the more specific sections. However, a comment box is provided so that more general comments can be provided if necessary.

Feedback Form 2: General comments (Intermediate Round)

1 – Samsung R&D Institute UK

Thank you for the summary.

We think that the discussion about study/work scope is very important in this email discussion based on the following guideline as

- *The **email discussion** should aim to **converge on a set of areas with a reasonable scope***

We think that it would be difficult to cover all three example areas in a single study/work item.

Also, down-scoping the issues within each example area is not enough.

2 – Ericsson LM

Some general comments:

- Proposals should be based on use cases and not on a particular way to solve the problem.
  - In previous releases the approach of pursuing a SI or WI has been to address use cases. Any deviation to this approach is not required.
  - Focus should be on addressing a positioning problem in a use case, not really pushing a technology and finding a use case justifying it.
- The following use cases should be considered.
  - RedCap – Addressing positioning needs with low complexity devices.

- IIoT – Addressing e.g. positioning in IIOT scenarios with low LoS probability
- Public safety – Providing positioning solutions in public safety scenario.
- V2X – Providing positioning solutions in V2X scenarios.
- We are open to studying any form of positioning solution (Uu based, sidelink based or any other) in above scenarios. The main intent here is to provide appropriate solutions.

- Since the discussed scope is very large, further pruning of the scope will obviously be needed. Our top priorities are RedCap and IIoT.

3.4 Moderator summary at end of intermediate round

General comments received in the intermediate round have been considered when preparing the the moderator updates in other sections of the document.

3.5 Final Round

As for the intermediate round, it is preferable to provide comments direct to one of the more specific sections. However, a comment box is provided so that more general comments can be provided if necessary.

Feedback Form 3: General comments (Final Round)

1 – Intel Corporation (UK) Ltd

We would like to encourage companies to consider possibility of using unlicensed spectrum for support of accurate NR Uu Positioning. We hope to continue further discussion on this and trigger study/work in a near term. The scenario is similar to SL positioning, where WiFi supports positioning but NR does not support accurate positioning in unlicensed bands for both Uu and PC5 air-interfaces so far. Thus NR is inferior in terms of positioning performance in unlicensed spectrum especially if standalone or non-standalone NR-U deployments with limited bandwidth on licensed carriers are considered. Support of NR Uu positioning in unlicensed spectrum provides more flexibility in terms of deployment options and can further increase positioning accuracy due to availability of additional spectrum.

2 – Ericsson LM

Proposals should be based on use cases and not on a specific technical solution.

Since the discussed scope is very large, further pruning of the scope will obviously be needed. Our top priorities are RedCap and IIoT scenarios with low LoS probability.

3.6 Moderator's summary at end of final round

The general comments provided in the final round earlier rounds are noted and have been considered in the moderator's updates to each individual topics area. There is nothing specific to be concluded from the general comments.

4 Sidelink positioning/ranging

4.1 Initial Round comments

Companies are invited to provide comments and suggestions for refinement to the example area of ”Sidelink positioning/ranging”, along with motivation/justification for any refinement.

Feedback Form 4: Sidelink positioning/ranging (Initial Round)

1 – InterDigital France R&D

Justification :

- Accuracy of 0.1 – 0.5 m with 95 – 99 % confidence level in TR 38.845 required for automated parking and tele-operated driving.
- Accuracy of 1 – 3 m with 95 – 99 % confidence level in TR 38.845 required for emergency break warning
- In/out/partial coverage, and public safety cases should be considered as defined in TR 38.845

Topics to be investigated :

- Identify positioning techniques for sidelink positioning
- Evaluate achievable relative and absolute accuracy and latency using timing/angle/RTT based positioning techniques for sidelink positioning
- Study bands/frequency ranges that can be considered for sidelink positioning
- Identify design elements for sidelink PRS (e.g., resource allocation, synchronization) to support the identified positioning techniques
- Study options for network architectures to support sidelink positioning for in/out/partial coverage scenarios

2 – Apple France

In our view, all three scenarios based on NW coverage (in coverage, out of coverage and partial coverage) can be considered.

3 – China Mobile E-Commerce Co.

As the study on sidelink positioning in RAN plenary will be finished by the end of RAN#93 meeting, which investigates the positioning use cases and requirements for V2X and public safety, we believe that it is reasonable to further discuss the enhancements in Rel-18. We understand that there are many potential use cases and scenarios on sidelink positioning, however, we should consider the limitations on TU and workload, and therefore, we should first figure out the reasonable target use case and requirements.

4 – Guangdong OPPO Mobile Telecom.

SL positioning is not only useful for V2X and public safety service but also for some commercial services (e.g., NCIS services in TR 22.842, ranging based services in TR 22.855). Thus, we support to specify sidelink positioning as an important new feature of Rel-18.

- Scenario: we support to include in-coverage, partial-coverage and out-of-coverage.

· Target: both absolute positioning and relative positioning should be considered.

· Radio link: Although both sidelink and Uu positioning can work, it is suggested to prioritize the work on sidelink-based solution first, before approaching hybrid solution (solution making use of measurements on both Uu and PC5 interface)

· Spectrum: It is suggested to prioritize the work on ITS-dedicated spectrum and licensed spectrum over unlicensed spectrum.

5 – Nokia Denmark

all three scenarios based on NW coverage (in coverage, out of coverage and partial coverage) can be considered.

6 – Beijing Xiaomi Mobile Software

For sidelink positioning/ranging, we think the following suggestions on use cases, spectrum, scenario, distributed antenna system and potential scope should be considered.

A unified solution is applicable for sidelink positioning and Ranging:

- Ranging: as defined in TS22.261, it is to acquire one component of 2D/3D coordinates, e.g. direction, angle;
- Sidelink positioning: acquire 2D/3D absolute/relative coordinates
- Both the term ranging and sidelink positioning are used.
- Solution should allow acquiring either the whole 2D/3D coordinates or only one component of 2D/3D coordinates, e.g. distance or angle.

Use Cases:

- R17 RAN level SI: FS_NR_pos_cov (TR38.845)
  - Focus on V2X and public safety use case.
  - KPIs include absolute/relative horizontal accuracy, vertical accuracy, confidence level, latency, etc.
- R18 SA1 SI/WI: Ranging based services (TR22.855/TS22.261)
  - Focus on commercial use cases and public safety
    - For commercial use cases, e.g. smart home, smart city, smart retailor, there are imperious demands from the market to support ranging. Although currently UWB is applied in smart phones like apple, xiaomi, it suffers from power consumption issue (rely on BLE for power management), cost of independent RF, and high interference from WiFi. 3GPP has the potential to overcome these drawbacks and develops more competitive technology for ranging.
  - KPIs include distance accuracy, direction accuracy, confidence level, latency, effective ranging distance, ranging interval, concurrent ranging operations, etc.

- Uniqueness of commercial use cases from V2X
  - Power consumption: IoT devices have more demanding battery requirement than V2X.
  - Low cost: IOT devices are very sensitive to cost
  - lSecurity and privacy: The position IoT devices may not link to user's location. sidelink positioning/ranging may be performed without security, e.g. broadcast mode.
  - Capacity: Unlike V2X and public safety, their might be a large number of IoT devices in an area, the positioning/ranging capacity in an area should be considered.

- Suggest: Commercial, V2X and public safety are considered.
- Suggest: power consumption and cost reduction for IOT device should be considered

spectrum

- For V2X, in areas like china, only 20MHz is available for ITS spectrum
- For commercial use case, it is much sensitive to the cost and is more tolerant to the reliability, unlicensed spectrum has more advantage than licensed spectrum
- To achive 10cm accuracy, hundreds of bandwidth is required, unlicensed spectrum has more advantage.
- Suggest: unlicensed spectrum is considered

Scenario:

- Sidelink based positioning and ranging: UE's position or distance/angle is estimated from the signal transmited on sidelink
  - Applicable for the scenario that Uu based solution is not available or accurate, e.g. indoor, out of coverage, NLOS.
- Sidelink assisted positioning and ranging: UE's position or distance/angle is estimated from signal transmitted on both Uu and sidelink
  - Applicable for the scenario that both Uu based and SL based solution are available but not accurate.
  - The scenario is limited.
  - The gain may be marginal.
- Suggest: Down prioritize the scenario of sidelink assisted positioning and ranging, no spec impact implementation is preferred

  Distributed Antenna System
- The antenna numbers, distribution pattern are diversed
- The antenna distribution can be any shape
- Due to the diversity in antenna pattern distribution, it is very hard to standardize the antenna distribution pattern. Solutions requires the antenna pattern info (e.g. number, distance interval, shape) on car is not applicable. Besides, reveal DAS information might not be acceptable for car vendor.
- Suggest: DAS is preferred to be supported without spec impact

Potential Scope:

- The objective of the sidelink positioning and ranging study includes the following objectives for commercial, V2X and public safety use cases, considering in-network coverage, out-of-network coverage, and partial network coverage:
  - Study requirements and corresponding evaluation scenarios/methodologies to enable sidelink positioning and ranging based on requirements defined in TS22.261 and in TR38.845 [RAN1]
  - Study and evaluate potential solutions for support of sidelink positioning and ranging based on the above identified requirements, evaluation scenarios/methodologies [RAN1/RAN2]
    - Bandwidth up to 400MHz are considered.
    - Both licensed band and unlicensed band(up to 71 GHz) are considered.
    - The solution should support power efficient SL positioning and ranging.
    - The solution should support one-hop SL positioning and ranging.

        - The solution should support Redcap UE, support high positioning/ranging signal bandwidth and small communication bandwidth.
        - The solution should support both network initiated and UE initiated SL positioning and Ranging.
        - The solutions should consider supporting control signalling sent over licensed band, and Ranging signal over unlicensed band.
    - Note: For sidelink assisted positioning, no specification impact is anticipated.
    - Note: For Distributed antenna system, no specification impact is anticipated.

7 – Qualcomm Incorporated

Suggested refinement for the "Sidelink Positioning / Ranging" example area:

- Design of Sidelink positioning reference signal (SL-PRS), measurements related to timing/angle-based positioning, and procedures, at least in relation to the use-cases & requirements studied in the TR 38.845, considering the following:
    - SL-PRS over either unlicensed or licensed, FR1 or FR2 spectrums
        - For V2X Positioning, control signaling (e.g., configuration information & reporting)
            - should be able to use same or different spectrum as the SL-PRS
            - should support LTE V2X and NR V2X
    - PC5-based positioning operation for Out-of-coverage & partial-coverage scenarios
    - Hybrid positioning operation (Uu & PC5-based measurements) for partial coverage & in-coverage scenarios
    - Positioning solutions should enable either a UE or the network to be the position calculation entity.
    - For V2X positioning, a UE can be installed in a vehicle, a road side unit, or a device of a vulnerable road user.

Motivation/Justification for the suggested refinement:

The above refinements are justified following the progress of the Rel-17 study item (TR 38.845) in relation at least to the use-cases & requirements appearing in this study.

- Why SL-PRS on unlicensed bands is a requirement for V2X Positioning?
    - Wideband signal (>40MHz) transmission is required for desired accuracy for timing-based methods. E.g., for V2V & V2P use cases, targeted 0.1 meters relative lateral accuracy, 0.5 meters relative longitudinal accuracy for V2X is challenging with limited ITS spectrum.
    - No such high BW licensed deployments exist, and therefore, unlicensed spectrum (e.g. UNII-3) is a natural choice for practical deployment
- Why should the Control Signaling support LTE V2X and NR V2X?
    - Allow deployment of V2X positioning without disrupting LTE V2X deployment
    - Deployment of V2X positioning without changing the low layer LTE V2X
- Is it a prerequisite to define SL communications over unlicensed before defining SL-PRS over unlicensed?
    - No. Control Signaling and SL-PRS can be sent over separate spectrum.

- The same Control Signaling information design can be used in-band if SL over unlicensed spectrum is adopted.

8 – Intel Corporation (UK) Ltd

For the first iteration, we think a high-level example area is sufficient. Maybe we can clarify that it is expected to be supported for InC and OOC scenarios. At the later stage, we assume more detailed objectives to be added, e.g.,:

- Definition of sidelink reference signals for sidelink positioning/ranging
- Introduction of sidelink measurements for sidelink positioning/ranging
- Procedures for transmission and reception of sidelink positioning reference signals
- Definition of signaling protocols and procedures for support of NR sidelink positioning/ranging including potential impact on NR positioning architecture
- Definition of positioning methods and location procedures including support of positioning reference units with sidelink air-interface and known antenna coordinates / system orientations

9 – LG Electronics Inc.

Sidelink positioning should be one of the most important improvement in positioning for Rel.18. Sidelink positioning complements a conventional Uu-link based positioning within the network coverage by providing a mean for positioning outside of the network coverage. There were lots of interests on sidelink positioning from industries including car manufacturers. In 5GAA, sidelink positioning was considered as the first priority candidate for positioning enhancement in RAN Rel.18 workshop. In 3GPP, RAN SI for positioning is targeting in-coverage, out-of-coverage and partial coverage scenario for Rel.18 positioning enhancement. From technical perspective, at least sidelink-based relative/absolute positioning and combined Uu-link and sidelink positioning needs to be studied in Rel.18.

10 – Huawei Tech.(UK) Co.. Ltd

We support normative work on SL positioning in coverage, in partial coverage and out of coverage in Rel-18. SL positioning can be used in coverage to assist NR RAT-dependent solutions, and SL positioning (alone) can be used for in-coverage, partial coverage, and out-of-coverage scenarios. Use case, scenarios and requirements are being studied at RAN-level and should form the basis for a RAN1-led study on solutions in Rel-18, followed by a WI within Rel-18.

11 – Samsung R&D Institute UK

We think that the meaning of ranging needs to be clarified further. Does the ranging have the same meaning or not with relative positioning in Rel-17 RAN study item? If not, does this mean that other use cases other than V2X and public safety can be considered in Rel-18?

In addition, it should be also carefully studied the sidelink positioning accuracy, latency requirement (over the air and/or end to end) for sidelink environment.

12 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility

It can be observed that the majority of interested companies and applicable verticals have shown the need for supporting absolute and relative positioning using SL. Therefore, from our perspective this is a high priority area for positioning to be considered for Rel-18. In addition, we have the following considerations:

- We would like to highlight that the potential study should aim to target as best as possible a uniform SL positioning framework that caters to the different use case requirements (as already documented in TS22.186, TS22.261, TR22.855 and TS22.104). Parallel use case and requirements analysis from RAN (TR38.845) and SA1 relating to ranging-based services should be considered as baseline input for the Rel-18 study.

-Furthermore, we would like to also note that the SL positioning aspect would require a separate ground up design study and therefore a shared study/work item with Redcap/LPHAP can potentially burden the overall shared Rel-18 study/work item.

-We also support sidelink positioning over ITS, licensed band and unlicensed bands, given that the limited ITS bandwidths for the V2X use case has an impact on achievable accuracy.

-We also view cooperative positioning techniques that utilise both Uu and SL interfaces to improve the overall UE location estimate as an important aspect and this could be perhaps considered as a sub-item under the broader Rel-18 SL positioning/ranging study.

13 – Spreadtrum Communications

Considering the study results of RAN plenary in the TR 38.845, sidelink positioning should safety the following requirements [TR 38.845]:

- Set 1 (Relatively lax requirement): 10 – 50 m with 68 – 95 % confidence level.

- Set 2 (Lane level accuracy): 1 – 3 m with 95 – 99 % confidence level.

- Set 3 (Below meter level accuracy): 0.1 – 0.5 m with 95 – 99 % confidence level.

- Apply for relative positioning and absolute positioning

- Considering in-coverage, partial-coverage and out-of-coverage scenarios.

Thus, the following objectives should be considered:

1. Define evaluation scenarios and assumptions for UE in in-coverage, partial coverage, and out-of – coverage

2. Study potential solutions of sidelink positioning, including positioning techniques (such as TDOA/AoA), positioning reference signals, measurements, signaling and procedures

14 – ZTE Corporation

Here is our suggestion below. Basically, we think it is better to strive for reusing Rel-16/17 sidelink signaling design. However, the current sidelink specification cannot support beam management in FR2 and unlicensed spectrum well (Rel-18 V2X may have the corresponding enhancement). So we propose to de-prioritize(or not support) sidelink positioning in FR2 and in unlicensed spectrum in Rel-18.

• Scenarios including V2X and public safety

• Positioning in out-of-coverage scenario: Network independent, GNSS is not reliable in some cases

• Positioning in in-coverage scenario: Complement to Uu positioning for better accuracy/low latency absolute positioning

• Positioning in partial-coverage scenario

• Motivation

• Low latency/high accuracy relative positioning for all scenarios

• Low latency/high accuracy absolute positioning for in-coverage and partial-coverage scenario

• Potential Further Study and Normative Work [RAN1, RAN2]

• A study phase is preferred to do evaluation for all scenarios

• Target to fulfill at least some of requirements captured in TR 38.845

• Support absolute positioning and relative positioning methods

• Solution to reduce positioning latency while maintain reliability

• Strive to reuse Rel-16/17 SL and positioning mechanism/procedure/physical signaling design

• FR1 is prioritized

• ITS and licensed spectrum is prioritized

15 – vivo Mobile Communication Co.

We think commercial use cases and related requirement based on SA1 input should be supported in addition to V2X and public safety use cases from TR38.845.

Besides, UE power consumption should be considered for all 3 use cases.

16 – VODAFONE Group Plc

In line with the 5GAA request in RWS-210360, we believe that all three scenarios based on NW coverage (in coverage, out of coverage and partial coverage) can be studied.

17 – Philips International B.V.

We propose to work on **Sidelink positioning/ranging** services to improve the (indoor and outdoor) location accuracy and tracking of victims, staff and devices, including **in-coverage, out-of-coverage and partial coverage situations**. This work on Sidelink positioning/ranging should consider **not only V2X and public safety** (TR 38.845) **but also commercial use cases** as defined in TR 22.855 by SA1. Furthermore, RAN should leverage the set of requirements and KPIs on ranging defined by SA1 in TS 22.261.

18 – CATT

Motivations

3GPP is currently working on the Study Item on "Scenarios and requirements of in-coverage, partial coverage, and out-of-coverage positioning use cases". As shown in TR 38.845, the V2X positioning requirements are defined based on TS 22.261 and TS 22.186. V2X positioning service should be provided in indoor, outdoor, tunnel areas. The UE velocity up to 250 km/h needs to be supported for outdoor and tunnel areas, inside the network coverage as well as when it is outside the network coverage. The requirements should be also fulfilled even when the GNSS-based positioning is not available. In addition, TR 38.845 has included the positioning requirements for public safety based on the positioning requirements for the "1st responders" use case in TS 22.261 with 1 m horizontal accuracy, e.g., 2 m (absolute) or 0.3 m (relative) vertical accuracy, 95 – 98 % positioning service availability. These requirements apply to both relative and absolute positioning.

Suggested SI/WI objectives

• Study and specify the positioning solutions to support the identified cases and positioning requirements within the considered in-network coverage, out-of-network coverage, and partial network coverage scenarios

• Study and specify new SL positioning reference signals for SL-based/assisted positioning for ITS, licensed and unlicensed bands in both FR1 and FR2 [RAN1]

• Study and specify new measurements, including timing, angle, and carrier phase measurements for SL-based/assisted positioning [RAN1]

- Study and specify the procedures and signaling support for SL-based/assisted positioning methods [RAN2, RAN3, RAN1]
- Study and specify the solutions for cooperative positioning for integrated SL and Uu interface positioning [RAN1, RAN2, RAN3]
- Define corresponding performance requirements and test cases [RAN4]

Note:Ranging can be revisited after the performance and solutions for SL based positioning are clear to see if additional aspects need to be specified.

19 – Ericsson LM

We consider sidelink positioning/ranging as a technology (or solution) while the focus of the discussion should be on addressing the positioning problem in public safety, V2X or any other use cases. Here, we believe that these use cases can be equally solved with Uu and any study or work item should not focus on a certain specific technology. The objectives should rather be on solving positioning problems in considered use cases.

20 – Sony Europe B.V.

Background

5GAA has identified the advanced C-V2X use cases and the corresponding positioning requirements.

On-going Rel-17 SI: Study on scenarios and requirements of in-coverage, partial coverage, and out-of-coverage NR positioning use cases (TR 38.845)

Proposed topics:

1. Specify technical solutions (particularly RAT dependent) to support relative and absolute positioning for V2X positioning according to the use-cases/requirements in TR 38.845.
2. Support these scenarios: in-coverage, partial coverage, and out-of-coverage.

Note: The V2X positioning solutions may be applied to Ranging Based Service (RBS). We consider RBS is not high priority in Rel-18.

21 – Fraunhofer IIS

We are supportive on including sidelink Positioning and Ranging in Release 18 while considering in the objectives the following:

- Support sidelink positioning for all coverage scenarios

- Study sidelink positioning in terms of relative positioning accuracy and absolute positioning enhancements in combination with RAT-dependent and RAT-independent positioning methods

22 – CEWiT

Sidelink positioning is one of the necessary and important enhancement for Rel 18.

It can be initiated with study item and followed by work item in Rel 18. Sidelink positioning study should include:

- Define the scenarios applicable and corresponding requirements
- Possible architecture for sidelink positioning

- Anchor UE selection and co-ordination procedures
- Evaluate the positioning accuracy using sidelink in in-coverage, partial coverage and out of coverage scenarios including relative and absolute accuracy and possible latency.
- Identify the positioning techniques used for the side link-based positioning (Uu link positioning methods will be baseline), sidelink positioning reference signals, signaling and procedures required to be enhanced

23 – MediaTek Inc.

1, 3 network coverage conditions are considered to support

2, The signal phase related measurement could be further investigated with SL related positioning

4.2 Moderator summary at end of Initial Round

Based on the responses received, I propose to refine the ”Sidelink positioning/ranging” example area to:

- Study/specify solutions (including reference signals, measurements, procedures, etc) for sidelink based positioning considering the following:
  - To include ranging (i.e. relative positioning) and absolute positioning
  - Coverage scenarios to cover: in-coverage, partial-coverage and out-of-coverage
  - Requirements: Based on requirements identified in TR38.845
  - Use cases: V2X and public safety
  - Spectrum: ITS and unlicensed

Note: Considerations above can be reviewed following completion of the RAN led SI]

Note that I said ’study/specify’ for now to avoid getting into debate about the detailed SI/WI structure. It is fairly clear to me that however the work is arrange this area will need to start with some study phase

Improved accuracy, integrity, and power efficiency

4.3 Intermediate Round

Please provide comments to the moderator’s updated description of the topic area.

In addition, please now also provide feedback on

- Leading WG and secondary WGs (for specific topic area)
- Identifying any potential impacts to SA/CT

Feedback Form 5: Sidelink positioning/ranging (Intermediate Round)

1 – Futurewei Technologies

We support the moderator's summary as it is also aligned with the findings from the RAN SI. RAN1 should be leading group to study/specify all the objectives as listed.

A note to highlight is on the inclusion of unlicensed operation in the scope.

Our understanding is that this would require some coordination with Sidelink enhancements since current Rel-17 do not yet support Sidelink in Unlicensed operations.

2 – InterDigital France R&D

We support the moderator's summary. RAN1 should lead the study and specification of solutions it includes positioning accuracy evaluation. RAN2 should be the secondary WG.

3 – CATT

We support the moderator's summary.

RAN1 should lead the work.

RAN2 and RAN3 should be the secondary WGs. RAN2 should study and decide procedure and signaling aspects. RAN3 should evaluate if there is architecture impact.

SA2 may have a SI for SL positioning, so coordination with SA2 is required.

4 – Apple France

We share similar view as Xiaomi about specific requirements for SL positioning on commercial usecases. Thus, in our view commercial use case shall also be considered under Rel-18 SL positioning/ranging, as well as V2X and public safety. In addition, we think all the objectives should be lead by RAN1, and RAN2 as secondary WG.

5 – Qualcomm Incorporated

Thanks for the efforts on progressing on this topic area. Four suggestions/clarifications from our side:

- A sidelink positioning control signaling design could enable operation over existing LTE V2X and NR V2X deployments and allow legacy V2X systems to benefit from the improved location accuracy sidelink positioning achieves. Such a design may be realizable without much extra impact, and we recommend 3GPP study a SL-Positioning control and signaling framework that is transferrable across LTE V2X or NR V2X.
    - **Suggestion**: Recommend adding an addition sub-bullet, "Control signaling design suitable for operation over LTE V2X and NR V2X."
- We would like to propose to not restrict explicitly to specific use-cases; the technical solutions that shall be specified tend to be agnostic on specific use-cases, and we prefer to keep it clear, that, even though, V2X and public Safety are the use-cases considered in the RAN study item, there are additional use cases considered in SA1 which could eventually benefit from a use-case-agnostic Sidelink Positioning technology.
    - Suggested modification:
        - **Requirements:**
            - **<u>For V2X and public safety, use</u> the requirements identified in TR38.845**

        - **For commercial, IIoT, use the requirements identified by SA1 (TS22.261, TS22.104)**
    - ~~o **Use cases: V2X, public safety**~~

- The first bullet seems to be limiting the discussion to only "sidelink based" positioning, and excluding sidelink & Uu solutions ("Hybrid solution" as used in Section 5.2 of TR38.845). At the same time, in-coverage scenarios are included in scope, in which case, using a hybrid approach would come very naturally and with possibly minimal specification impact.
    - **Suggestion**: Change the "sidelink based positioning", to "sidelink-based/assisted positioning", or to a generic term "sidelink positioning", with the understanding that further discussion could occur to clarify this aspect further, depending also on the progress of the ongoing RAN plenary.
- It will be useful to include a statement that the Position calculation entity could be either a UE or the network; for example, it should be evident that having the Position calculation entity at the network would be a non-starter for out-of-coverage positioning solutions scenarios. Even in the in-coverage scenarios, a UE could be the Position Calculation entity, as is the case for UE-based solutions in Uu Positioning.
    - **Suggestion**: Include a sub-bullet as follows: "Position Calculation Entity may either be a UE or the network."

Proposed Leading WG & Secondary Working Groups:

- Leading WG: RAN1
- Secondary Working Groups: RAN2, RAN4, RAN3

Potential impacts to SA/CT

- SA2 and CT WGs should be involved (e.g., for any architectural or upper layer protocol support)

6 – China Telecomunication Corp.

We think commercial use cases (e.g. smart home, smart city) could also be considered to overcome UE power consumption issues and make user experience better.

RAN1 can be the leading WG and RAN2/RAN3 can be the secondary WG.

7 – Guangdong OPPO Mobile Telecom.

We are supportive of moderator's summary except the unlicensed spectrum. For the Uu positioning, 3GPP haven't tried any dedicated work/optimization for unlicensed spectrum. For the work of SL positioning, it is preferred to keep a manageable scope and only focus on ITS and licensed spectrum.

We also prefer not to restrict the sidelink positining only to the two cases, with similar view as Xiaomi/Apple/QC

RAN1 should lead the work of SL positioning and RAN2/RAN4 can be the secondary WG.

8 – Beijing Xiaomi Mobile Software

We think it is important to include commercial use case. For commercial use cases, e.g. smart home, smart city, smart retailor, there are imperious demands from the market to support ranging. Smart phone companies like xiaomi and apple have already lauched hundreds of millions of smart phones supporting ranging. Its use cases are majorly for commercial use cases like smart home/smart city, etc. However, the

currently applied UWB technology in smart phones suffers from power consumption issue (rely on BLE for power management), cost of independent RF, and high interference from WiFi. 3GPP has the potential to overcome these drawbacks and develops more competitive technology for ranging.

And SA1 has already finished the SI/WI work for ranging commercial use cases with a lot of supporting companies, and corresponding requirements have been captured in TS22.261. Besides, as companies indicate, we should strive for a unified solution for all the use cases, including V2X, public safety and commercial use cases. There is no big solution differentiation in support these use cases. As such, we suggest that the commercial use case should also be included.

Besides, we think licensed spectrum should not be excluded at this stage.

9 – Spreadtrum Communications

Thanks for the efforts on progressing on this topic area.

For use cases, we share similar view as Xiaomi/Apple/QC/China Telecommunication. We prefer include the commercial use cases for sidelink positioning/ranging.

In addition, at this stage, we also think licensed spectrum should not be excluded.

And RAN1 should lead the work

RAN2, RAN3 and RAN4 should be the secondary WGs

10 – CATT

One more comment: we also think commercial use case is important which can be involved in SL positioning/Ranging.

11 – ZTE Corporation

We think working groups should be [RAN1, RAN2, RAN3]

For use cases, we think other commercial use case identified by SA1 should also be considered. So we suggest

For spectrum, we think ITS and licensed spectrum should be included, and further study for unlicensed spectrum is needed. The reason is, Rel-17 spec does not support sidelink communication in unlicensed bands, and the potential enhancement may be included in Rel-18 V2X SID/WID. It is clear that sidelink positioning in unlicensed bands should be based on some basic design on regular V2X in unlicensed bands which is not specified yet, e.g. how to implement sensing for SL channel in unlicensed bands, etc.. Therefore, we suggest not to include or at least deprioritize unlicensed spectrum in Rel-18. Otherwise, there will be severe collision between two topics.

- Spectrum: at least include ITS and licensed

12 – Fraunhofer IIS

We share views with a couple of comments raised by the companies above:

- Consider V2X, public safety and commercial use cases
- SL-assisted positioning is an important aspect for absolute positioning enhancement. We agree to Qualcomm's suggestion to include replace "sidelink based positioning" by "sidelink based/assisted positioning"

Leading WG: RAN1 and secondary WGs: RAN2, [RAN3,RAN4]

Potential impacts to SA2

13 – Samsung R&D Institute UK

Thank you for the summary.

Currently, only RAN1 centric issues are captured (e.g., solutions including reference signals, measurements, procedures, etc.) in our understanding. However, we need to study/specify sidelink positioning protocol and architecture including the entity of sidelink positioning configuration, location estimate, and the information to be transferred/exchanged via positioning protocol. Therefore, other WGs such as RAN2/RAN3/SA need to be involved for this.

In addition, we think that 'unlicensed' spectrum should be excluded since we do not support sidelink unlicensed operation yet.

14 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility

Generally fine with the Moderator's proposals. On requirements, given that there seems to be company interest and the requirements have been already specified, we would also like to see support for the ranging-based service use cases highlighted in TS22.261. In addition, we also see benefits in supporting the IIoT use cases such as tool assignment and tracking (TS22.104), which require relative positioning support. On spectrum, we would also like to consider SL positioning over licensed bands, which can benefit from larger bandwidths in FR1 and FR2 for higher accuracy.

Overall, we think that RAN1 can be the leading WG for this area, while RAN2, RAN3, RAN4 can be involved as secondary WGs. We also see potential involvement from SA2 and CT WGs.

General high-level specific topic areas for SL Positioning and potential responsible WGs can include:

- Design of Sidelink reference signals for sidelink positioning/ranging [RAN1]
- Signalling support and procedures for transmission and reception of sidelink positioning reference signals [RAN1, RAN2]
- Support for SL Positioning methods including timing-based and angular-based techniques for network-based and UE-based SL positioning [RAN1, RAN2]
- SL Positioning Measurements definition and requirements [RAN1, RAN4]
  -Define corresponding performance requirements and test cases [RAN4]
- Signalling and Procedures for cooperative positioning using Uu and PC5 interfaces [RAN2, RAN1, RAN3]
- Enhancements to SL Positioning/ranging reference Architecture [SA2]

15 – LG Electronics Inc.

We support the Moderator summary except the use case and the spectrum issue. We note that Rel-17 sidelink WID covers all of V2X, the public safety and the commercial use cases, and we have a concern on dropping the commercial use cases in this discussion without clear justification. As far as a common solution can be applied to them, we would like to keep all three use cases.

On the spectrum issue, SL positioning using the unlicensed spectrum requires a huge amount of development/specification effort at first ground without any base. We prefer to exclude the unlicensed spectrum

in Rel.18, and discuss the issue after Uu-link positioning and SL enhancement using the unlicensed spectrum are specified. Instead, we support to include the licensed spectrum for SL positioning in order to be aligned with the sidelink design principle of supporting both ITS-dedicated and the licensed spectrum: For example, Rel-16 sidelink already supports SL operation in a licensed band (i.e., n38 band is defined to be used for Rel.16 SL, and n79 & n14 are under discussion for Rel.17 SL). The use of the licensed spectrum for V2X usage is also explicitly mentioned together with the other two spectrum possibilities in TR 38.845 (Section 5.5) for RAN positioning SI.

Regarding the additional questions, we think RAN1 should be a leading WG and RAN2 be a secondary WG. Potential impact on SA/CT can be further discussed during the SI phase.

16 – China Mobile E-Commerce Co.

We are generally supportive of the objectives, except for two aspects:

- spectrum, we think that it should be first focused on **the licensed and ITS spectrum**;
- use cases, we understand there are some market needs of supporting sidelink positioning for commercial use cases, we think that the extension to commercial use cases/requirements can be considered if time/workload permits.

17 – CEWiT

We are supportive of Moderator summary with additional points as below:

Study on sidelink positioning should include commercial and IIoT usecases too along with V2X and public safety usecases. Rather study should not be restrictive to any specific usecase and include all SA1 use cases.

We are supportive of using sidelink positoning as additional mean to improve the Uu link positioning in terms of accuracy and latency. Therefore, hybrid solutions using sidelink and Uu positioning should be added in objective of study.

We expect some architectural changes for sidelink based positioning e.g. In out of coverage scenario, UE assisted positioning will be out of reach so there should be control entity (may be master UE / RSU) which will coordinating the signaling and final measurement of position of UEs. This requires coordination between RAN and at least SA2.

Leading WG: RAN1

Secondary WGs: RAN 2, RAN 3 and RAN4

Coordination between at least SA2 is necessary for possible architectural changes and impact on RAN work. RAN objectives should be revised based on SA2 inputs.

18 – Intel Corporation (UK) Ltd

Thanks a lot for proposed update of example area for sidelink positioning / ranging. We agree with proposed update and assume that some of the items can be further clarified/refined at a later stage (e.g., specific frequency bands/ranges for unlicensed spectrum or use cases such as I-IoT/commercial). The conclusions to be reached for the TR 38.845 can be also further considered.

Regarding the leading WG and secondary WGs, based on preliminary assessment of potential scope, we think that RAN1 should be a leading WG and RAN2 a secondary WG.

The potential impact on SA/CT may be dependent on proposed solutions for sidelink ranging and positioning, however some general aspects: privacy, authentication, security, authorization may need to be considered including positioning architecture, e.g., entities providing coordinate sharing / estimation.

19 – vivo Mobile Communication Co.

We have following two comments:

- The studied/specified solutions are agnostic to scenarios, i.e., the solutions would also be applicable for commercial scenarios. Thus it may not be necessary to explicitly preclude commercial scenarios;
- We don't have positioning over unlicensed, and we also don't have sidelink over unlicensed. It may not be appropriate to jump to sidelink positioning over unlicensed.

20 – DOCOMO Communications Lab.

Generally fine but two comments.

1. "sidelink based positioning"

There are multiple calculation categories. So "based" is not fine. "Sidelink positioning" is better.

2. "Spectrum: ITS and unlicensed"

NR-SL does not support unlicensed spectrum yet. ITS and licensed, which are supported in Rel-16/17 SL, should be focused on.

21 – SHARP Corporation

We support the moderator's summary

22 – Philips International B.V.

We strongly disagree with the rapporteur on two points

- Only including V2X and public safety. As raised by multiple companies (FristNet, Apple, Vivo, Qualcomm, OPPO, China Telecomunication) **commercial use case shall also be included**.
- The requirements and KPIs should not only be based on TR 38.845, but also the SA1 ranging use cases, requirements and KPIs as defined in **TR 22.855** have to be considered.

We think that RAN1 should be in the lead and RAN2 and RAN3 should be secondary groups.

23 – Sony Europe B.V.

We support the moderator summary. We agree that we should prioritize V2X and public safety use-cases as part of Rel-18. The proposed work-item may include reference signal design, new measurement, and procedure. Hence, it should be led by RAN1 (RAN2 as secondary WG).

24 – Ericsson LM

We propose changes to modify the moderator's proposal to be based on use-cases rather than on specific technical solutions:

- Study solutions for V2X and public safety based on the corresponding SA1 requirements, considering the following
    - To include ranging (i.e. relative positioning) and absolute positioning

- Coverage scenarios to cover: in-coverage, partial-coverage and out-of-coverage scenarios where GNSS isn't available
- Requirements: Based on requirements identified in TR38.845

We propose RAN1 as leading WG and RAN2 as secondary WG.

25 – Huawei Tech.(UK) Co.. Ltd

We wonder why licensed spectrum is excluded, but unlicensed spectrum is included. There is no proposal to delist licensed spectrum, but we observed some concern for unlicensed spectrum.

Also we agree with Futurewei, that sidelink positioning on unlicensed spectrum requires some coordination with Rel-18 sidelink enhancements.

We are concerned at the inclusion of ranging. It is not the same as sidelink positioning, and has different requirements and different error sources that can quite possibly lead to different designs. The RAN SI in Rel-17 has not considered ranging, so we suggest the Rel-18 SI/WI should follow that path.

4.4 Moderator summary at end of intermediate round

Based on the responses received, I propose to refined the topic area as follows (unfortunately not possible to show revision marks in NWM):

- Study/specify solutions (including reference signals, measurements, procedures, etc) for sidelink positioning considering the following: [RAN1, RAN2]
  - To include ranging (i.e. relative positioning) and absolute positioning
  - Coverage scenarios to cover: in-coverage, partial-coverage and out-of-coverage
  - Requirements: Based on requirements identified in TR38.845 and TR22.261
  - Use cases: V2X (TR38.845), public safety (TR38.845), commercial (TR22.261)
  - Spectrum: ITS, licensed and unlicensed
  - Coordination with SA2 as required (e.g. architecture aspects)

Some comments from the moderator about the updates:

- I have just added [RAN1, RAN2] to the top level bullet. It seems clear that a large part will be RAN1 and should lead this work, and some aspects (measurements, procedures, etc) will involve RAN2. RAN3/4 may be impacted at a later stage but I suggest to leave them out for now until their impacts become more clear.
- Regarding spectrum, I had previously included unlicensed based on the justification given by some companies that this spectrum can provide wide bandwidths that may not be available in either licensed or ITS spectrum. A number of companies proposed to include licensed and expressed concerns with unlicensed. To address this I have added licensed to the list but I have not removed the unlicensed due to the justification mentioned above. Furthermore, I think it would be useful to understand what spectrum is anticipated to be used for the commercial use cases, given that operators may have reservations about their spectrum being used by UEs for these use cases.

- Regarding use cases, clearly the functionality that is specified could be used for any use case, not just those mentioned here. The main point to conclude here is which use cases we consider during the design phase. However, as there seems to be very wide interest to address the commercial use cases identified in SA1, I have added them to the list.
- I removed the 'based' from the 'sidelink based positioning'. The intention here is to avoid the interpretation that the position calculation has to be solely based on sidelink measurements - i.e. to allow position calculation based on sidelink and other measurements.

4.5 Final Round

Please provide comments to the moderator's updated description of the topic area.

Feedback Form 6: Sidelink positioning/ranging (Final Round)

1 – InterDigital France R&D

Thank you very much for the summary. We support the moderator's proposal.

2 – CATT

We support the moderator's summary.

3 – vivo Mobile Communication Co.

For sidelink over unlicensed, our preference is to study positioning over unlicensed first, including both FR1 and above 52.6GHz. If this is common understanding, we would be fine to add this bullet.

4 – Intel Corporation (UK) Ltd

Thanks a lot for revised summary on sidelink positioning/ranging. We support the proposed summary. One addition, that may be further considered if there are no concerns from other companies, is position calculation entity, i.e., support of network-based and UE-based solutions utilizing sidelink measurements for UE positioning as per TR 38.845.

5 – Apple France

We support the moderator's proposal.

6 – TOYOTA Info Technology Center

We support the moderator's proposal.

7 – Qualcomm Incorporated

Thanks for the continued discussion and efforts progressing forward in this topic area.

We support the moderator's proposal with the following additional note/clarification to be added:

- In addition to V2X, Public Safety and commercial use cases, there is also a lot of interest in IIoT use cases, and IIoT requirements have been captured in TS22.104. Based on this, we propose adding IIoT to the sub-bullets on Requirements and Use cases.

We also wish to highlight several points regarding unlicensed band spectrum for sidelink positioning, and why it is essential to be kept in scope for V2X Positioning:

- Unlicensed spectrum would be used principally for transmission of SL-PRS.
- Control signaling (besides SL-PRS) can be sent over ITS or licensed band and need not be sent in unlicensed spectrum.
- As pointed out in the prior rounds, to achieve the positioning accuracy necessary to meet the TR requirements, SL-PRS will require bandwidth beyond what may be available in ITS and licensed bands. 3GPP has to define a solution that is deployable, and thus needs to consider the support of unlicensed bands.

  With the above, we emphasize again our continued preference to keep the unlicensed spectrum in scope as has been suggested by the moderator.

8 – Beijing Xiaomi Mobile Software

We support the moderator's summary.

9 – ZTE Corporation

We still have concern on SL positioning on unlicensed spectrum which should be based on regular SL signaling/sensing/procedure in unlicensed spectrum. However, this regular SL signaling/sensing/procedure in unlicensed spectrum is not specified yet, and will be discussed in Rel-18 V2X agenda. We prefer to focus on ITS and licensed band for SL positioning in Rel-18. And further discuss SL positioning in unlicensed band in Rel-19 which can follow the basic design of Rel-18 outcome of regular SL in unlicensed bands.

Hence, we suggest removing unlicensed spectrum or deprioritize it.

10 – MediaTek Inc.

We are okay for the proposal

11 – Samsung R&D Institute UK

Thank you for the summary.

We have two comments about commercial use case and unlicensed spectrum.

At first, we agree that the technical solutions need to be agnostic on specific use-cases. However, we do not need to develop positioning solutions for all use-cases. If we performs sidelink positioning evaluation work based on target scenario and requirements identified in TR 38.854 and then specifies sidelink positioning solutions, it can be applied other use cases also if available. If we include commercial use cases, it will increase the burden for evaluation work. Moreover, if we consider different target requirements for the commercial use case, it may increase specification work to do since depending on the target requirements, the solution can be different. In this regard, we prefer the original version as:

o Requirements: Based on requirements identified in TR38.845

Secondly, despite justification of wide bandwidths, sidelink unlicensed operation was not specified yet and we cannot assume simply that current NR sidelink can operate in unlicensed band since we may need to change many things to satisfying regulation for unlicensed spectrum. In addition, another concern for applying unlicensed is that the LBT operation and collision nature of unlicensed band operation could seriously impact the positioning signaling (e.g., reference signal, measurement, report etc) transmission and reception, so it could influence the accuracy and also the latency which should be important for some

sidelink use cases. Thus, we think it's natural to take step by step, we need to figure out more on the necessity of sidelink positioning before we introduce the unlicensed because it can provide larger bandwidth. For example, if licensed band can already provide qualified positioning accuracy and latency, the urgency for unlicensed may not be that much.

12 – Guangdong OPPO Mobile Telecom.

We are generally fine with proposal except the unlicensed spectrum. For the Uu positioning, 3GPP haven't tried any dedicated work/optimization for unlicensed spectrum. Moreover, 3GPP don't have SL for the unlicensed spectrum. It is premature to support SL positioning and unlicensed spectrum together for this stage. Moreover, the scope (if unlicensed spectrum is included) is too large and we don't think it can be done within a release. Thus, we prefer to remove unlicensed spectrum to keep a manageable scope

13 – Huawei Tech.(UK) Co.. Ltd

Regarding the moderator's proposal, we should emphasize again that "ranging" is not mentioned or defined (in terms of positioning) in TS 22.261 or in TR 38.845. According to 22.855, ranging may consist of only determining one component (i.e. distance), while relative positioning is more general (i.e. as defined in 22.261). We understand that some companies want to mention ranging, but it is incorrect to have relative positioning as an example of ranging, when it is actually the other way around. Therefore we suggest modifying the bullet as:

* To include **relative positioning** and absolute positioning

Note: Ranging can be supported using relative positioning

Without this correction, the moderator's summary is not acceptable to us and we would be fine simply having this entire discussion in RAN plenary as part of the conclusion of the RAN-level SI.

On this last point, we think that the note proposed earlier by the moderator should be reinstated:

- Note: considerations above shall be reviewed following completion of the RAN led SI

Regarding unlicensed sidelink based positioning, we would simply like to note that this has dependency on general support for unlicensed band for sidelink, thus this dependency should be noted as part of the final summary.

Note also that 22.261 is a TS not a TR.

14 – LG Electronics Inc.

We support the moderator's proposal except including the unlicensed band. Though moderator commented that the use of the unlicensed spectrum is justified by a benefit of a wide bandwidth that may not be available in either licensed or ITS spectrum, we share the concerns shown by many companies on the inclusion of the unlicensed spectrum for Rel.18 positioning. Let us add some technical issues on why it's too early to include the unlicensed spectrum for positioning in Rel.18.

- The claimed benefit of a wide bandwidth is also possible in the licensed spectrum. Please note that NR support up to 400MHz spectrum for bandwidth part.

- The cons of using the unlicensed band for positioning is that the channel access for transmission of a positioning reference signal is highly restrictive. The transmission opportunity is not guaranteed due

to other devices operating in the unlicensed spectrum. This certainly has an impact on the latency of the positioning service, which is a critical issue especially in V2X basic safety for collision avoidance or the public safety use cases. We need more time to have better knowledge on this aspect

- As many companies commented, we have no base as a ground to develop the positioning on the unlicensed band. NR V2X or Uu link positioning on the unlicensed band would greatly help to develop the positioning on the unlicensed band. Otherwise, the standardization effort will be significant to handle with in Rel.18.

With the reasons above and the concerns from many companies, we suggest to remove the unlicensed spectrum and consider this issue in a later release.

15 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility :

We are supportive of the Moderator's revised description for the SL positioning/ranging area. One editorial suggestion is that "TR22.261" should be corrected to "TS22.261". Additionally, we also share the view that IIoT use cases in TS 22.104 should also be captured as enabling use cases for SL positioning/ranging.

16 – DOCOMO Communications Lab.

We still have concern on unlicensed spectrum. Current SL does not support the spectrum. If this is included, so large scope is assumed. Unlicensed spectrum should be considered for SL pos after completing SL-U.

17 – Philips International B.V.

We support the moderator's proposal. By the way 22.261 is a TS not a TR.

18 – Ericsson LM

We propose changes to modify the moderator's proposal to be based on use-cases rather than on specific technical solutions:

- Study/specify solutions (including reference signals, measurements, procedures, etc) for ~~sidelink~~ positioning considering the following: [RAN1, RAN2]
- To include ranging (i.e. relative positioning) and absolute positioning
- Alternative solutions based on Uu and/or PC5 etc
- Coverage scenarios to cover: in-coverage, partial-coverage and out-of-coverage scenarios where GNSS isn't available
- Requirements: Based on requirements identified in TR38.845 and TR22.261
- Use cases: V2X (TR38.845), public safety (TR38.845), commercial (TR22.261)
- Spectrum: ITS, licensed and unlicensed
- Coordination with SA2 as required (e.g. architecture aspects)

19 – CEWiT

We are okay with moderator summary.

20 – Fraunhofer IIS

We support the moderator's summary.

21 – VODAFONE Group Plc

Generally we agree, however as stated by other companies, we also have concerns oner the use of unlicensed bands, and this required further study and consideration.

22 – Sony Europe B.V.

We, in principle, support the moderator's proposed summary. However, it seems the scope is too wide considering this is for the first time, we introduce sidelink positioning. We may have down-scoping later. We prefer to prioritize licensed spectrum over unlicensed spectrum for sidelink positioning.

4.6 Moderator's summary at end of final round

Comments from the moderator relating to the final round discussion

- Several companies maintain concern about the inclusion of unlicensed spectrum and as a consequence this has been removed from the summary.
- There remains some disagreement about the use cases to be considered with some companies preferring to narrow the use cases and others preferring to expand them. There is understandable concern that the work will become unmanageable if there are too many use cases to be considered. My proposal is that we list all potential uses cases and then include a note that says "Note: The next phase of discussion will include selection of use cases to be used for evaluation and design. This does not restrict use of the solutions for other use cases." I hope this can keep everyone happy for now and we will continue this aspect over the next few months.
- There was a comment to remove the word 'ranging'. In my view ranging and relative positioning referred to the same thing. As only only company commented on this I have not removed the term.
- There was a comment to remove any reference to sidelink. 'sidelink positioning/ranging' was the topic area endorsed at the WS and for most companies sidelink was the focus of discussion throughout the whole week and so as only one company commented on this I have not removed the term.
- The notes to the RAN chair are not intended to be part of the agreed summary but assistance to Wanshi when he reviews the conclusions.

Based on these comment my summary is as follows:

- Study/specify solutions (including reference signals, measurements, procedures, etc) for sidelink positioning considering the following: [RAN1, RAN2]
  - To include ranging (i.e. relative positioning) and absolute positioning
  - Coverage scenarios to cover: in-coverage, partial-coverage and out-of-coverage
  - Requirements: Based on requirements identified in TR38.845 and TS22.261 and TS22.104
  - Use cases: V2X (TR38.845), public safety (TR38.845), commercial (TS22.261), IIOT (TS22.104)
    - Note: The next phase of discussion will include selection of use cases to be used for evaluation and design. This does not restrict use of the solutions for other use cases.
  - Spectrum: ITS, licensed
  - Coordination with SA2 as required (e.g. architecture aspects)

- Notes from the moderator to RAN chair on possible controversial aspects:
  - 1 company wanted to remove the word ranging
  - 1 company wanted to remove mention of sidelink
  - Controversial whether or not to consider unlicensed spectrum

5 Improved accuracy, integrity, and power efficiency

5.1 Initial Round comments

Companies are invited to provide comments and suggestions for refinement to the example area of ”Improved accuracy, integrity, and power efficiency”, along with motivation/justification for any refinement.

Feedback Form 7: Improved accuracy, integrity, and power efficiency (Initial Round)

1 – Ericsson LM

For integrity, we see the following objectives:

- Identify positioning integrity KPIs and relevant use cases.
- Identify the error sources, threat models, occurrence rates and failure modes requiring positioning integrity validation and reporting.
- Study methodologies for network-assisted and UE-assisted integrity.

On improved accuracy and latency, we already see now that the objectives that were added late to Release-17 work item likely need to continue in Release-18. These include:

- Timing error: ‘NW control of UE TX TEG for UL SRS TX’ and ‘TX TEG sweeping of UL SRS’
- latency reduction (further enhancements to gapless measurement)
- NLOS/LOS measurement reporting enhancements (path information enhancements)
- latency enhancements with support of 1-symbol PRS

2 – InterDigital France R&D

Justification :

- During Rel. 17, multipath and timing error have been identified as factors which degrade performance
- Integrity is supported for RAT independent positioning techniques
- Rel. 17 focused on IIoT scenarios

Topics to be investigated :

- Identify KPIs and support a mechanism to enable integrity for RAT dependent positioning techniques
- Evaluate positioning accuracy and latency during mobility and handover

- Evaluate positioning accuracy and latency using frequency bands above 52.6GHz and unlicensed bands for enhanced positioning performance in IIoT scenarios

3 – Apple France

On positioning accuracy, the techniques were mainly discussed in R17 SI, where the feasibility and requirements to achieve such enhancements need RAN4's input. On positioning integrity, in general, it is more of a system reliability issue rather than the communication issue. GNSS integrity was considered to be ported in 3GPP R17 only after it has been adopted among GNSS community. For RAT-dependent positioning methods, we would like to wait to see if there is any clear business need relate to positioning integrity before letting 3GPP to extend integrity work into non-GNSS methods.

On power efficiency, it has been greatly improved by support of positioning in RRC_INACTIVE state in R17. If there are any left-over for R17 work on this aspect, R18 can attempt to complete them. But given that significant work needed to support RAT-independent positioning in RRC_IDLE, we think support IDLE positioning should be a low priority objective.

Thus, in our view, improved accuracy, integrity and power efficiency should be deprioritized from Rel-18 positioning

4 – China Mobile E-Commerce Co.

According to the feedback from the automotive industry market, the following requirement is observed under the NLOS dominant scenario:

- Accuracy for **NLOS indoor scenario**: **0.1m(Horizontal)@90%, 0.5m(Horizontal)@99.99%**
- Battery life: **1 year**

In Rel-17, information reporting to mitigate multipath is under investigation. However, there is still a gap between the achieved performance in Rel-17 and the requirement from the customer. In Rel-18, the accuracy and power efficiency under NLOS cases should be further enhanced.

In addition, in Rel-17, the objective on integrity of RAT-dependent positioning was down-scoped. We think that the integrity is **one of the most important metrics** to ensure the reliability of a positioning system, and it shall be defined for RAT-depended techniques in Rel-18 phase.

5 – Guangdong OPPO Mobile Telecom.

SA1 identified several use cases for low power high accuracy positioning (LPHAP) . From UE perspective, power consumption is a key aspect for further enhancement. Thus, we propose to study and specify lower power mechanism for positioning.

We believe the integrity part can be further evolved in R18: 1) In R17, the integrity for RAT-independent positioning approach has been agreed to be introduced. For the next release, it is a reasonable evolution to consider to introduce integrity evaluation for the RAT-dependent positioning approach. 2) The Integrity of the sidelink positioning could be further studied, especially identification of feared events and signalling procedure of delivery integrity KPI and results for sidelink positioning are required.

6 – Nokia Denmark

Enhanced accuracy:

- carrier-phase positioning
- PRS/SRS bandwidth aggregation

7 – Qualcomm Incorporated

Suggested refinement for the "Improved accuracy, integrity, and power efficiency" example area:

- Enhancements for enabling increased bandwidth using licensed and unlicensed spectrum for positioning measurements.
  - Support Aggregation of DL PRS resources and aggregation of SRS for positioning resources at least in the intra-band scenario (contiguous & non-contiguous intra-band).

Motivation/Justification for the suggested refinement:

- In order to be competitive in scenarios where NR-based positioning and UWB/WiFi may have to compete, Rel-18 should support PRS/SRS Bandwidth Aggregation
  - WiFi/UWB offers competitive positioning performance exploiting its large system bandwidth.
  - WiFi 6 can utilize up to 160MHz BW and it is expected that WiFi 7 will increase the supported BW to 320MHz.
  - Commercially available UWB based positioning utilizes at least 500MHz BW and higher in some scenarios.
- Performance Benefits in accuracy were studied, identified and captured in the NR Rel-17 Study Item Conclusions (TR 38.857)

8 – Intel Corporation (UK) Ltd

Improved accuracy

In our view to further improve accuracy at least the following work directions should be considered for NR Positioning in R18

- Aggregation of DL PRS transmissions from multiple frequency layers by UEs as well as joint processing SRS for positioning transmissions by gNBs are promising work directions for R18 scope
- Potential leftovers from the R17 design related to support of phase measurements for the first arrival and additional paths
- Further enhancements related to support of positioning reference units to facilitate NR positioning accuracy enhancements
- NR positioning support in unlicensed spectrum

Integrity

Identify error sources and integrity metrics suitable for RAT dependent positioning solutions including Uu and PC5 air-interfaces to support reliable positioning

Power efficiency

Further evolution of NR positioning support by RRC_INACTIVE / RRC_IDLE UEs

9 – Huawei Tech.(UK) Co.. Ltd

Power efficiency while maintaining high accuracy should be the focus for positioning enhancements in Rel-18. Use cases and requirements of LPHAP (low power high accuracy positioning) are captured by SA1 in TS 22.104. RAN should target specific requirements rather than working on positioning enhancements without a target. We propose targeting use case 6 ("Flexible modulare assembly area: Tracking of

workpiece (in- and outdoor) in assembly area and warehouse"), for which extracted requirements are 1 year battery life with 50 cm@90% accuracy and 15-second positioning interval. The requirements for use case 6 are stringent enough that it covers a few other use cases as well. There is clear commercial demand for devices reaching these requirements, which cannot be achieved by NR UEs based on Rel-15/16/17 specifications. A study would be needed to determine the power consumption model allowing to evaluate achievable battery life with positioning, and to study the technical solutions for achieving such low power state.

We should note that pursuing such LPHAP requirements under RedCap enhancements may not be possible because the RedCap UE bandwidth of 20 MHz does not allow reaching 50 cm@90% positioning accuracy. However, if some relaxation of the bandwidth definition is agreeable for Rel-18 RedCap UEs, i.e. 20 MHz bandwidth for control/communication and 100 MHz bandwidth for positioning, then solutions for LPHAP could also be discussed for RedCap UEs. Otherwise, work on LPHAP should be kept separate from RedCap.

In addition to LPHAP, PRS and SRS with intra-band carrier aggregation should be prioritized over all the leftovers from Rel-17. RAN1 already conducted evaluation, and the remaining work is on RAN4 to check the feasibility. Therefore, RAN4 should look into this in Rel-18, and if feasible, simultaneous transmission and reception of PRS/SRS from one or more intra-band continuous CCs should be specified in Rel-18 by RAN1/2/3/4.

10 – Samsung R&D Institute UK

During the discussion, it might be better to clarify the target of the improved accuracy is to increase the accuracy to a new level on top of R17 ePos or dealing with leftovers from R17. Regarding the integrity, it seems the necessity and the responsible working group of it should be discussed first. We do see some motivation for power efficiency aspect for positioning, however, due to lack of study and evaluation of the power consumption, we suspect how to quick identify the target and use scenarios.

11 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility :

Although this area of positioning has garnered a lot of company interest during the Rel-18 WS, we generally view these aspects as Rel-17 carryovers and therefore should be carefully weighed in terms of the time (TUs) and workload available in Rel-18 against the other expanded areas of positioning being discussed in this thread (SL Positioning and RedCap/LPHAP). However, we also acknowledge that other aspects such as multi-carrier positioning (PFL aggregation) and AI/ML for positioning has also been considered by companies under this area and may further improve the positioning accuracy and therefore the scope of such work needs to be further discussed. Integrity for RAT-dependent positioning methods had been briefly discussed in Rel-17 but due to lack of time, this feature has not been pursued and we understand that it can also be reasonably included under this area. On the power efficiency aspect, we view that such enhancements can be further considered under the SL Positioning/Redcap/LPHAP positioning areas.

12 – MediaTek Inc.

Accuracy-wise:

1, Study phase related measurement, such as carrier phase, phase difference between antennas

2, To identify LOS/NLOS, study other approaches, such as polarization. Not just report more paths and corresponding path power

13 – Spreadtrum Communications

In Rel-17, positioning integrity is supported only for A-GNSS positioning methods. In order to improve the positioning performance, we should extend positioning integrity for more positioning methods, thus the following enhancements should be considered:

1. Study and identify whether the new requirements are needed
2. Identify new feared events for new positioning methods
3. Identify reusable signalling and procedures for Rel-17 defined integrity

On improved accuracy and power efficiency, we can consider the following potential enhancements:

1. Study multiple carrier aggregation for positioning reference transmission and reception
2. Further study RRC_INACTIVE/IDLE positioning

a) Study Rel-17 RRC_INACTIVE positioning leftover issues

b) Study methods, measurements, signalling and procedures to support in RRC_IDLE

14 – Beijing Xiaomi Mobile Software

For improved accuracy, we think the unlicensed positioning can be considered, which provides larger bandwidth for positioning.

15 – ZTE Corporation

Here is our suggestion for the three aspects respectively:

For accuracy improvement [RAN1, RAN4]

- Motivation
- Pursue higher positioning accuracy for UEs supporting multiple frequency layers or carriers
- Potential enhancements
- Multiple PFLs for DL PRS transmission & reception
- Multiple carriers aggregation for UL SRS transmission & reception

For integrity improvement [RAN2]

- Motivation
- Specify the positioning integrity for other positioning methods, e.g.
- RAT-dependent: DL-TDOA, UL-TDOA, DL-AoD, UL-AoA, multi-RTT
- Potential Further Study and Normative Work
- Strive to reuse procedures and signaling for Rel-17 defined integrity
- Study whether new requirements are needed
- Introduce new feared events for new involved positioning methods

For power efficiency improvement, what kind of enhancement is unclear so far. The potential enchantments suggested by companies in last workshop are trivial. We think it should be deprioritized or discussed together with Redcap positioning which also has the similar requirement.

16 – vivo Mobile Communication Co.

Suggested refinement for the "Improved accuracy, integrity, and power efficiency" example area:

For improved accuracy, positioning from 52.6GHz to 71GHz can be considered, including:

• Define evaluation scenarios, and evaluate the achievable positioning accuracy, latency based on the following deployment parameters for 52.6GHz to 71GHz

Ø large bandwidth (e.g. 1G/2GHz)

Ø large SCS (e.g. 240/480/960/1920kHz)

Ø large number of antennas (e.g. 256 antennas)

• Study and identify potential positioning techniques, positioning reference signals, signaling and procedures in licensed band (e.g. 66-71GHz) and unlicensed band (e.g. 60GHz)

For improved power efficiency, positioning with DRX and idle/inactive positioning enhancement can be considered.

Motivation for the suggested change for improved accuracy:

The frequency ranges above 52.6 GHz potentially contain larger spectrum allocations and larger bandwidths that are not available for bands lower than 52.6 GHz. The larger bandwidth (e.g. 2GHz) and larger antenna number (e.g.256 antennas) enable better positioning service for some commercial use cases with ultra-high (e.g. cm level) accuracy such as augmented reality (AR)/virtual reality (VR), IIoT, etc.

Motivation for the suggest change for improved power efficiency:

Based on current RAN4 conclusion, PRS measurement requirement is defined independent of DRX configuration, that is when the UE is configured with DRX, the UE also wakes up to measure PRS during the DRX inactive time. In our view, it will cause larger power consumption if the UE receives PRS regardless of DRX state. For example, in DRX mode, the UE is probably in deep sleep state and will need at least 20ms to wake up only for receiving 1 PRS occasion. The power consumption loss exceeds the benefit. From our contribution in Rel-17, it is observed that PRS limited within DRX can reduce power consumption by about 34% under certain configuration. Therefore, we believe positioning with DRX should be considered in Rel-18 to further improve UE power efficiency.

In addition, to support power efficient positioning in more scenarios, we are supportive to expand inactive state positioning to idle state.

17 – VODAFONE Group Plc

A focus on indoor positioning is preferred as GNSS already solves many outdoor situations.

18 – Philips International B.V.

We propose the improvement of ranging and positioning capabilities by means of **virtual anchors** based on reflected (positioning) signals. **Virtual anchor-based positioning** can lead to enhanced accuracy, and it can be studied together with **RIS**. Virtual anchor-based supported ranging will be useful to discern corner case ranging situations, e.g., differentiating whether two UEs are in range *in a same room*.

In addition, we would like RAN to work on **RAT dependent positioning integrity** i.e. study solutions necessary to support integrity and reliability of assistance data and position information for RAT dependent positioning methods. To make this happen **RAN1** would have to identify the error sources before **RAN2** can proceed with the specification work. Therefore, some TUs will be needed In both groups.

19 – CATT

1. NR Carrier phase positioning (CPP)

Motivations

Further enhancements of the positioning accuracy should be one of the main focuses in Rel-18 for supporting 5G stringent performance requirements in TS 22.261 and to make 3GPP NR positioning to be competitive to other positioning techniques (e.g., GNSS positioning). CPP has been used very successfully in GNSS for cm-level positioning (e.g., real-time kinematic (RTK), precise point positioning (PPP)). However, the technique is so far not supported in 3GPP RAT-dependent positioning. In our view, centimeter-level NR positioning based on carrier phase measurements can be supported based on existing Rel-16 NR DL PRS and UL SRS signals with a very small impact on the specification. In comparison with GNSS carrier-phase positioning, the implementation of the NR carrier phase positioning would have the following advantages:

- NR signal power is much stronger than GNSS signal power.
- Lower implementation complexity.
- Flexible configuration for the transmission of positioning reference signals.

One of the critical issues for carrier phase positioning is how to deal with the timing synchronization errors. The introduction of the positioning reference unit (PRU) in Rel-17 can be used to remove the impact of timing synchronization errors for NR carrier phase positioning, e.g., based on the double differential positioning techniques.

The key issues, which need to be investigated for NR Carrier phase positioning, may include: a) whether it is sufficient to reuse existing DL/UL positioning reference signals for supporting the NR carrier phase positioning, or to introduce new reference signals specific for carrier phase measurements; b) the methods for resolving potential challenging issues, such as the impact of network time/frequency synchronization errors, the integer ambiguity resolution, the cycle slip detection, the impacts from phase discontinuity in time-domain, etc.

Suggested SI/WI objectives

- Evaluation of carrier phase positioning performance together with existing time measurements for DL-TDOA, UL-TDOA and Multi-RTT [RAN1]
- Study and specify the methods for resolving potential challenging issues, such as the impact of network time/frequency synchronization errors, the integer ambiguity resolution, the cycle slip detection, the impacts from phase discontinuity in time-domain, etc.[RAN1, RAN4]
- Define the new carrier phase measurements based on existing or new reference signals [RAN1]
- Specify the procedures and the signaling support for carrier phase positioning [RAN2/RAN3]
- Define corresponding performance requirements and test cases [RAN4]

2. NR Carrier aggregation positioning (CAP)

Motivations

During Rel-17 ePOS SI, NR carrier aggregation positioning was investigated, but it was not included in Rel-17 WI due to the concern of the feasibility. For Rel-18, we support continuing the study of Rel-17 ePOS SI and further explore the applicability and feasibility of carrier aggregation for NR positioning under different application scenarios.

Suggested SI/WI objectives

· Study and specify carrier aggregation positioning over licensed and unlicensed spectrum in both FR1 and FR2

· Performance evaluation of carrier aggregation positioning [RAN1]

· The procedures and the signaling support for carrier aggregation positioning [RAN2/RAN3]

· Feasibility study of carrier aggregation positioning on the impact of timing alignment error, phase continuity, etc. [RAN4]

· Define corresponding performance requirements and test cases [RAN4]

3. Low power high accuracy positioning (LPHAP)

Motivations

Low power high accuracy positioning is identified as an integral part of a considerable number of industrial applications. The total energy needed for a specific operation time for such a low power high accuracy positioning optimized IoT-device is a combination of energy for positioning (varies depending on the used positioning method), energy for communication/synchronization, and a difficult to predict factor to take additional losses through e.g. security, power management, microcontroller, and self-discharge of batteries into account in TS 22.104. Examples of target applications for low power high accuracy positioning are asset tracking in process automation, tracking of vehicles, and tool tracking.

Suggested SI/WI objectives

· Study and specify the physical layer enhancements, including physical layer signalling, measurement, procedures, and the UE capability to support LPHAP [RAN1]

· Study and specify the protocols and messages to support LPHAP [RAN2/RAN3]

· Define corresponding performance requirements and test cases [RAN4]

4. RAT-dependent positioning integrity

Motivations

RAT-dependent positioning integrity was down-scoped from Rel-17 due to the concern of the work load in Rel-17.

Suggested SI/WI objectives

· Study the solutions necessary to support RAT-dependent integrity and reliability of assistance data and position information: [RAN2, RAN3, RAN1]

· Identify RAT-dependent positioning integrity KPIs and relevant use cases.

· Identify the error sources, threat models, occurrence rates and failure modes requiring RAT-dependent positioning integrity validation and reporting.

· Specify the signalling, and procedures to support RAT-dependent positioning integrity, including [RAN2, RAN3]:

· The assistance information that will be used to support integrity determination

· The information that will be used to provide the RAT-dependent positioning integrity KPIs and integrity results

· Support of integrity for UE-based and UE-assisted NR positioning.

· Define corresponding performance requirements and test cases [RAN4]

Note: RAT-dependent integrity should reuse RAT-independent integrity as much as possible to avoid duplicated work.

20 – CEWiT

We support further enhancement in accuracy and power saving in positioning for all usecase studied in Rel 16 and Rel 17. This can be achieved using PSR/SRS bandwidth aggregation, further enhancement in NLOS/LOS detection mechanism, positioning in unlicensed spectrum and support of RRC IDLE state for positioning.

21 – Sony Europe B.V.

In general, we need to address positioning techniques/enhancements listed in study item report TR 38.857 that have not been addressed in Rel-17.

Proposed topics:

1. In the on-going Rel-17 WI, there are some proposed techniques which may not be included as Rel-17 due to limitation of the remaining meetings left. For example:

- Timing error aspects on the operation of Positioning Reference Unit (PRU)
- Accuracy improvements
- Latency improvements

2. UE power consumption enhancements for positioning.

3. Support Integrity aspects for RAT dependent positioning methods. (Note: Rel-17 includes the integrity aspects for GNSS only).

22 – Fraunhofer IIS

Power efficiency

- Support high accuracy for ultra low power devices for the industrial positioning use cases identified by SA1.

Accuracy Enhancements

[under the assumption that MI/AL positioning accuracy enhancements are discussed in RAN93e-R18Prep-12]

- Support accuracy enhancement which are not part of the scope of Rel-17 WI, including
  - Signalling and beam management enhancements for improved accuracy in multipath environments and mobility scenarios
  - Support phase measurements and reporting for positioning

Integrity

- Identify signalling and reporting for RAT dependent techniques and enhancements for RAT-independent techniques

5.2 Moderator summary at end of Initial Round

Responses on this topic area are very varied and clearly it is not possible to work on the all the specific topics that are suggested. Based on the following I suggest that the following would be a small subset for which there is good support and justification.

- Specify solutions for Integrity for RAT dependent positioning techniques
- Specify solution for accuracy improvement based on PRS/SRS bandwidth aggregation

Regarding LPHAP, a number of companies have commented and to different parts of document. I understand it to be independent from the ”Improved accuracy, integrity, and power efficiency” example area and also from the ”Redcap positioning” example area and my proposal is to treat this separately and continue discussion in section 7 ’Other proposals’.

5.3 Intermediate Round

Please provide comments to the moderator’s updated description of the topic area.

In addition, please now also provide feedback on:

- Leading WG and secondary WGs (for the specific topic area)
- Identifying any potential impacts to SA/CT

Feedback Form 8: Improved accuracy, integrity, and power efficiency (Intermediate Round)

1 – Futurewei Technologies

We are supportive as well for both objectives. On the first objective on Integrity, RAN2 should be the leading while RAN1 should be the leading group on the second objective on Accuracy improvement based PRS/SRS aggregation.

2 – InterDigital France R&D

We support the moderator’s summary. RAN2 should lead the work for integrity as RAN2 has led work on

integrity for RAT independent positioning. RAN1 should lead the bandwidth aggregation for PRS/SRS as it may potentially involve accuracy enhancement. If necessary, RAN1 and RAN2 should jointly perform latency evaluation for bandwidth aggregation.

3 – Apple France

As mentioned within the initial round of discussion, in our view there is no strong justification to continue Rel-17 work in Rel-18. Given the existing open problems for R18 positioning, we propose to down-prioritize further Uu positioning enhancement in Rel-18.

4 – Qualcomm Incorporated

Thanks for the efforts on progressing on this topic area. We consider the PRS/SRS BW aggregation as the highest priority in the Uu-based Positioning enhancements topic area, so we are supportive of the 2nd bullet.

With regards to Integrity solutions for RAT-dependent methods, we have concerns on the following:

- It appears from the responses that some of the supporters are mainly interested in integrity with regards to UE-assisted or network-based positioning solutions. On the other hand, it is generally known, at least in GNSS positioning, that integrity considerations are mostly related to UE-based solutions. The usefulness of integrity enhancements for UE-assisted technologies is questionable.
- We are concerned that "integrity for RAT dependent positioning techniques" can be a generic term covering many non-overlapping areas for different companies, with a risk that the scope under consideration is then not clear enough.

5 – MediaTek Inc.

We are surprised that the signal phase measurement (carrier phase, phase difference between antennas, etc) is not listed. Instead, aggregation for PRS and aggregation for SRS is there.

Given that a certain number of companies consider signal phase measurement, we suggest to list it for further study

6 – Guangdong OPPO Mobile Telecom.

We support the first objective and RAN2 should be the leading WG.

Regarding the second objective: we do not think it should be included. The phase offset and time delay between different chain at both gNB and UE side does not enable aggregating PRS and SRS in different BW. There were throughout discussions in Rel-17. However, its feasibility was not justified. Nothing is changed so far. Thus, we don't think it should be in the scope.

7 – Huawei Tech.(UK) Co.. Ltd

We have concern on supporting RAT-dependent positioning integrity. Even in Rel-17 GNSS integrity discussion, the solution is not complete at all:

- There is no LMF-based integrity yet, and the current work relies on UE-based integrity calculation.
- For RAT-independent integrity, we do not have other RAT-independent methods, e.g. sensors, which we believe should be the key to the timely warning on the failure of a positioning system.
- We would like to understand the use case for RAT-dependent positioning method that would require positioning integrity.

Power efficiency was clearly listed as an example area, and our comments on LPHAP were provided under this target. We understand that comments on LPHAP will be collected under "other proposals" in this round (and we provide our detailed comments there), but we think LPHAP eventually belongs to UE power efficiency enhancements. Even in Rel-17 when positioning in RRC *IDLE/RRC*INACTIVE state was studied, there was no systematic UE power consumption evaluation for positioning, and we think that Rel-18 should be a good opportunity to look into this aspect.

So we suggest adding the following bullet:

- Evaluate the UE power consumption for positioning, and study solution to enhance UE power efficiency, targeting LPHAP.

8 – Beijing Xiaomi Mobile Software

We support both objectives and PRS/SRS bandwidth aggregation cab be led by RAN1, and integrity for RAT dependent positioning techniques can be led by RAN2. We think the unlicensed spectrum and carrier phase based positioning also should be included. The unlicensed spectrum can provide larger bandwidth to improve the positioning accuracy and carrier phase based positoning can improve the postioning accuracy without larger bandwidth.

9 – Spreadtrum Communications

We support the moderator's summary. And On the first objective on integrity, RAN2 should be the leading. RAN1 should lead the second objective.

10 – China Mobile E-Commerce Co.

First, we are supportive of the two objectives.

Second, we would like to once again emphasize the requirement we collected from the automotive industry, where a cm-level accuracy under NLOS scenarios is required. The enhancement on NLOS mitigation is under discussion in Rel-17, however, there is still a big gap between what we could achieve in Rel-17 and what are expected from the market.

Additionally, we believe that the LPHAP is a typical example of improved accuracy and power efficiency, and therefore we propose to just add an objective of LPHAP under this topic.

11 – ZTE Corporation

We support Moderator's assessment/proposals.

For the first bullet on integrity issue, we think working group should be [RAN2, RAN1]

For the second bullet on bandwidth aggregation, we think working group should be [RAN1, RAN4, RAN2]

12 – Samsung R&D Institute UK

For the leading WG, we think the intergrity should be leaded by RAN2 while accuracy improvement is leading by RAN1.

In addition, we think it is worth to study the power efficiency aspects in RAT-based positioning based methods, as commented by other company, this areas were triggered by vertical services and market driven.

- Specify solutions for Integrity for RAT dependent positioning techniques [RAN2]
- Specify solution for accuracy improvement based on PRS/SRS bandwidth aggregation [RAN1]

- Study power efficiency for RAT-based positioning techniques, and specify, if needed, solutions for improving power efficiency. [RAN1]

However, we have a concern that all issues above can be managed within a single study/work item assuming that all other example areas are included. Further discussion is necessary how to manage a reasonable work scope.

13 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility

We are also generally supportive of the Moderator's initial subset of topic areas within this example area.

High-level topic areas for improved accuracy and integrity and potential responsible WGs can include (leading WG is initially indicated, while secondary WGs follow after):

- Specify solutions for accuracy improvement based on PRS/SRS bandwidth aggregation at least in terms of the following:
  o Simultaneous transmission by the gNB and reception by the UE of intra-band one or more contiguous carriers in one or more contiguous PFLs. [RAN1, RAN4, RAN2, RAN3]
  o Simultaneous transmission by the UE and aggregated reception by the gNB of the SRS for positioning in multiple contiguous intra-band carriers. [RAN1, RAN4, RAN2, RAN3]
- Study/specify integrity and reliability for RAT-dependent positioning methods [RAN2, RAN1]

14 – ZTE Corporation

For the concern on Integrity, we should clarify LMF based integrity is not precluded yet in Rel-17. For RAT-dependent integrity, we are open to further discuss on support of LMF based or UE based or both. For example, for UE based solution and for MT-LR, LMF needs to send KPIs to UE for integirty calculation, it still has spec impact including LMF signaling and KPI definition.

15 – CEWiT

We are supportive of the objective "Specify solution for accuracy improvement based on PRS/SRS bandwidth aggregation". This should be led by RAN1.

16 – Fraunhofer IIS

Based on companies inputs in the first round, we suggest including phase measurements as part of the accuracy enhancements: *Study and specify solutions for accuracy improvement based on PRS/SRS carrier phase measurements.*

17 – Intel Corporation (UK) Ltd

We support the proposed subset of work directions for further NR positioning accuracy and reliability improvement. We would like to check/clarify whether integrity is considered for both Uu and PC5 RAT-dependent positioning solutions or Uu only.

Regarding WG responsibilities our views are as follows:

- Specify solutions for Integrity for RAT dependent positioning techniques [RAN1 – leading WG, RAN2/RAN4 – secondary WGs]
- Specify solution for accuracy improvement based on PRS/SRS bandwidth aggregation [RAN1 – leading WG, RAN2/RAN4 – secondary WGs]

As for the impact to SA/CT, we do not see immediate impact on these groups for the proposed above objectives. There may be potential impact identified for integrity objective but it can be analyzed/decided at a later stage. We assume integrity framework specified for RAT independent positioning can be considered as a starting point for discussion and updated if it is needed.

18 – Nokia Denmark

"Solutions for accuracy improvement" should be the first point under "Improved accuracy" and it should be open for different solutions incl. carrier-phase and PRS/SRS aggregation.

We feel that carrier phase positioning should also be included in the accuracy improvements for the following reasons:

- From the initial round by our count there 8 companies mentioning aggregating carriers and 5 companies mentioning using phase measurements (with 2 companies supporting both). While we acknowledge there is more support for aggregation it is not overwhelming. We should at least evaluate which method can help to achieve higher accuracy.
- Aggregating carriers does not address all scenarios as it mandates that sufficient spectrum will be available. It is preferred to find a high accuracy technique which is not dependent on having multiple carriers.
- Simulation results show the potential accuracy improvement for the InF-SH scenario (the main scenario used in Rel-17 studies) by using carrier phase based positioning. Large improvement in the 2D and 3D positioning accuracies are possible with ~~1 cm of horizontal error and~~ 8 cm of vertical error for 80% of UEs.

19 – vivo Mobile Communication Co.

We have following comments:

- Positioning over unlicensed should be included. This could obviously provide larger bandwidth for PRS measurment considering beyond 52.6GHz operation.
- For PRS/SRS carrier aggregation, at least SRS should be deleted. Moreover, RAN4 should be the group that initiates the study to build common understanding on hardware impairment models.

20 – Philips International B.V.

We agree on working on RAT dependent position integrity topic, which was unfortunately postponed during release 17, and in general we also support working on accuracy and power efficiency improvements, but we find the current proposed list rather small. For the integrity topic, we think that RAN2 should be in the lead and RAN1 as secondary group. RAN1 would have to identify the error sources before RAN2 can proceed with the specification work

21 – CATT

We share the similar view with MTK, Nokia, Xiaomi, and Fraunhofer it is important to consider NR carrier phase positioning in R18. Thus, we suggest adding the objective: "Study and specify solutions for accuracy improvement based on PRS/SRS carrier phase measurements."

22 – LG Electronics Inc.

We think 1st objective (i.e., Integrity for RAT dependent positioning techniques) should be led by RAN2, and 2nd objective (i.e., accuracy improvement based on PRS/SRS bandwidth aggregation) should be led by RAN1.

23 – Sony Europe B.V.

We support Integrity for RAT dependent positioning techniques and this work is led by RAN2.

There are some other diverse proposed topics. At this stage, we should agree on which direction that we want to cover for Rel.18 (e.g. accuracy, latency, or UE power efficiency). We consider to prioritise UE power efficiency as it has not been addressed in the previous release.

24 – Ericsson LM

We are positive to the moderators first bullet

- Specify solutions for Integrity for RAT dependent positioning techniques

We don't agree with the moderators second bullet

- Specify solution for accuracy improvement based on PRS/SRS bandwidth aggregation

We think there are many more serious limitations to accuracy than the bandwidth, such as e.g. NLOS issues, timing errors, and exact location of UE antenna panels. We also think that we should avoid pointing out a specific solution. We would rather like to see objectives such as

- Latency reduction
- Improved positioning accuracy in scenarios with large NLOS probability
- Mitigation of positioning errors due to UE Timing errors and UE antenna panel position

RAN2 can be the leading WG with support from RAN1.

5.4 Moderator summary at end of intermediate round

Based on the responses received, I propose to refine the topic area to:

- Specify solutions for Integrity for RAT dependent positioning techniques [RAN2, RAN1, Coordination with SA2 as required]
- Specify solution for accuracy improvement based on PRS/SRS bandwidth aggregation [RAN1, RAN2, RAN4]

For this round I have only updated the bullets to add the impacted WGs.

5.5 Final Round

Please provide comments to the moderator's updated description of the topic area.

Feedback Form 9: Improved accuracy, integrity, and power efficiency (Final Round)

1 – InterDigital France R&D

Thank you very much for the summary. We support the moderator's proposal.

2 – CATT

We strongly suggest adding "Study/Specify solution for accuracy improvement based on NR carrier phase measurements". During both initial and 2nd round discussion, 5 companies has explicitly proposed to use phase measurement for improving the positioning accuracy, and we see no companies made objection to study it. In our view, NR carrier phase positioning provide the possibility to achieve centimeter-level accuracy indoor even under the multipath environment.

3 – Verizon UK Ltd

In some localized deployment scenarios, our aggregatable spectum may be limited. Also, we think eventually the target should be CM- accuracy. So time permiting, we are OK with a preliminary study of high accuracy positioning techniques that don't require very wide bandwidth.

4 – vivo Mobile Communication Co.

PRS/SRS bandwidth aggregation should be studied first before directly "specify". RAN4 should start discussion on the impairments model first.

~~Specify solution~~ *Study necessity* for accuracy improvement based on PRS/SRS bandwidth aggregation [RAN4~~1~~, RAN2, RAN14]

5 – Intel Corporation (UK) Ltd

Thanks a lot for revision. We support it.

6 – Apple France

Accuracy improvement based on PRS/SRS bandwidth aggregation is already extensively studied in RAN1 within R17 S. Indeed, as part of such study, it was already agreed that, "From both gNB and UE perspective, the applicability and feasibility of this enhancement for different scenarios, configurations, particular bands and RF architectures, can be further studied." If Improved accuracy is included in R18, in our view it shall be led by RAN4. Having said, in our view, specification is pending to further study at RAN4 (and RAN1). So not sure why the word specify is used at this stage.

7 – Nokia Denmark

We have concerns with only including an objective on accuracy improvement with aggregation and not including carrier phase. There seems to be some question marks as to the feasibility and overall accuracy gain using aggregation from at least two companies while there is quite some support for carrier phase. If no consensus can be reached we suggest to modify the bullet as follows:

- Evaluate performance and specify solution for accuracy improvement based on at least one of PRS/SRS bandwidth aggregation and carrier phase positioning. [RAN1, RAN2, RAN4]

If we aim for accuracy improvements we should specific the solution with the best performance and this has yet to be evaluated by the WGs in detail.

8 – China Mobile E-Commerce Co.

We are supportive of the 1st objective.

Regarding the 2nd one, it is apparent that there are urgent market needs to further improve accuracy for RAT-dependent positioning. We believe that the enhancement should not be limited to only SRS/PRS aggregation, and as proposed by CATT and Nokia, the carrier phase positioning should be added to the scope.

On the other hand, as what we replied in the intermediate round, the LPHAP use case and requirements is clearly an example under the improved accuracy and power efficiency. We understand that the moderator's preference to give companies the opportunity to express views on LPHAP in "Other proposals", and from the feedback, companies consider LPHPA as a valid case of high accuracy and power efficiency. Therefore, we propose to add the objective of LPHAP under this topic.

9 – Qualcomm Incorporated

Thanks for the continued discussion and efforts progressing forward in this topic area.

We support the 2nd bullet, which has already been studied and concluded to be beneficial in the previous RAN1 TR on Rel-17 Positioning.

For the 1st bullet, the concerns that we raised in the previous round are not addressed, as the proposed objective remains too broad in scope.

- For example, Rel-17 supports "GNSS positioning integrity determination" only, since the positioning integrity determination is different for each RAT-Independent method (e.g., GNSS, Sensors, WLAN, etc.). Similarly, the "integrity solutions" for "RAT-dependent methods" will be different for each method (e.g., DL-TDOA, UL-TDOA, multi-RTT, E-CID, etc.).
- Further, the feasibility of integrity for UE-assisted mode is unclear, even for GNSS only positioning in Rel-17, which is a technology for which integrity has been worked on for several years now.
- There was no feasibility study for RAT dependent positioning integrity before (i.e., the Rel-17 TR 38.857 studied GNSS integrity only).

10 – ZTE Corporation

Support

11 – MediaTek Inc.

1, We support the comments by CATT and Nokia that carrier phase measurement is included for study. Furthermore, we are also open to consider the study of measurement of signal phase, such as first path phase under DL-AOD, signal phase difference between antennas

2, For PRS/SRS aggregation, how many operators have intra-band CA? This is something we should be careful

12 – China Unicom

In general, we support the moderator's proposal. Regarding 2nd sub-bullet, we support to add the carrier phase positioning into the scope.

13 – Huawei Tech.(UK) Co.. Ltd

Since the Rel-17 SI did not complete its investigations of integrity for RAT-dependent positioning, especially on the requirements, the first bullet should start with "study the requirement and specify". With that modification, we would be ok with these two objectives as long as power efficiency (LPHAP) is also included because we consider power efficiency as a more pressing requirement for real commercial devices.

14 – Huawei Tech.(UK) Co.. Ltd

(continuing the comment, sorry for splitting...) we are open to consider carrier phase based positioning as well.

15 – ZTE Corporation

We are also OK to study NR carrier phase positioning.

Regarding integrity issue, we strongly support it. We don't think the proposal is broad as it is only for RAT-dependent positioning method. We are OK to further study whether it is applicable for UE assisted or UE based positioning which can be discussed for next details.

16 – Spreadtrum Communications

We support the moderator's proposal in principle. In addition, for accuracy improvement, carrier phase based positioning maybe beneficial in some scenarios and can be studied in this release.

17 – Samsung R&D Institute UK

Thank you for the summary.

Can we move LPHAP proposal in 'other' into this topic?

18 – Guangdong OPPO Mobile Telecom.

We support the first bullet.

We don't support the second bullet.

- **Feasibility not justifed:** As we commented before, the phase offset and time delay between different chain at both gNB and UE side does not enable aggregating PRS and SRS in different carriers. There were extensive discussions in Rel-17. However, its feasibility was never justified. Nothing is changed so far.
- **Questionalbe benfits:** Based on Rel-17 study, the bottlenecks to further improve positioning accuracy are mainly other factors, e.g., Tx/Rx timing delay. The performance gain of CC aggregations is marginal if the practical factors (e.g., Rx/Rx timing delay) are considered
- **Target spectrum**: We would like to know what operator have and intend to use the avaiable spetrum for carrier aggregation for positioning and what the frequency band(s) is.

  Based on the above discussion, we don't think it should be in the scope.

19 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility

Supportive of the Moderator's refined description.

20 – Philips International B.V.

We agree with the way forward proposed by the moderator.

21 – Ericsson LM

We are positive to the moderators first bullet

- Specify solutions for Integrity for RAT dependent positioning techniques

We don't agree with the moderators second bullet

- Specify solution for accuracy improvement based on PRS/SRS bandwidth aggregation

We think there are many more serious limitations to accuracy than the bandwidth, such as e.g. NLOS issues, timing errors, and exact location of UE antenna panels. We also think that we should avoid pointing out a specific solution. The specific technical solution 'PRS/SRS bandwidth aggregation we think is too complex to motivate achievable gains in accuracy, but this could be studied in a SI with an objective open to different solutions. We would rather like to see objectives such as

- Latency reduction
- Improved positioning accuracy in scenarios with large NLOS probability
- Mitigation of positioning errors due to UE Timing errors and UE antenna panel position

RAN2 can be the leading WG with support from RAN1.

22 – Beijing Xiaomi Mobile Software

We support the moderator's proposal.

23 – CEWiT

We are okay with the summary.

24 – Fraunhofer IIS

We share views of CATT, Nokia and MTK on including carrier phase positioning in the scope of Rel-18 improved accuracy enhancements.

25 – Sony Europe B.V.

We support the first bullet point.

On the second bullet point, we are not sure the applicability of the PRS/SRS bandwidth aggregation. Some operators express their view that their bandwidth is quite limited. We would prefer to focus on other aspects, such as UE power efficiency, and the left over from Rel-17 WI.

26 – VODAFONE Group Plc We generally agree and as stated by other companies it would be useful to have the Phase Position as one of the tools in our tool bag , however time and resources should be considered .
27 – vivo Mobile Communication Co. We would also like to express our openness to include more methods for accuracy improvement such as carrier phase based positioning and NLOS mitigation besides the listed one for potential study.

5.6 Moderator's summary at end of final round

Comments from the moderator relating to the final round discussion

- In the final round of comments many more companies expressed opinions to include carrier phase positioning in the second bullet. Consequently this has not been included.
- A few companies still express concern about the carrier aggregation techniques in the second bullet. Consequently, this second bullet has been been reworded to include a study instead of just specify.
- A few company have concerns regarding the integrity bullet, suggesting that some level of study is required. Consequently, this first bullet has been been reworded to include a study instead of just specify.
- The notes to the RAN chair are not intended to be part of the agreed summary but assistance to Wanshi when he reviews the conclusions.
-

Based on these comment my summary is as follows:

- Study/Specify solutions for Integrity for RAT dependent positioning techniques [RAN2, RAN1, Coordination with SA2 as required]
- Study/Specify solutions for accuracy improvement based on PRS/SRS bandwidth aggregation and NR carrier phase measurements [RAN1, RAN4, RAN2]

Notes from the moderator to RAN chair on possible controversial aspects:

- The topics to be included in the accuracy improvement bullet may still be controversial

6 Redcap positioning

6.1 Initial Round comments

Companies are invited to provide comments and suggestions for refinement to the example area of "Redcap positioning", along with motivation/justification for any refinement.

Feedback Form 10: RedCap positioning (Initial Round)

1 – Ericsson LM

The following basic support is needed:

- Specify RAN4 requirements for positioning of RedCap UEs (with reduced number of Rx branches) for existing positioning methods (if not specified as part of Rel-17)

The following enhancements should be considered:

- Define RedCap scenarios based on TR 38.875. [RAN1]
- Evaluate the achievable positioning accuracy, latency, scalability, and UE complexity with the Rel-17 positioning solutions in RedCap scenarios. [RAN1]
- Identify potential low cost and low complexity improvements of positioning techniques, signaling and procedures for improved accuracy, scalability, and reduced UE complexity and/or UE power consumption in RedCap scenarios. [RAN1, RAN2]

2 – InterDigital France R&D

Topics to be investigated :

- Evaluation of Rel. 16 positioning techniques with reduced capabilities
- Identify enhancement in positioning techniques to meet the performance requirements with reduced capability

3 – Apple France

If RedCap positioning is included in R18 positioning, it should be strived to have minimal specification impact. For example, RAN4 can study relaxation of reduced capabilities (BW, Rx chain, etc) only for the purpose of positioning measurements/processing.

4 – China Mobile E-Commerce Co.

Based on the feedback from the market, it is clear that in both commercial and vertical use cases, devices with positioning services of high performance (e.g., at least sub-meter accuracy, 1 2 years battery life) also have stringent requirements of low cost, which is within the scope of Redcap positioning. However, with reduced BW (e.g., 20MHz) and reduced Rx (e.g., 1 Rx), the positioning requirement may not be fulfilled, which needs further enhancement.

5 – Guangdong OPPO Mobile Telecom.

As a promising technology, RedCap is expected to be used widely for wearable devices and IoT devices. In many of these scenarios, positioning is usually required by the services. Thus, it is very import for RedCap UEs to support positioning. However, UE NR positioning is designed for normal UE and without any optimization for narrow-band UEs. For example, the positioning accuracy may be impacted by the limited bandwidth of RedCap UEs. The potential aspects may include the following

1. Define positioning performance requirement for RedCap devices
2. The positioning with narrow bandwidth reception/transmission

Ensuring the performance while keeping low power consumption

6 – Nokia Denmark

The following shoudl be included for RedCap positioning:

- Low cost & low power positioning for RedCap devices
- Low cost & low power positioning in RRC*IDLE*
- Low cost & low power positioning in *RRC*INACTIVE;

7 – Beijing Xiaomi Mobile Software

The following topics should be considered for RedCap positioning:

- Study the requirements for RedCap positioning based on the RedCap's typical service. Besides the accuracy requirement, the power consumption should be taken into account considering the RedCap devices are quite sensitive to the power consumption.
- Evaluate RedCap positioning performance based on the Rel-16 and/or Rel-17 positioning solutions
- Study the potential solutions to guarantee the accuracy, scalability, and solutions to reduce the UE power consumption in RedCap positioning.

8 – Qualcomm Incorporated

Suggested refinement for the "Redcap positioning" example area:

- Support Positioning enhancements to address limitations associated with low bandwidth, low processing capabilities and/or low power of Redcap Devices with respect to the existing NR Positioning methods.

Motivation/Justification for the suggested refinement:

- Performance of timing-based positioning methods depend on the bandwidth of the PRS. Redcap devices have limited bandwidth, and therefore, positioning enhancements to increase the effective BW of PRS (e.g., PRS Frequency Hopping, coherent stitching), would result in significant accuracy increase.
- Performance of angle-based positioning methods tend to be less dependent on the bandwidth, but further enhancements of angle-based positioning addressing the limitations of Redcap Devices could provide additional accuracy gains over NR Rel-17 solutions.

9 – Intel Corporation (UK) Ltd

Our understanding is that the main motivation behind support of RedCap positioning is to improve positioning accuracy for UEs with reduced capability in terms of RX/TX processing bandwidth. In general, RedCap positioning can be sub-optimally supported by R17 assuming that UE operates with reduced bandwidth. If further optimizations targeting RedCap UEs are considered, then we propose to study potential enhancements to physical structure of DL PRS and SRS for positioning transmission as well as UE/gNB measurements.

10 – Huawei Tech.(UK) Co.. Ltd

A Rel-17 RedCap UE can optionally support the positioning features by reporting the corresponding capabilities. The requirements for positioning with 1Rx need to be defined by RAN4 in Rel-18 (if not done in Rel-17). Some IIoT-positioning use cases with low cost and low communication requirement (e.g. asset tracking, inbound logistics) may benefit from REDCAP based positioning with higher accuracy than achievable in Rel-17. For accuracy enhancement, for example frequency hopping transmission/reception to approach a larger bandwidth, can be considered.

11 – Samsung R&D Institute UK

For Redcap positioning, it should be clarified the target requirements for Redcap positioning regarding accuracy, latency and power consumption. Furthermore, it should be checked to what can be achievable based on Rel-16 and Rel-17 NR positioning. This means that it should be clarified what specification enhancements are needed.

12 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility :

Based on the outcome of the Rel-18 WS, we also understand that Low Power High Accuracy Positioning use cases (TS22.104) needs to be addressed in conjunction with RedCap positioning. A further clarification is needed on whether RedCap and LPHAP considers absolute and/or relative positioning in the context of a potential Rel-18 study. Additionally, some of the previous discussions during the Rel-18 WS centered around the capability differences between Redcap UEs and LPHAP UEs, and this could be further understood at a later stage during the potential Rel-18 study. In terms of RedCap positioning devices (e.g. wearables), the requirements in terms of Rx complexity/bandwidth may inherently limit the accuracy but bring about power savings gains, while our understanding is that LPHAP devices may enable low cost and high accuracy positioning using advanced techniques especially for IIoT use cases (e.g. tool assignment and tracking, asset tracking, intralogistics). Though it may seem that some aspects such power efficiency may overlap between RedCap and LPHAP devices, a clear differentiation between these aspects can provide a basis for further discussions as well as defining the potential scope of the study. We generally support a Uu positioning work item for RedCap devices, which are deemed to be bandwidth limited. On the other hand, LPHAP devices, which target higher achievable accuracies can also be studied separately or together with SL positioning based on the IIoT relative positioning use cases such as tool tracking.

13 – Spreadtrum Communications

RedCap requires positioning in all the use cases, however, with reduced BW and reduced number of Rx branches, the positioning accuracy may be reduced. Therefore, narrow bandwidth positioning should be investigated and the following perspective should be considered.

1. Identify the positioning requirements for RedCap UEs (unified or different for RedCap use cases.)
2. Evaluation the achievable positioning performances with the Rel-17 positioning solutions for RedCap positioning and identify any performance gaps.
3. Positioning techniques with low power consumption and low complexity.

14 – ZTE Corporation

We think the related enhancement should be mainly on RAN4 requirement as below.

- Motivation
- high accuracy under low bandwidth, low power consumption
- low latency under low UE processing capability, low UE complexity

- Probably looser targets of accuracy and latency should be defined compared with Rel-17
- Large capacity, i.e. Large number of devices for positioning
- Potential enhancement [RAN4, RAN1]
- Define new positioning requirement/capability for low cost devices, e.g.
- New PRS processing capability including PRS buffering capability
- New Measurements Period Requirements
- Study and specifiy if need new positioning methods, positioning RS, signaling and procedures to improve capacity, latency reduction and positioning accuracy

Furthermore, some RedCap dedicated positioning solutions (e.g. frequency hopping) may affect the unicast transmission, scheduling, channel measurement and CSI feedback of Redcap UEs. This impact will cause Regular RedCap related standards effort. Therefore, it is better to handle this kind of discussion under RedCap related enhancement.

15 – vivo Mobile Communication Co.

The following can be considered for RedCap UE positioning

- Define positioning performance requirement considering UE complexity reduction features, such as

Ø Limited bandwidth: FR1:20MHz, FR2:100MHz

Ø Limited antenna number: 1Rx,2Rx

16 – VODAFONE Group Plc

A focus on indoor positioning is preferred as GNSS+cell ID already solves many outdoor situations.

17 – MediaTek Inc.

1, Whether RedCap and LPHAP mean the same thing could be further justified. If it is determined to define same data BW and PRS measurement BW for RedCap UE, then the decoupled BW between data and RS for positioning (DL/UL) for LPHAP could be considered

2, fe-MTC feature in LTE introduces PRS hopping. If similar concept is applied to RedCap UE for positioning, the UE may need to retune RF a couple of times to ”stitch” the BW to become a larger one. The phase offset between RF retuning needs to study to check the performance degradation

18 – CATT

Motivations

For supporting RedCap UE positioning, we envision is that there are no significant changes in existing positioning architecture and solutions. There may have some impacts on signalling, protocol, message, and procedures. The main issues that may need to be considered include the impacts of the reduced complexity on NR positioning coverage and performance and whether there is a need to have a further enhancement in the physical layer to support RedCap positioning, including the configuration of the DL PRS and UL SRS for positioning, the physical layer procedures, the UE capability, etc.

Suggested SI/WI objectives

- Evaluation of the positioning performance for RedCap UEs and determine whether to define new target positioning performance requirements for RedCap UEs [RAN1]
- Study and if needed specify physical layer enhancements to support RedCap positioning [RAN1]
- Study and specify the protocols and messages to support RedCap positioning [RAN2/RAN3]
- Define corresponding performance requirements and test cases [RAN4]

19 – Sony Europe B.V.

NR high accuracy positioning with low-cost UE can be enabled by introducing RedCap positioning.

The constraints / limitations of RedCap UE may affect the positioning accuracy.

Proposed topics:

1. Study the positioning requirements for RedCap UE in FR1 and FR2 (e.g based on Rel-17 positioning techniques and/or potential enhancements in Rel-18).
2. Support RedCap device with high accuracy positioning, low latency, and low power consumption. Positioning enhancements may be needed to improve the positioning accuracy of redcap UE.

20 – Fraunhofer IIS

Consider the following aspects needs within the objectives for supporting positioning for RedCap devices:

- Performance impact with reduced NW signalling and UE reporting
- Identify improvements for the RedCap positioning, at least for timing methods.

6.2 Moderator summary at end of Initial Round

Based on the responses received, I propose to refine the ”Redcap positioning” example area to:

- Define positioning support for RedCap UEs, considering the following:
  - Evaluate performance of existing positioning procedures with RedCap UEs
  - Based on the elevation define performance requirements for positioning by RedCap UEs
  - Based on the evaluation, identify potential enhancements to help address possible limitations associated with for RedCap UEs

6.3 Intermediate Round

Please provide comments to the moderator’s updated description of the topic area.

In addition, please now also provide feedback on

- Leading WG and secondary WGs (for the specific topic area)
- Identifying any potential impacts to SA/CT
-

Feedback Form 11: Redcap positioning (Intermediate Round)

1 – Futurewei Technologies

Support of the three objectives. Our understanding is that RAN4 should be leading group for the first two objectives on Evaluation and Definition of Performance requirements. In addition, these three objectives should be done in sequence and once RAN4 completed the first two objectives, RAN1 would start on the third objectives.

2 – InterDigital France R&D

We support the moderator's summary. The first objective can be lead by RAN4. The second and third objective can be led by RAN1. If necessary, RAN1 and RAN2 can jointly evaluate latency evaluation.

3 – CATT

We support the moderator's summary.

RAN4 should lead the work of the evaluation. RAN1 should lead the work if further enhancement are needed. RAN2/3 work can be triggered by RAN1.

4 – Apple France

In our view, the first objective should be led by RAN4. The 2nd and 3rd objective should be lead by RAN1.

5 – Qualcomm Incorporated

Thanks for the efforts on progressing on this topic area. We are generally supportive of the proposal, with the following small suggestions:

- 1st sub-bullet: We think it would be useful to indicate that the plan is to evaluate Positioning procedures **and measurements** with regard to RedCap UEs.
  - Suggestion: "Evaluate performance of existing positioning procedures and measurements with RedCap UEs"
- 2nd sub-bullet: We consider the expression "Based on the elevation" unnecessary. [Our understanding is that 'elevation' is a typo and the intent was to say 'evaluation', which we think is unnecessary] If the intention is to define requirements in RAN4, it is generally understood that RAN4 uses evaluations, and other analytical approaches to study and specify performance requirements.
  - Suggestion: "~~Based on the elevation~~ Define performance requirements for positioning by RedCap UEs"

Proposed Leading WG & Secondary Working Groups:

· Leading WG: RAN1

· Secondary Working Groups: RAN4, RAN2

Potential impacts to SA/CT

- Nothing to point out at this stage

6 – Guangdong OPPO Mobile Telecom.

We are general fine with moderator's proposl. Regarding the 3rd objective, we need emphasize that it does not require to increase the UE processing capability of RedCap UE. Thus, we suggest to modify it as below

- Based on the evaluation, identify potential enhancements to help address possible limitations associated with for RedCap UEs **without introducing additional processing complexity requirement for RedCap UEs**.

RAN1 should be the leading WG and RAN2/RAN4 are the secondary WGs.

7 – China Mobile E-Commerce Co.

We are supportive of the objectives. RAN4 should lead the performance evaluation, and if any enhancements, the leading WG should be RAN1.

8 – Spreadtrum Communications

We support the moderator's summary. The first and third objectives can be led by RAN1. The second objective can be led by RAN4. And RAN2/RAN3 work can be triggered by RAN1.

9 – ZTE Corporation

We basically share the same view as Moderator. The evaluation on the first bullet should be done first by RAN4. The second and third bullets can be handled by [RAN1, RAN2].

10 – Beijing Xiaomi Mobile Software

For the first objective, the performance evaluation should include positioning accuracy evaluation and measurement evaluation, and RAN1 should led the performance evaluation and RAN4 should led measurement evaluation. RAN1 should also led the last two objectives and RAN2 will be involved in the third objective.

11 – Samsung R&D Institute UK

Thank you for the summary.

The updated description looks good. The first and second bullets for the moderator's summary can be RAN4/RAN1 leading work and the last bullet can be RAN1 leading work.

However, we have a concern that all example areas including this Redcap positioning can be managed within a single study/work item

12 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility

Support the Moderator's refined proposal on high-level topic areas for RedCap positioning. Potential responsible WGs can include (leading WG is initially indicated, while secondary WGs follow after):

- Evaluate performance of existing positioning procedures with RedCap UEs [RAN1, RAN4]
- Based on the evaluation define performance requirements for positioning by RedCap UEs [RAN4]
- Based on the evaluation, identify potential enhancements to help address possible limitations associated with for RedCap UEs [RAN1, RAN2, RAN3]

13 – Intel Corporation (UK) Ltd

Thanks a lot for summary. We have the following suggestions:

- Replace "Define positioning support for RedCap UEs" with "Study/evaluate positioning performance for RedCap UEs"
- Remove the sub-bullet "Based on the evaluation define performance requirements for positioning by RedCap UEs", given that we do not foresee new specific positioning requirements for RedCap UEs but rather pursue to meet the existing requirements for regular UEs and evaluate potential gaps and solutions.

Regarding leading WG and secondary WG, we think that given scope can be handled by RAN1, possibly with some involvement from RAN2 and RAN4 WGs.

As for the impact to SA/CT, we do not see direct impact on these groups for the proposed above objectives.

14 – vivo Mobile Communication Co.

We are ok with the first two bullets and they should be led by RAN4.

For the third bullet, we are concerned on the scope of this item. We don't see the criticality of further enhancement of Redcap UE positioning enhancement.

"Based on the evaluation, identify potential enhancements to help address possible limitations associated with for RedCap UEs"

15 – LG Electronics Inc.

We support Moderator's summary. We think 1st objective should be led by RAN4, and 2nd and 3rd objective should be led by RAN1.

16 – Huawei Tech.(UK) Co.. Ltd

The moderator's summary is unclear to us. In all likelihood, Rel-17 positioning techniques can be applied and supported (optionally) by a Rel-17 RedCap UE, but performance requirements defined for normal UEs can't apply to RedCap UEs (because the positioning accuracy will be lower than for normal UEs due to 1Rx and reduced bandwidth). But it is not a matter of "defining positioning support for RedCap UEs", as the support will already be there in Rel-17 in our understanding. RAN4 could define performance requirements based on RAN4 evaluations used to determine what accuracy a RedCap UE can achieve. Such evaluations cannot be done in RAN1 on behalf of RAN4. RAN4 perform their own evaluations for defining their performance requirements.

If the proposal is for RAN1 to determine what positioning accuracy RedCap UEs can achieve based on methods specified in Rel-17, and then to define a target for a higher positioning accuracy, then it is unclear to us how the work/study would actually proceed in RAN1 without a use case in mind. The limitations are already understood (1Rx, 20 MHz) bandwidth. It would be sufficient to directly discuss which enhancements to the positioning techniques could improve accuracy.

17 – Sony Europe B.V.

We support the moderator' summary. The work is led by RAN1. On performance evaluation, RAN1 can start the initial evaluation (the same procedure as in Rel-16 and Rel-17).

18 – Ericsson LM

We are fine with moderator's proposals.

We propose RAN4 to be the leading WG for the first two bullets and RAN1 for the third bullet.

6.4 Moderator summary at end of intermediate round

Based on the responses received, I propose to refine topic area to:

- Define positioning support for RedCap UEs, considering the following:
  - Evaluate performance of existing positioning procedures and measurements with RedCap UEs
  - Based on the evaluation, identify potential enhancements to help address possible limitations associated with for RedCap UEs [RAN1, RAN2]
  - Define performance requirements for positioning by RedCap UEs [RAN4]

Many companies seem to be happy with the proposal from the Initial Round and so the updates are mainly to the detail wording and to capture the impacted WGs.

6.5 Final Round

Please provide comments to the moderator's updated description of the topic area.

Feedback Form 12: Redcap positioning (Final Round)

1 – InterDigital France R&D

Thank you very much for the summary. We support the moderator's proposal.

2 – CATT

We support the moderator's summary.

3 – Verizon UK Ltd

Support the moderator's summary.

4 – vivo Mobile Communication Co.

For the first bullet, we would also like to evaluate the performance of both power consumption and accuracy.

Evaluate performance *(including accuracy and power consumption)* of existing positioning procedures and measurements with RedCap UEs [RAN1, RAN4]

For the second bullet, we are concerned on the scope of Redcap positioning. Also we don't know which target Redcap positioning should have for identifying the limitation. If majority would like to go this way, we would like to revise this bullet as the following, including "necessity of" such enhancement and also this decision is not only up to RAN1/RAN2, but also RANP with sent LS to SA to determine.

Based on the evaluation, identify *necessity of* potential enhancements to help address possible limitations associated with for RedCap UEs [*RAN,* RAN1, RAN2]
5 – Intel Corporation (UK) Ltd Thanks a lot for update. We support it.
6 – Qualcomm Incorporated Thanks for the continued discussion and efforts progressing forward in this topic area. We support the proposal.
7 – Huawei Tech.(UK) Co.. Ltd We support the proposal, and would actually encourage further discussion until December on the possible target accuracy for RedCap positioning enhancements, in case this could be settled even before starting the study.
8 – ZTE Corporation Support moderator's proposal
9 – Beijing Xiaomi Mobile Software We support moderator's proposal.
10 – Guangdong OPPO Mobile Telecom. We are suppotive of the proposal
11 – Motorola Mobility Germany GmbH Lenovo, Motorola Mobility Supportive of the Moderator's proposed description.
12 – Ericsson LM We are fine with moderator's proposals. We propose RAN4 to be the leading WG for the first two bullets and RAN1 for the third bullet.
13 – Sony Europe B.V. We support the moderator's proposals.
14 – VODAFONE Group Plc We generally support

6.6 Moderator's summary at end of final round

Comments from the moderator relating to the final round discussion

- There was widespread support for the summary from the intermediate round and hence I will propose

that to be the conclusion from the final round without any modification.

- There was one comment regarding including power consumption in the evaluation, but as only one company made this comment no change was made.
- There was one comment regarding the lead WGs, but to the moderator the proposal didn't seem to make sense. We have anyway identified the key groups to involved in the work and we can refine which group leads each each objectives as they are expanded over the next months.

Based on these comments my summary is as follows:

- Define positioning support for RedCap UEs, considering the following:
  - Evaluate performance of existing positioning procedures and measurements with RedCap UEs[RAN1, RAN4]
  - Based on the evaluation, identify potential enhancements to help address possible limitations associated with for RedCap UEs [RAN1, RAN2]
  - Define performance requirements for positioning by RedCap UEs [RAN4]

7 Other proposals

7.1 Initial Round comments

Companies are invited to provide additional proposals along with motivation/justification for any additions. Any additional proposal should be based on submissions to the the RAN Rel-18 workshop and not completely new proposals which should be submitted directly to RAN#93e.

Feedback Form 13: Other proposals (Initial Round)

1 – Apple France Compared to the TN, NTN network may lack of NW-based positioning methods. Thus, R18 may consider a study on RAT-dependent NTN positioning.
2 – Nokia Denmark - PRS transmission in unlicensed spectrum, including 60 GHz. - Support of MT-triggered SDT for network-initiated positioning [RAN2]
3 – Intel Corporation (UK) Ltd NR positioning support in unlicensed spectrum (for both Uu and PC5) can provide additional benefits to further improve accuracy of positioning due to extra bandwidth availability and increased flexibility in terms of system deployment and spectrum utilization.
4 – ZTE Corporation In Rel-17, NR positioning is supported for UE in RRCINACTIVE state in the case when UE initiates location service (MO-LR or in deferred MT-LR). However, there may not be further enhancements to

support RRCINACTIVE state when network initiates location service (MT-LR or in deferred MT-LR). So we prefer to have further enhancements as below [RAN2]

- Specify positioning in RRC_INACTIVE state when network initiates location service.

5 – CATT

Positioning enhancements with AI/ML

Motivations

· Precise positioning is very challenging under unpredictable radio environments, especially the scenarios strongly influenced by multipath and non-line-of-sight (NLOS) radio channels.

· Various AI/ML positioning approaches have been investigated to overcomes the challenges

· AI/ML technologies may fully take 5G NR advantages of large bandwidth, high carrier frequency, and large antenna arrays of systems and support effectively integrated positioning.

Suggested SI/WI objectives

· Study and specify the framework/procedures/signaling/performance requirements for AI/ML positioning [RAN1, RAN2, RAN3].

· Study and specify the AI/ML positioning algorithms/models applicable to different application scenarios.

· Study and specify the framework for obtaining the training data [RAN1, RAN2, RAN3]

· Study and specify the UE/gNB processing capability for supporting AI/ML positioning [RAN1, RAN4]

· Study and specify the methods for validating and testing of the AI/ML positioning performance under various scenarios [RAN4, RAN1]

· Define corresponding performance requirements and test cases [RAN4]

6 – MediaTek Inc.

1, enhancement for UE based positioning

2, unlicensed band for PRS transmission and measurement

7 – CEWiT

To extend NTN support to non-GNSS capable Ues, specifying RAT dependent positioning for NTN is necessary. This should be included in positioning enhancement for Rel 17.

7.2 Moderator summary at end of Initial Round

Based on the comments in this section and other parts of the document, the only additional topic that has a good level of company interest and good justification is LPHAP. I understand the primary motivation comes from the use cases and requirements developed by SA1. Given that there was not a specific request for comments on LPHAP in the initial round, I would like to give all companies the opportunity to comment on LPHAP in the Intermediate Round before attempting to make a proposal.

7.3 Intermediate Round

Companies are invited to comment on LPHAP. I also provide a feedback form for any additional comments on 'other proposals'.

Feedback Form 14: LPHAP (Intermediate Round)

1 – Futurewei Technologies

Supportive of further analysis and study of the requirements from SA1 and on how it can be beneficial in meeting at least the high power efficiency objectives in Rel-18.

2 – CATT

We are supportive to study and specify the physical layer enhancements, including physical layer signalling, measurement, procedures, and the UE capability to support LPHAP. RAN1 should lead the work.

3 – Qualcomm Incorporated

Thanks for the efforts on asking comments on LPHAP. We acknowledge that SA1 has recently worked on specific use cases and requirements within the umbrella of Low Power High Accuracy Positioning.

However, given the current long list of items being considered for the Rel-18 work, we do not see a good justification to include a separate LPHAP topic and specify dedicated LPHAP positioning features, within the NR Rel-18 Positioning package. Focusing on Sidelink, DL/UL PRS aggregation (Rel-17 leftover), and Redcap Positioning would already be a full package to be considered.

4 – Guangdong OPPO Mobile Telecom.

We are supportive to study and specify lower power mechanism for positioning (LPHAP). SA1 identified several use cases for low power high accuracy positioning (LPHAP) . From UE perspective, power consumption is a key aspect for further enhancement.

5 – MediaTek Inc.

We also support to study LPHAP. In our view, this topic is more significant than RedCap positioning

6 – Huawei Tech.(UK) Co.. Ltd

We think the LPHAP has well justified use case and requirements, and has a good level of company interest. The Rel-17 UE power consumption study is not complete, and power efficiency optimization towards the UE that is designed for positioning should be the key to Rel-18 positioning. As stated in section 5.3, we think that this already falls under "power efficiency enhancements" as listed as outcome of the RAN workshop.

For LPHAP, we think the following issues could be discussed:

1. Identify the requirements for LPHAP, especially for the battery life. (we made a specific proposal in the initial round, but are of course open to discuss other proposals on requirements)

2. Discuss the power consumption evaluation model and evaluate the power consumption for the existing positioning procedures.

3. Based the evaluation, identify potential enhancements to help address possible performance gaps.

7 – China Mobile E-Commerce Co.

Based on the requirement defined by SA1 and observed from the market, we are supportive of studying the enhancement on LPHAP.

As we commented in the "Improved accuracy, integrity, and power efficiency" topic, we prefer to add this objective under that part.

8 – Fraunhofer IIS

In our views, LPHAP should have a higher priority in Rel-18 than RedCap positioning. Assuming that part of the identified LPHAP enhancements are applicable to RedCap, the study on LPHAP can include the last bullet in the moderator summary for RedCap positioning.

9 – Motorola Mobility Germany GmbH

Lenovo, Motorola Mobility

We are supportive of studying enhancements related to LPHAP devices for IIoT scenarios that target low positioning intervals/duty cycles while satisfying positioning service levels 1-5 (horizontal accuracies between 0.3-10m) as specified in TS 22.104. We also share the view that LPHAP should be prioritized over RedCap positioning due to the IIoT vertical need.

High-level topic areas for LPHAP positioning and potential responsible WGs can include:

- Study/specify enhancements to meet the specified positioning use cases in TS22.104 including requirements such as higher accuracies and longer battery life [RAN1, RAN2, RAN3]:
  o Study/specify positioning reference signal design enhancements to achieve higher accuracies, while maintaining low power consumption.
  o Study/specify energy efficient positioning methods including but not limited to low power positioning intervals/duty cycles.
- Potential enhancements to the LCS architecture [SA2].

10 – Spreadtrum Communications

LPHAP should be supported to achieve low power consumption of positioning devices. And RAN1 should lead the work

11 – Beijing Xiaomi Mobile Software

We are supportive to study lower power and high accuracy positioning and the difference between LPHAP and RedCap positioning should be clarified.

12 – Intel Corporation (UK) Ltd

Regarding LPHAP, we think that low power consumption is certainly a valid metric, but we assume that NR positioning support for UEs in RRC_INACTIVE / RRC_IDLE state is essentially a step in this work direction. It needs to be further analyzed what design components are missing for RRC INACTIVE UEs based on R17 work progress. Further enhancements can be considered for RRC_IDLE UEs to support this work direction. Our general comment for LPHAP is that it is unclear what kind of low power UE is considered. The power consumption needs to be addressed for communication first instead of positioning. So far, in NR, we only have RedCap UE. It is difficult to discuss battery life for normal UE since positioning

procedure may not significantly contribute to power consumption. Therefore, we would like to get clarification on high level features that UE is expected to support for reduced power consumption in general before considering whether/how to reduce power consumption for positioning.

13 – Ericsson LM

We are supportive of considering LPHAP as a use case for Release 18. There is quite a similarity between LPHAP and RedCap. However, positioning requirements on LPHAP is now available in SA1.

Feedback Form 15: Other proposals (Intermediate Round)

1 – ZTE Corporation

We are open to discuss LPHAP if the Rel-18 scope is affordable, but it should be discussed with clear examples, potential enhancement aspects.

2 – Intel Corporation (UK) Ltd

Regarding NR positioning support in unlicensed spectrum, given that it is considered as a valid option for sidelink positioning/ranging, we think it is also useful for Uu positioning and can be also considered to improve positioning performance for public safety, V2X and Industrial-IOT scenarios.

3 – vivo Mobile Communication Co.

We share similar view as Intel that unlicensed spectrum should be studied, including both FR1 and above 52.6 GHz. The target scenarios also include commercial use cases such as XR devices with high demand of positioning accuracy requirement.

7.4 Moderator summary at end of intermediate round

Acknowledging the LPHAP used cases and requirements that have been developed by SA1 and the high degree of interest among the views expressed, the moderator proposal is to add the following topic area:

- 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, identify potential enhancements to help address any limitations [RAN1, RAN2]

Apart from the above no other topic area from 'other proposals' is proposed to be added by the moderator.

7.5 Final Round

Please provide comments to the moderator's description of the LPHAP topic area.

Feedback Form 16: LPHAP (Final Round)

1 – InterDigital France R&D

Thank you very much for the summary. We support the moderator's proposal.

2 – CATT

We support the moderator's summary.

3 – Intel Corporation (UK) Ltd

Thanks a lot for update. We are fine to take it for further discussion on topic area but not as a potential SI/WI objective. We prefer to consider latest revision as a conclusion (homework task) for the next iteration of discussion aiming to come up with more concrete objectives.

4 – Qualcomm Incorporated

Thanks for the continued discussion and efforts progressing forward in this topic area. Per Chairman's guidance:

- *Any refinement of the areas for each topic from the email discussion require strong motivation/justification and the bar is very high!*
    - *Critical to keep all items under rigorous check; important to avoid "number counting" driven discussion, but focus on tangible commercial interests (near & longer terms)*

We don't consider that the "LPHAP use-case" justifies a new area separate from the area of "improved accuracy, integrity, and power" which already includes "accuracy" and "power" within its scope. A more appropriate consideration would be to stay within the initial conclusion from the workshop, without referring to specific use-cases, since other scenarios/use-cases beyond LPHAP, could benefit from improved power efficiency in positioning solutions. LPHAP should thus be considered along with the other 2 bullets within a more generic framework of "studying potential enhancements for improved power efficiency of the existing RAN positioning solutions". Therefore, we have concerns with this proposal.

5 – ZTE Corporation

The current summary is too broad to us. It is unclear what kind of solutions should be considered. From our view, enhancement of positioning in RRC_INACTIVE state is one way to save power consumption which is mentioned by several companies. So we would like to add one subbullet as

-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, identify potential enhancements to help address any limitations [RAN1, RAN2]

- Enhance positioning in RRC_INACTIVE state
- FFS other solutions

6 – Huawei Tech.(UK) Co.. Ltd

We support the moderator's proposal and suggest to eventually move it under "improved accuracy, integrity and power efficiency". We suggest that the targeted SA1 LPHAP requirement may continue be discussed in RAN plenary level when scoping the details WID/SID. We agree with Qualcomm, as commented earlier, that power efficiency enhancements are part of the already listed example area from the June workshop, and LPHAP falls into that category. We see that there are clearly defined requirements for LPHAP, so these should be the starting point as suggested by the moderator. It is unclear what other scenarios/use-cases Qualcomm is referring to, and it should be avoided to dilute precise objectives into very open-ended ones.

7 – MediaTek Inc. We also suggest to move this item to ”improved accuracy, integrity, and power efficiency”
8 – Guangdong OPPO Mobile Telecom. We support the study of LPHAP and also prefer to keep this item in ”improved accuracy, integrity and power efficiency”
9 – Motorola Mobility Germany GmbH Lenovo, Motorola Mobility Supportive of the Moderator’s proposed description to consider LPHAP as a separate topic at this stage.
10 – Ericsson LM We are supportive of considering LPHAP as a use case for Release 18. There is quite a similarity between LPHAP and RedCap. However, positioning requirements on LPHAP is now available in SA1.
11 – Beijing Xiaomi Mobile Software We support the moderator’s proposal.
12 – Sony Europe B.V. We support the moderator’s proposal to study the requirements on LPHAP.
13 – VODAFONE Group Plc We suggest further study whether this is a necessary feature and its practicalities/usefulness

7.6 Moderator’s summary at end of final round

Comments from the moderator relating to the final round discussion

- A few companies still felt that this topic was not yet sufficiently motivation to be included. Hence, I will flag this to the RAN chair that it may still be controversial.
- One company felt that example enhancements should be mentioned in order to narrow the scope. As this was only one company not change has been made. But this could be discussed more on the next few months.
- Several companies commented that this should be grouped under the label of ”Improved accuracy, integrity, and power efficiency” and I will do this in the final combined summary from this discussion.
- The notes to the RAN chair are not intended to be part of the agreed summary but assistance to Wanshi when he reviews the conclusions.

Based on these comment my summary is as follows (no change from intermediate round:

- 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, identify potential enhancements to help address any limitations [RAN1, RAN2]

Notes from the moderator to RAN chair on possible controversial aspects

- A few companies felt that the LPHAP bullet was not yet sufficiently motivation to be included

8 Final Summary

This final summary is created by copying the final round summaries from section 4.6, 5.6, 6.6, 7.6.

The refined topics areas from this discussion are:

- Study/specify solutions (including reference signals, measurements, procedures, etc) for sidelink positioning considering the following: [RAN1, RAN2]
  - To include ranging (i.e. relative positioning) and absolute positioning
  - Coverage scenarios to cover: in-coverage, partial-coverage and out-of-coverage
  - Requirements: Based on requirements identified in TR38.845 and TS22.261 and TS22.104
  - Use cases: V2X (TR38.845), public safety (TR38.845), commercial (TS22.261), IIOT (TS22.104)
    - Note: The next phase of discussion will include selection of use cases to be used for evaluation and design. This does not restrict use of the solutions for other use cases.
  - Spectrum: ITS, licensed
  - Coordination with SA2 as required (e.g. architecture aspects)
- Improved accuracy, integrity, and power efficiency:
  - Study/Specify solutions for Integrity for RAT dependent positioning techniques [RAN2, RAN1, Coordination with SA2 as required]
  - Study/Specify solutions for accuracy improvement based on PRS/SRS bandwidth aggregation and NR carrier phase measurements [RAN1, RAN4, RAN2]
  - Study the requirements on LPHAP as developed by SA1 and evaluate whether existing RANfunctionality can support these power consumption and positioning requirements. Based on the evaluation, identify potential enhancements to help address any limitations [RAN1, RAN2]
- Define positioning support for RedCap UEs, considering the following:
  - Evaluate performance of existing positioning procedures and measurements with RedCap UEs[RAN1, RAN4]
  - Based on the evaluation, identify potential enhancements to help address possible limitations associated with for RedCap UEs [RAN1, RAN2]
  - Define performance requirements for positioning by RedCap UEs [RAN4]

Notes from the moderator to RAN chair on possible controversial aspects:

- Regarding sidelink:
    - 1 company wanted to remove the word ’ranging’
    - 1 company wanted to remove mention of ’sidelink’
    - Controversial whether or not to consider unlicensed spectrum
- The set of topics to be included in the accuracy improvement bullet may still be controversial
- A few companies felt that the LPHAP bullet was not yet sufficiently motivation to be included
-