Electronic Meeting, 28th June - 2nd July, 2021

Agenda Item: 4.2

Source: Nokia, Nokia Shanghai Bell

Title: Email discussion summary for [RAN-R18-WS-non-eMBB-Nokia]

1 Introduction

This discussion covers the following contributions:

[1] RWS-210069 ”UAS Connectivity over NR”, Nokia, Nokia Shanghai Bell

[2] RWS-210071 ”Further enhancements for IIoT/URLLC in Release 18”, Nokia, Nokia Shanghai Bell

[3] RWS-210072 ”Sidelink Enhancements for Rel-18”, Nokia, Nokia Shanghai Bell, Toyota InfoTech

[4] RWS-210073 ”Sidelink Positioning for Rel-18”, Nokia, Nokia Shanghai Bell, Toyota InfoTech

[5] RWS-210115 ”Resilient timing via 5G in Rel-18”, Nokia, Nokia Shanghai Bell

[6] RWS-210116 ”RedCap / NR-Light enhancements in Rel-18”, Nokia, Nokia Shanghai Bell

[7] RWS-210117 ”High-accuracy positioning in Rel-18”, Nokia, Nokia Shanghai Bell

[8] RWS-210121 ”Railway, smart grid and PPDR support in Rel-18”, Nokia, Nokia Shanghai Bell

These are Nokia’s priority topics under the non-eMBB theme for Rel-18:

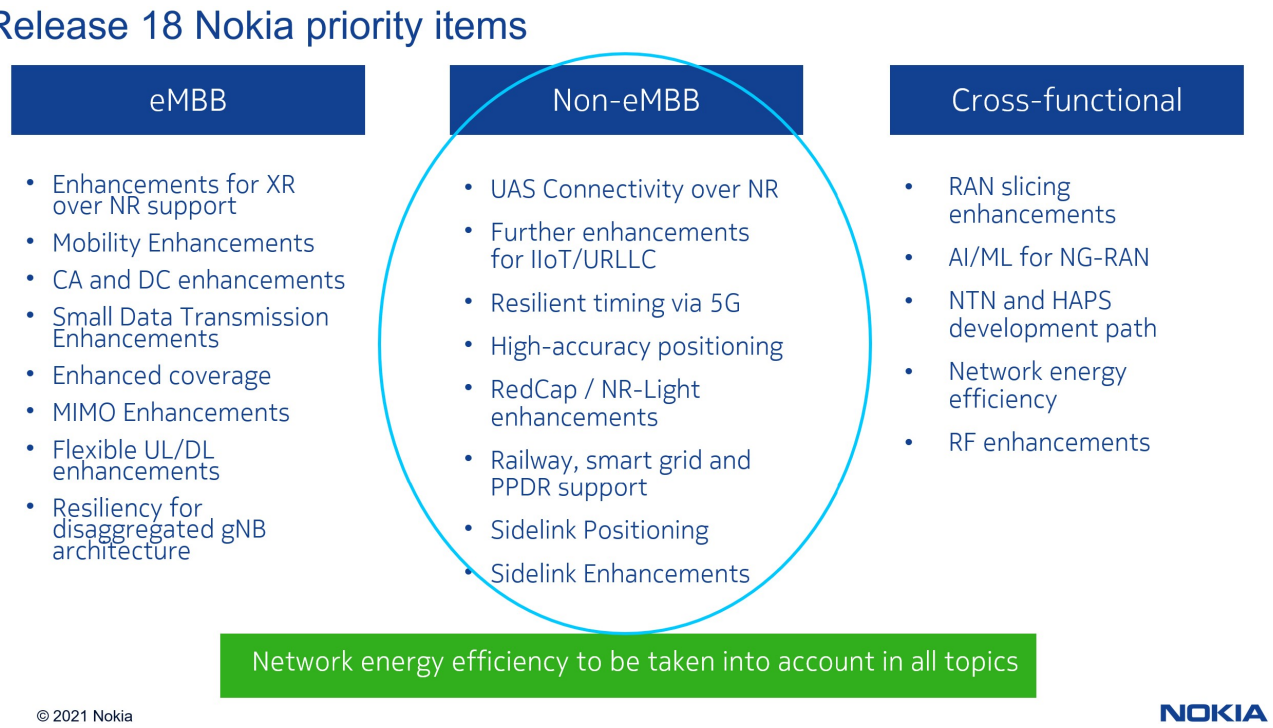

Figure 1: Nokia’s priority topics under the non-eMBB theme for Release 18

2 Comments and questions

2.1 RWS-210069 ”UAS Connectivity over NR”

Feedback Form 1: Comments and questions on RWS-210069

1 – Lenovo Mobile Com. Technology

Thanks for the proposals and we have some clarification questions for further understsanding consider following objectives:

1. control the amount of measurement for mobility: In LTE, multi-cell measurement was introduced and can reduce the measurement overhead to some extent. Do you think it is not enough and some enhancements are still needed especially for mobility purpose?

2. ensure reliability along the flight path: we are not so sure about the motivation that why existing mobility can not ensure the reliability, and also wondering why RAN1 is assumed to lead this issue since the issue seems relates to L3 measurement report?

3. co-existence for high uplink aerial throughputs: does the purpose to use different/separate directional antenna for aerial UEs to avoid interference to exisiting terrestrial UEs?

2 – Ericsson LM

What do you foresee getting specified as a result of these bullets?
- Support of mechanisms of ensuring reliability guarantees along the flight path [RAN1/RAN2]
- Enhancements for co-existence for high uplink aerial throughputs
- Enhancements for increased reliability

3 – ROBERT BOSCH GmbH

[Bosch]: Thank you for bringing this topic again in R18. We have the following questions:

- Regarding **Aerial UE specific** reporting:
  - Q1: should this reporting be also extended to "vehicle UE specific" as well, i.e., to cover advanced/autonomous/T operated driving use cases ? (i.e., including height)
- Regarding UAS UE type: do you support RedCap for power saving ? If yes, does the measurements/-Mob.Enh also applies to RedCap ?

4 – Intel Corporation (UK) Ltd

Q: Could you please provide an example for enhancements for increased reliability?

5 – Qualcomm Incorporated

Thank you for the detailed objectives. We share similar views on many of those items. However, particularly on the ensuring reliability in UL and reliability guarantee along flight path, we are wondering what kind of potential solutions you are considering?

6 – Samsung Electronics Co.

1. For the calculation of the positioning estimate, do you see the possiblity that the calulation might be done at local side (e.g., TRP/RSU/reference UE side) instead of LMF?
2. If it's for sidelink, do you think simply reusing sidelink RS or introducing new RS for sidelink positioning (DL PRS like or SRS like)?

2.1.1 Responses Round 1

Table 1: Responses to questions on RWS-210069 "UAS Connectivity over NR"

Measurement enhancements	For the Aerial UE specific reporting we are thinking of copying the release 15 enhancements for aerial vehicles. On the enhancements to control the choice and amount of signalling, we would prefer a different solution than what is included in the LTE Rel-15 specifications, even though the goal is the same, as our analysis shows that the LTE solution is not fulfilling its purpose. These enhancements are valid for all aerial UEs.

Flight path reliability	Flight path reliability is introduced such the UTM/USS can get an estimate from the RAN that the required reliability can be achieved over the flight path before the flight is allowed. The estimate can be updated during the flight. The impact on the specs are on signalling between the UE and RAN plus potentially introduction of new measurement reports.
Coexistence / high uplink throughput	We believe that using directional antennas on the aerial UE is a very powerful means to avoid uplink interference from UAVs with high uplink throughputs, when combined with network control over the beam selection, which has impact on the specifications.
Improved reliability	The specifications include many features which can be used to improve the reliability of connections to, for instance, aerial UEs. However, when using DC in the uplink to different cells, there is no mechanism to avoid that transmit power is shared by the two links. A simple mechanism shifting the timing of one of the transmissions can enhance this.

2.1.2 Questions Round 2

Feedback Form 2: Round 2 questions on RWS-210069 ”UAS Connectivity over NR”

1 – ZTE Corporation

Thanks for your contribution and replies. According to the previous study of UAV in R17, the network performance will be impacted by the UAV-UE, especially for the UL. In this case, we are supportive for the beam management part including potential control on beam selection by network. But w.r.t the reliability issue to optimize the power splitting in DC, the needs may not be well justified since the more connectivity between BS and one UAV may lead to severe interference. Any views on this part?

2 – Intel Corporation (UK) Ltd

Q1: Regarding network control over the beam selection for directional antennas on the aerial UE, could you please clarify what is the impact on the specification? At least for PUSCH beam direction can be already controlled (e.g. by using codebook-based transmission).

2.1.3 Responses Round 2

Table 2: Responses to Round 2 questions on RWS-210069 ”UAS Connectivity over NR”

Power splitting in DC	ZTE asked about power splitting and the generated interference. Thank you for the question. The avoidance of power splitting should only be applied to the links requiring high reliability, i.e. the C2 link, which is a low throughput link (in rel 15 3GPP assumed 100 kbps). Therefore the increase in interference will be marginal and in our opinion acceptable in order to ensure the required reliability for UAVs.
Beamsteering	Intel asked about the use of directional antennas and impact to the specifications for beam selection. We would like to be able to cover different beam steering capabilities on UAVs, like for instance a grid of beams where we need to ensure the network still can control the direction, while also getting information about neighbouring cells in certain directions. We expect some (small) impact on the neighbour cell reporting and potential beam control.

2.2 RWS-210071 ”Further enhancements for IIoT/URLLC in Release 18”

Feedback Form 3: Comments and questions on RWS-210071

1 – Sony Europe B.V.

1) We agree that broadband (high capacity) URLLC is important in future 5G. In Slide 2, it is suggested that the throughput for broadband URLLC is 1-10 Mbps, which may be supported in Rel-17. Thought we just note that we are considering 160 Mbps for broadband URLLC (Ref: RWS-210304)
2) Why Rel-17 procedure of transmitting only 1 SPS/CG-PUSCH not sufficient in handling persistent SPS/CG collisions (Slide 5)?

2 – Classon Consulting

[for FUTUREWEI]

In addition to RAN-level activity, Rel-18 URLLC could define some basic FGs including mandatory support of some existing optional rel-15/16/17 features. Please see the proposals in RWS-210037 and https://nwm-trial.etsi.org/#/documents/4714 .

3 – vivo Communication Technology

Thanks Nokia for the FeIIOT/URLLC proposal. We have quite a few questions and comments as below

1. On P4, regarding “FR1-FR2 CA/DC to circumvent/avoid scheduling unavailability due to e.g. measurement gaps.” It looks to us that FR1 carrier can be used for urgent traffic scheduling during scheduling restricted duration of FR2 carrier, e.g. during SMTC, but would be good to know what functionality is missing from the current specification to support such scheduling?

2. On P4, regarding “Improvements leveraging multi-panel (FR2) UEs, e.g. leveraging simultaneous Tx/Rx capabilities to avoid unnecessary cancellation/dropping of deprioritized signals”, would be good to understand which of the following is meant?

a) Simultaneous receptions of channel/signals with different priorities by separate UE panels

b) Simultaneous transmissions of channel/signals with different priorities by separate UE panels

c) Simultaneous transmission by one UE panel and reception by another UE panel for channel/signals with different priorities in the same carrier frequency, which is similar as UE full duplex?

d) Simultaneous transmission by one UE panel on one frequency, and reception by another UE panel on a different frequency?

3. On P5, regarding "Improve SPS/CG operation efficiency to serve a UE with multiple periodic flows of different periodicities", could you clarify the improvements intended here?

4. As a general question, what is Nokia's view on the handling of overlapping enhancements for FeURLLC/IIOT with other topics (e.g. SPS/CG enhancements in XR, and DAPS improvements in mobility enhancement?)

5. Would be good to understand how to carry on the "URLLC UE profile" discussion in the work item, as usually work items are used to develop new features and UE profiling is more like a UE feature discussion which usually happen at the end of a release.

6. From our perspective, we think some enhancements for low latency high reliability in CA case would be useful, as proposed in our paper RWS-210167 (https://nwm-trial.etsi.org/#/documents/4690), we are proposing HARQ retransmisison across CCs, and repetitions across different CCs. Would be good to know what is Nokia's view on such enhancements.

4 – CATT

Thanks for the proposals. We have the following comments/questions.

1) What kind of enhancements are expected for improved FR2 PDSCH/PUSCH/PDCCH/PUCCH reliability using FR1 as 'anchor carrier'?

2) For multi-panel enhancements, is the proposal to support simultaneous transmissions of UL channels/signals with different priorities with different panels?

3) For SPS/CG enhancements, what kind of enhancements are expected for FR2-oriented enhancements for analog-beamforming operation where gNB transmits/receives on only one beam at a time?

4) Can you please elaborate what kind of enhancements do you have in mind for efficient handling of persistent CG/SPS collisions and for non-integer SPS/CG periodicities?

5) For non-integer SPS/CG periodicities, if the proposal is to support "N" in the formula as a non-integer as proposed in previous releases, we do not expect companies would change their mind.

6) Why do you think it necessary in Rel-18 to define URLLC UE "Classes"/"Profiles" focusing on Rel-15 (potentially Rel-16) UE capabilities?

7) For mobility enhancement, what kind of enhancement(s) need to be considered based on current DAPS?

5 – HuaWei Technologies Co.

We share similar views on defining URLLC UE profiles, and to consider the marketing need to have it in Rel-17 could be even better, do you have the same view?

For other aspects, do you think they are all URLLC specific, or rather general enhancements?

6 – Guangdong OPPO Mobile Telecom.

Q1: Do you want to support both "XR" and "R18 URLLC enhancement" ? Or what's the relationship between "XR" and "R18 URLLC"?

7 – Intel Corporation (UK) Ltd

Q1: The cited scenario of audio-visual production looks at the border of eMBB and URLLC, similar to XR. Do you think this scenario may be handled together with XR enhancements or separately as part of URLLC/IIOT?

Q2: Do you think inter-UE CG/SPS collisions could also be handled/enhanced in addition to the intra-UE collisions mentioned in objectives?

Q3: Support of the traffic not aligned with NR numerologies is also being discussed as part of XR. Similar to Q1, how would you organize inter-work with XR which has similar target issues?

8 – ROBERT BOSCH GmbH

[Bosch]: we support an efficient handling of persistent CG/SPS collisions. However, we have the following questions:

- Should handling be functional safety aware or (at least) survival time aware handling, i.e., as not produce trouble for safety traffic ?

Non integer SPS/CG periodicities:

- do you expect more adaptive SPS/CG or SPS/CG with one (or more) out of sequence transmission or using multiple configured grants?

9 – Apple Italia S.R.L.

Q1: For "FR1-FR2 CA/DC to circumvent/avoid scheduling unavailability due to e.g. measurement gaps", can you elaborate more on the potential enhancements?

Q2: For SPS/CG enhancements and mobility enhancements, what is your view on whether this should be handled in an IIoT/URLLC WI or the XR WI? It seems that Nokia also includes them (or similar enhancements) in the XR scope.

10 – III

Q1: For"Non integer SPS/CG periodicities", what are the benefits of supporting non integer SPS/CG periodicities on your view and what technical problems will encounter?

11 – Samsung Electronics Co.

1. What enhancements are envisioned for FR1 and FR2 CA/DC operation that are particular to URLLC?
2. What additional gains are expected for UEs with multi-panel Tx/Rx capability to avoid dropping deprioritized signals over the mechanisms specified in R17, and what are corresponding FR2-related deployment scenarios while considering that transmissions in FR2 can also be slot-based for URLLC?
3. For SPS/CG enhancements to support traffic with periodicity not aligned with 5G numerology, isn't XR a more appropriate use case?
4. What actions are needed/expected for defining URLLC UE categories/profiles?

12 – ZTE Corporation Questions to be clarified: 1) How to solve scheduling unavailability due to the gap of measurement, any details? 2) The "Improvements leveraging multi-panel (FR2)" needs clarification, does it mean the UE in FR2 could simultaneously Tx/Rx with different panels? 3) Is there any details on Spectral-efficient solutions to support traffic with periodicity not aligned with the 5G numerology? 4) For the enhancement of only 1 resource used in case of overlapping SPS/CG P(D,U)SCH, do you think UE/gNB could receive multiple overlapped SPS/CG with **FDM** in the same time?
13 – Qualcomm Incorporated What type of improvements for FR 2 are targeted? Namely, which specific limitation of single beam transmission is addressed and how is it solved?
14 – Asia Pacific Telecom co. Ltd [FGI/APT] Thanks for the nice contribution! We share the same views on enhancements on CA/DC and SPS/CG configuraitons. Q1: For page 4: As It seems that the combination of FR1 and FR2 is an allowed deployment for CA/DC configuration in current spec, could you elaborate more on what further improvements could be achieved in your example? Or could you help clarify what "improving FR2 PDSCH/PUSCH/PDCCH/PUCCH reliability using FR1 as anchor carrier" means in your example. Q2: For page 5: efficient handling of persistent CG/SPS collisions Do you mean that simultaneous reception of SPS PDSCH/transmission of CG PUSCH should be allowed or the current mechanism for handling the collision between SPS/CG resources should be improved by other conditions (except for using the lowest index)?

2.2.1 Responses

Table 3: Responses to questions on RWS-210071 "Further enhancements for IIoT/URLLC in Release 18"

Use cases and overall motivation	**As a general comment (incl. use cases, motivation),** as pointed out by several companies (e.g. vivo, Huawei, OPPO, Intel, Apple, Samsung) there could be some overlap with a potential R18 XR WI in terms of use cases & related enhancements which clearly should be avoided. Nokia does not have a strong opinion if related enhancements should be handled in a R18 URLLC/IIoT or R18 XR WI as long as the issues raised are being appropriately addressed in some Rel-18 WI.

Improved FR2 PDSCH/PUSCH/PDCCH/PUCCH reliability using FR1 as 'anchor carrier'	**On "FR1-FR2 CA/DC to circumvent/avoid scheduling unavailability due to e.g. measurement gaps"**, one example focus area could be on pre-configured resource allocation mechanisms, e.g. providing the UE with a fallback allocation in one carrier that is only used upon unavailability in another carrier due to e.g. a measurement gap where the UE is not able to transmit or receive any data. Another potential enhancement is to use the FR1 carrier to indicate from the UE to the gNB when the UE has transmitted on a FR2 PUSCH resource. This allows the gNB to quickly react to occasions when the UE has transmitted on a FR2 PUSCH resource (i.e. not skipped) but such transmission was not detected by the gNB due to e.g. beam blockage or challenging FR2 propagation in general.
Improvements leveraging multi panel (FR2) UEs	**On "Improvements leveraging multi panel (FR2) UEs"**, the focus is on the scenarios where UE is equipped with multiple antenna panels and more than one antenna panel are in "active" state which means panel switching can be done seamlessly without antenna panel switching delay. Depending on UE capability, in our view, it is best to consider both scenarios for one UE with multiple antenna panels: (1) simultaneous transmission or reception from different UE panels on the same carrier; and (2) only one panel can be used for transmission or reception at a specific time instance. Most likely, the involved signals are with different priority unless clear benefits can be identified for the cases with the same priority. This should address the questions from Vivo, CATT, Samsung and ZTE. In addition, we would like to point out that UE full duplex, i.e. transmission on one panel and simultaneous reception on another panel is not within the scope of our proposal (@Vivo). By leveraging advanced UE capabilities, it is expected that certain cancellation of low priority traffic due to overlapping with high priority traffic can be avoided considering different multiplexing/prioritization scenarios (inter-UE and intra-UE) (@Samsung).

SPS / CG enhancements for persistent CG / SPS collisions	**On SPS / CG enhancements for persistent CG / SPS collisions**, the main use case of interest is to efficiently serve a UE with multiple periodic flows of different periodicities where the traffic arrivals may conflict/overlap once in a while (see figure in slide 5). Especially in the UL direction, multiple CG configurations may be provided to the UE (e.g. each matching a different periodic traffic flow); however, it is up to the UE to (down-)select one PUSCH for transmission in case two or more CG PUSCHs overlap in time. For example, with respect to the figure in slide 5, even if a "large" UL PUSCH grant is made available to serve the simultaneous arrivals of traffic flows #1, #2 and #3 (rightmost case in the figure), the UE still may transmit on another (smaller) PUSCH and the gNB still needs to listen on each of the multiple overlapping PUSCHs. On the potential enhancements, we are not thinking of allowing simultaneous FDM-ed transmissions of multiple SPS/CG PDSCH/PUSCH (@ZTE), but instead to provide a more predictable way to use a larger PUSCH/PDSCH resource to carry the traffic of more than one traffic flow with colliding CG/SPS when needed. @Sony: The gNB, by implementation, could apply some smart CG PUSCH scheduling techniques at the cost of additional implementation complexity, e.g. multiple CG configurations to create interlaced PUSCH allocations matching the expected TB size at each time instant; however, it is still difficult to fully avoid overlapping PUSCH situations, which may require a large number of CG PUSCH configurations, and the number of PUSCH decoding attempts in the gNB would still remain high. For DL / SPS PDSCH, we think this is less of an issue since there are clear prioritization rules for overlapping PDSCH. Nevertheless, if improvements would be defined for UL CG, it could be considered to extend those to DL SPS as well when possible. On whether inter-UE CG/SPS collisions could also be handled/enhanced in addition to the intra-UE case (@Intel), we do not have a strong opinion (yet), but it would be nice to hear more from you on what specific problems and solutions you have in mind. @Bosch: we are mainly thinking of multiple traffic flows where all of them have similar importance. For considerations relating to survival time, we think it depends on Rel-17 outcome. We are open to possible enhancements considering survival time in Rel-18, but only if a need is identified.

SPS / CG enhancements for non-integer periodicities	**On SPS / CG enhancements for non-integer periodicities**, different solutions were discussed as part of the R16 IIoT WI, but no solutions were agreed. After that, similar needs were raised during the R17 XR SI. So, overall, we think there is now more awareness/justification for this enhancement in general. On the benefits (@III), the main goal is to avoid overprovisioning of SPS/CG resources or having to employ multiple SPS/CG configurations to serve the same traffic flow, see e.g. our analysis in R2-1907198, Section 5, showing that up to 6 CG configurations would be needed to efficiently serve a single 1200Hz traffic flow.
SPS / CG enhancements for analog beamforming, …	**On SPS / CG enhancements for analog beamforming**, due to the 1 beam at a time limitation, the gNB may sweep (TDMA-like) the Tx/Rx beam fully dynamically (and not following a very strict sequence) depending on the specific set of users that need to be served. Therefore, the CG/SPS periodicity may need to be selected in a conservative/worst-case manner (e.g. every 20 FR2 mini-slots, assuming 20 analog beams), but quite often it could be possible to schedule some of the UEs much more often (e.g. if some beams can be skipped due to there being no active UEs). This is more of an issue for UL CG; whereas for DL, dynamic PDSCH scheduling could be used in those 'extra' occasions. So, we think that it would be worth investigating solutions to enable utilization of additional (CG) PUSCH occasions outside the configured regular CG PUSCH periodicity. In addition, if there is a a beam change/switch needed for a UE, this means that at least the timing of the SPS / CG configurations needs to be re-aligned with the periodic occasions of the new serving beam by CG/SPS re-activation for Type 2 CG & SPS and re-configuration for Type 1 CG operation. Potentially, there may be even a need for a RRC re-configuration of the SPS/CG configurations (and re-activation) if some other parameters would need to be changed for the new serving beam. Therefore, after each beam switch there will be not just the beam switching delay but also a time when the SPS / CG operation will not be available which for URLLC type of services is not really an option. Therefore, it seems important to address the issue of SPS / CG operation with beam mobility in FR2.

URLLC UE classes	**On "URLLC UE classes / profiles"**, we would like to clarify that this activity is not proposed as part of a specific WID, but rather as a RAN-level activity, as it would not in itself define new features. Hence, this is not about the upcoming Rel-18 features, but about the existing features in the specifications. For example, we can define a TR where we list the features/-capabilities particularly impacting reliability and/or latency, potentially with an assessment of the type of impact. This would already provide more clarity. Regarding the overall motivation, as it can be seen in the related discussion in RAN#92-e, there is significant operator interest on such activity, and also from many vendors, because it is acknowledged that there is a lack of clarity on which features effectively contribute to reliability and latency, and it is difficult to a non-3GPP person to dig into the specifications and understand the implications of supporting a certain feature in the specifications. The reason to propose starting with Rel-15 features is because we are lacking a clear foundation that the industry can rely on, but we are happy to extend the discussion to further releases as the work progresses too. On the timeline for the work, indeed we would be happy to start this work as early as possible, even within Rel-17 timeframe if agreeable by 3GPP.
Mobility enhancements	**For mobility enhancements**, we think this should be best handled in a mobility-specific WI, but we included it anyway in this proposal as zero handover interruption time is clearly an essential aspect of IIoT/URLLC. The mobility enhancements for Rel. 18 are summarized in RWS 210078. Among other objectives, at least the following would be relevant for IIoT/URLLC 1) specifying a solution to reduce the interruption time in FR2-FR2 handover close to 0ms, 2) reducing end-to-end UL delay in DAPS and 3) inter-working of CHO and DAPS to achieve both mobility robustness and small interruption time (or high reliability).

2.2.2 Questions Round 2

Feedback Form 4: Round 2 questions on RWS-210071 "Further enhancements for IIoT/URLLC in Release 18"

1 – vivo Communication Technology

Thanks for your reply. We have some additional questions

On "FR1-FR2 CA/DC to circumvent/avoid scheduling unavailability due to e.g. measurement gaps

Regarding the potential solution mentioned, i.e. "providing the UE with a fallback allocation in one carrier that is only used upon unavailability in another carrier due to e.g. a measurement gap where the UE is not able to transmit or receive any data." It seems to us the current specification can allows such operation in CA case already (e.g. gNB can schedule data or configure CG occasion on another carrier as "fallback" resource), could you comment on what do you think is missing from current spec?

On "use the FR1 carrier to indicate from the UE to the gNB when the UE has transmitted on a FR2 PUSCH resource.,

Is the intention to reduce the gNB blind detection due to PUSCH skipping on FR2?

2 – Classon Consulting

[for FUTUREWEI]

We understand your proposal, and while we are not supportive of introducing UE categories in NR we would not be opposed to a RAN-level study of URLLC features. However, as you can see from the Rel-16 and Rel-17 RAN level discussions, some companies remain firmly against profiling activities in RAN. What has worked to some degree, however, is using basic feature discussions to better set highest level FG components and pre-requisites. The pre-requisites can be related to a scenario (see e.g. NRU) and not necessarily a strict functional necessity, and they can be from any release. Essentially, if you can bring in enough support for certain rel-15 FGs into the current release FG discussions, you could make some of those existing FGs pre-requisites when a related new feature is standardized. For example, if you have a new reliability or latency feature then you could make an existing reliability or latency feature a pre-requisite. We understand this isn't really what you are looking to do, but it could be a step in that direction and help the adoption of existing features as new ones are developed.

3 – CATT

Thanks for your reply. We have two follow-up questions for clarification.

1) On "providing the UE with a fallback allocation in one carrier that is only used upon unavailability in another carrier" do you support HARQ retransmission of a TB in a different carrier from the carrier of initial transmission?

2) On SPS / CG enhancements for non-integer periodicities, as you clarified, the intention is to provide a more predictable way to use a larger PUSCH/PDSCH resource to carry the traffic of more than one traffic flow with colliding CG/SPS when needed. Can you clarify how to allocate a larger PUSCH/PDSCH resource to the UE in your mind?

4 – Intel Corporation (UK) Ltd

Further Q/Comment: For inter-UE CG/SPS collision, we mainly refer to the issues of consecutive packet dropping when persistent CG/SPS interference exists between cells/UEs (RWS-210377). In this case the communication service availability (CSA) for non-zero survival times may suffer the probability of consecutive packet errors. If the collisions of CG/SPS configuration can be randomized, improvement of CSA is expected.

5 – China Unicom

Thanks for your contribution. Relating to URLLC UE classes, we fully support the motivation to have a full picture and capability of URLLC features. If time is allowed, we think this work should be started as soon as

possible. However there are number of URLLC features especially for R15 and R16, the discussion will not be easy. And for each particular feature, we also wonder if all companies have common understanding on the performance of reliability and/or latency. In your opinion, how to start the work or what's the efficient way to discuss URLLC UE classes?

2.2.3 Responses Round 2

Table 4: Responses to Round 2 questions on RWS-210071 "Further enhancements for IIoT/URLLC in Release 18"

Response to vivo	Thanks vivo for the follow up. Regarding the first question on **"FR1-FR2 CA/DC to circumvent/avoid scheduling unavailability due to e.g. measurement gaps"**, it is correct that CG occasions can be provided on both a first and a second carrier, e.g. in FR1 and FR2, respectively. Nevertheless, we see the following problems: i) The UE, by default, is free to decide whether to transmit on the CG resources on the first and/or second carrier. This means that gNB would need to still do blind decoding on the PUSCH resources on both carriers/cells (even though only a few of the PUSCHsd may be used by the UE). More importantly, if there are multiple URLLC/IIoT UEs to be served simultaneously on both carriers, the FR1 carrier will quickly get congested and become the bottleneck (especially considering 'high-throughput' URLLC use cases). Since the events that result in scheduling unavailability are well defined in TS 38.133, we think it is beneficial to have some clearly defined rules that some resources (e.g. in FR1 cell) may only be used when there is certain scheduling unavailability in another cell. This reduces unnecessary blind decoding and keeps the load in the FR1 carrier more under control. On **"use the FR1 carrier to indicate from the UE to the gNB when the UE has transmitted on a FR2 PUSCH resource"**, the indication is not necessarily a priori but a posteriori with the main goal to deal with false-DRX detections at gNB. For example, to allow gNB to quickly react (e.g. by triggering HARQ re-transmission) to occasions when the UE has transmitted on a FR2 PUSCH resource (i.e. not skipped) but such transmission was not detected by the gNB due to e.g. beam blockage or challenging FR2 propagation in general.

Response to Futurewei	**On URLLC UE classes / profiles**, we are in general favourable to extend further the use of the concept of basic feature groups, and we hope this is continued in Rel-17 as well. However, there are so many flavours of URLLC that it might be very difficult to converge to a meaningful set, and this has been the main difficulty in the past. We see those as complementary approaches, and we are open to discuss it further.
Response to CATT	Thanks for the follow up. With respect to question 1 on **"providing the UE with a fallback allocation in one carrier that is only used upon unavailability in another carrier"**, we had been mainly thinking about the initial transmission opportunities there with respect to SPS/CG operation to limit the impact on MAC and UE & gNB complexity. HARQ re-transmission on another CC as discussed in some other companies' proposals will have a large impact to MAC operation as well as UE & gNB complexity. With respect to question 2, first of all, we understand that the question is related to '**persistent CG/SPS collisions**' and not 'non-integer periodicities'; if this is correct, one solution we have in mind is to define a new 'conditional' CG/SPS allocation that takes place whenever there is overlap in time of two or more other CG/SPS PUSCH/PDSCH resources. For instance, with respect to the figure in RWS-210071, the gNB could configure one conditional resource that would be used/prioritized when there is collision of the CG/SPS resources of traffic flows #2 and #3, and a second (larger) conditional resource that would be used when there is collision of the CG/SPS resources carrying traffic flows #1, #2 and #3.
Response to Intel	Thanks for the clarifications on **Inter-UE CG/SPS collisions**. Don't you think that randomization of the CG/SPS resources, e.g. frequency hopping-like, to avoid persistent CG/SPS interference could already be achieved using multiple SPS/CG configurations?
Response to China Unicom	On **URLLC UE classes/profiles**, perhaps the very first step is to discriminate the features that contribute to latency and reliability, without ranking them in terms of importance. That would increase transparency and improve communications outside 3GPP, while avoiding the most difficult aspects of the discussion.

2.3 RWS-210072 "Sidelink Enhancements for Rel-18"

Feedback Form 5: Comments and questions on RWS-210072

1 – Classon Consulting

FUTUREWEI also supports sidelink FR2 and unlicensed enhancements, see RWS-210039 and https://nwm-trial.etsi.org/#/documents/4714 . Do you feel that the sidelink enhancements for FR2 should include work on CSI feedback?

2 – LG Electronics Inc.

Q1: We understand most objectives under ”enhancement of relay link management” in slide 2 are being specified in Rel-17 (like relay discovery and selection, link establishment and configuration based on QoS, resource allocation for relay discovery and communication). Do you propose additional enhancement on top of Rel-17 design? If so, can you describe potential enhancements?

Q2: Can you elaborate on the enable the combined use of licensed and unlicensed carriers? In particular, which out of Uu and sidelink will be used for the control plane in the example?

3 – HuaWei Technologies Co.

Please could you clarify what reliability enhancement you have in mind for inter-UE coordination?

4 – Intel Corporation (UK) Ltd

[Q1] Relay Use Case: Please clarify whether you assume that Rel.16/17 resource allocation framewrok should be used as a baseline or you consider new framework for relay use case?

[Q2] Considering CSI framework for Uu URLLC and sidelink V2X was somewhat controvercial topic, could you please clarify in which use case CSI framework is considered important and what kind of CSI feedback do you have in mind (whether it is to cope with interference or channel characteristics, etc.)?

5 – ROBERT BOSCH GmbH

[Bosch]:

Q1: Do you support SL in IIoT/URLLC use cases? If yes, what enhancement is missing on the top of Rel-17 SL?

6 – CATT

Do you consider unlicensed sidelink as a separate WI or do you want to have this topic combined with other sidelink enhancement?

7 – Qualcomm Incorporated

What is Nokia’s view on video streaming for infotainment in addition to video for rear view camera?

8 – Samsung Electronics Co.

Q1: Is it the correct understanding that the proposal of sidelink unlicensed enhancements targets both 5/6 GHz and 60 GHz unlicensed bands?

Q2: How unlicensed technologies can meet the strict requirement in factory automation?

Q3: Are the objectives on slide 2 for both SL U2U relay and SL U2N relay enhancement?

Q4: Regarding joint handover of relay and remote UE, is this objective about group mobility?

2.3.1 Responses

Table 5: Responses to questions on RWS-210072 ”Sidelink Enhancements for Rel-18”

Targeted use cases	IIoT use cases are among the targeted use cases (requiring further enhancement on SL reliability via e.g. inter-UE coordination enhancement or other SL resource allocation enhancement). In-vehicle infotainment is also considered as one targeted use case (SL-U is good solution for this use case).
Scope of FR2 and 60 GHz enhancement	CSI enhancement should be part of the beam management feature if FR2 is in the scope of SL enhancements in Rel-18.
Scope of unlicensed sidelink	For SL unlicensed operation the first targeted bands should be 5/6 GHz as we can leverage the existing FR1 SL design. If operation in 60 GHz were to be considered, it would require beam management and regulation requirements to be taken into account.
Joint use of licensed and unlicensed spectrum	The joint use of licensed and unlicensed spectrum can be considered for resource allocation Mode 1 and/or Mode 2. In Mode 1, the NW would be in charge of the allocation in both licensed and unlicensed spectrum. In Mode 2, the resource selection procedure would have to occur at both licensed and unlicensed carriers. We expect that there is a benefit of utilizing the licensed spectrum for the exchange of control information, e.g. in Mode 1 the resource requests for unlicensed carrier resources can be made via the licensed carrier.
CSI in unlicensed spectrum	The SL CSI reporting procedure when operating in unlicensed spectrum needs to consider any LBT induced failures. The same observation is applicable to all SL physical layer procedures.

scope of SL relay enhancements	Enhancements on SL relay discovery, selection, link management, resource allocation etc. are for support of U2U relay and multi-hop relay, e.g. link management and relay switch based on HARQ feedback, and topology related resource allocation to support multiple-hop relay for tracking applications. The Rel16/17 SL features should be used as baseline to make the necessary enhancements. Joint handover of relay and remote UEs can be considered as group handover. Common enhancements for U2N and U2U should be pursued whenever possible.
Inter-UE coordination enhancement for high reliability	Potential enhancements may include e.g. reliability enhancement on coordination procedure and/or signaling exchange, and coordination signaling overhead reduction. This can be used to enhance the support of IIoT/URLLC use cases. Inter-UE coordination should also be extended to unlicensed spectrum in order to enable high reliability.

2.3.2 Questions Round 2

Feedback Form 6: Round 2 questions on RWS-210072 ”Sidelink Enhancements for Rel-18”

1 – ROBERT BOSCH GmbH

Thank you for your answers. In SL enhancements, do you consider leftovers from R16/17, e.g.:

- carrier aggregation
- Mode 1/Mode 2 cooperation (if yes, how to operate them simultaneously ?)
- HARQ enhancements (joint blind and feedback-base)? if yes, how do consider backward compatibility to old releases (16/17)?

2 – HuaWei Technologies Co.

For SL relay, do you have any priority on which to be supported in Rel-18? Does multi-hop relay mainly applies to U2N relay, or it also applies to U2U relay?

3 – Intel Corporation (UK) Ltd

Q1: Thanks for responses. Let us further clarify your view on FR2 sidelink. Given that IIoT was considered as a target use case for sidelink evolution and Uu IIoT design was mainly focusing on FR1 considering conditional responses on FR2 sidelink enhancements, it seems sidelink optimizations for FR2 is not considered as a high priority sidelink feature from Nokia side. Is that correct understanding?

Q2: Resource allocation enhancements were mentioned for sidelink relay support. Could you clarify what gaps do you see and whether incremental enhancement to mode-1/mode-2 are considered sufficient or new sidelink mode resource allocation mode (e.g. scheduling UE) is needed?

2.3.3 Responses Round 2

Table 6: Responses to Round 2 questions on RWS-210072 ”Sidelink Enhancements for Rel-18”

Sidelink carrier aggregation (response to Bosch)	We are open to discuss this enhancement.
Sidelink mode 1/2 cooperation (response to Bosch)	We are open to discuss this enhancement.
Sidelink HARQ enhancements (response to Bosch)	We are open to discuss this enhancement. For mixing blind and feedback-based HARQ ReTX, we don’t think there should be a backward compatibility issue; according to our reading of TS 38.321 section 5.22.2.2.2, a legacy RX UE will send HARQ feedback according to the corresponding flag in the 2nd stage SCI, so there should be no ambiguity about the behaviour of the RX UE if the TX UE mixed blind and feedback-based.
SL relay (response to Huawei and Intel)	SL multi hop relay in Rel. 18 should include both U2N relay and U2U relay. For resource allocation enhancements, joint mode 1 and mode 2 could be one option but also Uu and PC5 joint operation could be considered.
FR2 (response to Intel)	We are open to considering FR2 if there is need, but we do note that 5GAA has deprioritized it from their perspective.

2.4 RWS-210073 ”Sidelink Positioning for Rel-18”

Feedback Form 7: Comments and questions on RWS-210073

1 – CATT

We have the similar views with Nokia on the SL use cases and SI/WI objectives.

In RWS-210117, Nokia has proposed NR carrier-phase positioning for R18. What is Nokia's view of using NR carrier-phase measurements for SL positioning? In our view, NR carrier-phase positioning for R18 may have specially application for SL positioning. For example, once one UE is phase-locked to another UE, any changes of the relative between the two UEs can be monitored precisely from the change of the carrier phase measurements even without the need to resolve the integer ambiguity. What is Nokia's view on supporting SL carrier-phase positioning?

2 – Beijing Xiaomi Mobile Software

1. Do you think the commercial and public safety use cases and requirements identified in SA1 Ranging WI(TR22.855/TS22.261) should be taken into account?

2. According to the definition and the KPI requirements of relative positioning and ranging in TS22.261(see below), do you agree that relative positioning and ranging are different, i.e. relative positioning requires to acquire the 2D/3D coordinates(e.g. the horizontal accuracy of relative positioning set requirements on both distance accuracy and angle accuracy) while Ranging requires to acquire only one component of 2D/3D coordinates(either distance or angle) and thereby only set requirements on one component(either distance or angle)?

- relative positioning: relative positioning is to estimate position relatively to other network elements or relatively to other UEs.

- Ranging: refers to the determination of the distance between two UEs and/or the direction of one UE from the other one via direct communication connection.

3. Do you think unlicensed band should be considered? If so, what frequency range is considered(e.g. 60GHz)?

4. What bandwidth do you think is needed to acheive 10cm distance accuracy and 2 degree angle accuracy?

5. For in coverage case, do you think UE based SL-positioning should also be supported?

6. Do you think power consumption and Redcap UE should be taken into account?

3 – Huawei Tech.(UK) Co.. Ltd

Q1: Does the categorization imply that absolute SL positioning and relative SL positioning should be "device-based SL positioning"? We wonder if the three bullets are mutually exclusive.

Q2: Are there changes intended to LCS architecture etc?

4 – Guangdong OPPO Mobile Telecom.

1. SL positioning for commercial use cases can be also useful/beneficial.

2. SL relative positioning in in/partial coverage is also necessary.

5 – Sony Europe B.V.

We have a similar view on the need of sidelink positioning in Rel-18 as indicated in our contribution RWS-210301.

1) On sidelink-assisted, would you only consider gNB to receive measurement and forward to LS?

Would you also consider the case where gNB/TRP transmits PRS and the UE utilise this reference signal(s) together with the sidelink reference signal(s) from other UE for the UE-based positioning?

6 – InterDigital Communications Does UE-assisted/based positioning apply to all sidelink positioning types (i.e., absolute/relative/assisted sidelink positioning)?
7 – Intel Corporation (UK) Ltd [Q1]: Since the spectrum considerations are important for sidelink positioning framework, please clarify your views on spectrum applicable for NR sidelink positioning.
8 – ROBERT BOSCH GmbH [Bosch]:
- Q1: Do you support sidelink (relative, ranging) positioning in in-coverage and partial coverage or only ”Sidelink Assisted” positioning (as described in 3) ?
- Q2: If your answer to Q1 is ”Sidelink Assisted” positioning? would you like to force all ranging over radio to be only conducted in upper layers (e.g., utilizing V2X cooperative positioning messages only like CPM, LCM, etc.)?

2.4.1 Responses

Table 7: Responses to questions on RWS-210073 ”Sidelink Positioning for Rel-18”

Architecture	No changes to LCS architecture are expected. The gNB is expected to receive UE-assisted measurements (in Mode 1) and forward them to LS.
Targeted use cases	Use cases in Rel-18 should be focused on Public Safety and V2X. In general, the specification should be flexible to allow other use cases as well.
Scenarios	Out-of-coverage scenario supporting relative Sidelink positioning in transmission Mode 2 is the baseline. Both UE-based and UE-assisted methods could be supported for absolute and relative Sidelink positioning in in-coverage scenarios. In Sidelink transmission Mode 1, the network would control the resource allocation and the Sidelink positioning can be UE-based or UE-assisted. Sidelink positioning can use hybrid Uu+PC5 positioning approach where gNB is transmitting PRS and UEs also receive Sidelink reference signals from other UEs. Hybrid positioning methods should be supported after the baseline positioning methods are available.

Sidelink positioning and ranging	In our view, ranging refers to distance between UEs or between a UE and a network element, while relative positioning can additionally acquire azimuth and elevation angle (2D/3D) positioning information. The usage and applicability of ranging or relative positioning to other network elements or UEs depends on the coverage scenario (out, in, partial) and use case (e.g. V2X). Ranging over radio in co-operative V2X cases should not be limited only to upper layers. Carrier phase-based positioning is suitable also for Sidelink positioning. We expect that integer ambiguity resolution would be needed if applying carrier phase methods for relative positioning or ranging.
Spectrum	Sidelink positioning should follow the same spectrum usage and principles as Sidelink Enhancements for Rel-18.
Others	Power consumption is important but RedCap and Sidelink positioning should be handled in different topics.

2.4.2 Questions Round 2

Feedback Form 8: Round 2 questions on RWS-210073 ”Sidelink Positioning for Rel-18”

1 – Beijing Xiaomi Mobile Software

1. As you clarified that”ranging refers to distance between UEs or between a UE and a network element”, however, TS22.261 clearly defines ranging as distance and/or direction between UEs. We would like understand If it is better to adopt the SA1 definition in order to have a unified understanding.

2. As you clarified that ”RedCap and Sidelink positioning should be handled in different topics”, we would like to understand where do you think to address the support of RedCap UE for sidelink positioning?

2 – Guangdong OPPO Mobile Telecom.

Thanks for the response. It is mentioned by Nokia that ”Sidelink positioning should follow the same spectrum usage and principles as Sidelink Enhancements for Rel-18.”. For SL-PRS transmission, does it need to be integrated as part of existing SL frame/slot structure? Or is the transmission of SL-PRS is suppose to be done independent to the normal SL transmission? I assume they are independent to each other since SL-PRS needs to be transmitted over wideband and normal SL transmission could occupy only a few sub-channels. Therefore, the transmission timing and resource allocation for SL-PRS transmissions would be very different to the normal SL. Additionally, in our understanding, the normal SL could be operating in a licensed carrier while the SL positioning could be in an unlicensed one. Do you also assume the same?

3 – Intel Corporation (UK) Ltd

Q1: Considering your view that "sidelink positioning should follow the same spectrum usage and principles as Sidelink Enhancements for Rel-18" and interest in sidelink support in unlicensed spectrum, do you think that NR Uu based positioning should also include support for unlicensed spectrum?

2.4.3 Responses Round 2

Table 8: Responses to Round 2 questions on RWS-210073 "Sidelink Positioning for Rel-18"

1 –Xiaomi	1) Exact scope of ranging and relative positioning can be defined as part of the WID. The SA1 definition is OK. 2) RedCap Positioning in general could be handled for example in Further NR Positioning Enhancements since the RedCap positioning methods may be using Rel-17 positioning as the baseline. If RedCap UEs should also support sidelink positioning, then any RedCap-specific adaptations of sidelink positioning should probably be taken into account wherever sidelink positioning in general is covered.
2 – Guangdong OPPO Mobile Telecom	That's right. Existing SL is optimized for communication and SL-PRS transmission should allow wideband transmission, and could also utilize unlicensed spectrum.
3 – Intel	We did propose NR Uu based positioning support in unlicensed spectrum in Rel-17, but we no longer see that as a high priority at the moment.

2.5 RWS-210115 "Resilient timing via 5G in Rel-18"

Feedback Form 9: Comments and questions on RWS-210115

1 – Intel Corporation (UK) Ltd

Q1: Do you think the need for further enhancements needs to be studied first or it can proceed to normative phase directly?

Q2: Do you expect further PHY layer enhancements would be required or it can build upon what is specified in Rel-17 for propagation delay compensation?

Q3: How would you handle the increased overhead for accurate PD estimation due to unicast exchange with multiple UEs, compared to broadcast signals for Rel-16 mechanisms?

Q4:It was understood that there was proposed SA2 SID to support 5GS Timing Resiliency. Does the RAN work related to timing resilience depend on SA2 progress (if SA2 SID is approved)?

2.5.1 Responses

Table 9: Responses to questions on RWS-210115 ”Resilient timing via 5G in Rel-18”

On the need for a study phase	A demanding scenario is a wide-area smart grid (possible rural) where we should provide UTC time to UEs with 250ns E2E accuracy. A study phase might be needed to determine whether the Rel-17 specified PDC method is sufficiently accurate in this scenario in potentially challenging radio conditions for the UE and, if not, what enhancements are needed. Such a study will also need to consider other time synchronization error factors such as mobility and asymmetry.
Predicted PHY layer enhancements relative to Rel-17 PDC	We predict that we will need an Rx-Tx based PDC method in Rel-18, and if it gets introduced in Rel-17, we should study if the procedure is sufficiently accurate for the most demanding use cases. If it isn’t, we should consider what enhancements are needed.

PDC scalability	The lowest overhead solution is clearly to utilize UE based PDC and legacy TA. We should stick to UE based PDC, but we have to consider Rx-Tx based PDC to increase PD estimation accuracy. The baseline Rx-Tx procedure (subject to Rel-17 progress) could incur quite a high overhead, and hence we should study overhead reduction techniques for an Rx-Tx based PDC. Examples could be: - specifying the use of broadcast DL signals to trigger measurements at the UE. - looking at how the UE can assist with relevant measurement data such that we avoid updating PD if it is not needed. - utilizing the NG-RAN budget for optimizing the PD update rate.
Dependency on SA2	The RAN and SA work is closely related, but the RAN impacts are not dependent on SA2 Rel-18 progress. The main impacts to RAN relate to achieving the accuracy for demanding wide-area use-cases and giving the network control over the achieved accuracy level (see above). It is unclear if the SA2 work will trigger additional RAN level impacts related to the SA features of Timing Resiliency System (TRS) or if TRS will be transparent to RAN.

2.5.2 Questions Round 2

Feedback Form 10: Round 2 questions on RWS-210115 "Resilient timing via 5G in Rel-18"

1 – Fujitsu Limited

Thanks for the contribution.

It is mentioned to specify the impact from asymmetry to propagation delay compensation and compensation techniques. Which part of asymmetry do you consider, only Uu or overall RAN (e.g. including F1 interface)?

2 – CATT

Comments (Round 2):

If NR carrier-phase measurements are used to calculate directly the absolute/relative positions, we would agree that there is a need to resolve the integer ambiguity. In the example of our previous comment, we refer to the use of the changes of the carrier-phase measurements to monitor the change of the relative position between UEs.

Questions (Round 2):

About the LCS architecture, Nokia says: "No changes to LCS architecture are expected. The gNB is expected to receive UE-assisted measurements (in Mode 1) and forward them to LS":

Q1: Is the statement "No changes to LCS architecture are expected" only applicable for in-coverage scenarios? For partial- and out-coverage, are we expecting some changes in LCS architecture, e.g., support distributed positioning where UEs may exchange their positioning information (including the measurements) with each other, and each UE may calculate its own location?

2.5.3 Responses Round 2

Table 10: Responses to Round 2 questions on RWS-210115 "Resilient timing via 5G in Rel-18"

On the impact from asymmetry to propagation delay compensation	Thank you very much for the question. We have only considered the asymmetry error over the air interface. It is our assumption that the error due to asymmetry over the F1 interface will not influence PDC as the PDC procedure and reference points are at the air interface. It can, however, influence the uncertainty of the SFN timestamping relative to the transmitted DL frame timing. Despite this, F1 asymmetry has no direct impact on the PDC procedure.

2.6 RWS-210116 "RedCap / NR-Light enhancements in Rel-18"

Feedback Form 11: Comments and questions on RWS-210116

1 – Classon Consulting

FUTUREWEI supports studying redcap positioning, but should be in positioning not redcap.
Additional coverage may be achieved by mandatory support of some existing optional rel-15/16/17 features.
Please see the proposals in RWS-210037 and https://nwm-trial.etsi.org/#/documents/4714 .

2 – vivo Communication Technology

Thanks for Nokia's contribution. We are very supportive on eRedCap WI in Rel-18. Some questions:

1. Regarding cost reduction, in order to achive comparable data rate and cost as LTE Cat 1bis, do you think UE RF BW reduction (e.g. to 5MHz) is a must? or we can keep the 20MHz UE BW but reduce the baseband capability such as TBS/RB resctriction, reduced number of HARQ processes, relaxed processing timeline, etc.

2. for power saving, could you clarify the potential spec change to enable the narrowband DL monitoring on top of Rel-17? And do you think further RRM relaxation such as serving cell RRM relaxation can be considered for stationary devices?

3 for redcap positioning, what technique do you have in mind to ensure high accuracy with significantly reduced UE BW?

4 for coverage recovery, could you explain how the 10dB MCL improvement target is derived?

3 – Huawei Tech.(UK) Co.. Ltd

1. For the proposal on improved SDT for RedCap, what are the specific issues for RedCap?
2. For the proposal on positioning, high accuracy is mentioned. What accuracy level is targeted for RedCap?

4 – Guangdong OPPO Mobile Telecom.

What is the issue solved by the ACK/NACK bundling of HD-FDD UE and how the throughput can be improved?

5 – MediaTek Inc.

Thank you for sharing your views. We share your view that accurate positioning should be supported by RedCap. However, we prefer that this topic is discussed in an associated work item to have all the relevant experts in the same room.

We also had the following questions:

Q1: As highlighted by 3GPP in the Rel-17 discussions, economies of scale is an important factor for reducing cost. What new use-cases do you consider here that require a lower bandwidth device, and has the impact of market fragmentation been taken into consideration when suggesting a different BW from Rel-17 RedCap? Also have the limited cost benefits associated with lower bandwidths as outlined in RWS-210313 and RWS-210409 been considered?

Q2: What new usecase(s) do you foresee for an MCL increase of 10dB? From Rel-17 evaluations, UL and DL coverage is asymmetric. So is the MCL increase targeted at a specific physical channel (e.g. PUSCH), or for both DL and UL?

6 – Ericsson LM

Regarding further reduced UE bandwidth (RWS-210116), we would like to ask what potential UE cost reduction you expect from reduction from 20 MHz to 5-10 MHz? The estimates from CATT (RWS-210409) and Ericsson (RWS-210313) indicate that according to the established cost evaluation methodology (TR 38.875), there may not be a very significant further cost reduction compared to 20 MHz.

7 – Intel Corporation (UK) Ltd

Q: Are the additional CE for RedCap only for coverage recovery for DL (from further BW reduction from 20 MHz) or applicable to UL as well? To avoid overlap with LPWA, it may be better to limit CE enh. for 5MHz RedCap UEs only for DL coverage recovery. For UL, additional coverage recovery may only be considered if lower UL power class(es) are introduced.

8 – ROBERT BOSCH GmbH

[Bosch]: RedCap enhancements: due support RedCap to include sidelink ? If no, why? What do you envisage for reduced capability/micro mobility devices (e.g., eBike) with Uu and Sidelink ?

9 – Lenovo (Beijing) Ltd

Thanks Nokia for the nice contribution. In general we have similar view to introduce lower cost/complexity RedCap UEs in Rel.18. One question is if you support also cost/complexity reduction in FR2, if so, what's the target BW to be supported? Another question for clarification, the coverage recovery is for both lower BW RedCap UEs (in Rel.18) and RedCap UEs with Rel.17 defined BW, correct?

10 – CATT

Thanks for the contribution. We have the following comments/questions.

1. Further cost reduction due to reduced BW seems small but lead to market fragmentation and potential impact on initial access. How much cost/complexity reduction is expected by BW reduction smaller than 20MHz based on your evaluation?

2. If the UE BW is reduced to 5MHz, SSB with 30kHz SCS cannot be accommodated within 5MHz BW. Then there will be big spec/implementation impact. Otherwise if 30kHz SCS SSB is not supported, the usefulness in the real deployment is quite limited.

3. Relaxed processing time was dropped in Rel-17 due to marginal cost reduction but significant negative impact to network. What additional justification is found to pursue this in Rel-18?

4. Have you evaluated the performance impact of narrowband monitoring and measurement?

5. What kind of enhancements do you have in mind for SDT enhancement for RedCap?

6. We support RedCap positioning in Rel-18 which can be included in the positioning item.

7. By default, Rel-17 RedCap supports current coverage enhancement techniques, and no need for coverage recovery dedicated for RedCap in Rel-17. Is there any new motivation for RedCap coverage enhancement in Rel-18?

11 – Qualcomm Incorporated

1) could you elaborate why target 10 dB for coverage enhancement of eRedCap UE?
2) do you think coverage enhancement should include both DL and UL ?
3) do you think Type-B HD-FDD can be considered in R18 for eRedCap UE with reduced BW/cost ?

12 – Guangdong OPPO Mobile Telecom.

One more question from us:

For power-efficient beam management, does it intend to reuse relaxing UE measurements for RLM and/or BFD in R17 Power saving WI, or some enhancement are needed?

13 – LG Electronics Inc.

Thanks for the contribution.

Q1) Regarding the objective on positioning, low-complexity, low-power positioning seems to be somehow contradictory to the high accuracy positioning. Is your proposal mainly intended for high accuracy or low cost/complexity? Or still believe both can be achieved?

14 – Samsung Electronics Co.

Why 10dB MCL increase is needed for coverage enhancement? Do you propose to enhance both DL and UL?

15 – Apple Poland Sp. z.o.o.

<Apple>

Thanks for the contribution.

1) On 'Improved power consumption', could you please elaborate a bit on 'narrowband monitoring and measurement'? For NR, the frequency-domain resource of CORESET for PDCCH monitoring is configurable already. In addition, the RB number of CSI-RS can be configured to be fraction of the bandwidth of BWP. In addition, what are further enhancement on 'MO/SDT' for Redcap UE on top of Rel-17 scheme?

2) On 'High data rate', could you please clarify what is the use case in your mind? Is ACK/NACK bundling motivated by UL coverage enhancement?

16 – Sony Europe B.V.

Comments / questions on slide 2:

- complexity : The R17 study determined that 20MHz BW was a sweetspot for UE redcap bandwidth capability. What percentage further complexity reduction do you expect with a 5/10MHz UE bandwidth?
- positioning: Would you consider accuracy enhancements to compensate the reduced bandwidth (which may degrade the accuracy)?
- LPWA. The slides target complexity reduction, power consumption reduction and coverage extension (by 10dB MCL). They also say "not targeting LPWA". How are these statements compatible? What is the difference between (1) a complexity reduced/low power consumption/coverage extended redcap device and (2) an LPWA device?

2.6.1 Responses

Table 11: Responses to questions on RWS-210116 "RedCap / NR-Light enhancements in Rel-18"

Lower-complexity device (reply to vivo [2], MediaTek [5], Ericsson [6], Lenovo [9], CATT [10], Sony [16])	The intended use cases for a very low complexity device are similar to that of Rel-17 but addressing the lower end of the Rel-17 requirements. There are a significant number of mid-range IoT applications (industrial sensors, wearables, videos, telematics/fleet management, industrial gateways/routers, etc.) that only require data rates in the order of few Mbps. Therefore, these applications can benefit from further device cost reduction. Our understanding of the complexity analysis in RWS-210313 and RWS-210409 is that only bandwidth reduction was considered and therefore the saving was rather limited. Our analysis in RWS-210116 shows that complexity reduction in the order of 71% compared to the reference NR device defined in 38.875 can be achieved using a combination of techniques considered in Rel-17 (e.g. bandwidth reduction, TBS limitation, reduced number of HARQ processes, relaxed modulation, etc.). This is a significant reduction compared to Rel-17 RedCap device. Currently, we do not see the need to support Type B HDD for the very low complexity device. We feel that reducing the device bandwidth is an important aspect for very low complexity devices. In addition to cost saving, reducing device bandwidth is also beneficial in term of power consumption. For 30kHz SCS, there are various methods of supporting it that could be considered, but this needs further investigation.
Improved power consumption (reply to vivo [2], CATT [10], OPPO [12], Apple [15])	On narrowband monitoring and measurement, we feel that the existing specification provides a good starting point but potential optimization e.g. in switching time, frequency hopping, scheduling, etc. can be beneficial. In our view, additional measurement relaxations, e.g. for stationary devices, can also be considered for improved power consumption.

SDT (reply to Huawei [3], CATT [10], Apple [15])	Currently it is not clear whether Rel-17 SDT can be implemented by RedCap devices. It would be good to check after the Rel-17 SDT is specified whether it can be implemented by RedCap devices and consider what kind of changes, if any, may be required. Also, further enhancements such as Mobile Terminated SDT could be considered for RedCap. MT-triggered SDT is covered in our proposal RWS-210080: Small Data transmission Enhancements for Rel-18.
Positioning (reply to FUTUREWEI [1], vivo [2], HW [3], LG [13], Sony [16])	For low-complexity, low-power positioning, our intention is to study and specify positioning enhancements that are suitable for RedCap devices (i.e. techniques targeting low complexity and low power consumption) but can still provide reasonably high level of accuracy. The accuracy requirements targeted for RedCap use cases can be studied. Enhancements to currently specified techniques (e.g., UL-TDOA and UL-AoA) which achieve these goals can be considered as higher priority. We tend to agree with companies' suggestions that this should be part of a positioning WI; we just included it here for the sake of completeness.
Coverage enhancement (reply to vivo [2], MediaTek [5], Intel [7], CATT [10], Qualcomm [11], Samsung [14], Sony [15])	On coverage enhancement, the proposal is to enhance cell coverage (e.g. based on MIL of the limiting channel) for RedCap devices by 10 dB compared to Rel-17 baseline. This is intended to help IoT coverage in challenging locations e.g. deep indoors and would be beyond coverage recovery that may be needed for the very low complexity device. It would be for both UL and DL. We feel that 10 dB provides a good balance between coverage enhancement based on realistic network deployments and specification / implementation impact.
Higher data rate (reply to OPPO [4], Apple [15])	ACK/NACK bundling would reduce the amount of time needed for HD-FDD UE to transmit the ACK-/NACK. This would improve DL data rate without impact to UL coverage.
Sidelink (reply to BOSCH [8])	Support of sidelink in RedCap devices is worth considering. One benefit would be reduced power consumption on the sidelink. A key question would be whether the cost of a device supporting both sidelink and Uu would still be at an acceptable level.

2.6.2 Questions Round 2

Feedback Form 12: Round 2 questions on RWS-210116 ”RedCap / NR-Light enhancements in Rel-18”

1 – vivo Communication Technology

Thanks for your reply. We have some additional questions

Q1: While we can understand the cost reduction to reduce UE RF BW to 5MHz, however, it also lead to degradation of both link level (less frequency diversity) and system level (less frequency selective scheduling gain) perspective, do you share such understanding, and if so do you see the need to specify additional solutions to compensate such degradation?

Q2: In addition to BW reduction and reduced HARQ processes, we wonder what is your view on the following potential areas for Rel-18 eRedCap?

1) UE Processing time relaxation (data, CSI) for cost and power reduction
2) serving cell RRM relaxation for stationary devices for power reduction
3) lower UE power class for cost reduction and power reduction (better PAE)

2 – Spreadtrum Communications

Regarding the BW, we share your views that reducing the device bandwidth is an important aspect for very low complexity devices. We would like to ask your views on BW reduction level, e.g. 5 MHz,10 MHz, or other values?

3 – Ericsson LM

Regarding further reduced UE bandwidth to 5 MHz (including various other further UE complexity reduction techniques), you estimate that the complexity reduction is 71% compared to the reference NR device. Is it correctly understood that this corresponds to about 15% reduction compared to the Rel-17 RedCap UE?

4 – VODAFONE Group Plc

Thank you for your contribution. What are your views concerning the coexistence between legacy RedCap UEs and non-RedCap UEs? Will there be a need to further define a new type of RedCap device or do you aim to reutilize most of the previous legacy specifications?

5 – Sierra Wireless

WRT a 5MHz RedCap device - We are not supportive of creating yet another LPWA device type, for many reasons.

No Market – We feel a 5MHz Redcap device will further fragment the Redcap and NB-IOT/CAT-M1 market and not grow the TAM. A 5MHz Redcap device can only operate with SCS=15MHz unless massive standard changes are implemented - this further limits TAM. The Cat-M2 5 MHz device type which is similar to what is being proposed has never been commercialized as no market has materialized – NB-IOT,CAT-M1 and CAT1Bis are enough to fulfill the market need. Why is Redcap different? Can you please elaborate on TAM for such a 5MHz RedCap device?

Consider a smaller ScalingFactor (e.g. 0.1) - using the already specified ScalingFactor of 0.4,will bring the peak rate of a Rel17 Redcap down to 34mbps which already close enough to Cat1Bis in our view. But if lower is needed, specifying a new scaling factor of e.g. 0.1 would bring this down to Cat1bis speeds. Would you consider only changing the ScalingFactor?

Minimal Cost savings: The industry has shown that reducing bandwidth is not a good way to reduce cost – changing peak rate has a large impact. If the peak rate is reduced e.g. using the ScalingFactor, your predicted 15% cost of goods reduction compared from Redcap Rel17 will not occur. Please comment?

WRT 10dB Coverage gain – from the eMTC, NB-IoT and Rel17 CovEnh work, the only practical way to add that much coverage is to add "repeats" or lower the code rate which will significantly lower data rates well below the 100kbps that the Rel17 CovEnh work assumed as the minimum data rate. Supporting applications which can tolerate data rates of 10kbps will directly overlaps with the eMTC and NB-IoT market. Why not direct customers with this need to eMTC and NB-IOT?

6 – MediaTek Inc.

Thank you for your response. As per the analysis in this paper, the complexity reduction associated with these proposals are in the order of 71% compared to the reference NR device defined in 38.875. However the baseline R17-RedCap device can already achieve 60% complexity reduction when compared to the reference NR device. Do you think that it is reasonable to fragment the market (and thereby increase device costs) for a gain of just 11%?

7 – Samsung Electronics Polska

In WID for Rel-17, it was noted that UL coverage enhancements in NR coverage enhancement WI shall be assumed to be available to RedCap UE by default. So, for at least UL, do you think UL coverage enhancement in Rel-17 is not enough to achieve 10dB MIL?

2.6.3 Responses Round 2

Table 12: Responses to Round 2 questions on RWS-210116 "RedCap / NR-Light enhancements in Rel-18"

Lower-complexity device (reply to vivo [1], Spreadtrum [2], Ericsson [3], Sierra Wireless [5], MediaTek [6])	Our analysis shows complexity reduction of 59% for Rel-17 RedCap UE with 1Rx and 71% for lower-complexity device. We feel this is a considerable reduction comparable to LTE Cat-4 and Cat-1 complexity comparison, both of which are commercially used for broadband IoT applications. On the BW, our view is that it would be beneficial from cost and power consumption perspective to further reduce BW. We feel 5MHz would be the minimum BW to be considered. However, we are open to keeping 20 MHz BW for lower-complexity UE and focus on other cost reduction techniques. With respect to Vivo's question, we are open to further discussion on UE processing time relaxation and lower UE power class.
Coexistence between device types (reply to Vodafone [4])	Our view is that coexistence between legacy RedCap UEs and non-RedCap UEs can be supported using Rel-17 specifications and via implementation. A second RedCap UE type could be introduced in Rel-18.

Coverage enhancement (reply to Samsung [7], Sierra Wireless [5])	Our view is that the PUSCH/PUCCH enhancements being specified in NR CE WI may be sufficient for those channels. Additional enhancements beyond the CE WI (e.g. on the DL, PRACH) may be needed for RedCap UE to reach 10 dB cell coverage enhancement.

2.7 RWS-210117 ”High-accuracy positioning in Rel-18”

Feedback Form 13: Comments and questions on RWS-210117

1 – DanKook University

1) Support the opinion that carrier-phase positioning should be studied in Rel-18. But what does round-trip based carrier-phase method mean? Why do we need this other than just the Downlink and Uplink method?

2 – CATT

We share the similar view with Nokia for the motivation and objectives of carrier phase positioning using the NR signals.

Questions:

Q1: In our understanding, carrier phase measurements can be obtained from existing DL PRS/UL SRS, or adding new very narrow band signals for continuous carrier phase measurements. Using adding new very narrow band signals for continuous carrier phase measurements may be specially useful for particular scenarios where the power consumption for continue tracking of the phase measurement in a short period of duration is not the main issue. What is Nokia’s view on adding very narrow band signals for continuous carrier phase measurements?

3 – Sony Europe B.V.

We see a risk that there may be a major spec impact on the introduction of carrier-phase positioning.

1) Would Nokia only consider carrier-phase positioning aspect for Rel-18 Pos WI?

2) Carrier-phase positioning is quite sensitive to timing error, What is your view on this?

3) Where < 10 cm accuracy requirement comes from? What are the use-cases?

4 – Intel Corporation (UK) Ltd

Q1: Please elaborate more on additional requirements, if any, in terms of phase continuity for PRS transmission, level of inter-gNB synchronization, as well as sensitivity to multipath for considered carrier phase solution? Is it considered as a LOS-centric solution?

5 – Beijing Xiaomi Mobile Software

- Q1: We would like to understand what is the target error to mitigate. As we know that, there are 4 major kinds of error source for GPS, i.e. clock error, ionized stratum/troposphere error, ephemeris error, multi-path error. For GPS, RTK is mainly to mitigate clock error, ionized stratum/troposphere error, ephemeris. But for NR RAT-dependent positioning, there is no ionized stratum/troposphere error and ephemeris error. For clock error, it can be handled by gNB itself (e.g. by broadcasting clock error, etc.). Besides, the density of GPS RTK reference station is comparable or less than the density of gNB. To introduce carrier phase based NR positioning, what is the consideration for the deployment of reference station (e.g. what density in a cell)?
- Q2: In page 5, it noted that the use case and performance requirement of Rel-18 low cost and RedCap positioning is in the Rel-17 area. Does it mean that the Rel-17 positioning solutions already satisfy the requirements of low cost and RedCap positioning?
- Q3: In page 7, could you please clarify what is the meaning of 'Configuration from LMF/LMC, gNBs to gNBs, UEs'?
6 – Samsung Electronics Co. 1. Can you comment on the accuracy of the carrier phase method in NLOS environment. 2. In slide 7 a reference device is used for calibration. How close should the reference device be to the target UE for accurate calibration? 3. Additional question to the reference device. currently in rel17, the reference device is under discussion to be used. what is the major difference? and how to handle the non mitigated error from reference UE positioning information?
7 – LG Electronics Inc. Q1: We see that carrier phase based positioning method has a potential benefit of providing high accuracy for narrower bandwidth case. On the other hand, it is mentioned that the performance could be limited due to sensitivity to multi path, time/frequency synchronization, impacts on RF and so on. If there is any idea to overcome the drawback of carrier phase based positioning method, could you explain more?

2.7.1 Responses

Table 13: Responses to questions on RWS-210117 "High-accuracy positioning in Rel-18"

Time-sync/reference UE	In terrestrial carrier phase positioning, a reference UE is used to mitigate phase offsets between the gNBs/TRPs as well as the target UE through double differential methods. The reference UE is not as dependent on distance to the target UE as in RTK-GNSS due to the phase offsets not having a distance dependent component (e.g., as in ionospheric impacts). The exact density of reference UEs required can be studied further but we do expect the required density will be less than the density of TRPs.

1 – DanKook University	Similar to multi-RTT for timing, techniques using both DL and UL measurements for carrier phase can be beneficial and suffer from less impairments and simplify the protocols/signalling needed. The carrier phase measurements would be done independently in downlink and uplink, and then combined.
2 – CATT	The advantage of narrowband signals would be that they could enable continuous phase estimation, but on the other hand they are more impacted by multi-path propagation. This trade-off needs to be evaluated.
3 – Sony	Q1: So far we have not identified major specification impacts. New measurements would be required, but it may be possible to use existing reference signals. We do see it important to achieve in Rel-18 a step-change in accuracy that is not dependent on GNSS. The other main positioning enhancement we are proposing for Rel-18 is support of positioning for RedCap devices. Q2: There are methods for mitigating timing errors like, e.g., the reference device discussed in Rel. 17. Q3: The primary use case for <10cm accuracy is industrial automation, AR/XR.
4 – Intel	We assume there is phase continuity within a PRS transmission; phase continuity between PRS transmissions is not required, as each carrier phase measurement is independently performed using an individual PRS transmission. Carrier phase positioning can mitigate phase (or time) offsets between gNBs by making use of double differential measurements and using a reference device. Carrier phase measurements do suffer from multi-path errors, but, similar to timing techniques, there are methods that can determine the LoS path.

5 – Xiaomi	Q1: Target errors to be mitigated are the group delay and the phase rotation between baseband and antenna. The gNB is not able to measure and correct the phase at its antenna. See also the general response on "Time-sync/reference UE" above. The aim of carrier phase positioning is to improve the resolution of the position measurement that can be made, down to a fraction of the carrier wavelength. Q2: The latency and accuracy requirements for asset tracking indeed fall within what we expect to be achievable with Rel-17 positioning, but we expect work to be needed in Rel-18 to achieve these targets within the cost and bandwidth constraints of RedCap UEs. Q3: Reference signals and measurements need to be configured.
6 – Samsung	Q1: In a pure NLOS environment without a sufficient number of LoS paths no high accuracy positioning method will work with cm accuracy. Generally the accuracy of carrier-phase positioning depends on the ability of the receiver to identify and resolve the first path. Q2: The exact density of reference UEs required should be studied, but we do expect the required density will be less than the density of TRPs. Note also that the impairments that the reference device aims to mitigate are not distance dependent (unlike in the case of GNSS). Q3: The reference UE concept is basically the same as in Rel-17, but for carrier phase positioning the reference UE becomes an essential part of the system. The reference UE can have a similar measurement performance as the target UE. Measurement errors in the reference UE can be mitigated in the same way as for the target UE and the gNBs by (double) differential measurements. No extra process is needed for this.
7 – LG Electronics	LoS path separation is required. Generally the accuracy of carrier-phase positioning depends on the ability of the receiver to identify and resolve the first path. Synchronization errors can be mitigated by double differential methods using a reference device. The target is to increase accuracy without increasing the PRS bandwidth beyond the carrier bandwidth.

2.7.2 Questions Round 2

Feedback Form 14: Round 2 questions on RWS-210117 "High-accuracy positioning in Rel-18"

1 – Intel Corporation (UK) Ltd

Q1: Do you have any priority between support of DL and UL carrier phase-based positioning?

Q2: Which spectrum is considered for carrier-phase based solutions?

Q3: Do you assume additional requirements on gNB and/or reference UE in terms of synchronization in time/frequency?

2 – Beijing Xiaomi Mobile Software

Thanks for your answers, please see our further questions below:

Q1: You explained that "Target errors to be mitigated are the group delay and the phase rotation between baseband and antenna. The gNB is not able to measure and correct the phase at its antenna." Regarding the group delay, do you mean the phase offsets between the gNBs/TRPs? In our understanding the phase offsets comprise of rotation errors at gNB and clock errors at gNB. For clock error, do you think that it can be implemented by gNB broadcasting the clock error? Regarding the phase rotation error, can you explain how much would the phase rotation error at gNB impact the accuracy? Since the reference UE will also introduce additional phase rotation error when measuring the carrier phase, will it counteract the gain from mitigating phase rotation error at gNB.

Q2: If without terrestrial carrier-phase positioning method, What bandwidth do you think is needed to achieve 10cm distance accuracy and 2 degree angle accuracy?

Q3: For redcap, do you think is there a need to define new accuracy requirement for redcap positioning or just reuse the requirement defined for eMBB? Is there a need to have a short study phase to clarify the requirement for IoT or RedCap and perform the evaluation to see if there is gap to reach that requirement?

3 – CATT

Comments (Round 2):

Thanks for Nokia's responses to our questions. We share the similar view with Nokia that it is essential to use a positioning reference (UE/TRP) for NR carrier phase positioning and that there should be no significant impact on the specification, especially when existing PRS/SRS are used to obtain the carrier phase measurements.

Questions (Round 2):

For the discussion related to "round-trip based carrier-phase method", although we share the similar view as Nokia that "using both DL and UL measurements for carrier phase can be beneficial", it is unclear to us how round-trip time is obtained from the carrier phase measurements can be obtained. We are wondering if it is feasible or meaningful to support UE/gNB Rx-Tx time (or carrier phase) difference measurements with the accuracy of a fraction of the wavelength of the carrier frequency. What is Nokia's view on this?

4 – Huawei Tech.(UK) Co.. Ltd

Q1: What is the assumption of the oscillator's frequency stability in terms of ppm/ppb to allow double-differential methods? Should the reference device track the phase correction data in every slot that contains the PRS for carrier phase positioning?

Q2: Does the Tx group delay affect the carrier phase measurement accuracy or they can be separate issues?

2.7.3 Responses Round 2

Table 14: Responses to Round 2 questions on RWS-210117 ”High-accuracy positioning in Rel-18”

1 – Intel	Q1: We feel both DL and UL are important to specify as they both have advantages and the specification impact difference of specifying both vs only one will not be high in our view as there will be many similarities. One advantage of NR carrier phase vs RTK-GNSS is that NR can use both UL and DL while RTK-GNSS only uses signals from satellite to UE. Q2: FR1 at the beginning. In FR2 there is less need for additional solutions and the challenges with carrier-phase measurements are higher. Q3: No. Double differential measurements are assumed to mitigate the impacts of offsets and we do not think additional requirements on synchronization will be needed.
2 –Xiaomi	Q1: By group delay we mean the delay from the baseband to the antenna. We don’t think the clock error needs to be broadcast. The reference device will perform single differential measurements which remove the local impairments. The target UE will also do single differential measurements. By combining these single differential measurements from target UE and reference device we achieve double differential measurements which remove the impairments at both the UE and the gNB from phase offsets (and group delays). This is quite similar to the state of the art in RTK-GNSS. Q2: We have not evaluated a specific necessary value but certainly higher than the currently available 100/400 MHz and we feel that carrier aggregation has some drawbacks which make it unattractive (see our contribution). The angle accuracy is less dependent on the BW. Roughly speaking, the carrier-phase method has the potential to improve the accuracy by the ratio between carrier frequency and bandwidth without increasing the bandwidth. Q3: For low-complexity, low-power positioning, our intention is to study and specify positioning enhancements that are suitable for RedCap devices (i.e. techniques targeting low complexity and low power consumption) but can still provide reasonably high level of accuracy. One option would be to have a short study phase to clarify the requirements and understand the achievable performance for reduced BW.

3 – CATT	Our intention with RTT is to combine measurements made independently in UL and DL and not to specify a UE/gNB Rx-Tx time (or carrier phase) difference measurement.
4 – Huawei Tech.(UK) Co.. Ltd	Q1: In our understanding the reference device should measure the carrier phase in the same reference signal occasions as used by a target UE and report them to at least the LMF. No additional assumption on the frequency stability is made. Q2: Yes, the group delay does affect the measurement accuracy but can be mitigated using double difference measurements. Please see also our reply to Xiaomi above.

2.8 RWS-210121 ”Railway, smart grid and PPDR support in Rel-18”

Feedback Form 15: Comments and questions on RWS-210121

1 – vivo Communication Technology

Thanks Nokia for the proposa, we think this is an interesting area to consider. Please find some questions and comments below

1.For these use cases, the UE cost and power consumption may not be critical, so it seems also possible to reuse Rel-17 Redcap UE capability as 20MHz BW, or do you intend to specify new UE type with further reduced BW capability to 3MHz or 5MHz?

2. Do you think coverage recovery solutions needs to be studied as narrow band NR would mean reduced link level performance (e.g. diversity gain), in addition, what is the typical ISD assumption/target for network deployment used for railway communication?

2 – Intel Corporation (UK) Ltd

Q1. For PDCCH, a purely puncturing-based solution implies no support beyond AL8 for PDCCH. What is your view on impact on signifcant shrinkage of DL coverage with such restrictions?

Q2. For SSB, have you conisdered impact to DMRS detection performance with the puncturing based solution?

Q3:The proposal mentions ”Interference between NR and GSM-R handled by implementation”. Can you provide more details on the expected way of handling adjacent channel interference?

3 – QUALCOMM Europe Inc. - Italy

We share the similar view on the support of narrowband NR for multiple vertical use cases in their dedicated spectrum with minimum changes. Thanks for the evaluation results in Appendix to show the way how PBCH is punctured to fit into the 3MHz. For the impact of the punctured PBCH, is it possible to use power boosting on the remaining RBs to reduce the link budget degradation?

4 – Samsung Electronics Co.

In the paper, it seems like nothing needs to be done in RAN 1 perspective. So, do you only expect to have some study? What is the expectation for this NR-R?

2.8.1 Responses

Table 15: Responses to questions on RWS-210121 "Railway, smart grid and PPDR support in Rel-18"

Vivo	Response to Q1: The key factor for these railway, smart grid and PPDR cases is the spectrum availability, which is in the range 3-5 MHz, while constraints on number of Rx branches do not apply. Hence the kind of devices in view is rather different from RedCap. Further, there is no specific need for these devices to have their maximum BW requirement reduced, but rather allow for extending the lowest supported carrier BW below 5 MHz with minimal impact. Response to Q2: Currently our thinking is that the link budget loss from puncturing and the limited diversity would not be sufficient to warrant specific coverage recovery solutions, especially considering that the device form factor and number of Rx branches are not unduly constrained. That said, there should be no reason why existing coverage enhancement features could not also apply to these devices. ISDs for railways vary depending on the scenario, environment and the applications used (voice or train control). As the benefit of the solution is to reuse existing GSM-R sites, ISDs vary typically between 4 and up to about 8 km.

Intel	Response to Q1: So far, we have initial analysis for PBCH puncturing in our contribution. We expect further evaluations to follow. It is true that AL16 could not be supported in this scenario, but it is worth noting that AL16 (over AL8 of LTE) was introduced for ultra-reliability while we expect the UL to be the coverage bottle neck and thus don't expect to see any coverage shrinkage due to PDCCH limitation. Response to Q2: DMRS is punctured on the frequency part where there are no PBCH REs. There could be some performance degradation in the PBCH DMRS based estimates e.g. at the edge if the channel estimation filter interpolates from the actually transmitted DMRS REs to the DMRS REs that are actually not there. Further evaluations are needed. Response to Q3: What we mean by "interference between NR and GSM-R handled by implementation" is that no specified RF requirements would be needed (e.g. no new channel bandwidth), since the operator of the NR and GSM-R channels would be the same. Any performance degradation would be expected and could be planned for, and scheduling could partly mitigate it.
Qualcomm	Power boosting on transmitted PBCH REs would certainly be worth considering to compensate some of the puncturing loss.
Samsung	We expect minimal work in RAN1.

2.8.2 Questions Round 2

Feedback Form 16: Round 2 questions on RWS-210121 "Railway, smart grid and PPDR support in Rel-18"

1 – MediaTek Inc.

Q1: It is often the case that it is difficult to source RF components for bands that are not for mass market devices. We believe that Half Duplex support would help make this easier (Mediatek is making a similar proposal for NR NTN for a similar reason). Have you considered Half Duplex support for NR in Railways/smartgrids/PPDR, and if not, do you think it would be feasible?

Q2: In the case where you have GSM-R and NR both deployed, would these generally be provided by the same operator and use collocated sites? If the answer is yes, there is no mobility and service continuity between NR and GSM defined today. What is the expected deployment and migration plan given this restriction?

Q3: Is this purely a standalone deployment, e.g. not aggregated with other frequency bands from MNOs for example?

Q4: We observe very limited LTE-R demand. What will be the key drivers for using NR when compared

to LTE in this scenario, causing you to expect robust demand?

Q5: Is it foreseen that RedCap will be reused to address this market?

2.8.3 Responses Round 2

Table 16: Responses to Round 2 questions on RWS-210121 ”Railway, smart grid and PPDR support in Rel-18”

Q1: Half-Duplex	We would not rule out half-duplex at this stage, but full duplex would be much preferable due to its superior performance. Anyway we would see HD as UE capability related discussion rather than something impacting the system design.
Q2: Mobility between NR and GSM	Yes, in a given area, typically GSM-R and NR would be deployed and operated by the same operator, probably using co-location as much as possible. But mobility and service continuity between GSM-R and NR is not seen as[KD1] [MPJB2] a high priority as the main reason for parallel deployments is the long lifetime of equipment in the railway industry.
Q3: Standalone vs aggregation	For the rail scenarios, aggregation with other frequency bands is not foreseen, but for other scenarios, such as smart grids and public safety, there may be some interest in aggregating with other bands.
Q4: Demand	The European rail industry has decided to adopt NR for its Future Rail Mobile Communication System (FRMCS) project to upgrade existing GSM-R networks.
Q5: Redcap	As commented in the first round, the key factor for the use cases discussed here is the 3-5 MHz spectrum availability, while constraints on number of Rx branches do not apply. Hence the kind of devices in view is rather different from RedCap. Further, there is no specific need for these devices to have their maximum BW requirement reduced; the target is to extend the lowest supported carrier BW below 5 MHz with minimal impact. We do not envisage reducing the RedCap minimum BW below 5 MHz.

3 Summary

3.1 UAS connectivity over NR

Proposals focus on introducing into NR similar enhancements for UAVs as were already introduced in NR Rel-15, in addition to some other enhancements in areas such as measurements/mobility, co-existence and reliability.

Questions mainly focused on the detailed specification impact of these enhancements, especially in relation to UAV-specific aspects of reliability.

3.2 IIoT/URLLC

Proposals focus mainly on FR2-related enhancements to enable higher throughputs to be achieved with strict latency and reliability, further enhancements for SPS / CG (including for traffic requiring non-integer periodicities and for collisions of multiple data flows with different periodicities), and the definition of URLLC device “classes” or “profiles” to promote a more consolidated URLLC device ecosystem.

There are also aspects of mobility enhancement that are important for URLLC, and these could be handled in a mobility-focused work item.

The demand for broadband URLLC is recognised. It was noted that there could be a close relationship with the needs of XR; overlap between WIs should be avoided, so agreement on the overall workplan will be needed.

There is significant support for defining URLLC UE profiles, and this could even be done in the Rel-17 timeframe. It was, however, observed that convergence could be a challenge. It was clarified that this could be done as a RAN-level activity, independent of whether any additional URLLC features are introduced in Rel-18, and identification of feature groups relevant to URLLC could be a good starting point.

3.3 Sidelink Enhancements

Proposals focus mainly on UE-UE and multi-hop relays for public safety, and sidelink in unlicensed spectrum.

There were various questions on details of the specification impact, as well as different views on the importance of including FR2.

3.4 Sidelink Positioning

The main motivations observed are V2X and public safety. Support for absolute and relative sidelink positioning is proposed (where relative positioning is understood to imply more than just ranging), and sidelink assisted positioning for in-coverage and partial coverage scenarios.

3.5 Resilient Timing

The motivation is the need for wide-area accurate timing that is resilient to the loss of GNSS.

Some questions were discussed around the detailed specification impacts, including how to build on the Rel-17 propagation delay compensation mechanism, and the relationship to ongoing SA2 work.

3.6 RedCap Enhancements

Proposals focused on further cost/complexity reduction beyond Rel-17, power consumption, low-complexity/low-power positioning, and coverage enhancement.

Regarding cost/complexity reduction, there is uncertainty about the value of RF bandwidth reduction below 20 MHz, both considering the feasibility of generating meaningful device cost reductions and from the perspective of potential market fragmentation.

There is some interest in power consumption reduction, with some discussion on the detailed technical methods.

There seems to be rather strong support for RedCap positioning; this could be included in a positioning enhancement WI.

For coverage enhancement, further discussion on the target level of enhancement may be needed.

3.7 High-accuracy Positioning

Terrestrial carrier-phase positioning is proposed, in order to deliver an order-of-magnitude higher accuracy indoors, and an alternative to RTK-GNSS outdoors for improved resilience.

Quite some interest is observed in this topic, including questions to understand the requirements and specification impact of terrestrial carrier-phase positioning (both of which are suggested to be relatively minor), as well as the impact of non-idealities such as group delay and multipath propagation on the accuracy achievable by terrestrial carrier-phase positioning. Double-differential measurements including the use of a reference device were highlighted as important components for robust terrestrial carrier-phase positioning.

3.8 Narrowband NR for railways, smart grid and PPDR

The proposal is to adapt NR to the available bandwidths for these systems (in the range 3-5 MHz) with minimal changes, building on the existing NR ecosystem

There was some support for addressing these scenarios, and some discussion on the detailed specification impacts.