3GPP TSG RAN WG1 #103-e R1-200xxxx

e-Meeting, October 26th – November 13th, 2020

**Agenda item: 8.8.2.3**

**Title: [103-e-NR-CovEnh-06] Feature lead summary on coverage enhancement for channels other than PUSCH and PUCCH**

**Source: Moderator (ZTE Corporation)**

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

# Introduction

In the RAN1#102-e meeting, the potential enhancements for channels other than PUSCH and PUCCH were discussed [1] and the following agreements were reached.

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| Agreements:   * Study Msg3 PUSCH enhancement in NR coverage enhancement SI   + Study at least Msg3 PUSCH repetition     - FFS the aspects to be enhanced, e.g., signaling indication, repetition pattern, interplay between Msg1 and Msg3, DM-RS enhancements related to repetition etc.   + FFS multiple-antenna techniques.   Agreements:   * Study whether or how to enhance MsgA PUSCH in NR coverage enhancement SI   Agreements:  If PRACH enhancement is needed, study it in NR coverage enhancement SI, e.g. multiple PRACH transmissions.  Agreements:  Study whether/how to enable potential techniques for early CSI and/or beam refinement for physical channels during initial/random access procedure.  Agreements:   * If PDCCH enhancement is needed based on evaluation, study PDCCH enhancement for NR coverage enhancement   + Study at least for broadcast PDCCH     - For broadcast PDCCH, it includes a PDCCH monitored in a Type0/0A/1/2-PDCCH CSS set.   + FFS unicast PDCCH   + Study the aspects to be enhanced, e.g., PDCCH repetition.   Agreements:  Further discuss the evaluation of PDSCH and discuss whether/how to enhance PDSCH in NR coverage enhancement SI.  Agreements:  Enhancement to PUSCH scheduled by RAR UL grant will not consider the optimization specific for CFRA case in NR coverage SI.  Agreements:   * Capture the following structure in TR 38.830.   6.3 Coverage enhancements for channels other than PUSCH and PUCCH  6.3.1 Enhancements for Msg3 PUSCH  ~~6.3.2 Others~~   * Note: The above structure can be further updated by adding more sections under section 6.3 for other enhancements if justified. |

This contribution provides a summary of proposed enhancements in contributions submitted under AI 8.8.2.3.

# Proposals for approval

**Updated Proposal 7: Capture the followings into the TR**

* *PRACH enhancements were studied from several aspects, including multiple PRACH transmissions with the same transmission beam and with beam sweeping.*
* *Potential specification impacts of multiple PRACH transmissions include: [the association between RO, SSB and preamble index], determination of multiple PRACH transmissions, transmission beam to be used for each initial transmission, finer beam for msg1 based on CSI-RS resources configured during initial access, beam indication for the following steps for RACH procedure, differentiation between enhanced UE and legacy UE, possible collision handling between PRACH transmission with and without multiple PRACH transmissions.*

**Proposal 9: Capture the followings into the TR.**

* *PUCCH repetition carrying HARQ-ACK for Msg4 was studied. Potential specification impacts include related signaling design, differentiation between enhanced UE and legacy UE.*

**Updated Proposal 11: Capture the followings into the TR**

* *Beam reporting during initial/random access procedure was studied from several aspects, including the best SSB, alternative SSB beam and early CSI report in Msg3 PUSCH. Potential specification impacts include signaling design in Msg3 PUSCH, CSI-RS resources configured during initial access, beam indication for the following steps for RACH procedure.*

***Updated Proposal 12-1:* Capture the followings into the TR**

*A-CSI repetition on PUSCH and PUCCH were studied. Potential specification impacts include mechanism to determine the repetitions on repeated PUSCH, mechanism to determine the dynamic repetition of A-CSI PUCCH and the mechanism for the PUCCH resource determination.*

**Proposal 13: Capture the followings into the TR**

* *Broadcast PDCCH repetition was studied. Potential specification impacts include PDCCH repetition configuration, DMRS design among PDCCH repetition.*

**Updated Proposal 15: Capture the followings into the TR**

* *Msg4 PDSCH enhancements were studied from several aspects, including introducing early CSI on Msg3 PUSCH, scaling factor for TBS determination and PDSCH repetition. Potential specification impacts include CSI-RS resources configured during initial access, TBS determination, PDSCH repetition configuration, DMRS design among PDSCH repetitions.*

# Discussion

## Msg3/MsgA PUSCH enhancements

In RAN1#102-e, it was agreed to study at least Msg3 PUSCH repetition in NR coverage enhancement SI. In [2, Huawei, HiSilicon], [3, vivo], [4, ZTE], [5, CATT], [7, Intel], [8, China Telecom], [[9, CMCC], [10, NEC], [11, Samsung], [12, OPPO], [15, Sharp], [16, LG Electronics], [17, Ericsson], [18, Apple], [19, InterDigital], [20, NTT DOCOMO], [21, Qualcomm], [22, Nokia], [23, Potevio] and [24, WILUS], totally 20 companies show their interests on Msg3 enhancements and provide further analysis on potential enhancements aspects.

In the following, enhancements aspects are summarized for Msg3/MsgA PUSCH enhancements.

### Aspect 1: Performance evaluation on Msg3 repetition

There are 6 companies provide evaluation results for Msg3 repetition, and the observations are summarized as follows.

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| * [2, Huawei, HiSilicon]: About 2 dB gain can be obtained by doubling Msg3 repetition times at 10% BLER, 6 dB gain can be obtained by 8 repetitions. * [4, ZTE]: About 2.4~2.6 dB and 4.7~5.2 dB gain can be obtained by employing 2 repetitions and 4 repetitions respectively. * [7, Intel]: ~2 dB performance gain can be observed when the repetition level for Msg3 PUSCH is doubled. * [9, CMCC]: The 2 slot repetition could improve Msg 3 PUSCH coverage about 2.25 dB. * [17, Ericsson]: A gain of around 5.8 dB can be achieved for Msg3 with 8 repetitions. * [22, Nokia]: About 1.9 dB, 2.8 dB, 2.1 dB gain for 2, 4 and 8 repetitions respectively at 10% BLER in 4GHz urban scenario, and about 1.3 dB, 1.4 dB, 1.6 dB gain for 2, 4 and 8 repetitions respectively at 10% BLER in 28GHz urban scenario. |

Based on the evaluation results from companies above, which are basically aligned, the following observation is made.

***Observation 1: For Msg3 repetition, about 2 dB gain can be obtained at 10% BLER if the number of repetitions is doubled.***

**FL suggestion: The intention is to capture the observation into TR. Considering the deadline for evaluation inputs is 6th Nov, we can further discuss this after the deadline.**

### Aspect 2: Indication of the number of repetitions for Msg3

**Indication of the number of repetitions for Msg3 initial transmission**

For Msg3 initial transmission, it can be scheduled by RAR UL grant or fallbackRAR UL grant. Based on companies’ input, the following options are proposed for indication of the number of repetitions for Msg3 initial transmission.

* Option 1: RAR UL grant or fallbackRAR UL grant
  + [2, Huawei, HiSilicon], [3, vivo], [5, CATT], [7, Intel], [8, China Telecom], [11, Samsung], [12, OPPO], [18, Apple], [23, Potevio]
* Option 2: DCI format 1\_0 with CRC scrambled by RA-RNTI
  + [3, vivo], [8, China Telecom], [11, Samsung], [18, Apple], [24, WILUS]
* Option 3: Implicit method, e.g, implicitly determined by PRACH configuration or information carried by RAR.
  + [2, Huawei, HiSilicon], [3, vivo], [5, CATT], [15, Sharp], [24, WILUS]
* Option 4: SIB1
  + [8, China Telecom], [11, Samsung], [24, WILUS]

It is also possible to consider some combined signaling, e.g., [11, Samsung] and [3, vivo] mention that a set of candidate values can be configured by system information, and RAR UL grant or DCI format 1\_0 with CRC scrambled by RA-RNTI can indicate further information for actual number of repetitions. In [24, WILUS], it proposes to consider enabling of Msg3 repetition and activation of Msg3 repetition.

Based on above summary, FL suggests to discuss the following proposal.

***Proposal 1: Study the indication of the number of repetitions for Msg3 initial transmission, including at least following options.***

* + ***Option 1: RAR UL grant or fallbackRAR UL grant***
  + ***Option 2: DCI format 1\_0 with CRC scrambled by RA-RNTI***
  + ***Option 3: Implicit method.***
  + ***Option 4: SIB1***

***Note: signaling indication with combined options is not precluded.***

**Indication of the number of repetitions for Msg3 re-transmission**

For Msg3 re-transmission, it is scheduled by DCI format 0\_0 scrambled by TC-RNTI. Based on companies’ input, the following options are raised for indication of the number of repetitions for Msg3 re-transmission.

* Option 1: DCI format 0\_0 with CRC scrambled by TC-RNTI.
  + [3, vivo], [4, ZTE], [7, Intel], [12, OPPO], [24, WILUS]
* Option 2: Implicit method. E.g., the repetition factor is implicitly determined by Msg3 initial transmission.
  + [4, ZTE] [5, CATT], [24, WILUS]

Based on above summary, FL suggests to discuss the following proposal.

***Proposal 2: Study the indication of the number of repetitions for Msg3 re-transmission, including at least following options.***

* + ***Option 1: DCI format 0\_0 with CRC scrambled by TC-RNTI.***
  + ***Option 2: Implicit method.***

### Aspect 3: Support of repetition Type A or/and repetition Type B

In NR up to Rel-16, PUSCH repetition Type A and repetition Type B are supported for RRC connected mode UE. For Msg3 PUSCH repetition, the following options are proposed for supported repetition type.

* Option 1: Support both PUSCH repetition Type A and repetition Type B.
  + [2, Huawei, HiSilicon], [3, vivo], [4, ZTE], [15, Sharp], [23, Potevio]
* Option 2: Support PUSCH repetition Type A only.
  + [7, Intel], [11, Samsung]

FL’s suggestion is not to down-select one option at this stage, and propose to discuss the following proposal.

***Proposal 3: Study the repetition type for Msg3 PUSCH repetition.***

### Aspect 4: Study the feasibility and applicability of normal PUSCH enhancements (if supported) for Msg3 PUSCH initial/re-transmission

In AI 8.8.2.1, enhancements to normal PUSCH has been discussing, including aspects such as time domain enhancements, frequency domain enhancement, DM-RS enhancements and power domain enhancements.

As discussed in [2, Huawei, HiSilicon], [4, ZTE], [8, China Telecom], [9, CMCC], [17, Ericsson], [19, InterDigital] , [23, Potevio], **cross-slot channel estimation/DMRS bundling can be studied for Msg3 PUSCH**. Simulation results are also provided in [4, ZTE], [9, CMCC], and the following observations are derived.

|  |
| --- |
| [4, ZTE]: Msg3 PUSCH repetition with cross-slot channel estimation can provide 0.5dB~ 1.07dB performance improvement in urban scenario.  [9, CMCC]: The 2 slot repetition could improve Msg 3 PUSCH coverage about 2.25dB. And the cross channel estimation could provide additional 1.75dB gain based on 2 slot repetition. |

More generally, it is proposed in [4, ZTE], [8, China Telecom] that techniques for normal PUSCH enhancements, including time domain enhancements, frequency domain enhancement and DM-RS enhancements, can be studied for Msg3 PUSCH enhancement. In [11, Samsung], it proposes that the applicability of solutions for coverage enhancements of ‘normal’ PUSCH to Msg3 PUSCH should be separately considered for each solution. [22, Nokia] proposes to study solutions to reduce the difference between RRC-idle and RRC-connected PUSCH operations and performance, and study enhancement of the existing features of RRC-idle PUSCH, e.g., frequency hopping, if they provide evidence of a positive impact in terms of MCL/MIL/MPL.

Based on above summary, FL suggests to discuss the following proposals.

***Proposal 4-1: Study cross-slot channel estimation for Msg3 repetition.***

***Proposal 4-2: Study the feasibility and applicability of normal PUSCH enhancements (if supported in AI 8.8.2.1) for Msg3 PUSCH initial/re-transmission.***

### Aspect 5: gNB identification of whether a UE supports Msg3 PUSCH enhancements or not

For legacy UE, Msg3 PUSCH repetition is not supported, while it has been agreed to study Msg3 PUSCH enhancements for Rel-17 NR coverage UE.

According to [4, ZTE], [5, CATT], [8, China Telecom], [10, NEC], if a Rel-17 UE supports Msg3 repetition and related enhancements, gNB needs to identify whether the UE supports Msg3 PUSCH enhancements or not before it indicates corresponding signaling e.g., the number of repetitions for Msg3 PUSCH.

More specifically, [8, China Telecom] proposes that whether a UE supports Msg3 repetition or not can be implicitly indicated, e.g. different ROs or different preamble sequences. Similarly in [10, NEC], it proposes that special PRACH resources and/or preamble for msg3 repetition enhanced UE should be configured by gNB broadcasting.

Based on above summary, FL suggests to discuss the following proposal.

***Proposal 5: Study solutions for gNB to identify whether a UE supports Msg 3 PUSCH enhancements or not.***

### Aspect 6: Support of MsgA PUSCH repetition

In RAN1#102-e, the following agreements were reached for MsgA PUSCH enhancement.

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| --- |
| Agreements:   * Study whether or how to enhance MsgA PUSCH in NR coverage enhancement SI |

For 2-step RACH, an RSRP threshold is configured, and a UE selects 2-step random access type to perform random access based on this threshold. Based on companies’ input, the support of MsgA PUSCH repetition is summarized as follows.

* **Alt. 1: Support MsgA PUSCH repetition** 
  + [14, Sony], [12, OPPO]?
  + Main reasons are:
    - The configurable RSRP threshold allows the network to steer cell-centre UEs towards using 2-step RACH and cell-edge UEs to use 4-step RACH, the setting of the threshold value is down to network implementation and a network can set the threshold low such that all UEs use 2-step RACH.
    - RAN1 should look to enhance the coverage of channels whose Rel-16 coverage is worse rather than those Rel-16 channels that already have good coverage.
* **Alt. 2: Do not support MsgA PUSCH repetition** 
  + [7, Intel], [15, Sharp], [18, Apple]
  + Main reasons are:
    - RSRP based RACH type selection mechanism was defined for selection between 2-step RACH and 4-step RACH. More specifically, when measured RSRP is greater than a threshold, 2-step RACH is used for RACH procedure. Based on this, it is evident that 2-step RACH is mainly targeted to UEs in good channel conditions, where coverage enhancement is not needed.
    - If the UE has the coverage issue, it will not select the 2-step RACH, otherwise access failure and falling back to 4-step RACH will increase the access delay and occupy the MsgA PUSCH resource.
    - If the MsgA PUSCH coverage enhancement is supported, the MsgA PUSCH repetition or hopping would require more resources reserved, and these resources are hard to be shared with Rel.16 2-step RACH UE.
    - More repetitions could increase the access delay.

Based on above summary, FL suggests to discuss the following proposals.

***Proposal 6: MsgA PUSCH repetition can be studied with low priority.***

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | We are not positive on applying coverage enhancement for 2step RACH so far.  As we commented even in last meeting, 2step RACH is designed for good coverage (good link) case, although the SSB-threshold is implemented by gNB thus anything can happen, but it is not reasonable to apply coverage enhancement for 2step RACH. |
|  |  |

### Other aspects for Msg3 enhancements

**Multiple antenna techniques**

In [11, Samsung], it notes that the msg3 spatial setting is left to UE implementation and refinement of spatial setting from msg1 tx to msg3 tx was not finalized in NR Rel-15. In NR Rel-16 2-step RACH, the PRACH and msgA PUSCH are specified to use a same spatial setting. It proposes to **specify that a same spatial setting applies for PRACH preamble and corresponding msg3 PUSCH transmissions**.

In NR up to Rel-16, Msg3 PUSCH transmission, which is scheduled by DCI format 0\_0, is based on a single antenna port. In [17, Ericsson], it observes that **open-loop Tx Diversity together with Msg3 repetition** can improve Msg3 coverage through diversity gain and Tx chain power combining, and **closed-loop Tx Diversity for Msg3** can benefit from coherent combining or antenna selection as well as Tx chain power combining.

**Waveform of Msg3**

In [6, Indian Institute of Tech (H)], it observes that UL transmission can benefit from power boosting wherein the max transmission power can reach up to 26dBm or 29dBm based on the UL duty cycle when DFT-s-OFDM waveform with pi/2 BPSK modulation is used. Every dB gained in transmission power significantly enhances the coverage of the UE. **Thus, pi/2 BPSK waveform with spectrum shaping is proposed for Msg3 transmission.**

**Power domain consideration for Msg3**

In [11, Samsung], it finds UEs in different conditions may experience better msg3 reception reliability using different values of power adaptation parameters (e.g., power ramping step powerRampingStep and pathloss compensation factor msg3-Alpha) . It can be beneficial from a latency perspective to use a suitable set of power adaptation parameters which can, e.g., faster achieve higher transmission powers in fewer number of retransmissions. **Thus, it proposes to consider multiple sets of power adaptation parameters for msg3 PUSCH coverage enhancement.**

**Inter-slot frequency hopping for Msg3 repetition**

In [18, Apple], it observes the inter-slot frequency with the repetition can provide 2dB performance gain. This gain is worthwhile to specify inter-slot frequency hopping and time domain repetition for Msg3 PUSCH coverage enhancement. Thus, it proposes **Msg3 repetition with inter-slot frequency hopping are supported.**

**More inputs regarding to above four aspects are needed. FL proposal will be provided after collecting more views from companies.**

## PRACH enhancements

### Necessity of PRACH enhancement

In [2, Huawei, HiSilicon], [3, vivo], [4, ZTE], [5, CATT], [7, Intel], [11, Samsung], [12, OPPO], , [14, Sony], [15, Sharp], [16, LG Electronics], [19, InterDigital], [22, Nokia], PRACH enhancement is discussed and views on the necessity of enhancement are summarized as follows.

* **Alt. 1: Support PRACH enhancement** 
  + [2, Huawei, HiSilicon], [3, vivo](lower priority), [4, ZTE], [7, Intel], [11, Samsung], [12, OPPO], [14, Sony], [19, InterDigital], [21, Qualcomm], [22, Nokia], [23, Potevio]?
  + Main reasons are:
    - Most of proponents find that the PRACH link performance is worse than the target performance in many scenarios, and enhancement to PRACH itself is needed.
    - PRACH repetition can provide significant MIL/MPL gains for msg1, and it allows UE to enjoy larger antenna array gain for both msg1 and msg3 when Tx sweeping is used for multiple PRACH transmissions.
    - UE can benefit from full antenna array gain only if the angular direction to steer the TX beam used for transmission is known. Acquiring reliably this information in the current random-access procedure, i.e., during RRC-idle operations, is not guaranteed.
    - Transmitting PRACH re-attempts with different beams incurs long latency for initial access and it would increase the possibility that the SSB the UE selected does not remain the “best” SSB, for example due to UE mobility. In other words, it allows that a UE without beam-correspondence capability may transmit multiple PRACH preambles using multiple different UE Tx beams in a more timely manner. This can provide more UL beam gain and reducing RACH preamble re-transmission.
    - Based on the typical TDD configuration, there might be only one or two consecutive UL slots. This will limit the usage of long PRACH format and lead to coverage issue based on short PRACH format transmission.
* **Alt. 2: No need for PRACH enhancement** 
  + [5, CATT], [15, Sharp], [16, LG Electronics]?, [17, Ericsson]?
    - One company ([5, CATT]) observes that the performance of PRACH format B4 is much better than the target performance in terms of MPL.
    - In Rel-15/16, UE can sweep the transmission beam when UE tries RACH preamble re-transmission, wherein a proper transmitting beam can be applied at the UE side.
    - PRACH collision rate between UE support MSG1 repetition and legacy UEs would increase when more PRACH preambles are transmitted per RACH attempt.
    - For multiple PRACH transmission for beam refinement, it observes higher PRACH collision rate, higher interference level on PRACH resources and measurement accuracy cannot be guaranteed.
    - There are abundant PRACH formats which are defined for different deployment and coverage in the current specification, e.g. PRACH format 4 is defined for coverage enhancement. It is an implementation issue for network to select a proper TDD UL DL configuration which supports a PRACH format targeting to a large coverage.
    - The benefit of PRACH enhancement for the enhancement of msg3 is not technically clear.

Based on above summary, FL suggests to discuss the following observation based on majority view.

***Observation 2: PRACH enhancement is needed in NR coverage enhancement SI.***

### Multiple PRACH transmissions

Based on the input from proponents, there could be two ways for PRACH enhancements. Depending on the same or different beams used for each transmission, the two ways can be catheterized as ‘PRACH repetition’ and ‘PRACH beam sweeping’. An example is shown in Figure 1.



**Figure.1 - RO bundle for same Tx beam an different Tx beam [11, Samsung]**

**Evaluation results**

In [4, ZTE] and [22, Nokia], evaluation results for multiple PRACH transmissions are provided and have the following observations.

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| In [4, ZTE], it observes that, for PRACH repetition, about 1.7~3.7 dB and 3.7~5.2 dB gain can be obtained by employing 2 repetitions and 4 repetitions respectively. And PRACH sweeping transmission with 2 Tx beam can provide 2.5dB coverage improvement for channels in RACH procedure.  In [22, Nokia], it finds, by applying multiple PRACH transmissions, the MIL/MPL gap between SSB and msg1 transmission can be reduced to almost zero when UE max transmit power is 23 dBm, and more than halve the MIL/MPL gap when UE max transmit power is 12 dBm. It can achieve around 65% MIL/MPL gap reduction between SSB and msg3, irrespective of the UE max transmit power. |

Although limited simulation results are provided, it seems reasonable that multiple PRACH transmissions could provide performance gain also considering the deterministic analysis from majority companies. Thus, FL suggests to discuss the following observation.

***Observation 3: PRACH repetition can provide non-negligible performance gain, and multiple PRACH transmissions with beam sweeping allows UE to make use of the potential of multiple antenna NR technology in RRC-idle state to provide larger antenna array gain.***

**FL suggestion: The intention is to capture the observation into TR. Considering the deadline for evaluation inputs is 6th Nov, we can further discuss this after the deadline.**

**Spec impacts**

Based on the input from [2, Huawei, HiSilicon], [3, vivo], [4, ZTE], [7, Intel], [11, Samsung], [12, OPPO], [14, Sony], [21, Qualcomm], [22, Nokia], the spec impacts are summarized as follows.

* Determination of PRACH repetition.
* The number of repetitions, repetition pattern (e.g., time or frequency domain repetition).
* The applicability for FR1 and/or FR2, and applicability for short and/or long PRACH preamble format.
* The TX beam to be used for each initial transmission, e.g., same or different beam across the multiple msg1 transmissions, and finer beam for msg1 based on CSI-RS resources configured during initial access etc.
* If TX beam used for each msg1 transmission is different, how to let UE know which one should be used for the following steps for RACH procedure;
* gNB may need to be able to differentiate between enhanced UE and legacy UE.
* How to handle possible collisions between PRACH transmission with and without multiple msg1 transmissions.

Based on Chairman’s guidance in GTW session on 10/27, we need to discuss in parallel about the spec impacts for interested enhancements. So, it suggested to discuss the following spec impacts for multiple PRACH enhancements.

**Proposal 7: Capture the followings into the TR**

* *PRACH enhancements were studied from several aspects, including PRACH repetition with the same transmission beam and multiple PRACH transmissions with beam sweeping.*
* *Potential specification impacts of PRACH enhancements include: determination of PRACH repetition, transmission beam to be used for each initial transmission, finer beam for msg1 based on CSI-RS resources configured during initial access, beam indication for the following steps for RACH procedure, differentiation between enhanced UE and legacy UE, possible collision handling between PRACH transmission with and without multiple PRACH transmissions.*

## PUCCH with Msg4 HARQ-ACK

In Rel-15/16, PUCCH repetition can only be configured via higher layer parameter PUCCH-Config which is unavailable during the initial random access.

In [4, ZTE], [15, Sharp], it observes that PUCCH carrying Msg4 HARQ-ACK may also encounter coverage issues in some scenarios. They both propose to study PUCCH repetition when a UE does not have dedicated PUCCH resource configuration.

In addition, simulation results are provided in [4, ZTE]. It observes that, for PUCCH carrying 1-bit HARQ-ACK for Msg4, about 3 dB and 6 dB gain can be obtained by employing 2 repetitions and 4 repetitions respectively.

In [5, CATT], it notes that it may need further study on whether coverage enhancement for PUCCH corresponding to Msg4 is needed or not.

Considering the necessity of enhancement highly depends on the outcome of sub-agenda 8.8.1, FL suggests to discuss the following proposal.

***Proposal 8:* Contingent on the outcome of sub-agenda 8.8.1, s*tudy PUCCH repetition for PUCCH carrying HARQ-ACK for Msg4 in NR coverage enhancement SI.***

As for the spec impacts, FL suggests to discuss the following proposal.

**Proposal 9: Capture the followings into the TR**

* *PUCCH repetition carrying HARQ-ACK for Msg4 was studied. Potential specification impacts include related signaling design, differentiation between enhanced UE and legacy UE.*

## Beam refinement during initial/random access

In this section, solutions for beam refinement (**except for** multiple PRACH transmissions which is discussed in Section 3.2 and multiple PDCCH transmissions which is discussed in Section 3.6**)** during initial/random access procedure are summarized.

Based on companies’ input, the following solutions for beam refinement are raised.

* **Candidate solution 1: SSB enhancements** 
  + Support: [2, Huawei, HiSilicon], [4, ZTE], [14, Sony]
    - This could provide beam refinement for all channels in initial/random access procedure. Proposed solutions include time/frequency domain solutions to improve SS/PBCH performance, increasing the number of SSB beams, SSB polarization.
    - [4, ZTE] observes that increasing the number of SSBs from 4 to 8 at 700MHz can provide 1.84 dB performance gain, and the method for indicating candidate SSB index in Rel-16 NR-U can be reused for index indication of refined SSBs.
    - In [14, Sony], it observes that, between 25% and 40% of the times, a UE will make an erroneous beam selection if it is not aware of polarization properties.
  + Not support: [3, vivo], [5, CATT]
    - [3, vivo]: There is backward compatibility issue if the number of SSB beams is supported by simply extending the number of SSBs in a half frame.
    - [5, CATT]: The performance of PDSCH, PDCCH and SSB are much better than the target performance in terms of MPL.
* **Candidate solution 2:** Reporting the best SSB/alternative SSB beam/early CSI in Msg3 PUSCH.
  + Support: [11, Samsung], [13, AT&T], [16, LG Electronics], [17, Ericsson], [19, InterDigital], [21, Qualcomm].
    - This could provide beam refinement for Msg4 in random access procedure.
    - [11, Samsung]: By having finer beam reference signal, e.g., NZP CSI-RS resources, configured during initial access, a UE is able to refine a selected DL beam, and can be reported in Msg3. A UE can use CSI-RS, if present, for beam refinement for PRACH transmission – e.g. to determine an appropriate PRACH transmission power and minimize PRACH attempts/overhead/latency.
    - [13, AT&T]: Beam adjustment using alternative beam reporting in Msg3 is beneficial for initial access coverage enhancement
    - [16, LG Electronics]: The possibility that the UE preferred SSB index could be changed after receiving msg2 PDCCH/PDSCH. If the benefit of DL Tx beam refinement is revealed clearly for DL coverage enhancement, we may consider to discuss a potential techniques for reporting UE preferred SSB index.
    - [17, Ericsson]: Maintaining PDSCH coverage without accurate CSI may require relatively high amounts of downlink resource; Msg4 PDSCH has worse coverage than other DL PDSCH; Early CSI availability can provide downlink coverage for small PDSCH packet sizes before normal CSI is available without excessive latency, RRC signalling overhead or excessive downlink resource.
    - [19, InterDigital]: Early CSI reporting would be beneficial for the selection of a proper MCS for msg4 PDSCH and subsequent PDSCH messages until the UE obtains a suitable CSI reporting configuration.
    - [21, Qualcomm]: Beam reporting by UE can be used simply as reporting a better SSB beam index, or selection of a refined beam for refinement of the SSB beam.
  + Not support: [3, vivo],
    - [3, vivo]: According to the evaluation results, Msg4 is robust enough for the required scenarios, hence there is on strong motivation to support early CSI report.

Based on above summary, FL suggests to discuss the following proposal based on majority view.

***Proposal 10: Study solutions for beam refinement during initial/random access, including at least beam reporting in Msg3 PUSCH.***

As for the spec impacts, FL suggests to discuss the following proposal.

**Proposal 11: Capture the followings into the TR**

* *Beam reporting in Msg3 PUSCH was studied from several aspects, including the best SSB, alternative SSB beam and early CSI report in Msg3 PUSCH. Potential specification impacts include signaling design in Msg3 PUSCH, CSI-RS resources configured during initial access, beam indication for the following steps for RACH procedure.*

## A-CSI enhancements

**A-CSI/SP-CSI in PUSCH**

In NR Rel-15/16, three types of CSI reporting, periodic CSI reporting (P-CSI), semi-persistent CSI reporting (SP-CSI) and aperiodic CSI reporting (A-CSI), were supported. Among them, P-CSI and SP-CSI can be transmitted on PUCCH. A-CSI and SP-CSI can be transmitted on PUSCH, but CSI on PUSCH cannot be repeated.

In [17, Ericsson], it proposes to support CSI repetition on PUSCH with repetition Type A or Type B, based on the following observations.

* CSI on PUSCH is one of the coverage bottlenecks and its coverage needs to be enhanced.
* A-CSI repetition on PUSCH has already been studied in NR release 15 and release 16 and can be a good baseline for its study in R17.
* Around 4 dB gain can be achieved with up to 8 repetitions of CSI (6+5 bits) on PUSCH for mid-band.
* The estimated maximum isotropic loss of CSI on PUSCH is worse than CSI on PUCCH, becoming one of the most limiting factors for cell coverage.

On the other hand, it is observed in [5, CATT] that, if A-CSI on PUSCH is problematic, UE can rely on P-CSI which will be certainly taken care of in PUCCH coverage enhancement. The motivation of coverage enhancement for A-CSI is not clear.

Based on above summary, FL suggests to first collect more inputs from companies.

**A-CSI on PUCCH**

In NR Rel-15, A-CSI can only be transmitted on PUSCH. In [17, Ericsson], it finds that the estimated maximum isotropic loss of CSI on PUSCH is around 3.5dB less than CSI on PUCCH without repetition, becoming one of the most limiting channels for cell coverage. However, the CSI coverage bottleneck can be resolved by the support of A-CSI on PUCCH. It proposes to continue investigation and evaluation of A-CSI on PUCCH in coverage enhancement topic, and then discuss in RAN#90-e to decide where specification of A-CSI on PUCCH will be, e.g. Rel-17 feMIMO or Rel-17 IIoT/URLLC.

Based on above limited interests and the discussion in the last meeting, FL suggests to first collect more inputs from companies.

***Proposal 12: A-CSI repetition on PUCCH is deprioritized in NR coverage enhancement SI.***

## PDCCH enhancements

In [3, vivo], [4, ZTE], [5, CATT], [12, OPPO], [20, NTT DOCOMO], [19, InterDigital], [21, Qualcomm], PDCCH enhancement is discussed and companies’ views are summarized as follows.

* **Support PDCCH repetition at least for broadcast PDCCH**
  + Support: [4, ZTE], [12, OPPO], [19, InterDigital], [20, NTT DOCOMO], [21, Qualcomm]
    - [4, ZTE]: There still exists some scenarios that needs coverage enhancement for broadcast PDCCH based on link budget evaluation. Study compact DCI, PDCCH repetition and PDCCH-less mechanism.
    - [21, Qualcomm]: There is a 5.4dB gap between broadcast PDCCH to PUCCH format 3, so a small number of repetitions upto 4 is sufficient.
    - [19, InterDigital]: Study PDCCH enhancements for RAR relate to configuration of PDCCH repetitions and whether/how to provide indication of a best PDCCH repetition among a repetition bundle in msg3 or in early CSI report.
    - [20, NTT DOCOMO]: Study smaller DCI payload size and PDCCH repetition etc.
  + Not support: [3, vivo], [5, CATT]
    - [3, vivo]: Beam refinement based on PDCCH repetition may suffer from low measurement accuracy and higher power consumption.
    - [5, CATT]: The performance of PDCCH is much better than the target performance in terms of MPL.

**Evaluation results**

In [4, ZTE] and [21, Qualcomm], evaluation results for broadcast PDCCH repetition are provided and have the following observations.

|  |
| --- |
| [4, ZTE]: For PDCCH repetition, about 2.8~3.1 dB and 4~5.8 dB gain can be obtained by employing 2 repetitions and 4 repetitions respectively.  [21, Qualcomm]: For broadcast PDCCH, 2 repetition and 4 repetition yield 2dB and 4dB gain respectively. If DMRS bundling is considered, the gains are increased to 3dB and 6dB. |

Based on the evaluation results provided, FL suggests to discuss the following observation.

***Observation 4: For broadcast PDCCH, 2 repetitions and 4 repetitions yield about 2~3dB and 4~6dB gain respectively***

**FL suggestion: The intention is to capture the observation into TR. Considering the deadline for evaluation inputs is 6th Nov, we can further discuss this after the deadline.**

As for the spec impacts, FL suggests to discuss the following proposal.

**Proposal 13: Capture the followings into the TR**

* *Broadcast PDCCH repetition was studied. Potential specification impacts include PDCCH repetition configuration, DMRS design among PDCCH repetition.*

## Msg4 PDSCH

In this section, inputs on Msg4 PDSCH enhancements are summarized except for beam refinement related enhancements which is discussed in Section 3.4.

In [17, Ericsson], it noted that in NR up to Rel-16, Msg4 PDSCH doesn’t support beam management or PDSCH slot aggregation since RRC connection is not established yet, nor does it support TBS scaling which is applicable for Msg2 PDSCH scheduled by RA-RNTI or for paging.

In [15, Sharp], it proposes that if enhancement to message 4 PDSCH is supported, scaling factor S can be applied to PDSCH scheduled by DCI format with TC-RNTI.

In [21, Qualcomm], it proposes that NR should support coverage enhancement of Msg4 PDSCH, e.g. via PDSCH repetition.

Based on above, FL suggests to discuss the following proposal.

***Proposal 14:* Contingent on the outcome of sub-agenda 8.8.1, study *Msg4 PDSCH enhancement in NR coverage enhancement SI.***

As for the spec impacts, FL suggests to discuss the following proposal.

**Proposal 15: Capture the followings into the TR**

* *Msg4 PDSCH enhancements were studied from several aspects, including introducing scaling factor for TBS determination and PDSCH repetition. Potential specification impacts include TBS determination, PDSCH repetition configuration, DMRS design among PDSCH repetitions.*

## PDSCH enhancement

In [5, CATT], it observes that the performance of PDSCH is much better than the target performance in terms of MPL. However, in [20, NTT DOCOMO], it proposes that improvement of PDSCH may be considered, and potential techniques for PUSCH coverage enhancements can be also applied to PDSCH. In addition, PDSCH repetition for frequency domain can be one of the potential techniques.

Considering the limited interests and expected good link budget performance for PDSCH, FL suggests to discuss the following proposal.

***Proposal 16: PDSCH enhancement is not studied in NR coverage enhancement SI.***

# Proposals for discussion (1st round)

## [H] Msg3/MsgA PUSCH enhancements

***Proposal 1: Study the indication of the number of repetitions for Msg3 initial transmission, including at least following options.***

* + ***Option 1: RAR UL grant or fallbackRAR UL grant***
  + ***Option 2: DCI format 1\_0 with CRC scrambled by RA-RNTI***
  + ***Option 3: Implicit method.***
  + ***Option 4: SIB1***

***Note: signaling indication with combined options is not precluded.***

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | Generally fine with the proposal except the “***fallbackRAR UL grant***” part. Even though the format of fallbackRAR is same as the RAR in 4step RACH, but fallbackRAR implies the UE is currently operating the 2step RACH which is not the coverage limit case. So we suggest to remove the fallbackRAR UL grant; |
| Apple | Support, with note from Samsung |
| CATT | For option 2 and option 4, both signaling are common to all the received UEs. What if the requirement on coverage for each UE is different from each other? |
| NTT DOCOMO | Msg2 RAR could be the first choice to indicate the number of repetition, since it has UL grant for Msg3 initial transmission. |
| Qualcomm | We propose to remove fallbackRAR UL grant in Option 1 since it is not part of 4-step RACH. Other than that, we support the proposal. |
| Intel | We are in general fine with the proposal. For Option 3, it is more appropriate to list the detailed solution for implicit method, e.g., determined based on PRACH configuration/repetitions if supported. |
| Sharp | As indicated by companies, we also think *fallbackRAR* UL grant should be removed from the proposal. Enhancement to 2-step RACH (including fallback to 4-step in 2-step RA procedure) can be discussed separately. |
| WILUS | Support the FL proposal in principle. We agree with Samsung’s comment about fallback RAR UL grant. Also, please clarify repetition number of above options also include ‘1’ as the possible indication number (i.e., Msg3 transmission w/o repetition). For option 3, more details about this option seem necessary, such as captured e.g. points in section 2.1. |
| China Telecom | We share the same view with Qualcomm and Samsung, i.e. remove “*fallbackRAR UL gran*t” in Option 1. Other than that, we support this proposal. |
| Panasonic | We share the same view with other companies, i.e., “fallbackRAR UL grant” in Option 1 should be removed. |
| OPPO | Support after remove the fallbackRAR UL grant in Option 1. |
| ZTE | Support the proposal and also fine to remove “fallbackRAR UL grant” in Option 1 as commented by other companies. |
| CMCC | Generally fine with the proposal. If the enhancement related to 2 step RACH cannot reach a consensus, we are fine to remove it. |
| Nokia/NSB | Support the proposal with the removal of “fallbackRAR UL grant” in Option 1. On the other hand, we think that the presence of the “***at least***” in the first sentence enables the possibility for other options to be considered/studied as well. Other options exist, can be studied and considered for the discussion. In other words, and unless we mistake the FL’s intention, we think the goal of the proposal is to provide a starting point for the discussion, not the conclusion. If this is the case, we do not see the need to discuss about implicit signaling mechanisms right now, or any other explicit mechanisms for that matter. *Can FL confirm that this the intention of the proposal*? |
| Ericsson | These signaling options can be discussed in the work item stage.  Regarding the fallback RAR scheduled msg3 repetition, we can not understand that 2-step RACH can only be applied when UE is not coverage bottleneck, it depends on the RSRP threshold defined for RA type selection. And also be noted that when fallback happens, it means UE is already coverage limited and cannot have the MsgA PUSCH be received. At least technically we can not understand why this fallback RAR scheduled msg3 repetition should be specifically precluded.  To avoid too detailed discussions at this stage, it might be enough to say that **whether repetition factor can e.g. be implicitly determined and/or explicitly indicated in RAR, DCI and/or system information can be further discussed in work item stage.** |
| InterDigital | Support |
| FL | @WILUS Details for Option 3 is added as examples. Current proposal doesn’t preclude the number of repetitions is 1. FL suggest not to clarify this point to avoid further potential confusion.  @CATT and Nokia, the intention is to list the possible solutions as proposed by companies, and no plan to down-select any option at this stage. We will not discuss the details for each option now and these options will server as starting point for future discussion.  @Ericsson and all, it seems Ericsson’s point is valid. Fallback RAR is for switching to 4-step RACH. It is more like the Msg3 scheduled by fallback RAR is in a 4-step RACH procedure. If it is precluded, it means a UE cannot fall back to 4-step RACH to ensure the coverage. So, FL suggests to keep it.  @ all, these options will server as starting point for future discussion, and it would be helpful for us to keep it considering all discussion here. FL would like to check whether it is acceptable for all about the updates below. If companies still have strong concerns (hope not), we can then delete the options here. |
| vivo | We share the same view with Samsung, “fallbackRAR UL grant” which associated with 2 step RACH should be removed. |

***Updated Proposal 1: Study the indication of the number of repetitions for Msg3 initial transmission, including at least following options.***

* + ***Option 1: RAR UL grant or fallbackRAR UL grant***
  + ***Option 2: DCI format 1\_0 with CRC scrambled by RA-RNTI***
  + ***Option 3: Implicit method, e.g., implicitly determined by PRACH configuration or information carried by RAR.***
  + ***Option 4: SIB1***

***Note: signaling indication with combined options is not precluded.***

**Please comment on the updated proposal 1 only if you have concerns on.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| vivo | “fallbackRAR UL grant” implies that 2 step RACH is also considered for enhancement, thus we still prefer removing it.. |
| Ericsson | “fallbackRAR UL grant” schedules a msg3 PUSCH in 4-step RACH, not sure how this is related to 2-step RACH enhancement, it’s just the signaling in a RAR used in 2-step RACH when it switches to 4-step RACH. Fallback means the link budget is already bad. |
| LG | The updated proposal 1 is saying to study very detail solution. The result of study is not clear. Also, we wonder the study result is necessity to capture in TR. As mentioned, these detail options should be discussed in WI phase.  During this e-meeting, we should capture the study result which may include potential specification impact. We think previous Ericsson’s proposal to capture study item result in TR is very reasonable in SI phase. |
| FL | @LG The study result includes two parts:   1. Discuss whether an enhancement is needed, if needed, whether should be low priority or not. 2. Capture the studied techniques including the spec impacts into TR.   The proposal here serves the purpose of the first part. As how to capture into TR, I will draft the TP for discussion later on.  As for whether to list the detailed options, please refer to my reply above. |
| Samsung | Remove “fallbackRAR UL grant”, we provide reasons in the first round. And E///’s argument is incorrect. I think we have already stated the msgA PUSCH failure is not necessarily due to coverage, it could be due to the collision of DMRS, the time-offset between UE is quite large etc. The success of preamble in a way shows the coverage is not the problem. |

***Proposal 2: Study the indication of the number of repetitions for Msg3 re-transmission, including at least following options.***

* + ***Option 1: DCI format 0\_0 with CRC scrambled by TC-RNTI.***
  + ***Option 2: Implicit method.***

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| **Company** | **Comments** |
| Samsung | Fine. |
| Apple | Support |
| CATT | We are fine with the proposal. Our position is added under option 2. |
| Qualcomm | We support the proposal |
| Intel | We are in general fine with the proposal.  For Option 2, it is more appropriate to list the detailed solution for implicit method, e.g., determined by Msg3 initial transmission. |
| Sharp | We are OK with the proposal. |
| WILUS | Similar comment with Proposal 1. Please clarify repetition number includes value ‘1’. Also, more details about option 2 seem necessary. |
| Panasonic | We are fine with the proposal. |
| OPPO | We are fine with the proposal. Option 2 is a general method. Details are needed for further consideration. |
| ZTE | Support |
| CMCC | Fine with the proposal |
| Nokia/NSB | Our comment to Proposal 1 applies here as well. |
| Ericsson | It looks fine though these signaling can be further discussed in work item stage. |
| InterDigital | We would like to propose the following  Option 3 : Dynamic indication of the number of repetitions in RAR |
| FL | @InterDigital, you proposed Option 3 seems that can be included in Option 2 below. Because RAR UL grant is only for scheduling Msg3 initial transmission.  Similar comments as in Proposal 1. FL would like to check whether it is acceptable for all about the updates below. |
|  |  |

***Updated Proposal 2:* Study the indication of the number of repetitions for Msg3 re-transmission, including at least following options.**

* + **Option 1: DCI format 0\_0 with CRC scrambled by TC-RNTI.**
  + **Option 2: Implicit method, e.g., the repetition factor is implicitly determined by Msg3 initial transmission.**

**Please comment on the updated proposal 2 only if you have concerns on.**

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| --- | --- |
| **Company** | **Comments** |
| LG | It is required to study the indication details in WI phase.  I think, in SI phase, it is enough to capture high level description (e.g., the explicit/implicit method for the indication of the number of repetitions for Msg3 re-transmission) as a potential specification impact. |
| FL | @LG Similar comment as above. |

***Proposal 3: Study the repetition type for Msg3 PUSCH repetition.***

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| --- | --- |
| **Company** | **Comments** |
| Samsung | The PUSCH repetition Type B is UE optional feature, it is not suitable to be supported during random access when UE has not been identified by gNB. |
| Apple | As mentioned in the call, Type B repetition for Msg3 is not justified. Let’s be specific here on Msg3 TypeA PUSCH repetition |
| CATT | Repetition type B is designed for low latency instead of good coverage. Type A repetition is sufficient. |
| Qualcomm | We do not support this proposal. Supporting Type B PUSCH repetition has been UE capability. During RACH, UE capability is unknown. |
| Intel | We share similar view as other companies that only repetition type A for Msg3 is supported. |
| China Telecom | We also think it is reasonable that only repetition type A is supported for Msg3. |
| Panasonic | We share the similar view with other companies that PUSCH repetition Type A is sufficient for Msg.3. |
| OPPO | Type A repetition is sufficient. It is not clear why we need type B. |
| ZTE | We support both repetition type A and B. For repetition type B, it can also improve the reliability in terms of not simply dropping the transmission as repetition type A in case of collision with invalid symbols. |
| CMCC | Repetition type A should have a higher priority. If the Msg 3 have coverage issues, we do not see the motivation to use type B repetition. |
| Nokia/NSB | Similar comment as Qualcomm and Samsung. |
| Ericsson | Fine, type A could be a start point. |
| InterDigital | Support |
| FL | Only one company explicitly shows support for repetition type B. So, the proposal is updated to follows. |

***Updated Proposal 3: Study ~~the~~ only repetition type A for Msg3 PUSCH repetition.***

**Please comment on the updated proposal 2 only if you have concerns on.**

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| --- | --- |
| **Company** | **Comments** |
| LG | We do not have any strong view regarding the updated proposal#3. But, we provide our view for calcification.  It seems that the purpose of the updated proposal#3 is not clear. In SI phase, we may study on possible candidates. Then, we may capture the study result in TR. But, it seems that the updated proposal#3 is intended to down-select one option between repetition type A and type B. |
| FL | @LG Similar comment as above. The proposal means, we studied both repetition type A and type B, while only agree on repetition type A. So, in the TR, we will say something like: Repetition type for Msg3 repetition was studied including both repetition type A and type B, while it concluded repetition type B is not needed. This would be discussed later on. |

***Proposal 4-1: Study cross-slot channel estimation for Msg3 repetition.***

***Proposal 4-2: Study the feasibility and applicability of normal PUSCH enhancements (if supported in AI 8.8.2.1) for Msg3 PUSCH initial/re-transmission.***

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| --- | --- |
| **Company** | **Comments** |
| Samsung | Having proposal 4-2 so far is enough. |
| CATT | Agree with Samsung. P 4-2 already covers P 4-1. |
| Qualcomm | Agree with Samsung that Proposal 4-2 is sufficient. |
| Intel | We suggest to wait the conclusion/agreements from PUSCH coverage enhancement. After we have clear picture, we can further check the solutions adopted from the normal PUSCH coverage enhancement for Msg3 PUSCH. |
| Sharp | We support P 4-2. |
| China Telecom | Support P 4-2. |
| Panasonic | We agree with Samsung. |
| OPPO | We are fine with proposal 4-2. |
| ZTE | Support both proposals. |
| CMCC | Support both proposal 4-1 and 4-2. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | Support 4-2 |
| Nokia/NSB | Agree with Samsung in principle. However, we would like to note that Proposal 4.2 seems to include Proposal 3 implicitly as well. More precisely, enhancing repetition type B framework for RRC-connected PUSCH is still a controversial aspect in 8.8.2.1. As we can see from the comments, this seems to be even more the case in this AI. Maybe we could add a note to Proposal 4-2 to clarify that “applicability and feasibly” should also consider UE capabilities in RRC-idle phase? |
| Ericsson | Fine. |
| InterDigital | Agree with others that Proposal 4-2 is enough |
| FL | @Nokia, a note is added to address the concern.  There are 3 companies support/fine with both proposals while majority companies only support proposal 4-2. Note, the intention of proposal 4-1 is we will no need to study the feasibility and applicability and directly support to study the cross slot channel estimation for Msg3 given 6 companies observe the benefits as summarized in section 3.1.  FL suggests to first agree on proposal 4-2, and after that, we can further check whether Proposal 4-1 is acceptable if time permits. |

***Updated Proposal 4-2: Study the feasibility and applicability of normal PUSCH enhancements (if supported in AI 8.8.2.1) for Msg3 PUSCH initial/re-transmission.***

***Note: UE capabilities in RRC-idle phase should be considered.***

**Please comment on the updated proposal 4-2 only if you have concerns on.**

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| **Company** | **Comments** |
| LG | It seems that clarification of the study result is necessity. I guess FL might intend to gather study result whether normal PUSCH enhancements is feasible and/or applicable for Msg3 PUSCH initial/re-transmission or not. Is my understanding is correct? |
| FL | @LG Yes, also find similar comment as above. |

***Proposal 5: Study solutions for gNB to identify whether a UE supports Msg 3 PUSCH enhancements or not.***

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | For proposal itself, it is general enough thus fine for us.  But our thinking was that it is not always necessary that “gNB needs to identify whether the UE supports Msg3 PUSCH enhancements or not **before** it indicates corresponding signaling”; gNB could make separate configurations in case of UE support or UE doesn’t support repetitions. For example, currently the msg.3 DMRS is using DMRS port 0 by default. We can specify that if UE is capable of msg3 repetitions, then the UE will use another specific DMRS port, e.g., DMRS port 1. Then gNB just needs to check twice of the DMRS then it can identify whether a UE supports Msg 3 PUSCH enhancements or not, which consumes not much gNB overhead. |
| CATT | Support. To be specific, it should be ‘***whether a UE supports Msg 3 PUSCH coverage enhancements or not.***’ |
| Qualcomm | Support the proposal. |
| Intel | We are fine with the proposal. |
| Sharp | We are OK with the proposal. |
| China Telecom | Support this proposal. |
| Panasonic | We are fine with the proposal. |
| OPPO | We are fine with the proposal. |
| ZTE | Fine with the proposal |
| CMCC | Generally fine with the proposal. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | Support |
| Nokia/NSB | Support. |
| Ericsson | Fine to study. Implicit indication of the support of msg3 new features (e.g. repetition) via Msg1 is also discussed on other topics to differentiate small data UEs vs. non-small data UEs, i.e. whether msg3 carries small data. But we’re not sure whether these can be combined. |
| FL | An editorial update as CATT suggested. |

***Updated Proposal 5: Study solutions for gNB to identify whether a UE supports Msg 3 PUSCH coverage enhancements or not.***

**Please comment on the updated proposal 5 only if you have concerns on.**

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| **Company** | **Comments** |
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***Proposal 6: MsgA PUSCH repetition can be studied with low priority.***

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| **Company** | **Comments** |
| Samsung | We are not positive on applying coverage enhancement for 2step RACH so far.  As we commented even in last meeting, 2step RACH is designed for good coverage (good link) case, although the SSB-threshold is implemented by gNB thus anything can happen, but it is not reasonable to apply coverage enhancement for 2step RACH. |
| Apple | Do not support. We share similar view as Samsung |
| Sony | We would like to see the possibility of the coverage of 2-step RACH being enhanced, so we do not support the proposal.  The main argument against coverage enhancement of MsgA PUSCH seems to be that there is a configurable RSRP threshold that is used to determine whether 2SR or 4SR is used in Rel-16. However, that threshold is *configurable*, so it can be set low in order to favour 2SR. If both PRACH and PUSCH are coverage enhanced, then it seems reasonable to enhance the coverage of 2SR, in which case the configurable threshold would be set lower.  In terms of there needing to be more resources of MsgA PUSCH: yes, if PUSCH is coverage enhanced through repetition, then more resources will be required. This argument applies to both PUSCH coverage enhancement in AI 8.8.2.1, Msg3 coverage enhancement and MsgA PUSCH coverage enhancement. |
| Qualcomm | We support the proposal. |
| Intel | We share similar view as Samsung and Apple and do not support this proposal.  It is unclear to us why we need to consider MsgA PUSCH for 2-step RACH. As mentioned above, 2-step RACH is mainly targeted to UEs in good channel conditions, where coverage enhancement is not needed. |
| Sharp | We think that msgA PUSCH enhancement can be deprioritized. As stated above, 2-STEP RACH is not designed for coverage edge UEs. |
| Panasonic | We share similar view as Samsung. |
| ZTE | We are fine to study as low priority or not study MsgA enhancement. |
| Nokia/NSB | Same view as Samsung. |
| Ericsson | Fine to study this with low priority given limited time.  MsgA PUSCH is collision based PUSCH which may require more enhancements than Msg3 PUSCH. Whether 2-step RACH is only used by UEs in good coverage depends on the RSRP threshold defined for RA type selection and note that 2-step RACH only operation is also possible meaning that all UEs in one cell may have to use 2-step RACH only in this case. |
| InterDigital | Support |
| FL | One company supports to study MsgA enhancement. 4 companies support or fine with the proposal. 7 companies don’t support to study MsgA enhancement.  Wait a bit for more input, and then FL will make corresponding proposal. |
| vivo | We are ok with lower priority. |

Companies are encouraged to provide views for the following aspects for Msg3 enhancement.

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| **Multiple antenna techniques**  In [11, Samsung], it notes that the msg3 spatial setting is left to UE implementation and refinement of spatial setting from msg1 tx to msg3 tx was not finalized in NR Rel-15. In NR Rel-16 2-step RACH, the PRACH and msgA PUSCH are specified to use a same spatial setting. It proposes to **specify that a same spatial setting applies for PRACH preamble and corresponding msg3 PUSCH transmissions**.  In NR up to Rel-16, Msg3 PUSCH transmission, which is scheduled by DCI format 0\_0, is based on a single antenna port. In [17, Ericsson], it observes that **open-loop Tx Diversity together with Msg3 repetition** can improve Msg3 coverage through diversity gain and Tx chain power combining, and **closed-loop Tx Diversity for Msg3** can benefit from coherent combining or antenna selection as well as Tx chain power combining.  **Waveform of Msg3**  In [6, Indian Institute of Tech (H)], it observes that UL transmission can benefit from power boosting wherein the max transmission power can reach up to 26dBm or 29dBm based on the UL duty cycle when DFT-s-OFDM waveform with pi/2 BPSK modulation is used. Every dB gained in transmission power significantly enhances the coverage of the UE. **Thus, pi/2 BPSK waveform with spectrum shaping is proposed for Msg3 transmission.**  **Power domain consideration for Msg3**  In [11, Samsung], it finds UEs in different conditions may experience better msg3 reception reliability using different values of power adaptation parameters (e.g., power ramping step powerRampingStep and pathloss compensation factor msg3-Alpha) . It can be beneficial from a latency perspective to use a suitable set of power adaptation parameters which can, e.g., faster achieve higher transmission powers in fewer number of retransmissions. **Thus, it proposes to consider multiple sets of power adaptation parameters for msg3 PUSCH coverage enhancement.**  **Inter-slot frequency hopping for Msg3 repetition**  In [18, Apple], it observes the inter-slot frequency with the repetition can provide 2dB performance gain. This gain is worthwhile to specify inter-slot frequency hopping and time domain repetition for Msg3 PUSCH coverage enhancement. Thus, it proposes **Msg3 repetition with inter-slot frequency hopping are supported.** |

**More inputs regarding to above four aspects are needed. FL proposal will be provided after collecting more views from companies.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | We support (dynamic) indication of waveform type (OFDM/DFT-S) for Msg3 PUSCH. Also as a note, in our understanding FH for Msg3 is already specified (for both initial and retransmission Msg3 PUSCH). |
| ZTE | We are fine to study inter-slot FH for Msg3 repetition. Note that, only intra-slot FH is supported in Rel-15/16. It would be nature to also consider inter-slot hopping in case of Msg3 repetition supported. Performance gain is expected as for PUSCH in RRC-connected mode. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | As shown in our tdocs, pi/2 BPSK is a straightforward way to get gains due to power boosting which enhances Msg3. Further this waveform already supports 26 dBm power in Rel-16. We only need to provide mechanisms to use this waveform in Msg3. |
| Nokia/NSB | We fully agree with Samsung’s proposal to *specify that a same spatial setting applies for PRACH preamble and corresponding msg3 PUSCH transmissions*, i.e., specifying for 4SR what has been specified for 2SR in Rel-16. This seems a very sensible and rational approach. It is unclear why UE should behave differently in the two cases, given that the information UE has access to in the two cases is the same.  We also think we can study inter-slot FH for msg3 repetition. |
| Ericsson | We’re fine to capture different techniques in TR as well. And agree that inter-slot frequency hopping of Msg3 should be naturally studied |
| FL | Wait a bit for more input, and then FL will make corresponding proposal. |
| vivo | We suggest to also study early termination for MSG3 repetition.  In TDD spectrum and frame structure with limited UL resources, e.g. DDDSU, there would be DL resources between MSG3 repetitions, we suggest to consider early termination of MSG3 repetition, if UE have received MSG4 before UE finished the *N* MSG3 repetitions as indicated by NW. Unnecessary MSG3 transmission should be avoided. |

## [H] PRACH enhancements

***Observation 2: PRACH enhancement is needed in NR coverage enhancement SI.***

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| --- | --- |
| **Company** | **Comments** |
| Samsung | Fine with this observation or conclusion. |
| CATT | It is too hurry to have the observation, at least several companies have different views.  It should be noted that the performance metric is still under discussion in the other AI, which will have directly impacts on what the bottleneck channel is. We should wait for the outputs from 8811 and 8812. Then we can determine whether it is necessary to enhance PRACH.  We should firstly focus on the channels surely with consensus, for example Msg3 PUSCH. |
| Qualcomm | Support the observation. We propose to add into the observation that PRACH enhancement could not only enhance PRACH coverage, but also enhance coverage of other RACH messages (including Msg3). |
| Intel | Based on our link budget analysis, it was observed that short PRACH format needs coverage enhancement in TDD configuration. In our view, it would be good to restrict to short PRACH format as we have PRACH format 1 and 2 which can be used for coverage enhancement for long PRACH format. We suggest to modify the observation as “PRACH enhancement for short PRACH format is needed in NR coverage enhancement SI.” |
| Sharp | Enhancement to PRACH coverage can be considered (e.g., repetition). We are not sure if multiple PRACH transmission within RAR window is necessary for PRACH (and/or msg3 PUSCH) coverage extension. Latency reduction is not the target for CE SI. |
| Panasonic | We support the observation. |
| OPPO | Fine with this observation. |
| ZTE | Fine with the observation and also the modification from Intel. |
| CMCC | Prefer to wait for the outcome of AI 8811 and 8812. The necessity should be justified based on the outcome of those two agenda items. |
| Sony | We support this observation. |
| Nokia/NSB | We support the observation. Concerning Intel’s comment, it may be premature to make such a strong statement. Indeed, it has been stated by several companies that PRACH enhancements can have a big positive impact on msg3 coverage as well, especially when the enhancements allow UE to get more information on the beam space and use a better, likely narrower, beam for msg3 transmission. This was actually one of the first observations companies had on this topic. Such positive impact would occur regardless of the considered PRACH format. On the other hand, we see the logic of what Intel suggests, hence maybe we could modify the observation as follows:  ***Observation 2: PRACH enhancement at least for short PRACH format is needed in NR coverage enhancement SI.***  **FFS: if the above applies to long PRACH formats as well** |
| Ericsson | Do not agree on this observation. PRACH is not a bottleneck based on our system level results. And if PRACH reattempt with power ramping is further considered, the performance will be even better as we’ve discussed a lot in last meeting. |
| InterDigital | Support the observation |
| FL | Wait a bit for more input, and then FL will make corresponding proposal. |
| vivo | Since PRACH is not a channel with high delay requirement, the coverage can be improved by multiple attempts in a RACH procedure instead of repeat PRACH in a single attempt. Hence, we do not prefer PRACH repetition is considered with higher priority in CE SI. |
| Nokia/NSB | From our perspective, stating that PRACH reattempt with power ramping can address concerns related to PRACH coverage is not correct nor compatible with how simulations have been performed by all companies. Indeed, all the companies who studied PRACH performance (and the performance of any other channels, actually) assumed max TRP is set at the UE in the LB template. This implies that all the corresponding MCL/MIL/MPL values are already assuming that power ramping, if any, has been performed, since UE cannot further increase its power above the maximum TRP. In other words, we cannot improve MCL/MIL/MPL by power ramping in this case. Therefore, if a bottleneck exists (and many companies show that it does, at the very least for 12 dBm max TRP) then retransmissions with power ramping cannot be considered as “a way out” and other solutions are necessary. |

Based on Chairman’s guidance in GTW session on 10/27, we need to discuss in parallel about the spec impacts for interested enhancements. So, it suggested to discuss the following spec impacts for multiple PRACH enhancements.

**Proposal 7: Capture the followings into the TR**

* *PRACH enhancements were studied from several aspects, including PRACH repetition with the same transmission beam and multiple PRACH transmissions with beam sweeping.*
* *Potential specification impacts of PRACH enhancements include: determination of PRACH repetition, transmission beam to be used for each initial transmission, finer beam for msg1 based on CSI-RS resources configured during initial access, beam indication for the following steps for RACH procedure, differentiation between enhanced UE and legacy UE, possible collision handling between PRACH transmission with and without multiple PRACH transmissions.*

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| **Company** | **Comments** |
| CATT | Not clear why it is an individual proposal. The motivation is to capture how we study PRACH? If so, the other potential techniques should also deserve the same proposal. |
| Qualcomm | Support the proposal |
| Intel | We are in general fine with the proposal. We are not sure “possible collision handling between PRACH transmission with and without multiple PRACH transmissions”. It would be good to clarify this. |
| OPPO | Support the proposal |
| ZTE | Fine with the proposal. |
| Sony | Support the proposal. |
| Nokia/NSB | Support the proposal. Concerning comment from Intel, our understanding is that “possible collision handling between PRACH transmission with and without multiple PRACH transmissions” refers to a situation in which some UEs in the cell support PRACH enhancements and some others do not. In this regard, for instance, at least three options could be envisioned:   1. The two sets of UEs do not use the same set of ROs for transmitting msg1; 2. The two sets of UEs use the same set of ROs for transmitting msg1; 3. The two sets of UEs use a same sub-set of ROs, plus some exclusive ROs.   Other options are possible, of course. However, if we consider the 3 above, we already have two examples in which collisions between msg1 transmissions performed by the two sets of UEs can occur.  RAN1 has not decided yet this is a problem or not and, if it is, if it should be solved or not.  Having said this, we think that the list of potential spec impact should not be considered as an exhaustive list with all possibilities. We hope this is the understanding. Could FL clarify this aspect, please?  If this is the understanding, we would be ok with restructuring it, if such is the will of the majority. |
| Ericsson | Fine to capture all techniques with the common understanding that all techniques will be captured especially those for channels with bottleneck identified. |
| InterDigital | Support |
| FL | FL responses to CATT in email reflector are copied below.  *Comment#1: Per Chairman’s guidance in GTW session, we need to discuss the spec impacts for interested enhancements before the output of evaluation results are available, so that we would capture these spec impacts into TR in time. The reason I didn't make any TP for Msg3 yet is Msg3 enhancement has been agreed and I'd like to discuss more detailed enhancement aspects first. After this, I will certainly prepare the TP for Msg3 for review.*  *Comment #2: I think it is just a matter of in which formulation we discuss the potential techniques, using proposal or text proposal. Based on what we are doing for email discussion of the TR and also PUSCH agenda, I would expect we will capture all related studied techniques to the TR. As also clarified by Chairman before, capturing into TR doesn't mean these aspects will be certainly included in WI scope. So, in this sense, I would expect discussing in format of TP for spec impacts would be easier for us. Note that, except for the TP, I also have an corresponding proposal for whether to study the enhancements for each of the channel/signal.*  @Intel, please refer to Nokia’s clarification.  @Nokia, yes, it only includes the proposed spec impacts from companies so far. It may not be an exclusive list, additional impacts could be added at later stage as long as it has technical merits.  @all, Please comment further **only if you have concerns.** |
| vivo | It is fine to capture generic statement, however it should also be noted that PRACH is not identified at bottleneck, hence enhancement technique is less of relevance. Otherwise we end up capturing all the channel which do not have coverage issue. |
| Ericsson | We propose to treat this with lower priority. i.e. change [H] to [L] as well since PRACH is not a bottleneck while the bottle neck channel A-CSI on PUSCH is put with [L]. |
| LG | As mentioned, we also think the priority of this proposal changed into lower priority. The needs of RACH enhancement itself is not clear, so far.  Also, the further clarification is necessary for the proposal.  In the first bullet, we may modify that the *PRACH enhancements for FR2 were studied* *from several aspects, … .*  *For the second bullet, it is required that if the benefit of the proposed solution is revealed, the potential standardization impact can be captured as an example. But, so far,* |
| FL | @vivo Ericsson, LG, as commented in the reflector, the plan is:  As Chairman's guidance, we could discuss the spec impacts before the evaluation results are available. If some techniques are interested by many companies, we would include our corresponding study in the TR. As what we are discussing in Email-01, basically all techniques including FFS points like OCC spreading based repetition, symbol-level repetition, FDD high power UE etc., and de-prioritized techniques are all captured in the TR. To follow the same principle here, we should include all our studied techniques into TR. However, we would also capture the prioritization or de-prioritization for these techniques.  Please note, for each TP I proposed, I also made a proposal for it. If a channel is not a bottleneck or an enhancement is not needed based on further evaluation results and our further discussion,  we will make a conclusion/observation to say corresponding enhancement is not needed or study as low priority or de-prioritized. Then, such statement will be also captured in the TR.  To sum up, we can first agree to the TPs for the spec impacts of our studied techniques. Then, after evaluation results are available, we can then make further decision on support of an enhancement, and add potential prioritization or de-prioritization in the TR. Note, **we cannot do these only at the last moment when we get results (expected to be available very late), that would be too late for us**!  @LG, It seems both FR1 and FR2 are studied. If we only agree on FR2 or short PRACH, we will also capture these decisions into TR. But we cannot wait all at the final moment especially for those aspects not related to the evaluation results. |
| Samsung | One editorial change suggestion:   * Unified the term PRACH repetitions and multiple PRACH transmission, since the latter one has more general meaning, suggest to use multiple PRACH transmission; * Check the understanding of “determination of PRACH repetition”, it should include the meaning of both the conditions to initiate multiple PRACH transmission and also the resource determination of multiple PRACH transmission; * *PRACH enhancements were studied from several aspects, including multiple PRACH transmissions ~~PRACH repetition~~ with the same transmission beam and ~~multiple PRACH transmissions~~ with beam sweeping.* * *Potential specification impacts of PRACH enhancements include: determination of multiple PRACH transmissions ~~PRACH repetition~~, transmission beam to be used for each initial transmission, finer beam for msg1 based on CSI-RS resources configured during initial access, beam indication for the following steps for RACH procedure, differentiation between enhanced UE and legacy UE, possible collision handling between PRACH transmission with and without multiple PRACH transmissions.* |
| CATT | For proposal 7 on PRACH, we are OK capture it in the TR at this moment although think it may be a little hurry. Now that we have mentioned the specification impacts in the proposal, it should be as comprehensive as possible. At least the association between preamble index and SSB index within RO or cross RO is also the serious specification impact if PRACH enhancement is introduced. Could you please capture it in the next update?  **Proposal 7: Capture the followings into the TR**   * *PRACH enhancements were studied from several aspects, including PRACH repetition with the same transmission beam and multiple PRACH transmissions with beam sweeping.* * *Potential specification impacts of PRACH enhancements include: the association between RO, SSB and preamble index, how to support multiple PRACH transmission, determination of PRACH repetition, transmission beam to be used for each initial transmission, finer beam for msg1 based on CSI-RS resources configured during initial access, beam indication for the following steps for RACH procedure, differentiation between enhanced UE and legacy UE, possible collision handling between PRACH transmission with and without multiple PRACH transmissions, etc.* |
| FL | It seems revision from Samsung is ok, and let’s check if any concerns.  @CATT, We can add ‘*the association between RO, SSB and preamble index*’. For ‘*how to support multiple PRACH transmission,*’ it can be merged to Samsung’ revision.  I would suggest not to include ‘*, etc*’. As I commented above to Nokia, the list of spec impacts only include the proposed spec impacts from companies so far. It may not be an exclusive list, additional impacts could be added at later stage as long as it has technical merits.  Proposal is updated in section 2. |
| Nokia/NSB | This comment is about whether PRACH is bottleneck or not, given that some comments were made in this sense. If we look at the aggregated results shared by FLs of 8.8.1.1 and 8.8.1.2, we observe that PRACH is a bottleneck for FR2 and it could be a bottleneck for FR1, where for the latter it depends on how we define the bottleneck. This result is not difficult to explain and stems from the numerical results each company shared (with 6 of them explicitly stating that PRACH is a bottleneck at least for FR2). Stating that this channel is not a bottleneck does not seem accurate, nor it seems to consider that RAN1 works should be a group effort, as reminded to everyone by Mr. Chairman during last GTW.  Discussions can always be held, of course, and they should be held. However, it would be fair to have them based on the observations made by all companies. In this sense, it was mentioned by Ericsson that A-CSI over PUSCH can be a bottleneck. This statement is supported by only one company. RAN1 should keep an open mind and discuss about it, of course. On the other hand, latest aggregated results shared by FL of 8.8.1.2 show that MIL of A-CSI over PUSCH and PRACH is similar, and MPL of A-CSI over PUSCH is higher than MPL of PRACH. Based on these results, and from our perspective, it is not very intuitive to conclude that A-CSI over PUSCH is a bottleneck and PRACH is not. |

## [M] PUCCH with Msg4 HARQ-ACK

***Proposal 8:* Contingent on the outcome of sub-agenda 8.8.1, s*tudy PUCCH repetition for PUCCH carrying HARQ-ACK for Msg4 in NR coverage enhancement SI.***

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| **Company** | **Comments** |
| Samsung | No hurry to study, we first need to conclude whether or not there is a problem |
| Intel | Given that this is the last meeting in SI, suggest to wait for the outcome of AI8.8.1 and accordingly we can check which channels need to be improved. |
| Sharp | We support the proposal. Msg 4 HARQ-ACK cannot apply repetition up to Rel-16. The situation is similar to msg3 PUSCH. |
| Panasonic | We share similar view with Samsung and Intel. |
| ZTE | We find there could be coverage issues for this channel. So, we support the proposal. But, we are fine to wait for the outcome of AI 8.8.1 first. |
| Nokia/NSB | Agree with Samsung and Intel. |
| Ericsson | Fine to study if it’s a bottleneck. |
| FL | Wait a bit for more input, and then FL will make corresponding proposal. |
| vivo | We share similar view with Samsung and Intel. |

**Proposal 9: Capture the followings into the TR.**

* *PUCCH repetition carrying HARQ-ACK for Msg4 was studied. Potential specification impacts include related signaling design, differentiation between enhanced UE and legacy UE.*

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| **Company** | **Comments** |
| CATT | Same comments as P7. |
| Intel | It may be good to wait the outcome of AI8.8.1. If it is concluded that PUCCH carrying HARQ-ACK for Msg4 is not identified as bottleneck channel, we do not need to include this in the TR. |
| ZTE | Fine with the proposal. |
| Nokia/NSB | According to our understanding this proposal (and other proposals of this kind in other 8.8.2.x AIs) is meant to describe what has been studied. Mr. Chairman confirmed this during the online GTW on Tuesday, 10/27. Assuming we all agree on this, as it seemed to be the case during the GTW, we are fine with the proposal. |
| Ericsson | Fine to capture all techniques studied in TR if it’s a common understanding, as Nokia indicated, that we will only do enhancements for bottleneck channels, and this will be only put in the section for the description of different techniques proposed by companies. |
| FL | With the FL comments made in Proposal 7, and also from Nokia above. FL suggestion is to take current proposal 9 for approval.  @all, Please comment further **only if you have concerns.** |
| vivo | It is fine to capture generic statement, how to capture the statement should be discussed based on outcome of AI8.8.1. Otherwise we end up capturing all the channel which do not have coverage issue. |
| LG | We are fine with capture the generic statement. But, it seems to clarify the potential specification impact especially, the necessity of *differentiation between enhanced UE and legacy UE*. |
| FL | @vivo and LG, please find similar clarification as above.  @LG, the differentiation here is similar to Updated Proposal 5 above. |

## [H] Beam refinement during initial/random access

***Proposal 10: Study solutions for beam refinement during initial/random access, including at least beam reporting in Msg3 PUSCH.***

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| **Company** | **Comments** |
| Samsung | Fine with the proposal. |
| Sony | We think that both solutions, candidate 1 and candidate 2, are important and should be studied. Therefore, we suggest modifying the text in the proposal to “***Proposal 10: Study solutions for SSB enhancements and beam refinement during initial/random access, including at least beam reporting in Msg3 PUSCH****.”* |
| CATT | The fundamental question is whether the enhancement is really needed. From our evaluation results, it is not necessary to do anything for the DL channels. |
| Qualcomm | Support the proposal |
| Sharp | Without early CSI/beam reporting in msg3 PUSCH, the coverage may be enhanced by lowering the coding rate. We propose to lower the coding rate for msg4 PUSCH by using scaling factor as in msg2 in our contribution [15]. Further, why do we discuss this separately from msg4 enhancement (in proposal 14/15)? |
| ZTE | We are fine to study beam reporting in Msg3. But we also see clear performance gain for SSB enhancement based on our SLS simulation results presented in our contribution. We also find the spec impacts for SSB enhancement would be small.  In our understanding, beam reporting in Msg3 can apply for both Msg3 re-transmission, Msg4 and also DL transmissions before dedicated RRC is configured. |
| Nokia/NSB | Fine. |
| Ericsson | Fine and agree that this early beam (eg. best SSB index, best CRI if early CSI-RS is configured) will help on all the downlink channels after msg3 and before the dedicated CSI-RS and CSI report are configured. |
| AT&T | We support this proposal and agree with Ericsson that this early reporting will help msg. 4 and all downlink channels after msg. 3 |
| InterDigital | Support the proposal |
| FL | Wait a bit for more input, and then FL will make corresponding proposal. |
| vivo | Beam refinement should be down prioritized in CE SI, we should focus on the enhancement solution of the bottleneck channels. Because Msg4 is robust enough for the required scenarios. |

**Proposal 11: Capture the followings into the TR**

* *Beam reporting in Msg3 PUSCH was studied from several aspects, including the best SSB, alternative SSB beam and early CSI report in Msg3 PUSCH. Potential specification impacts include signaling design in Msg3 PUSCH, CSI-RS resources configured during initial access, beam indication for the following steps for RACH procedure.*

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| **Company** | **Comments** |
| Sony | We think that both solutions, candidate 1 and candidate 2, are important and the aspect of SSB enhancements should be captured in the TR. |
| CATT | Same comments as P7 and P9. |
| Qualcomm | Support the proposal |
| ZTE | Support the proposal, and suggest to make similar proposal for SSB enhancement. |
| Nokia/NSB | Support the proposal. |
| Ericsson | Fine to capture this in the TR with the common understanding that this is just for the description of different techniques proposed by companies in the TR. |
| AT&T | Support the proposal |
| InterDigital | Support |
| FL | With the FL comments made in Proposal 7, FL suggestion is to take current proposal 11 for approval.  @Sony and ZTE, FL suggest to first agree on Proposal 11, and the discuss SSB related proposal and TP in the next round.  @all, Please comment further **only if you have concerns.** |
| LG | If beam reporting and/or early CSI report are beneficial, it can be acceptable. But, so far, the performance benefit is not clearly revealed.  Also, containing SSB index and/or CSI in msg3 PUSCH is one of example for reporting beam and/or CSI. So, it is better to use more general statement (e.g., *Beam reporting ~~in Msg3 PUSCH~~ during initial/random access procedure was studied from several aspects, including the best SSB, alternative SSB beam*).  It needs to be clarified the examples of potential standardization impact |
| FL | @LG similar clarification as above.  Updated as follows as LG suggested. |

**Updated Proposal 11: Capture the followings into the TR**

* *Beam reporting during initial/random access procedure ~~in Msg3 PUSCH~~ was studied from several aspects, including the best SSB, alternative SSB beam and early CSI report in Msg3 PUSCH. Potential specification impacts include signaling design in Msg3 PUSCH, CSI-RS resources configured during initial access, beam indication for the following steps for RACH procedure.*

**Please comment on the updated proposal 11 only if you have concerns on.**

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| **Company** | **Comments** |
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## [L] A-CSI enhancements

Companies are invited to provide input on whether to support study A-CSI enhancements on PUSCH, and whether do you think we need to capture something in the TR, e.g, the followings?

* *A-CSI repetition on PUSCH was studied. Potential specification impacts include signaling indication for repetition and supported repetition type.*

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| **Company** | **Comments** |
| Ericsson | Capture this in the TR with the common understanding that this is just for the description of different techniques proposed by companies in the TR. |
| FL | Companies are encouraged to provide input on this aspect, especially for the TP above. Given limited input, FL suggest to discuss potential TP in the next round. |
| Ericsson | Include the impacts from our side:  Mechanism to determine the repetitions on repeated PUSCH or signaling indication for A-CSI repetition and/or supported repetition type. |

***Proposal 12: A-CSI repetition on PUCCH is deprioritized in NR coverage enhancement SI.***

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| **Company** | **Comments** |
| Ericsson | We have results shown the gains with repetitions and we also have MIL results shown the bottneck for A-CSI on PUSCH.  With that we need to capture this in the TR with the common understanding that this is just for the description of different techniques proposed by companies in the TR. |
| Ericsson | Include the impacts from our side, please update the proposal to capture it to TR if this is the common understanding:  Mechanism to determine the dynamic repetition of A-CSI PUCCH or signaling indication for A-CSI repetition or the PUCCH resource determination for A-CSI transmission on PUCCH. |

***Proposal 12-1:* Capture the followings into the TR**

1. *CSI repetition on PUSCH was studied. Potential specification impacts include mechanism to determine the repetitions on repeated PUSCH e.g. signaling indication for A-CSI repetition and/or supported repetition type.*

*Companies are encouraged to provide your views on above proposal.*

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| **Company** | **Comments** |
| **Samsung** | To save time, we can compromise to following version:  **Suggested change:**  A-CSI repetition on PUSCH and PUCCH was studied. Potential specification impacts include mechanism to determine the repetitions on repeated PUSCH, and mechanism to determine the dynamic repetition of A-CSI PUCCH. ~~.e.g. signaling indication for A-CSI repetition and/or supported repetition type.~~ |
| **Ericsson** | Copied from email reflector:  Regarding the updates on A-CSI from Qi, it looks fine to remove the examples but some text for PUCCH resource determination is missed, and I make some minor updates and include the text missed for PUCCH:  A-CSI repetition on PUSCH and PUCCH ~~was~~were studied. Potential specification impacts include mechanism to determine the repetitions on repeated PUSCH, ~~and~~ *mechanism to determine the dynamic repetition of A-CSI PUCCH and the mechanism for the PUCCH resource determination.* |
| **FL** | Updated the proposal in section 2 as suggested by Samsung and Ericsson. |

***Proposal 12-2:* Capture the followings into the TR**

*A-CSI repetition on PUCCH was studied. Potential specification impacts include mechanism to determine the dynamic repetition of A-CSI PUCCH, e.g. signaling indication for A-CSI repetition, and the mechanism for the PUCCH resource determination for A-CSI transmission on PUCCH.*

*Companies are encouraged to provide your views on above proposal.*

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| **Company** | **Comments** |
| **Samsung** | See comments in above. |

## [M] PDCCH enhancements

**Proposal 13: Capture the followings into the TR**

* *Broadcast PDCCH repetition was studied. Potential specification impacts include PDCCH repetition configuration, DMRS design among PDCCH repetition.*

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| **Company** | **Comments** |
| NTT DOCOMO | In addition to the repetition, compact DCI may be considered for broadcast PDCCH enhancement. |
| Qualcomm | Fine with the proposal |
| Intel | It may be good to wait the outcome of AI8.8.1. If it is concluded that PDCCH is not identified as bottleneck channel, we do not need to include this in the TR. |
| Panasonic | We agree with the view from Intel. |
| OPPO | Fine with the proposal |
| ZTE | Fine with the proposal. |
| Nokia/NSB | Same comment as for P9. |
| Ericsson | Although we do not see PDCCH is a bottleneck. Fine to capture all the technique descriptions in the TR with the common understanding that this is just for the description of different techniques proposed by companies in the TR. |
| InterDigital | Support |
| FL | With the FL comments made in Proposal 7, FL suggestion is to take current proposal 13 for approval.  @all, Please comment further **only if you have concerns.** |
| vivo | It is fine to capture generic statement, how to capture the statement should be discussed based on outcome of AI8.8.1. Otherwise we end up capturing all the channel which do not have coverage issue. |
| FL | @vivo, similar comments as above in proposal 7. |

## [M] Msg4 PDSCH

***Proposal 14:* Contingent on the outcome of sub-agenda 8.8.1, study *Msg4 PDSCH enhancement in NR coverage enhancement SI.***

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| **Company** | **Comments** |
| Intel | Given that this is the last meeting in SI, suggest to wait for the outcome of AI8.8.1 and accordingly we can check which channels need to be improved. |
| Sharp | We support the proposal. However, why do we discuss it separately from early CSI/beam reporting in msg3 PUSCH? |
| Panasonic | We agree with the view from Intel. |
| ZTE | Support the proposal but we are fine to wait for the outcome of AI8.8.1. |
| Ericsson | Fine. But please be noted that all the msg4 results are based on the assumption that best SSB is selected if we understand correctly. Maybe this is worth double checking. |
| FL | Wait a bit for more input, and then FL will make corresponding proposal. |
| vivo | Agree with intel. |

**Proposal 15: Capture the followings into the TR**

* *Msg4 PDSCH enhancements were studied from several aspects, including introducing scaling factor for TBS determination and PDSCH repetition. Potential specification impacts include TBS determination, PDSCH repetition configuration, DMRS design among PDSCH repetitions.*

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| **Company** | **Comments** |
| Qualcomm | Early CSI should be also added as an aspect for enhancement of Msg4 PDSCH |
| Intel | It may be good to wait the outcome of AI8.8.1. If it is concluded that this is not identified as bottleneck channel, we do not need to include this in the TR. |
| ZTE | Fine with the proposal. |
| Nokia/NSB | Same comment as for P9. |
| Ericsson | Capture this in the TR with the common understanding that this is just for the description of different techniques proposed by companies in the TR.  But please also include early CSI on Msg3/MsgA PUSCH as another possible solution for this Msg4 enhancement. |
| FL | Early CSI on Msg3 PUSCH is added based on comments from Qualcomm and Ericsson.  @Ericsson, whether to update to add MsgA here could be further decided after there is conclusion for proposal 6.  @all, with the FL comments made in Proposal 7, FL suggestion is to take following updated proposal 15 for approval. |

**Updated Proposal 15: Capture the followings into the TR**

* *Msg4 PDSCH enhancements were studied from several aspects, including introducing early CSI on Msg3 PUSCH, scaling factor for TBS determination and PDSCH repetition. Potential specification impacts include CSI-RS resources configured during initial access, TBS determination, PDSCH repetition configuration, DMRS design among PDSCH repetitions.*

**Please comment on the updated proposal 15 only if you have concerns on.**

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| **Company** | **Comments** |
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## [L] PDSCH enhancement

***Proposal 16: PDSCH enhancement is not studied in NR coverage enhancement SI.***

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| **Company** | **Comments** |
| Intel | It may be good to wait the outcome of AI8.8.1. If it is concluded that this is not identified as bottleneck channel, we do not need to include this in the TR. |
| Panasonic | We agree with the view from Intel. |
| ZTE | Ok to wait a bit for the outcome of AI 8.8.1. |
| Nokia/NSB | Agree with Intel. |
| Ericsson | Agree that we do not discuss dedicated PDSCH enh. at this stage. |
| FL | Wait a bit for more input, and then FL will make corresponding proposal. |
| vivo | Fine with the proposal. |

# Reference

1. 3GPP RAN1#102-e, [R1-2007392](file:///C:/Program%2520Files%2520(x86)/zMail/app/zMail/WebContent/pcWeb/Scripts/MailControls/ReadPanelIframe/javascript:void(0);), Feature lead summary on coverage enhancement for channels other than PUSCH and PUCCH, Moderator (ZTE Corporation).
2. [R1-2007585](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007585.zip) Discussion on the potential coverage enhancement solutions for other channels Huawei, HiSilicon
3. [R1-2007682](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007682.zip) Discussion on coverage enhancement for channels other than PUCCH and PUSCH vivo
4. [R1-2007745](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007745.zip) Discussion on potential techniques for channels other than PUSCH and PUCCH ZTE
5. [R1-2007876](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007876.zip) Discussion on coverage enhancement for channels other than PUSCH and PUCCH CATT
6. [R1-2007906](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007906.zip) Coverage enhancement for Msg3 Indian Institute of Tech (H)
7. [R1-2007956](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007956.zip) On coverage enhancement for channels other than PUSCH and PUCCH Intel Corporation
8. [R1-2007996](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007996.zip) Discussion on Msg3 PUSCH enhancements China Telecom
9. [R1-2008028](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008028.zip) Discussion on coverage enhancement for channels other than PUSCH and PUCCH CMCC
10. [R1-2008080](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008080.zip) Discussion on Msg3 coverage enhancement NEC
11. [R1-2008183](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008183.zip) Coverage enhancement for channels other than PUSCH and PUCCH Samsung
12. [R1-2008273](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008273.zip) Coverage enhancement on NR channels other than PUSCH and PUCCH OPPO
13. [R1-2008310](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008310.zip) Coverage Enhancements for initial access AT&T
14. [R1-2008372](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008372.zip) Coverage enhancement for initial access Sony
15. [R1-2008401](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008401.zip) Coverage enhancement for channels other than PUCCH/PUSCH Sharp
16. [R1-2008405](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008405.zip) Discussions on coverage enhancement for channels other than PUSCH and PUCCH LG Electronics
17. [R1-2008421](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008421.zip) Coverage enhancement for channels other than PUSCH and PUCCH Ericsson
18. [R1-2008480](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008480.zip) Discussion on Msg3 coverage enhancement Apple
19. [R1-2008485](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008485.zip) Coverage enhancements for initial access InterDigital, Inc.
20. [R1-2008561](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008561.zip) Potential techniques for coverage enhancement for channels other than PUSCH and PUCCH NTT DOCOMO, INC.
21. R1-2009309 Potential coverage enhancement techniques for other channels Qualcomm Incorporated
22. [R1-2008705](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008705.zip) Discussion on approaches and solutions for NR coverage enhancement: other channels than PUSCH and PUCCH Nokia, Nokia Shanghai Bell
23. [R1-2008716](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008716.zip) Potential techniques for Msg3 PUSCH coverage enhancement Potevio
24. [R1-2008731](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008731.zip) Discussion on potential techniques for coverage enhancement for channels other than PUSCH and PUCCH WILUS Inc.