**3GPP TSG RAN WG1 #102e R1-2007022**

**e-Meeting, August 17th – 28th, 2020**

**Source: Moderator (NTT DOCOMO, INC.)**

**Title:** **Summary on [102-e-NR-UEFeatures-Others-01]**

**Agenda Item:** **7.2.11**

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

1. Introduction

This contribution summarizes the following email discussion/approval in AI 7.2.11.

[102-e-NR-UEFeatures-Others-01] Email discussion/approval on new FGs that are not dedicated to a specific Rel-16 work item/TEI (17th – 20th August), Hiroki (DCM)

* Whether/how to define new FGs related to PUCCH group based on proposals in R1-2006482 and potentially following points
  + A UE should not be mandated to support the case where cells from different NR PUCCH groups are in the same TAG, but there is no such capability signalling in Rel.15.
  + A UE should not be mandated to support the case where cells from two NR PUCCH groups are in the same band, but there is no such capability signalling in Rel.15
* Whether/how to define new FG for supporting offset between the end of PDCCH triggering A-SRS and the SRS transmission for CB PUSCH and antenna switching for UEs supporting PDCCH capabilities besides FG 3-1
* Whether/how to define new FG for supporting partial cancellation of configured PUCCH/PUSCH/PRACH due to dynamic SFI, dynamically granted PDSCH and CSI-RS, and UE behavior for UE not supporting the FG

1. New FGs related to PUCCH group

In [2], following proposals are made.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| * 1. Issue with current PUCCH group   From the previous discussion, 3 band FR1 + FR1 + FR2 NR BC is newly introduced in Rel-16 in RAN4, and more importantly, it is attracting commercial deployment interest. In this subsection, we discuss the inadequacy of the current PUCCH group capability reporting in terms of supporting FR1 + FR1 + FR2 deployment   * UE is not allowed to support 3 different numerologies in the same PUCCH group   + For FR1 + FR1 + FR2 NR-CA deployment, this forces UE and NW to use two PUCCH groups since, currently, UE can only support two different numerologies in the same PUCCH group   + Compared to supporting two PUCCH group, a single PUCCH group with 3 different numerologies may offer UE more implementation flexibility and better system performance as well * UE cannot indicate the preferred PUCCH group configuration   + Rel-15 UE capability reporting is unclear, our understanding is that, it allows both PUCCH groups configurations     - (FR1 + FR1) + FR2     - (FR1) + (FR1 + FR2)   + UE either has to support both or support neither based on the current capability reporting * UE does not have full flexibility to indicate the location of PUCCH in the PUCCH group. Below are the details   + For (FR1 15kHz + FR1 30kHz), UE may want to support both PUCCH on 15kHz and on 30kHz, so UE can report to support both FG6-9 and FG6-9a   + For (FR1 15kHz + FR2 120kHz), UE may want to support PUCCH on 15kHz only, so UE has to support that it does not support FG6-9a   + The above two conflict each other   To resolve the above issues, we propose the following new PUCCH group related FGs in order to better support the emerging FR1 + FR1 + FR2 deployment   * 1. Proposed new FGs   We propose the following new FGs with some explanation of the purpose   * FG22-5a, this is to indicate whether UE supports 3 different numerologies in the same PUCCH group and the restrictions on PUCCH configuration * FG22-5b, this is to indicate whether UE supports FR1 + (FR1 + FR2) PUCCH group configuration * FG22-5c, this is to indicate, for FR1 + (FR1 + FR2) PUCCH group configuration, whether PUCCH can be configured on FR2 on the secondary PUCCH group, or SCG.  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (V2X WI only)”.** | **Consequence if the feature is not supported by the UE** | **Type** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/Optional** | | 22. NR Others | 22-5a | Support of three different numerologies in the same PUCCH group for EN-DC, NGEN-DC, NE-DC, NR-DC and NR-CA | For EN-DC, NGEN-DC, NE-DC, NR-DC and NR-CA, support three different numerologies in the same PUCCH group   1. Which SCS can be configured to transmit NR PUCCH |  | Yes | N/A |  | Per BC | N/A | N/A | N/A | Candidate value for component 1, 3 bit bitmap {smallest SCS, second smallest SCS, largest SCS} | Optional with capability signalling  Component 1: {smallest SCS, second smallest SCS, largest SCS} | | 22. NR Others | 22-5b | Not supporting more than one NR PUCCH group per frequency range for both NR-DC and NR-CA | For both NR-DC and NR-CA, UE does not support more than one NR PUCCH group per frequency range |  | Yes | N/A |  | Per BC | N/A | N/A | N/A |  | Optional with capability signalling | | 22. NR Others | 22-5c | Not supporting of NR PUCCH-Scell on FR2 in the NR PUCCH group with both FR1 and FR2 | UE does not support NR PUCCH-Scell being sent on the carrier in FR2 when NR PUCCH group is configured with carriers in both FR1 and FR2 |  | Yes | N/A |  | Per BC | N/A | N/A | N/A |  | Optional with capability signalling | |

Based on the above contribution, it is agreed to discuss following point in the email discussion [4].

**Discussion point #1**

* **Whether/how to define new FGs related to PUCCH group to better support the FR1 + FR1 + FR2 deployment**

During the preparation phase email discussion, following comments were provided [4].

|  |  |
| --- | --- |
| Company | Comment |
| Qualcomm | For the first topic, we suggest adding two more issues related to the current UE capability signalling for two NR PUCCH groups:   * + A UE should not be mandated to support the case where cells from different NR PUCCH groups are in the same TAG, but there is no such capability signalling in Rel.15.   + A UE should not be mandated to support the case where cells from two NR PUCCH groups are in the same band, but there is no such capability signalling in Rel.15. |
| Intel | On the discussion point #1:  Discussion point #1  Ÿ Whether/how to define new FGs related to PUCCH group to better support the FR1 + FR1 + FR2 deployment  So far, we only support up to two different numerologies within the same PUCCH group. We think we need to firstly check if three numerologies within the same PUCCH group can be already supported as per the current specification. It will be weird if three numerologies within the same PUCCH group have been already supported as per the current spec since it means the absence of the corresponding UE capability means it is mandatory feature without capability signaling already.  In that sense, I think we can discuss the issue under TEI, not UE feature. The outcome of the discussion can of course result in the UE capability. |
| Huawei, HiSilicon | Discussion for issues 2.1 and 2.2 is fine while more justification is expected, and we assume these are for Rel-16 only. |
| Apple | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (V2X WI only)”.** | **Consequence if the feature is not supported by the UE** | **Type** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/Optional** | | 22. NR Others | 22-5a | Support of three different numerologies in the same PUCCH group for EN-DC, NGEN-DC, NE-DC, NR-DC and NR-CA | For EN-DC, NGEN-DC, NE-DC, NR-DC and NR-CA, support three different numerologies in the same PUCCH group   1. Which SCS can be configured to transmit NR PUCCH |  | Yes | N/A |  | Per BC | N/A | N/A | N/A | Candidate value for component 1, 3 bit bitmap {smallest SCS, second smallest SCS, largest SCS} | Optional with capability signalling  Component 1: {smallest SCS, second smallest SCS, largest SCS} | | 22. NR Others | 22-5b | ~~Not supporting~~ Support more than one NR PUCCH group per frequency range for both NR-DC and NR-CA | For both NR-DC and NR-CA, UE ~~does not~~ supports more than one NR PUCCH group per frequency range |  | Yes | N/A |  | Per BC | N/A | N/A | N/A | FFS: Rel-15 UE expected capability when FG22-5b cannot be reported | Optional with capability signalling | | 22. NR Others | 22-5c | ~~Not supporting~~ Support of NR PUCCH-Scell on FR2 in the NR PUCCH group with both FR1 and FR2 | UE ~~does not~~ supports NR PUCCH-Scell being sent on the carrier in FR2 when NR PUCCH group is configured with carriers in both FR1 and FR2 |  | Yes | N/A |  | Per BC | N/A | N/A | N/A | FFS: Rel-15 UE expected capability when FG22-5c cannot be reported | Optional with capability signalling | |

## Proposal and discussion

Based on the contributions and above inputs in the preparation phase, following proposal is made.

### **FL proposal 1:**

* **A new FG to indicate whether UE supports 3 different numerologies in the same PUCCH group and the restrictions on PUCCH configuration is introduced.**
* **A new FG to indicate whether UE supports FR1 + (FR1 + FR2) PUCCH group configuration is introduced.**
* **A new FG to indicate, for FR1 + (FR1 + FR2) PUCCH group configuration, whether PUCCH can be configured on FR2 on the secondary PUCCH group, or SCG is introduced.**
* **A new FG to indicate whether UE supports cells from different NR PUCCH groups in the same TAG is introduced.**
* **A new FG to indicate whether UE supports cells from different NR PUCCH groups in the same band is introduced.**

Companies are encouraged to check above FL proposal and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

Cannot accept the proposals:

|  |  |
| --- | --- |
| Company | Comment |
| Intel | For the first proposal, we see one specific scenario to introduce such FG for FR1 (15kHz – DSS) + FR1 (30kHz) + FR2 (120kHz). On the other hand, we are wondering what prevents to use FR1 (30kHz – DSS) + FR1 (30kHz) + FR2 (120kHz) while reusing existing Rel-16 capability signaling.  For the second proposal, we see UE may want to avoid two PUCCH groups in the same frequency range, but it seems just preference of UE. We also like to firstly understand why UE wants to avoid it.  For the third proposal, we would like to understand why FR2 PUCCH needs to be avoided. We understand sending PUCCH in FR2 in FR1+FR2 CA may not be reasonable, but we would like to understand which aspects prevent to send PUCCH in FR2 in such scenario.  For the fourth and fifth proposals, since there is already no further granularity of the signaling, it is already there. Creating more granularity in Rel-16 which hasn’t been supported for Rel-15 would result in non-backward compatibility in ASN.1 (and 3GPP spec) perspective. We haven’t heard answer to our questions since a while ago. It is also difficult for us to better understand it without tdoc. Thus, it is better to be precluded for the discussions in this meeting and it can be considered once the relevant tdoc is available in the next meeting. On the other hand, if the proponent can clarify on time, we are willing to discuss it in this meeting once the answers are reasonable. On the other hand, even though we will discuss, we don’t have a good solution to address non-backward compatibility dilemma in ASN.1 perspective (hope other people have a good solution except something like ‘magic sentence’ which had been misused in LTE).  In addition, we would like to ask companies’ views on the following discrepancy. In our understanding, FG 6-9a (PUCCH on larger SCS) was introduced after the below description in 38.213 was made that we probably missed it due to last spurt of Rel-15.   |  | | --- | | <From 38.822>  *6-9a Different numerologies across NR carriers within the same NR PUCCH group, with PUCCH on a carrier of larger SCS*  <From Section 9 of 38.213>  A UE does not expect to multiplex in a PUSCH transmission in one slot with SCS configuration  UCI of same type that the UE would transmit in PUCCHs in different slots with SCS configuration  if . | |
| Samsung | In general, further discussion is necessary regarding which use cases should be addressed and then whether or not current UE features are sufficient in the use cases for FR1+FR1+FR2 deployment.  First bullet: We understand the motivation to support 3 different numerologies in the same PUCCH group and then it may be beneficial for both UE and NW. But, as Intel commented, it is good to be clarified why a use of different SCSs for both FR1 should be considered.  Second/third bullet: Regarding the preferred PUCCH group configuration and PUCCH location, it may provide some benefits to reduce UE mplementation and testing complexity because UE can implement only one option it prefers. On the other hand, it may impact on NW scheduling/configuration in case UE support only one option for the PUCCH group configuration and PUCCH location.  Forth/fifth bullet: more clarification about the issues is necessary. |
| NTT DOCOMO | * First bullet: we are OK with the direction.   A part of diffNumerologyWithinPUCCH-GroupLargerSCS and diffNumerologyWithinPUCCH-GroupSmallerSCS is to indicate support of two different numerologies within a PUCCH group. For three different numerologies, new capability can be introduced. To align with these two capabilities, component 1 would be necessary.   * Second/third bullet: further discussion is necessary.   Firstly, it should be clarified that considered case is wihiin a cell group (i.e. NR-CA).  Secondly, exact intention of Rel-15 capability should be clarified, since it seems that no restriction is defined. diffNumerologyWithinPUCCH-GroupLargerSCS and diffNumerologyWithinPUCCH-GroupSmallerSCS are used to indicate support of the following:  - NR CA/EN-DC/NE-DC with one NR PUCCH group: two different numerologies across NR carriers within the same NR PUCCH group  - NR CA with two NR PUCCH groups: two different numerologies across NR carriers within the same NR PUCCH group  - EN-DC/NE-DC with two NR PUCCH groups: two different numerologies across NR carriers within an NR PUCCH group in FR1 and same numerology across NR carriers within another NR PUCCH group in FR2 for data and control channel at a given time  - NR-DC: two different numerologies across NR carriers within the same NR PUCCH group in MCG (in FR1) and same numerology across NR carriers in SCG (in FR2)   * Forth/fifth bullet: further discussion is necessary, with discussion of second/third bullet.   As mentioned above, Rel-15 capability for PUCCH group is unclear. If the Rel-15 capabilities intend for example (FR1 + FR1) + FR2, this means that two PUCCH groups with the same TAG or the same band are untargeted. The same thing can be considered for the case of (FR1) + (FR2). |
| Ericsson | We are OK with the proposal in 1st bullet.  With respect to proposals in 2nd and 3rd bullets, we are not OK as it is. It should be clarified whether the bullets are referring to configuration per CG or whether this is overall configuration spanning across CGs (in which case the MCG/SCG split needs to be clarified). Also, the relation to existing 6-9/6-9a needs to be clarified.  With respect to proposals in 4th and 5th bullets, in principle we are OK but such differentiation didn’t exist in Rel-15. This should be clarified. |
| Nokia, NSB | We think this is a relevant issue to be addressed, and it would be important to actually agree first on what is the intended behaviour for the Ues supporting such band combinations, i.e. are those Ues expected to then support 2 PUCCH groups or the 1 PUCCH group according to the new FG? We think proposals 1-3 are tightly interconnected and it would be easier to do the actual definitions after the basic understanding is clear. Proposals 4 and 5 are also dependent on the outcome of the conclusions related to the first 3 proposals, so it would make sense to have more discussion on the issue before defining the FGs proposed here. |
| Qualcomm | The problem is that there has been no way for a UE to indicate which combinations of PUCCH-grouping are supported with the existing UE capability signalling. To resolve the issue, instead of the above FG22-5b and FG22-5c, we propose the following:   * **Introduce capability signalling for PUCCH-grouping for NR-CA with two PUCCH groups**   + **For a given band combination, the UE reports how the bands in the band combination can be grouped into the two PUCCH groups subject to the capability of *twoPUCCH-Group***     - **Cell-grouping capability for NR-DC would be reusable, but details can be up to RAN2**   + **If the UE does not report the capability signalling for PUCCH-grouping for NR-CA with two PUCCH groups for a given band combination,**     - **If the UE reports the capability of *twoPUCCH-Group* for the band combination, the capability is same as in Rel.15, i.e., the UE supports NR-CA with two PUCCH groups with arbitral grouping for the two PUCCH groups subject to the capability of *twoPUCCH-Group***   So far, there has been no way to indicate the support of three different numerologies. For this, a separate UE capability would be the solution as Apple’s proposed FG22-5a.   * **Introduce a capability signalling for NR-CA with three different numerologies in one PUCCH group**   + **Adopt Apple’s proposed FG22-5a**   In addition, we believe that PUCCH + PUCCH simultaneous transmission within a band is not supported for NR-CA, which is the same as for PRACH + PUCCH/PUSCH/SRS simultaneous transmissions and SRS + PUCCH/PUSCH simultaneous transmissions (see NOTE 6 and NOTE 7 of TS38.202 Section 6.1). This should be the common understanding and should be confirmed. In addition, the PUCCH transmissions in the cells in different bands should be associated to different TAGs.   * **Clarify following**   + **When a UE is configured with two PUCCH groups, the cells from different NR PUCCH groups are not in the same TAG.**   **When a UE is configured with two PUCCH groups, the cells from two NR PUCCH groups are in the same frequency band.** |
| ZTE | For the first three bullets, as also commented by other companies, maybe it is better fo further clarify the target scenarios/use cases. In general, we are fine with first bullet, but for the second and the third bullets, maybe more discussion is needed. Besides, if the main motivation is to support three different numerolgoies, it seems another alternative is to support two PUCCH groups for per CG.  For the last two bullets, it seems Rel-15 doesn’t have such limitation. Maybe some more discussion is needed. |
| Nokia | Coming back to the CA with 3 different SCSs which maybe on the GTW call today and using Seunghee’s questions as a template to provide our views.     * 1/ Can I learn what makes critically difficult so to introduce new FG with such restriction?   + Nokia: The flexibility that the Rel-15 UE indicating support for 2 PUCCH groups and 2 SCSs on a PUCCH group implies a lot of configuration flexibility. What exactly is the pain point, I don’t know and it probably differs depending on who you ask, but it seems we have to take it at face value that the two capabilities are jointly too broad for the setup that is being sought after. * 2/ Rel-16 UE reports both *twoPUCCH-Group* (Rel-15 signaling) and new Rel-16 FG. The *twoPUCCH-Group* has no restriction but new FG has restriction (others are the same as *twoPUCCH-Group*) For the network based on Rel-15 specification but with new band combination introduced in Rel-16 (and onwards), the network will recognize the UE to have no restriction for two PUCCH groups. UE would need anyway to support ‘no restriction’. Then, could you explain why we need such restriction if UE has capability without restriction?   + Nokia: This is a bit of an odd question. The UE needing the restriction would not indicate support for two PUCCH groups and two SCS on a PUCCH group, but it looks like there is a desire in the UE side to have the restriction in place because the Rel-15 capabilities are too broad. Such UEs would not be able to support the 3-SCS CA without the new capability, so assuming the new capability is in Rel-16, then they would need to be (at least) Rel-16 devices. If the UE just indicated 2 PUCCH groups, but not that it supports 2 SCS per PUCCH group, then the band combination support would not be possible. * 3/ could you also shed light on why the first bullet (22-5a in Apple’s proposal; three numerologies within the same PUCCH group) is not sufficient, if introduced?   + Nokia: In principle this would work, but having FR2 PUCCH mapped on an FR1 carrier with a large SCS offset would not work with DC, so the DC deployments would anyway require 2 PUCCH groups. In addition 1 PUCCH group on FR1 would cause large (relatively speaking) additional delay for the HARQ loop for the FR2 carriers potentially leading to HARQ stalling, imply fairly complicated HARQ-ACK configurations to implement and test, and not scale as the FR1 PUCCH load that the FR2 carriers would cause would quickly become a bottleneck. Because of this, we believe that the two PUCCH group based setup should be the baseline. And given that Rel-15 capabilities are understood to be too broad for UEs to support this, we are not OK to introduce 1-PUCCH group based capability while leaving the 2-PUCCH group essentially not supported due to lack of proper capability signalling.     Hence we would suggest starting with the proposal that details the 2-PUCCH setup for 3-SCS CA before spending time on the 1-PUCCH group capability. What I would try to achieve is a capability that   * When we have a DC or CA setup one PUCCH group is limited to one frequency range * 1 PUCCH group has carriers of at most 2 SCS * [If two PUCCH groups are configured], there is one PUCCH on FR1 where the corresponding PUCCH group consists of carriers on FR1 only, and another PUCCH on FR2 where the corresponding PUCCH group consists of carriers on FR2 only.   + Not sure if this restriction of a PUCCH group on FRx should have carriers from FRx only should be defined as generic or only in the case of 2 PUCCH groups are configured. Need to discuss.   + Not sure if we should make the 2 PUCCH group capability integral part of this (pre-requisite or separately written in). Need to discuss.     I think we should first agree what the targets are, and only then get to the actual FG, but anyway I am below paraphrasing the Rel-15 6-9 capability fairly freely. Do bear in mind that I am not sure where the painpoints in the UE implementations are so take this as an attempt to get the discussion going rather than something that I would yet expect to be somehow ready for approval.     |  |  |  | | --- | --- | --- | | 22-xx | Different numerologies across NR carriers within the same NR PUCCH group with frequency range restrictions | 1) For NR CA, EN-DC/NE-DC and NR-DC, same numerology between DL and UL per carrier for data/control channel at a given time  2) For NR CA, EN-DC/NE-DC and NR-DC, different numerologies across NR carriers within the same NR PUCCH group, up to two different numerologies within the same NR PUCCH group (should the FR1-only or FR-2 only restriction be defined here already?)  3) For NR CA, EN-DC/NE-DC and NR-DC, support of two 2 PUCCH groups, where one PUCCH group is on FR1 with carriers on FR1 only, another PUCCH group is on FR2 with carriers on FR2 only. | |
| Moderator | Based on the discussion in GTW sessions so far, in the next GTW session, we should discuss on what issues we are trying to resolve at first.  Regarding one PUCCH group configuration vs two PUCCH groups configuration, we should put equal priority since both would be interested scenarios for operators.  Also, as pointed by some companies, we should consider following Rel-15 capabilities regarding two PUCCH groups.   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 6-7 | Two NR PUCCH group with same numerology | 1) For NR CA UE, same numerology across NR carriers for data/control channel at a given time  2) For EN-DC UE, same numerology across NR carriers for data/control channel at a given time, wherein an NR PUCCH group is configured in FR1 and another NR PUCCH group is configured in FR2 | 6-5, 6-6 | *twoPUCCH-Group* | *FeatureSetUplink* | n/a | n/a |  | Optional with capability signalling | | 6-8 | Different numerology across NR PUCCH groups | For both NR CA UE and EN-DC UE, different numerology between two NR PUCCH groups for data/control channel at a given time | 6-5, 6-7 | *diffNumerologyAcrossPUCCH-Group* | *CA-ParametersNR* | n/a | n/a |  | Optional with capability signalling | | 6-9 | Different numerologies across NR carriers within the same NR PUCCH group, with PUCCH on a carrier of smaller SCS | 1) For both NR CA UE, EN-DC/NE-DC UE and NR-DC UEs, same numerology between DL and UL per carrier for data/control channel at a given time  2) For both NR CA UE and EN-DC/NE-DC UE with one NR PUCCH group, different numerologies across NR carriers within the same NR PUCCH groups up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with smaller SCS for data/control channel at a given time  3-1) For NR CA UE with two NR PUCCH groups, different numerologies across NR carriers up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with smaller SCS for data/control channel at a given time  3-2) For EN-DC/NE-DC UE with two NR PUCCH groups, different numerologies across NR carriers up to two different numerologies within an NR PUCCH group in FR1 wherein NR PUCCH is sent on the carrier with smaller SCS, and same numerology across NR carriers within another NR PUCCH group in FR2 for data/control channel at a given time  4) For NR DC UE, different numerologies across NR carriers within the same NR PUCCH group in MCG (in FR1) and up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with smaller SCS for data/control channel at a given time; and same numerology across NR carriers in SCG (in FR2). | 6-5 | *diffNumerologyWithinPUCCH-GroupSmallerSCS* | *CA-ParametersNR* | n/a | n/a | The terminologies 'UL' and 'carrier' in this FG do not refer to 'SUL'.  NR PUCCH is sent on a carrier with SCS not larger than SCS of any DL carriers corresponding to the NR PUCCH group.  The case with PUCCH on UL carrier with different numerologies within SCG is not supported for NR-DC. | Optional with capability signalling | | 6-9a | Different numerologies across NR carriers within the same NR PUCCH group, with PUCCH on a carrier of larger SCS | 1) For both NR CA UE, EN-DC/NE-DC UE and NR DC UEs, same numerology between DL and UL per carrier for data/control channel at a given time  2) For both NR CA UE and EN-DC/NE-DC UE with one NR PUCCH group, different numerologies across NR carriers within the same NR PUCCH groups up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is on the carrier with larger SCS for data/control channel at a given time  3-1) For NR CA UE with two NR PUCCH groups, different numerologies across NR carriers up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with larger SCS for data/control channel at a given time  3-2) For EN-DC/NE-DC UE with two NR PUCCH groups, different numerologies across NR carriers up to two different numerologies within an NR PUCCH group in FR1 wherein NR PUCCH is sent on the carrier with larger SCS, and same numerology across NR carriers within another NR PUCCH group in FR2 for data/control channel at a given time  4) For NR DC UE, different numerologies across NR carriers within the same NR PUCCH group in MCG (in FR1) and up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with larger SCS for data/control channel at a given time; and same numerology across NR carriers in SCG (in FR2). | 6-5 | *diffNumerologyWithinPUCCH-GroupLargerSCS* | *CA-ParametersNR-v1560* | n/a | n/a | The terminologies 'UL' and 'carrier' in this FG do not refer to 'SUL'.  NR PUCCH is sent on a carrier with SCS not smaller than SCS of any DL carriers corresponding to the NR PUCCH group.  The case with PUCCH on UL carrier with different numerologies within SCG is not supported for NR-DC. | Optional with capability signalling |   Followings are my brief understanding based on contribution and discussion so far.   * For one PUCCH group configuration for 3 or more band CA scenario;   + It has not been supported that one PUCCH group contains cells with three (or more) different numerologies. New capability for the support of such case would be necessary. * For two PUCCH groups configuration for CA (and DC with one PUCCH group per CG scenario) scenario;   + Two PUCCH groups related capabilities are defined in Rel-15. However, e.g., for UE intending to support FR1a+FR1b+FR2 BC with two PUCCH groups, in order to indicate the support, the UE would need to support all of PUCCH grouping patterns {(FR1a+FR1b, FR2), (FR1a+FR2, FR1b), (FR1b+FR2, FR1a}). If at least one of the patterns cannot be supported or successfully tested, the UE cannot indicate the support of two PUCCH groups. In order to allow UE to indicate the support of two PUCCH groups for part of patterns, new capability would be necessary.     - What PUCCH cell grouping pattern UE supports       * Which band/FR/duplexing mode PUCCH can be configured for the UE (i.e., FG6-9/6-9a are already in place for NR-CA in Rel-16, and those FGs can address some of cases but may not be sufficient)     - Whether UE can support more than one PUCCH group per band   + Considering potential NBC issue, Rel-16 UE supporting the part of patterns would indicate the support of Rel-16 new capability (and there would be no interaction with existing Rel-15 capabilities for two PUCCH groups)   + For sync/async NR-DC case RAN2 is discussing on cell grouping capability, but not yet for NR-CA case. |
| Huawei, HiSilicon | The above is generally aligned with our understanding. If they are aimed for potential conclusion or agreements, we suggest   * Remove the text of “would be necessary” -  we should aim to reach common understanding of issues * Remove the part of “there would be no interaction” from the second last bullet – we don’t think it can be avoided to have interaction with existing R15 capabilities * Remove the last bullet -  no need to mention what RAN2 is doing (and it is incorrect, as ran2 only support cell grouping for async DC) |

1. New FG for supporting offset between the end of PDCCH triggering A-SRS and the SRS transmission for CB PUSCH and antenna switching

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2-58 | For SRS for CB PUSCH and antenna switching on FR1, zero slot offset for aperiodic SRS transmission | For SRS for CB PUSCH and antenna switching on FR1, support of zero slot offset between aperiodic SRS triggering and transmission | 2-53 | *zeroSlotOffsetAperiodicSRS* | *FeatureSetUplink-v1540* | n/a | n/a |  | Optional with capability signalling |

In [3], following proposal is made.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| If a UE does not support FG 2-58, a UE expects a gap between the last symbol of PDCCH carrying SRS triggering and the earliest SRS symbol to be offset by at least 1 slot, i.e., SRS triggering and resource for transmission cannot be in the same slot. This gap helps the UEs supporting only PDCCH based on FG 3-1. In particular, assuming a 3-symbol PDCCH at the beginning of slot n, the earliest time for SRS transmission is over the last 6 symbols of slot n+1, i.e., the gap between the end of PDCCH triggering SRS and the first potential symbol for SRS transmission is 19 symbols. However, the same gap cannot be maintained for UEs supporting any other PDCCH capability, e.g., 3-2, 3-5/a/b or the new Rel. 16 PDCCH.  To address the issue for the UEs supporting PDCCH monitoring capabilities besides FG 3-1, we propose to adopt the following FG:   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 2-58a | For SRS for CB PUSCH and antenna switching on FR1 with symbol level offset for aperiodic SRS transmission | For UEs supporting a PDCCH monitoring capability in addition to FG 3-1:   1. For SRS for CB PUSCH and antenna switching on FR1, support d symbols offset between aperiodic SRS triggering and transmission | 2-53 | Yes | N/A |  | FS | n/a | n/a | n/a |  | Optional with capability signalling  The value range for component 1 = {0, 19} |   **Proposal: Add an FG for supporting offset between the end of PDCCH triggering A-SRS and the SRS transmission for CB PUSCH and antenna switching for UEs supporting PDCCH capabilities besides FG 3-1.** |

Based on the above contribution, it is agreed to discuss following point in the email discussion [4].

**Discussion point #2**

* **Whether/how to define new FG for supporting offset between the end of PDCCH triggering A-SRS and the SRS transmission for CB PUSCH and antenna switching for UEs supporting PDCCH capabilities besides FG 3-1**

During the preparation phase email discussion, following comment was provided [4].

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | Discussion for issues 2.1 and 2.2 is fine while more justification is expected, and we assume these are for Rel-16 only. |

## 3.1 Proposal and discussion

Based on the contributions and above inputs in the preparation phase, following proposal is made.

### **FL proposal 2:**

* **A new FG for supporting offset between the end of PDCCH triggering A-SRS and the SRS transmission for CB PUSCH and antenna switching for UEs supporting PDCCH capabilities besides FG 3-1 is introduced.**

Companies are encouraged to check above FL proposal and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

Cannot accept the proposals:

|  |  |
| --- | --- |
| Company | Comment |
| Intel | While we understand motivation of the proposal, we would prefer to see first TP to 38.214 capturing the proposed change. It is better to make a decision after that. |
| Samsung | The FL proposal only considers when PDCCH capabilities besides FG 3-1 is introduced by UE. In our understanding, although a basic PDCCH capability (only FG 3-1) is supported by UE, the problem (the symbol gap between triggering DCI and AP-SRS transmission is smaller than 19 which is the symbol gap when the UE supports FG 3-1 and does not support other PDCCH capabilities) elaborated by [3] is still there when the UE supports FG 10-11 (in NR-U) or FG 13-8 (in Positioning).  Hence we suggest the modified proposal as follows:  **Modified proposal:**   * **A new FG for supporting offset between the end of PDCCH triggering A-SRS and the SRS transmission for CB PUSCH and antenna switching for UEs supporting PDCCH capabilities besides FG 3-1 or FG 10-11 or FG 13-8 is introduced.** |
| Ericsson | We understand the motivation of the proposal and would like to have a discussion on the proposal. |
| Nokia, NSB | Similarly to others we can understand the motivation for the proposal but we would like to have more discussion first, for example to better understand if this is an issue to be addressed by feature definition or actually a CR first. |
| ZTE | We are generally ok with the FL proposal and we are open to further discuss this issue. |
| Huawei, HiSilicon | It may be good to reach some common understanding as well. It is our understanding that:   * The FG is proposed for Rel-16; thus the issue for Rel-15 is not addressed (or cannot be address without NBC) * With this new FG for Rel-16, the Rel-16 network may need to interpret the Rel-15 FG 2-58 differently from Rel-15. * Why the candidate value start from 0. There is minimum protection of N2+Tswitch values as specified in 214 section 6.2.1. |

1. New FG for supporting partial cancellation of configured PUCCH/PUSCH/PRACH due to dynamic SFI, dynamically granted PDSCH and CSI-RS

In [3], following proposal is made.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A partial cancellation according to the following clause from Section 11.1.1 of 38.213 (f90) was included in Rel. 15 specification:  *If a UE is configured by higher layers to transmit SRS, or PUCCH, or PUSCH, or PRACH in a set of symbols of a slot and the UE detects a DCI format 2\_0 with a slot format value other than 255 that indicates a slot format with a subset of symbols from the set of symbols as downlink or flexible, or the UE detects a DCI format 1\_0, DCI format 1\_1, or DCI format 0\_1 indicating to the UE to receive CSI-RS or PDSCH in a subset of symbols from the set of symbols, then*  *-     the UE does not expect to cancel the transmission in symbols from the set of symbols that occur, relative to a last symbol of a CORESET where the UE detects the DCI format 2\_0 or the DCI format 1\_0 or the DCI format 1\_1 or the DCI format 0\_1, after a number of symbols that is smaller than the PUSCH preparation time  for the corresponding PUSCH processing capability [6, TS 38.214] assuming  and  corresponds to the smallest SCS configuration between the SCS configuration of the PDCCH carrying the DCI format 2\_0, DCI format 1\_0, DCI format 1\_1 or DCI format 0\_1 and the SCS configuration of the SRS, PUCCH, PUSCH or r, where r corresponds to the SCS configuration of the PRACH if it is 15kHz or higher; otherwise r=0*  *-     the UE cancels the PUCCH, or PUSCH, or PRACH transmission in remaining symbols from the set of symbols and cancels the SRS transmission in remaining symbols from the subset of symbols.*  The behavior defined according to the text basically means that the UE should be able to cancel an ongoing configured uplink transmission if it detects a DCI scheduling PDSCH or CSI-RS or SFI. The cancellation could be partial based on the timeline. (A similar text with new DCI formats exists in the Rel. 16 spec.) Based on this text, e.g., a DL DCI scheduling a PDSCH can force a UE to interrupt an ongoing P-CSI transmission. However, the Rel. 15 UEs are not able to ***partially cancel*** an ongoing uplink transmission. Hence, we propose to add the following FG to support the feature:   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | XX | XX | Cancellation of PUCCH, PUSCH or PRACH with a DCI scheduling a PDSCH or CSI-RS or a DCI format 2\_0 for SFI | A UE supports the partial cancellation of the SRS or PUCCH or PUSCH or PRACH configured transmission:   1. The UE cancels the configured PUCCH or PUSCH or PRACH in a set of symbols of a slot due to detection of a DCI format 2\_0 with a slot format value other than 255 *255* that indicates a slot format with a subset of symbols from the set of symbols as downlink or flexible 2. The UE cancels the configured PUCCH or PUSCH or PRACH in a set of symbols of a slot due to the detection of a DCI format 1\_0, DCI format 1\_1, DCI format 1\_2 or DCI format 0\_1 and DCI format 0\_2 indicating to the UE to receive CSI-RS or PDSCH in a subset of symbols from the set of symbols. |  | Yes | N/A |  | FS | N/A | N/A | N/A | Optional with capability signaling.  Component-1 is subjected to FG 3-6 |   If the UE does not support this feature, then cancellation of the configured PUCCH/PUSCH/PRACH is possible if their starting symbol is at least after a number of symbols that is larger or equal to the PUSCH preparation time T\_proc,2 from the last symbol of a CORESET where the UE detects the DCI format 2\_0 or the DCI formats 1\_0, 1\_1, 1\_2 or the DCI format 0\_1/0\_2. In such a case, the entire duration of the configured transmission is cancelled.  **Proposed Conclusion: A UE not supporting the proposed FG, including the Rel. 15 UEs, is not expected to cancel a transmission of a configured PUCCH/PUSCH/PRACH over a subset of symbols if the gap between the starting symbol of the PUCCH/PUSCH/PRACH transmissions and the last symbol of a CORESET where the UE detects the DCI format 2\_0 or the DCI format 1\_0 or the DCI format 1\_1or DCI format 1\_2 or the DCI format 0\_1 or DCI format 0\_2, is smaller than the PUSCH preparation time  for the corresponding PUSCH processing capability [6, TS 38.214] assuming  and  corresponds to the smallest SCS configuration between the SCS configuration of the PDCCH carrying the DCI format 2\_0, DCI format 1\_0, DCI format 1\_1, DCI format 1\_2, DCI format 0\_1 or DCI format 0\_2 and the SCS configuration of the SRS, PUCCH, PUSCH or r, where r corresponds to the SCS configuration of the PRACH if it is 15kHz or higher; otherwise r=0.**  **Proposal: Add an FG for supporting partial cancellation of configured PUCCH/PUSCH/PRACH due to dynamic SFI, dynamically granted PDSCH and CSI-RS.** |

Based on the above contribution, it is agreed to discuss following point in the email discussion [4].

**Discussion point #3**

* **Whether/how to define new FG for supporting partial cancellation of configured PUCCH/PUSCH/PRACH due to dynamic SFI, dynamically granted PDSCH and CSI-RS, and UE behavior for UE not supporting the FG**

During the preparation phase email discussion, following comments were provided [4].

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | * + We are fine to discuss for issues 2.1 and 2.2, but we think that the discussion is not needed for issue 2.3. |
| Qualcomm | For the 3rd topic, clearly the Rel. 15 NR UEs are not designed/are not supposed to perform “partial” cancellation; the Rel. 15 agreement itself was based on the full cancellation, not partial cancellation. Note that no capability even is defined for performing partial cancellation of configured UL transmissions due to PDSCH/CSI-RS/SFI. |
| Huawei, HiSilicon | As to issue 2.3, it is related on both Rel-15 and Rel-16. We need to clarify the current behavior in Rel-15 first, e.g. based on the current specification, whether “partial cancellation” is supported or not; and if the conclusion is it is supported, it seems the proposal to have a feature group for it is necessary. Based on the conclusion for Rel-15, we can further discuss what to do for Rel-16. |

## 4.1 Proposal and discussion

Based on the contributions and above inputs in the preparation phase, following proposal is made.

### **FL proposal 3:**

* **A new FG for supporting partial cancellation of configured PUCCH/PUSCH/PRACH due to dynamic SFI, dynamically granted PDSCH and CSI-RS is introduced.**

Companies are encouraged to check above FL proposal and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

Cannot accept the proposals:

|  |  |
| --- | --- |
| Company | Comment |
| Apple | I think we there are two question we need to first clarify   * Do we support partial cancellatin PUCCH/PUSCH/PRACH in the current specification? From our perspective, cancellation due to duplexing direction change can lead to complicated design especially partial cancellatio and then resuming the transmission., since it can be impossible for UE to maintain phase continuity. We would prefer this case not to be supported by the specification. |
| Intel | Based on Rel-15 specifications, partial cancelation of PUCCH/PUSCH/PRACH triggered by dynamic SFI or dynamically assigned PDSCH/CSI-RS is supported.  Our understanding is that partial cancelation does not involve any resumption of transmission following a partial cancelation; the “partial cancelation” always includes (i.e., the symbols are canceled) the trailing symbols of the PUSCH/PUCCH/PRACH from the first canceled symbol.  These aspects were discussed in Rel-15 and the decision was to not expect the UE to resume transmission after cancelling a certain number of symbols, but not that the cancellation has to start from the first symbol. In Rel-15, the latter constraint was only imposed for cases involving cancelation of PUSCH transmissions following prioritization at MAC (at the “UL grant-level”) for PUSCH transmissions.  The FL proposal 3 suggests introducing a FG and corresponding UE capability for Rel-16. However, it is not clear what is expected of Rel-15 UEs. It should be noted that this behaviour is currently expected from all Rel-15 UEs supporting TDD bands as the component of “*7) Dynamic UL/DL determination based on L1 scheduling DCI with/without cell specific RRC configured UL/DL assignment*” is part of FG #5-1 that is mandatory w/o capability signalling (even if the UE does not support dynamic SFI per FG 3-6.  Furthermore, it is suggested/implied that for UEs that do not indicate such capability may only be expected to cancel PUSCH/PUCCH/PRACH only if the corresponding trigger (the DCI format) is received such that the last symbol of the PDCCH is at least Tproc,2 before the first symbol of the UL channel. We do not think it would be a good idea to “specify” such detailed behaviour via a conclusion in RAN1 without reflecting anything in core specifications. On the other hand, in such a case (of spelling out the “default/fallback” behaviour in RAN1 specs for Rel-16), applicability to Rel-15 UEs becomes even more convoluted.  In summary, we should either leave existing specifications unchanged following Rel-15, or, else, address the issue also for Rel-15 (preferably via a solution that is not NBC – but we don’t have a good proposal while keeping backward compatibility). |
| Samsung | From our understanding, partial cancellation is clearly Rel-15 behavior. Since there is no specific FG related to partial cancellation in Rel-15, we understand the partial cancellation behaviour is supported by all UEs. As long as it is clear, we do not prefer to include the new FG for Rel-15, but we can further discuss whether or not to introduce the FG for Rel-16. |
| Ericsson | We understand the intention of the proposed new FG due to the problem creates based on the description in the spec. From our perspective, it is up to UE when to cancel if enough cancellation time is provided. The important fact for us that is supported by specificaitons is that there is no transmission on the set of symbols subject to cancellation. We have the same view for Rel-16 as well.  From our perspective, when a transmission is subject to cancellation, it is not of use for the gNB. On the other hand, the description in the spec implies that the UE has to support partial cancellation, which unnessary increases the burn on the UE.  Consideirng the comments expressed, it seems to be difficult to solve the issue by introducing a new FG, although we acknowledge that the issue should be solved somehow.  Maybe one approach could be to conclude that “no transmission in the set of symbols” is interpreted as the requirement if gNB provides enough time for cancellation, not that it should be cancelled partially. And leave it up to UE when to cancel as long as there is no transmission on the set of symbols. |
| Nokia, NSB | In our understanding the issue should be addressed in maintenance instead of feature session, as the underlying functionality needs to be clarified in the specs first. |
| MediaTek | For the issue in the 3rd bullet, it’s not clear to me why Rel-15 UEs can’t support partial cancellation. The cited paragraph describing partial cancellation UE behavior is already there since TS38.213v15.1.0. It’s better to clarify the necessity.  In addition, it should be clarified that the proposed UE capabilities are for Rel-15 or Rel-16. |
| ZTE | Based on our understanding, partial cancellation is clearly define in Rel-15. Thus, maybe it is better to clarify the Rel-15 UE behaviours first. |
| Huawei, HiSilicon | Firstly, we need to clarify the behavior the behavior in Rel-15. Our view is that the current spec based on Rel-15 agreements does support partial cancellation, and the gNB should guarantee that partial cancellation will not happen to a Rel-15 UE.  *If a UE is configured by higher layers to transmit SRS, or PUCCH, or PUSCH, or PRACH in a set of symbols of a slot and the UE detects a DCI format 2\_0 with a slot format value other than 255 that indicates a slot format with a subset of symbols from the set of symbols as downlink or flexible, or the UE detects a DCI format 1\_0, DCI format 1\_1, or DCI format 0\_1 indicating to the UE to receive CSI-RS or PDSCH in a subset of symbols from the set of symbols, then*  *-     the UE does not expect to cancel the transmission in symbols from the set of symbols that occur, relative to a last symbol of a CORESET where the UE detects the DCI format 2\_0 or the DCI format 1\_0 or the DCI format 1\_1 or the DCI format 0\_1, after a number of symbols that is smaller than the PUSCH preparation time cid:image002.png@01D67AC8.02FBC2B0 for the corresponding PUSCH processing capability [6, TS 38.214] assuming cid:image003.png@01D67AC8.02FBC2B0 and cid:image005.png@01D67AC8.02FBC2B0 corresponds to the smallest SCS configuration between the SCS configuration of the PDCCH carrying the DCI format 2\_0, DCI format 1\_0, DCI format 1\_1 or DCI format 0\_1 and the SCS configuration of the SRS, PUCCH, PUSCH or r, where r corresponds to the SCS configuration of the PRACH if it is 15kHz or higher; otherwise r=0*  *-     the UE cancels the PUCCH, or PUSCH, or PRACH transmission in remaining symbols from the set of symbols and cancels the SRS transmission in remaining symbols from the subset of symbols.*  Our reading of current spec is that, it does not support partial cancellation. For the red part above, a UE receive DL in a) a subset, e.g. 4 from 14 OS and will b) cancel the remaining 11 OS from the 14 OS. Only SRS may support partial cancellation.  Then, for Rel-16, given the discussion from other sessions, we think a new FG to allow partial cancellation should be introduced. |

1. Conclusion

**FL proposal 1:**

* **A new FG to indicate whether UE supports 3 different numerologies in the same PUCCH group and the restrictions on PUCCH configuration is introduced.**
* **A new FG to indicate whether UE supports FR1 + (FR1 + FR2) PUCCH group configuration is introduced.**
* **A new FG to indicate, for FR1 + (FR1 + FR2) PUCCH group configuration, whether PUCCH can be configured on FR2 on the secondary PUCCH group, or SCG is introduced.**
* **A new FG to indicate whether UE supports cells from different NR PUCCH groups in the same TAG is introduced.**
* **A new FG to indicate whether UE supports cells from different NR PUCCH groups in the same band is introduced.**

**FL proposal 2:**

* **A new FG for supporting offset between the end of PDCCH triggering A-SRS and the SRS transmission for CB PUSCH and antenna switching for UEs supporting PDCCH capabilities besides FG 3-1 is introduced.**

**FL proposal 3:**

* **A new FG for supporting partial cancellation of configured PUCCH/PUSCH/PRACH due to dynamic SFI, dynamically granted PDSCH and CSI-RS is introduced.**

Reference

[1] R1-2006462 Updated RAN1 UE features list for Rel-16 NR Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2006482 Discussions on NR Rel-16 UE features Apple

[3] R1-2006788 Discussion on NR Rel-16 UE features Qualcomm Incorporated

[4] R1-2006715 Summary on NR UE features for others Moderator (NTT DOCOMO, INC.)

Appendix: UE features list for FGs that are not dedicated to a specific Rel-16 work item/TEI in [1]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 22. NR Others | 22-1 | Indicating supported option for UL Tx switching for inter-band UL CA | Indicating supported option for UL Tx switching for inter-band UL CA   * Candidate values set is {option1, option2, both option 1 and option 2} | 6-6 and RAN4 FG 7-1 (Tx switching period between two uplink carriers) | Yes | N/A |  | Per BC | N/A | N/A (FR1 only) | N/A | It has been agreed in RAN1 that UE can report support of one of the three candidates {option1, option2, both option1 and option2}. It is up to RAN2 to design the corresponding UE capability signalling. | Signaling of this FG is mandatory conditioned on the support of switching time capability for Tx switching between two uplink carriers in inter-band UL CA band combinations in RAN4 FG 7-1 (i.e. Tx switching period between two uplink carriers) |
| 22. NR Others | 22-2 | Indicating supported option for UL Tx switching for EN-DC | Indicating supported option for UL Tx switching for EN-DC   * Candidate values set is {option1, option2} | EN-DC and RAN4 FG 7-1 (Tx switching period between two uplink carriers) | Yes | N/A |  | Per BC | N/A | N/A (FR1 only) | N/A |  | Signaling of this FG is mandatory conditioned on the support of switching time capability for Tx switching between two uplink carriers in EN-DC in RAN4 FG 7-1 (i.e. Tx switching period between two uplink carriers) |
| 22. NR Others | 22-3a | CBG based transmission for UL with 1 unicast PUSCH per slot per CC with UE processing time Capability 2 | CBG based transmission for UL with 1 unicast PUSCH per slot per CC with UE processing time Capability 2 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-3b | CBG based transmission for UL with up to 2 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 | CBG based transmission for UL with up to 2 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-3c | CBG based transmission for UL with up to 7 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 | CBG based transmission for UL with up to 7 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-3d | CBG based transmission for UL with up to 4 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 | CBG based transmission for UL with up to 4 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-3e | CBG based transmission for DL with 1 unicast PDSCH per slot per CC with UE processing time Capability 2 | CBG based transmission for DL with 1 unicast PDSCH per slot per CC with UE processing time Capability 2 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-3f | CBG based transmission for DL with up to 2 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 2 | CBG based transmission for DL with up to 2 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 2 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-3g | CBG based transmission for DL with up to 7 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 2 | CBG based transmission for DL with up to 7 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 2 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-3h | CBG based transmission for DL with up to 4 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 2 | CBG based transmission for DL with up to 4 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 2 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-4a | CBG based transmission for UL with 1 unicast PUSCH per slot per CC with UE processing time Capability 1 | CBG based transmission for UL with 1 unicast PUSCH per slot per CC with UE processing time Capability 1 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-4b | CBG based transmission for UL with up to 2 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 1 | CBG based transmission for UL with up to 2 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 1 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-4c | CBG based transmission for UL with up to 7 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 1 | CBG based transmission for UL with up to 7 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 1 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-4d | CBG based transmission for UL with up to 4 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 1 | CBG based transmission for UL with up to 4 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 1 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-4e | CBG based transmission for DL with 1 unicast PDSCH per slot per CC with UE processing time Capability 1 | CBG based transmission for DL with 1 unicast PDSCH per slot per CC with UE processing time Capability 1 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-4f | CBG based transmission for DL with up to 2 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 1 | CBG based transmission for DL with up to 2 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 1 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-4g | CBG based transmission for DL with up to 7 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 1 | CBG based transmission for DL with up to 7 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 1 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 22. NR Others | 22-4h | CBG based transmission for DL with up to 4 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 1 | CBG based transmission for DL with up to 4 unicast PDSCHs per slot per CC for different TBs with UE processing time Capability 1 |  | Yes | N/A |  | Per FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |