**3GPP TSG RAN WG1 #101-e R1-2004415**

e-Meeting, May 25th – June 5th, 2020

Source: NTT DOCOMO, INC.

Title: Summary on NR UE features for others

Agenda Item: 7.2.11.13

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

# **Introduction**

This contribution summarizes the discussions and proposals in AI 7.2.11.13 regarding UE features for others.

Following discussion points are identified based on contributions [1-7] in AI 7.2.11.13. The proposal in [4] is covered by summary for NR-U UE feature discussion in AI 7.2.11.2.

* Potential new FG(s) or potential update of Rel-15 FG(s) as summarized in section 2
* FDD/TDD and FR1/FR2 differentiation as summarized in section 3.1
* Basic feature group as summarized in section 3.2
* UE capability reporting granularity as summarized in section 3.3
* Applicability of all Rel-15/16 features to NR-U and licensed/unlicensed differentiation as summarized in 3.4
* Default value as summarized in section 3.5
* Clarification on FR1/FR2 cells in a same TAG as summarized in section 3.6
* Clarification on prerequisite FGs as summarized in section 3.7

Based on the discussions summarized in Section 2 and 3, following is the suggested list of email discussions/approvals for AI 7.2.11.13. Although there are several general discussion points for UE features as summarized in section 3, RAN1 has discussed UE features per-WI and per-FG basis and RAN1 should focus on finalizing ASN.1 impact of UE features in this e-meeting. Therefore, only email discussion/approval for potential new FG(s) that are not dedicated to a specific Rel-16 work item is proposed for this sub-agenda. FL would like to ask companies’ feedback if there is a strong need of having email discussion/approval for any general issue.

**FL proposal of list of email discussion/approval:**

**[101-e-NR-UEFeatures-Others-01] Email discussion/approval on potential new FGs that are not dedicated to a specific Rel-16 work item/TEI (25th – 27th May)**

* **Discuss and decide whether or not to introduce any new FG(s) based on identified issues/proposals in R1-2004415**
* **Discuss and decide capability signaling design for** **FG(s) decided to be added in this email discussion (if any)**

Companies are encouraged to check above FL proposals and to provide feedback if any in below.

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| Company | Comment |
| China Telecom | In RAN1#100b-e, for uplink Tx switching, we have agreed that “For inter-band UL CA, if UE reports via capability signaling to support uplink Tx switching, UE further reports via capability signaling which option (between Option 1 and Option 2) is supported.” The agreements were included in LS on Rel-16 RAN1 UE features lists for NR to RAN2/4 (R1-2003072), while FG has not been discussed yet due to limited time in RAN1#100b-e.We suggest to discuss FG for uplink Tx switching during RAN1#101e. |
| ZTE | We support the suggestion from China Telecom. Since the agreements on UE capability of Option1 and Option2 for inter-band UL CA were made in RAN1, it is better to further discuss the details of the UE feature of uplink Tx switching in RAN1.  |
| OPPO | Support the suggestion from China Telecom. We should capture the agreed UE capability in the UE capability list in this meeting.  |
| Moderator (NTT DOCOMO) | Thank you very much for feedbacks.I see RAN1 should discuss UE features for uplink Tx switching according to the agreements.If there is no objection, it can be a part of the proposed email discussion approval [101-e-NR-UEFeatures-Others-01], and hence following bullet can be added in the updated FL proposal.* **Discuss and decide whether/how to introduce a new FG for uplink Tx switching according to the agreements made at RAN1#100bis-e**
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| Ericsson | * Fine to add the discussion on UL TX switching
* For the proposals in 2 that were already discussed in RAN1#100bis-e, we do not see that repeating the discussion here would bring something new
* For the proposal from [3] on simultaneous use of UE processing time capability 2, multi-TRP or span-based PDCCH monitoring are given as motivations, perhaps these are better discussed in the corresponding Rel-16 feature discussions (eURLLC/eMIMO). Also, the subbullet from [5] is not related to Rel-16 feature and is also duplicated (present under 2nd main bullet in section 2).
* For 3.1 and 3.7, we do not see a need for a general discussion, but this can be discussed for the applicable FGs individually
* For 3.2 and 3.5, the discussion in RAN1 has moved beyond what was discussed in the plenary so no need to discuss this further
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| Nokia, NSB | * In general we agree with Ericsson that we should avoid discussing again proposals that have already been discussed and concluded in RAN1#100bis-e, in particular considering the current time constraints. This applies also for those proposals we have already taken action upon when defining the structure of FGs and components, e.g. 3.2 and 3.5.
* It is not clear if 3.6 is a feature definition or a functional restriction, and in the latter case it should be handled as maintenance CR, if needed
* 3.1 and 3.7 can be discussed together with the relevant FGs, if needed
* We are OK to add discussion on UL TX switching
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| Huawei | * Agree with FL update on uplink Tx switching
* On section 2, the simultaneous operation of CBG and mini-slot needs explicitly capability signalling due to
	+ in-optimized performance in Rel-15 when configured, which means in Rel-15 it is actually incapable to do as expected
	+ lack of testing thus also lack of insurance/prediction what would be the minimum performance that can be expected for operators and network
* On section 3.1, see the need for a general clarification for “*Capability interpretation for mixture of FDD/TDD and/or FR1/FR2*” as it applies to all feature lists and seems being misunderstood on what it means. Our suggested proposal in this section is below and the concrete decision can be done per WI/TEI

**Suggested conclusion:**Clarify the intention of “Capability interpretation for mixture of FDD/TDD and/or FR1/FR2” is to understand what is the intended support of UE capability when a FG is FRX (or XDD) differentiated and can apply to both the cell receiving the corresponding indication and the cell applying the indication* Note in Rel-15, the UE shall support the cross FR (or XDD) operation associated with the capability if the UE indicates support of the capability for both FRs (or duplex modes) and support for FR1-FR2 (or FDD-TDD) CA
* On section 3.2, see a need to clarify this since we sent LS to RAN2 with using ‘basic’ while they are not clear on what that means. However, this can be done per WI/TEI basis, as not all features require basic FGs. Thus we suggested proposal in this section is as below and the concrete decision for each basic FG can be done per WI/TEI

**Suggested conclusion**: Clarify when applicable (i.e. if there is basic FG for a feature) that, what the “basic” means in the corresponding feature, e.g. CY (“conditional mandatory” in RAN2 spec) for a given operation/band/FR etc.* Not see the need for a general discussion of proposals in 3.3, 3.4 and 3.5. They are either in RAN2 LS or depend on technical discussion of individual FGs.

Proposal in 3.7 can also be done per WI/TEI. While a general conclusion in this section does not harm in sense of alerting. |
| Samsung | * Support to discuss uplink Tx switching
* For the proposal in 2, it seems RAN1 can discuss on new FG(s) for simultaneous use of UE processing time capability 2, at least discuss whether each WI will handle this or not.
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# **Proposals for potential new FGs or update of existing FGs**

* **Necessity of new FGs for up to 3 unicast PDSCHs/PUSCHs per slot per CC for different TBs**
	+ **FGs are necessary: [5]**
		- **This should take msgB into account: [7]**
	+ **FGs are not necessary: [3]**
* **Necessity of new FG(s) for simultaneous use of CBG-based transmission and multiple PDSCHs/PUSCHs per slot per CC for different TBs**
	+ **FG for simultaneous use of CBG and multiple PDSCHs is necessary: [7]**
	+ **FGs for simultaneous use of CBG based UL and UE processing time capability 2 are necessary: [5]**
	+ **FGs are not necessary: [3]**
* **Necessity of new FG(s) for simultaneous use of UE processing time capability 2 and a certain Rel-16 features in the same CC**
	+ **Define Rel-16 UE processing time capability 2 as per FSPC reporting: [3]**
	+ **Define new FG(s) to indicate support of simultaneous cap2 and a certain Rel-16 features in the same CC in case-by-case manner: [3]**
		- **FGs for simultaneous use of CBG based UL and UE processing time capability 2 are necessary: [5]**

Above discussion points and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

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| [3] | During the email discussion, the following yellow highlighted parts were proposed.

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| **Index** | **Feature group** | **Components** | **Prerequisite feature groups** |
| 8-1 | Dynamic power sharing for LTE-NR DC | When total transmission power exceeds Pcmax, UE scales NR transmission power.  | EN-DC |
| [5-11c] | Up to 3 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 1 | Up to 3 unicast PDSCHs per slot per CC only in TDM is supported for Capability 11) PDSCH(s) for Msg. 4 is included |  |
| [5-12c] | Up to 3 unicast PUSCHs per slot per CC for different TBs for UE processing time Capability 1 | Up to 3 unicast PUSCHs per slot per CC only in TDM is supported for Capability 1 |  |
| [5-13g] | Up to 3 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 2 | Up to 3 unicast PDSCHs per slot per CC only in TDM is supported for Capability 2UE can report values ‘X’ and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology* When configured with less than or equal to X DL CCs, the UE may expect to be scheduled with up to 3 PDSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled

2) No scheduling limitation3) N1 based on Table 5.3-2 of TS 38.214 for given SCS from {15, 30, 60} kHz | 5-5a or 5-5b |
| [5-13h] | Up to 3 unicast PUSCHs per slot per CC for different TBs for UE processing time Capability 2 | Up to 3 unicast PUSCHs per slot per CC only in TDM is supported for Capability 2UE can report values ‘X’ and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology• When configured with less than or equal to X UL CCs, the UE may expect to be scheduled with up to 3 PUSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled2) N2 based on Table 6.4-2 of TS 38.214 for given SCS from {15, 30, 60} kHz | 5-5c |
| [5-35] | Simultaneously enable CBG and multiple PDSCHs per slot | Simultaneously enable CBG and multiple PDSCHs per slot | 5-11,5-11a, 5-11b, 5-13. 5-13a. 5-13c, 5-22, 5-23, 5-24 |

For FGs 5-11c/5-12c/5-13g/5-13h above, there are already capabilities for UE to receive up to 2 or 4 PDSCH/PUSCH, respectively, while the proposed FGs are for UE to receive up to 3 PDSCH/PUSCH. This would bring UE fragmentation with no clear benefits. Also for FG 5-35, this seems a signaling to indicate less capability than Rel-15. It is also not clear to have this signaling.**Observation 1: There is no clear benefit to introduce new FGs 5-11c/5-12c/5-13g/5-13h, and 5-35.*****Processing time capability#2***In rel-15, declaration of support of cap#2 is per-FS, which means that a UE declare the support of cap#2 for all CC’s in certain band of certain band combination. However, some rel-16 features may be difficult to be supported simultaneously in the same CC’s together with cap#2 due to UE implementation complexity. One example of such rel-16 feature is multi DCI-based multi-TRP operation with out of order operation and/or overlapping PDSCH’s. Another example is span-based PDCCH monitoring. Under the current UE capability signaling, a UE may need to avoid simultaneously signaling support of cap#2 and those rel-16 features for certain band in the band combination. This means that none of CC’s in that band will support that feature, and such under-reporting is not desirable. A straightforward way to improve this situation is to define FSPC cap#2 support signaling for rel-16 UE’s. In this case, the existing rel-15 signaling may be ignored by network when rel-16 signaling is utilized. Another possible solution is to define new capability signaling to indicate support of simultaneous cap#2 and certain rel-16 features in the same CC, and this may need to be done case-by-case manner for each rel-16 feature.**Proposal 3: Following 2 options can be considered.** **Option 1: define FSPC cap#2 support signaling for rel-16 UE’s,** **option 2: define new capability signaling to indicate support of simultaneous cap#2 and certain rel-16 features in the same CC in case-by-case manner.**In rel-15, cap#2 processing time is only supported for self-scheduling case, but support of cap#2 with cross-carrier scheduling (CCS) is being considered in rel-16. Under the current signaling, it is possible that CCS can be configured between cap#1 and cap#2 scheduling cell and scheduled cell. It would be natural to think that at least scheduled cell should be cap#2 to apply cap#2 processing time, but scheduling cell may also need to be cap#2 since PDCCH decoding on cap#1 could take longer time. To handle this, several possible solutions can be considered.**Proposal 4: Following 2 options can be considered.** * **Option 1: Capability#2 processing time is applied for CCS only if both scheduling and scheduled cell are configured with cap#2. Otherwise, cap#1 processing time is applied,**
* **Option 2: Define UE capability to support cap#2 processing time for CCS even if only one of scheduling and scheduled cell is configured with cap#2****.**
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| [5] | Furthermore, we propose new FGs for Rel. 15 NR. The proposed changes in 5-11c, 5-12c, 5-13d and 5-13g are to allow for scheduling 3 TBs in both UL and DL. Considering the (4,3) span pattern of FG 3-5b, these additions would allow for matching the number of TBs and the spans in each slot. In addition, the proposed FG 11-3a-e would allow for capability signalling for the simultaneous use of CBG-based UL transmission and minimum processing capability 2.**Proposal 4: Add Rel-15 FGs to allow for scheduling 3 TBs in both UL and DL in order to match the number of control spans per slot****Proposal 5: Add Rel-15 FGs for the simultaneous use of CBG-based UL transmission and UE processing time capability 2.**

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| 5-11c | Up to 3 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 1 | Up to 3 unicast PDSCHs per slot per CC only in TDM is supported for Capability 1PDSCH(s) for Msg. 4 is included |  | Yes | N/A |  | FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 5-12c | Up to 3 unicast PUSCHs per slot per CC for different TBs for UE processing time Capability 1 | Up to 3 unicast PUSCHs per slot per CC only in TDM is supported for Capability 1 |  | Yes | N/A |  | FS | N/A | N/A |  | This capability is necessary for each SCS | Optional with capability signalling |
| 5-13d | Up to 3 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 2 | Up to 3 unicast PDSCHs per slot per CC only in TDM is supported for Capability 2UE can report values ‘X’ and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology* When configured with less than or equal to X DL CCs, the UE may expect to be scheduled with up to 3 PDSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled

2) No scheduling limitation3) N1 based on Table 5.3-2 of TS 38.214 for given SCS from {15, 30, 60} kHz | 5-5a or 5-5b | Yes | N/A |  | FS | N/A | N/A |  | This capability is necessary for each SCSMore than one set of per SCS per band reports can be signaled for a given band combination | Optional with capability signalling |
| 5-13g | Up to 3 unicast PUSCHs per slot per CC for different TBs for UE processing time Capability 2 | Up to 3 unicast PUSCHs per slot per CC only in TDM is supported for Capability 2UE can report values ‘X’ and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology• When configured with less than or equal to X UL CCs, the UE may expect to be scheduled with up to 3 PUSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled2) N2 based on Table 6.4-2 of TS 38.214 for given SCS from {15, 30, 60} kHz | 5-5c | Yes | N/A |  | FS | N/A | N/A |  | This capability is necessary for each SCSMore than one set of per SCS per band reports can be signaled for a given band combination | Optional with capability signalling |

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| 11-3a | CBG based transmission for UL with 1 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 | CBG based transmission for UL with 1 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 | 5-5a or 5-5b | Yes | N/A |  | FS | No | FR1 only |  | [Modification of Rel-15 capability] | Optional with capability signalling |
| 11-3b | 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 | 5-13 | Yes | N/A |  | FS | No | FR1 only |  | [Modification of Rel-15 capability] | Optional with capability signalling |
| 11-3c | 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 | 5-13a | Yes | N/A |  | FS | No | FR1 only |  | [Modification of Rel-15 capability] | Optional with capability signalling |
| 11-3d | 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 | 5-13c | Yes | N/A |  | FS | No | FR1 only |  | [Modification of Rel-15 capability] | Optional with capability signalling |
| 11-3e | CBG based transmission for UL with up to 3 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 | CBG based transmission for UL with up to 3 unicast PUSCHs per slot per CC for different TBs with UE processing time Capability 2 | 5-13d | Yes | N/A |  | FS | No | FR1 only |  | [Modification of Rel-15 capability] | Optional with capability signalling |

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| [7] | The maximum data rate which UE supports is determined by the supported maximum data rate defined in subclause 4.1.2 of TS 38.306 [1], at both physical layer and high layer. At the physical layer, the statements in subclause 5.1.3 of TS 38.214 [2] determine the maximum amount of data required UE to be handled per cell group or per cell respectively. Then, the successfully decoded TB will be delivered to high layer for further processing.It is common understanding that high layer capabilities pipeline, including buffer size, processing capability, bus capacity, etc., are also designed based on the maximum supported data rate defined in subclause 4.1.2 of TS 38.306 [1]. However, when CBG based retransmission is scheduled, the amount of data delivered to high layer may exceed the maximum data rate calculated as above. This issue was discussed in [3] at RAN1 #97. Given the potential NBC change, it was understood that for Rel-15 when the scenarios described in [3] happens, it is up to UE implementation, for example, UE may have to drop correctly decoded TB(s) during peak data rate reception and the performance will be degraded accordingly. The following was concluded:***Conclusion****:** *The scenario described in the draft CR (*[*R1-1907505*](file:///C%3A%5CUsers%5Cp00350264%5CAppData%5CLocal%5CMicrosoft%5CWindows%5CINetCache%5CContent.Outlook%5CDocs%5CR1-1907505.zip)*) can happen but can be handled via implementation in which case the UE performance may not be optimal*

The conclusion was made with compromise of peak rate not reaching the NR design targeted. However, it is worth noting that configuration of CBG operation is actually one of the scheme introduced for higher data rate traffic. Thus the described case is not a corner case, rather can be a typical scenario that data rate is the KPI. As one example assuming two CBGs are configured as in Figure 1 below, in slot n, TB0 is received at UE side with decoding failure for CBG1. In slot n+3, CBG1 of TB0 is retransmitted and a new TB is also scheduled by a separate DCI, TB1 in the same slot. At physical layer, both CBG1 of TB0 and TB1 are correctly decoded and sent to high layer. That means, UE needs to handle the amount of data of TB0 and TB1 at corresponding processing time to physical layer slot n+3. Assume UE is under peak data rate required service, TB0 and TB1 are scheduled with full channel bandwidth, highest code rate, highest number of layer, and highest modulation order, in order to not block the pipeline, UE needs to increase its high layer memory and processing capability 1.5 times than those of non-CBG based retransmission.In the worst case if the number of CBGs is 8, then UE needs to increase its capability 7 times than CBG is disabled if all unsuccessfully decoded CBGs are retransmitted in one slot assuming the maximum number of DL TB per slot is 7. On the other hand, if peak rate performance is sacrificed as concluded in RAN1, significant data rate degrade (more than 10%) can be expected due to e.g. dropping one or more successfully decoded TBs, which further leads to more potential retransmissions consequently and is highly undesirable. Figure 1. One CBG based retransmission exampleIn order to maintain the NR designated peak rate performance, it is desired to solve this problem in Rel-16 and beyond. Several approaches can be considered:* ***Option 1****: Change* $C'$ *to* $C$ *in* $V\_{j,m}$*for DataRate calculation and DataRateCC calculation in subcluase 5.1.3 and 6.1.4 of TS 38.214 as described in R1-1907505.*

However, this requires specification changes and needs to consider impact on Rel-15 implementations.* ***Option 2****: When CBG based retransmission is enabled, only one unicast PDSCH is scheduled per slot.*

However, this restricts the network scheduling and applicable scenarios for CBG based operation especially for traffic heavy/data rate oriented cases.* ***Option 3:*** *UE reports newtork that whether UE supports more than one unicast PDSCH reception per slot on this cell, when CBG based retransmission is configured for a cell.*

This has benefits of no specification impact and actually relying on UE implementation evolution with sufficient flexibility, if the device has the capability to work under the enhanced operation.***Proposal 1****: Agree on FG 5-35 as an optional per-UE reported capability for Rel-16 to indicate whether UE supports more than one unicast PDSCH reception with UE processing capability 1 per slot on a carrier when CBG based (re)transmission is configured for that carrier.*~Since msgB is introduced from 2-step RACH WI in response to successfully decoding of msgA, which can similar to msg4 when carrying successRAR, further discussion would be needed for relevant UE capabilities in DL. This may be either handled in specific 2-step RACH WI, or as enhanced UE capabilities of DL of FG 5-11 ~ 5-13h.***Proposal 2****: UE capabilities for multiple PDSCHs reception should take msgB into account.* |

# **General issues on UE features for NR Rel-16**

## 3.1 FDD/TDD and FR1/FR2 differentiation

* **Clarification on FDD/TDD and FR1/FR2 differentiation**
	+ **“Need of FDD/TDD differentiation” and “Need of FR1/FR2 differentiation” are applicable to other types than per UE type: [1]**
	+ **Clarify how to interpret the UE capability in case of cross-carrier operation: [1], [7]**
		- **For a UE capability that the FRX (or XDD) differentiation applies to both the cell receiving the corresponding indication and the cell applying the indication, the UE shall support the cross FR (or XDD) operation associated with the capability if the UE indicates support of the capability for both FRs (or, FDD & TDD) and support for FR1-FR2 (or FDD-TDD) CA: [7]**
	+ **Clarify the intended interpretation for combinations if both xDD and FRx differentiations are allowed: [2]**
		- **Such clarification seems not necessary: [7]**

Above discussion points and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

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| [1] | According to the discussion in [2], the rapporteur also made the following proposal.* + “Need of FDD/TDD differentiation” and “Need of FR1/FR2 differentiation” are applicable only to “per UE” feature group, and hence those should be “N/A” for all feature groups other than per UE feature group.

Based on our understanding, in addition to “per UE” feature group, “Need of FDD/TDD differentiation” and “Need of FR1/FR2 differentiation” may also be applicable to other types of feature group in case of cross-carrier operation, e.g., “per band”, “per band of band combination” or “per CC per band per band combination”. Take the Rel-15 UE capability *aperiodicTRS* as an example. UE capability *aperiodicTRS* is a “per Band” signaling, which is to indicate the network whether the UE supports DCI triggering aperiodic TRS associated with periodic TRS. Without XDD/FRX differentiation, it is not clear how to interpret the UE capability. For example, if UE indicates support of *aperiodicTRS* for Band A and not support of *aperiodicTRS* for Band B. If UE needs to trigger A-TRS for Band B from Band A, it is not clear whether UE supports this kind of operation. XDD/FRX differentiation may be one way to clarify the UE behavior with these capabilities in case of cross-carrier operation.

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| Definitions for parameters | Per | M | FDD-TDDDIFF | FR1-FR2DIFF |
| ***aperiodicTRS***Indicates whether the UE supports DCI triggering aperiodic TRS associated with periodic TRS. | Band | No | No | Yes |

Another way to handle this issue is to clarify in the field description. For example, for *aperiodicTRS,* we could add one clarification in the field description like “In case of cross-carrier triggering, UE supports DCI triggering aperiodic TRS associated with periodic TRS as long as the UE supports it in the triggering cell”.***Proposal 3****: To clarify the interpretation of Rel-16 UE feature in case of cross-carrier operation, the following approaches can be considered:**1. In addition to “per UE” feature group, “Need of FDD/TDD differentiation” and “Need of FR1/FR2 differentiation” may also be applicable to other types of feature group in case of cross-carrier operation, e.g., “per band”, “per band of band combination” or “per CC per band per band combination”.**2. Add clarification in the field description to make it clear how to interpret the UE capability in case of cross-carrier operation.* |
| [2] | RAN2 LS [2] provided guidance to RAN1 UE capability definition. One input was to provide rationale for necessity of both xDD and FRx differentiations for per-UE capability.

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| **7 Rationale for necessity of both xDD and FRx differentiations for per-UE capability**RAN2 did not discuss the RAN1 LS on XDD-FRX Differentiation (R1-1913579/R2-2000013) at the RAN2#109-e meeting, but RAN2 would anyway appreciate to be provided with rationale in case Per-UE capability with both FDD/TDD and FR1/FR2 differentiations is deemed as necessary for a feature.  |

**Proposal 1: If both xDD and FRx differentiations are allowed for a feature, the rationale of the combination is captured in UE feature list.**Also, there was a discussion in Rel-15 UE feature on how to interpret the combination of xDD and FRx differentiation bits. For instance, in case that both capability signalling is allowed, when UE reports TDD=NotSupport and FR2=Support, it is self-contradictory as FR2 has TDD only. Therefore, we propose to clarify the interpretation when both xDD and FRx differentiations are allowed for a feature. **Proposal 2: If both xDD and FRx differentiations are allowed for a feature, the intended interpretations for combinations are clarified in UE feature list.** |
| [7] | There is company preference on discussion on‘Capability interpretation for mixture of FDD/TDD and/or FR1/FR2’, by coupling this entry of UE feature list to the RAN2 inquiry of ‘rationale for necessity of both xDD and FRx differentiations for per-UE capability’.Our view is that the above coupling is incorrect. The feature list entry of mixture of xDD/FRx was set from RAN2 LS in [5] in Reno meeting, even before the issue raised about support of possible combinations of XDD/FRX. As a matter of fact, the interpretation of mixture of xDD/FRx was motivated by the discussion of CA with cross-carrier operation, and there had been clear conclusion in RAN1. To inherit from that concluded for Rel-15 as request by RAN2, the following is therefore proposed***Proposal 3****: Clarify that “Capability interpretation for mixture of FDD/TDD and/or FR1/FR2” is interpreted as below:** *For a UE capability that the FRX (or XDD) differentiation applies to both the cell receiving the corresponding indication and the cell applying the indication, the UE shall support the cross FR (or XDD) operation associated with the capability if the UE indicates support of the capability for both FRs (or, FDD & TDD) and support for FR1-FR2 (or FDD-TDD) CA.*

Further, the issue of ‘rationale for necessity of both xDD and FRx differentiations for per-UE capability’ may or may not be due to the concern of the support of all 8 possible combinations of xDD/FRx by the current Rel-15 UE capability signalling framework [7], as RAN2 in [6] has indicated that they has not discussed the issue. In our view, issue raised in [7] could be solely resolved in RAN2 and does not seem to require any further discussion in RAN1 for Rel-16, unless further required by RAN2. Thus,***Observation 1****: RAN1 does not seem to have a need to further work on the issue raised in R1-1913579, unless further requested by RAN2.* |

## 3.2 Basic feature group

* **Basic feature group**
	+ **Adopt Approach 1 (A basic feature group(s), which is a set of components that are viewed necessary to provide a minimum level of support for the feature. Defining a basic feature group(s) is not always possible or necessary for a given feature.): [1], [3]**

Above discussion points and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting. However, it has already been discussed per WI basis as proposed, and hence further discussion on the basic feature group in this sub-agenda is not necessary.

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| [1] | As shown above, two approaches have been identified to group feature groups/components together. Approach 1 is the ordinary way as we adopted in Rel-15 and Approach 2 is more like the ‘UE feature profile’.* Approach 1: A basic feature group(s), which is a set of components that are viewed necessary to provide a minimum level of support for the feature. Defining a basic feature group(s) is not always possible or necessary for a given feature.
* Approach 2: A set(s) of feature groups necessary to be supported for the purpose is defined somewhere in specification(s).

During Rel-16 initial UE feature discussion, Approach 1 is preferred. If companies couldn’t converge on the basic UE feature for certain WI, then companies could further discuss it via Approach 2 later.***Proposal 1****: During Rel-16 initial UE feature discussion, Approach 1 is adopted to define basic UE feature group(s) for WIs with consensus.*  |
| [3] | The features introduced in Rel-16 are basically optional for NR UEs, because those features are additional ones upon Rel-15 NR features. Which features are implemented by the UEs are determined by commercial market needs, then Approach 2 seems not proper. As Approach 1 describes, basic feature group consisting of essential components in order to support a give feature can be decided for some features. One possibility is that, the defined basic feature group can be pre-requisite for other components of the feature. RAN1 needs to further discuss whether/how the basic feature group is determined per WI basis.Proposal 1: Adopt Approach 1 for basic feature group. |

## 3.3 UE capability report granularity

* **UE capability report granularity**
	+ **Per-component “support or not” signaling should be avoided: [1]**
	+ **FG should be defined so that it has a single reporting type: [7]**
	+ **Unnecessary fragmentation of UE capabilities (e.g., by not applying per-UE reporting for baseband related capability) should be avoided: [6]**

Above discussion points and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting. Although these are general issues for UE features, FL thinks RAN1 should just continue the discussion per WI and per FG with considering above proposals. FL believes first two proposals in above list have already been considered in UE features list for all WIs.

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| [1] | According to the discussion in [2], the rapporteur made the following proposal for common principle.* RAN1 should take followings into account as a common principle for UE features list in addition to RAN2 guidances in R1-2001513.
	+ The UE capability signaling reporting (i.e. support or not) for a feature group applies to all the components in the feature group, which means there should not be capability signaling reporting for individual component.

The above proposal should be the principle unless per-component signaling is clearly specified.   However, it is not clear whether all WIs follow this principle in [2]. It can be understood in some cases per-component signaling is necessary for UEs to choose among the maximum candidate values per component but there are components which are simply to indicate the "support or not" of a functionality.  However, it is not clear whether these components need individual per-component signaling.  To make things clearer to RAN2, basic components and optional components should be put in different FGs.   If per-component "support" signaling is needed, it is better to have a separate FG at least for optional components.***Proposal 2****: The UE capability signaling reporting (i.e. support or not) for a feature group applies to all the components in the feature group unless extra per-component signaling is clearly stated otherwise. RAN1 aims to avoid per-component “support” signaling for Rel-16 UE features.* |
| [6] | Compared to LTE, a lot more functionality was included already in the first release of NR making it unrealistic to implement, test and deploy all of them from the beginning. With the additional introduction of different options for supporting the same functionality, this led to an even higher increase in the number of features requiring UE capabilities to indicate testing and support. The result is potentially a very defragmented UE population. Also, the UE capability signalling size have become so large that the maximum signalling size has to be increased. Not just the signalling size is a problem, but analysing UE capabilities and determining the best possible UE configuration for the gNB considering the enabled features, current load and coverage is one of the most complex functions in current networks. With different UEs reporting different capabilities, the optimisation gets even more complicated.Another problem with fragmentation of the UEs population is that risks shrinking the common subset of features supported, making many features unattractive to due lack of wide UE support. For the first release of a new radio technologies, there is a large set of features that have to be implemented to justify a new deployment, but also network implementations require economies of scale to justify adding functionality, where a global uptake of a feature is needed to make it worth implementing. In a later release like Rel-16, each individual feature will need to justify its use case in order to get implemented. If the fragmentation of the UE population, getting economies of scale is difficult and the end result will be that such features are not implemented at all or only very basic functionality sees deployment.The RAN1 specifications have intentionally been written frequency band agnostic as much as possible. The main exceptions have been differences between paired and unpaired frequency bands and differences between FR1 and FR2. In both cases there are already the possibility to differentiate in the UE capability signalling testing and support between FDD/TDD and FR1/FR2.Still, we see many requests to have RAN1 feature groups defined per band, per band combination or per band per band combination. RAN2 already instructed RAN1 to limit the number of such combinations We see no need to have such differentiation for functionality that is clearly baseband related. From the experience from LTE and early Rel-15 NR, UEs in as pretty all cases report the same capabilities for different band combinations or bands within band combinations. Hence, having such fragmentation with the argument “nice to have” is not a viable way forward.Based on this we strongly recommend:1. Unnecessary fragmentation of UE capabilities shall be avoided
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| [7] | In addition to the issues above, in [5], RAN2 has requested RAN1 for input of UE feature list for Type (i.e. 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)) as below* *Following the above granularity, RAN2 requests that all the UE features fall into one of the above categories uniquely, for example, some UE features which are categorized as ‘Per FSPC’ are not defined to be applicable across all CCs*

This has been the usual case for most of the UE features that are being discussed. However, there may be some cases unclear whether the above request has to be met, as can be found in Rel-15 that the capability of *csi-ReportFramework* is per ‘band or UE’ reported. In our view, whenever possible, the above shall be met in RAN1 UE feature list discussion. It would be then understood that also for Rel-16 eMIMO feature, division of a single large FG into separate ones that each has uniquely reported UE type may be preferable.  |

## 3.4 Applicability of all Rel-15/16 features to NR-U and licensed/unlicensed differentiation

* **Applicability of all Rel-15/16 features to NR-U**
	+ **Agree that all features should be applicable to NR-U as default, and possibly discuss only some exception cases: [5]**
* **Licensed/unlicensed differentiation for Rel-15/16 capabilities**
	+ **Convert most per-UE capability to per-band capability and discuss only exception cases: [5]**
	+ **Add a new column of “licensed/unlicensed differentiation”: [2]**
	+ **Any discussion should therefore be on a per FG basis based on technical issues with supporting a certain feature in the unlicensed case: [6], [7]**

Above discussion points and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting. Regarding licensed/unlicensed differentiation, RAN1 made a conclusion that it is recommended to discuss appropriate reporting type or necessary clarification for each FG individually at the RAN1#100bis-e meeting. Therefore, any discussion per FG basis is already possible.

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| [2] | There has been a discussion to introduce per-band UE capability to allow separate indication between licensed and unlicensed operation due to potentially different implementation, IODT, etc. If a feature has an implication of baseband capability without RF (e.g. per-UE), the feature can be supported without restriction of licensed and unlicensed bands. If a feature requires per-band, FS, or FSPC signalling, the signalling itself can explain whether or not to be applied to licensed or unlicensed band. Therefore, we do not think a special handling is needed due to unlicensed operation, but if there is any, per-band signalling is too much. We prefer to have licensed/unlicensed differentiation (or non-shared/shared spectrum differentiation) as a new column in UE feature list. In addition, given that unlicensed operation is based on TDD, clarification on the intended interpretation for combination of xDD differentiation and licensed/unlicensed differentiation deem to be necessary.**Proposal 3: In case that separate capability for a feature is necessary due to unlicensed operation, add a new column of ‘licensed/unlicensed differentiation’ with properly clarified interpretation in conjunction with ‘xDD differentation’.** |
| [5] | An important high priority issue is to discuss the applicability of all Rel-15 and Rel-16 features to NR-U. For example, whether mTRP is supported in NR-U, etc. In order to avoid an extended debate, we suggest agreeing that all features should be applicable to NR-U as a default, and possibly discuss only some exception cases. At the same time, this does give rise to IODT concern, since all the Rel-15 and Rel-16 features will not be introduced at the same time in licensed and unlicensed. Therefore, even though as default all features should apply to unlicensed, a UE capability differentiation is still needed. In order to introduce the capability differentiation with the smallest possible change in the structure of the capability signaling, we propose to convert most per-UE capability to per-band capability. It would need further discussion how to do the same for Rel-15 features. **Proposal 1: Agree that all features should be applicable to NR-U as default, and possibly discuss only some exception cases.** **Proposal 2: Convert most per-UE capability to per-band capability and discuss only exception cases. It would need further discussion how to do the same for Rel-15 features.** |
| [6] | During RAN1#100bis-e, it was proposed to discuss the applicability of all Rel-15 and Rel-16 features to NR-U. First of all, it should be emphasized that unlicensed is just another frequency band with additional functionality to address channel access. As stated above, most functionality in RAN1 specifications is frequency band agnostic and, in many cases, Rel-15 and Rel-16 functionality should still work even when applied to an unlicensed band. Even if licensed and unlicensed bands are not deployed at the same time, implementations will be reused between the two and new testing should not be needed. Similarly, some of the features introduced for unlicensed can equally well be applied with no further testing. As mentioned above, from an ecosystem perspective, the more use cases a feature can be used in, the more likely it is to be implemented. 3GPP specifies technology and not use cases and limiting the use of a certain functionality is not good for innovation or the ecosystem.Converting most UE feature from per UE to per band would have large implications to the UE capability signaling since it would allow not only different UE capabilities signaling for unlicensed bands, but also different signaling for different licensed bands. There are also RAN2 implications since as mentioned the signaling per band is already very large. In addition, backwards compatibility in the signaling must be ensured which means that this is not moving Rel-15 UE capabilities, but copying. Any discussion should therefore be on a per FG basis based on technical issues with supporting a certain feature in the unlicensed case.Based on this we propose:1. Separation of UE capabilities into licensed and unlicensed should only be done if technical issues have been identified that would warrant a separation
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| [7] | There was a proposal to discuss possibility of converting all per-UE reported UE feature to per-band, mainly motivated by a different commercialization timing consideration of NR-U UEs v.s. licensed UEs. Our view is that this will cause significant signalling overhead on UE capability report which is strongly preferred to be avoided by RAN2, and there does not seem to be any issue for the mentioned purpose for UEs to still report a per-UE capability. We may look into it only if there is any issue identified for a specific UE feature, with an understanding that the below conclusion as a recommendation does not mandate to re-discuss each per-UE likely FG especially if it is agreed already.**Conclusion:*** It is recommended to discuss appropriate reporting type or necessary clarification for each FG individually
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## 3.5 Default value

* **Default value**
	+ **Discuss whether/how to define the default values including Rel-15 NR features for Rel-16: [3]**

Above discussion points and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

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| [3] | Another discussion point in RAN summary [1] is default value:

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| * For each feature group (capability bit(s)) defined as “mandatory with capability signaling”, each WG should take either one of following approaches.
	+ Approach 1: default value should be defined in each WG for the case where UE does not report or the case before UE reports.
	+ Approach 2: the capability signaling is mandatory present so that UE must report.
 |

In many cases, UE can report one of the candidate values as its capability. In Rel-16 features as well as Rel-15 existing features, a default value may be needed in case that the UE does not report the value. If the UE does not report the value, then an ambiguity may occur. For example, there is an ambiguity in calculation of TBSLBRM for limited buffer rate matching before the UE reports its maximum supported layers. In Rel-15, RAN1 decided not to define the default value for backward compatibility. Including this feature, RAN1 needs to discuss whether/how to define the default values.Proposal 2. RAN1 needs to discuss whether/how to define the default values including Rel-15 NR features for Rel-16. |

## 3.6 Clarification on FR1/FR2 cells in a same TAG

* **Clarification on FR1/FR2 cells in a same TAG**
	+ **Clarify that FR1 cells and FR2 cells cannot be in the same TAG: [5]**

Above discussion points and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

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| [5] | As an additional topic, we would like to clarify whether or not FR1 and FR2 serving cells can be in the same TAG in UL CA. This clarification may impact both Rel-15 and Rel-16.**Proposal 3: Clarify that FR1 cells and FR2 cells cannot be in the same TAG.** |

## 3.7 Clarification on prerequisite FGs

* **Clarification on prerequisite FGs**
	+ **Proper clarification on prerequisite FGs is necessary for the case with cross causality between Rel-15 and Rel-16 capabilities: [7]**

Above discussion points and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

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| [7] | The Rel-16 UE features appear to lead to multiple pre-requisite FGs for some FGs without clear causality. As one example in MR-DC/CA session, some companies consider FG 6-6 is not a pre-requisite FG for FG 18-7. Then, it seems unclear on what is the intended UE support capability for the following case:* A UE report:

- Support of 6-5 basic DL NR CA- No-support of 6-6 basic UL NR-NR CA- Support of 18-7 including both DL and UL CA operationUnderstanding 1: a UE support basic DL CA and DL CA with non-aligned frame boundaries;Understanding 2: a UE support basic DL CA and both DL&UL CA only if non-aligned frame boundaries are configured;Understanding 3: invalid report.We suggest to make this point clear for the input of pre-requisite FGs in order to achieve proper signalling design.***Proposal 4****: Proper clarification on pre-requisite FG seems to be needed for the cases with cross causality between Rel-15 UE capabilities and relevant Rel-16 UE capabilities.* |

# **References**

[1] R1-2003336 Remaining issues on Rel-16 NR UE features ZTE

[2] R1-2003762 Rel-16 UE feature - Others Intel Corporation

[3] R1-2003902 UE features for other aspects Samsung

[4] R1-2004062 Discussion on the support of SRS transmission in all symbols of a slot OPPO

[5] R1-2004488 Discussion on UE features for Others Qualcomm Incorporated

[6] R1-2004682 General discussion on NR Rel-16 UE features Ericsson

[7] R1-2004628 Other aspects of Rel-16 NR UE features Huawei, HiSilicon