**3GPP TSG RAN WG1 #100bis-e R1-2002887**

e-Meeting, April 20th – 30th, 2020

Source: NTT DOCOMO, INC.

Title: Summary on Email discussion [100b-e-NR-UEFeatures-MRDCCA-05]

Agenda Item: 7.2.11.10

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

# **Introduction**

This contribution summarizes the following email discussion in AI 7.2.11.10 regarding UE features for MR-DC/CA.

[100b-e-NR-UEFeatures-MRDCCA-05] Email discussion/approval on issues with capability signaling impacts for other MR-DC/CA enhancements than single Tx switched uplink solution for EN-DC (27th-29th April) – Hiroki (DCM)

* Discuss whether FG18-4/4a/[4b] are per band combination or per UE
* Discuss followings on FG18-5
  + Whether per band is added for FG18-5/[5a] or not
  + Whether the component 2 of 18-5 “Processing up to X unicast DCI scheduling (DL and UL) per scheduled CC” is kept or removed
  + Whether the component 3 of 18-5 is added to FG[18-5a] or not
  + Whether or not to define the maximum number of unicast DCIs in one scheduling slot/span across all scheduled cells
* Discuss whether per band is added for FG18-6/[6a] or not
* Discuss whether/how to define a signaling structure where the UE can indicate the grouping of cells across which the UE is capable of applying time offsets

Following agreements were made in the email discussions [100b-e-NR-UEFeatures-MRDCCA-01], [100b-e-NR-UEFeatures-MRDCCA-02] and [100b-e-NR-UEFeatures-MRDCCA-03].

**Agreements:**

* FG18-4/4a are kept.
* FG18-7 is kept.
* FG18-8 is kept.

**Agreement:**

Update the FG18-1/18-1a/18-1b as following.

* If a new FG to indicate support of async DC operation is introduced, delete sync/async differentiation in FG18-1b (given the understanding that such differentiation should be done outside of this FG).
* Add “Semi-static power sharing mode 2 between MCG and SCG cells of same FR is applicable only for synchronous NR dual connectivity” in the note of FG18-1a.

**Agreements:**

Following FGs are included in the UE features list for MR-DC/CA enhancements

* FG18-5a for Default QCL assumption for cross-carrier scheduling with same/different SCS
  + Dependency with other corresponding FGs will be discussed later.
* FG18-6 for cross-carrier A-CSI-RS triggering with different SCS
* FG18-6a for Default QCL assumption for cross-carrier A-CSI-RS triggering with same/different SCS
  + Dependency with other corresponding FGs will be discussed later.
* FG18-5 for DL cross-carrier scheduling with different SCS
* FG18-5b for UL cross-carrier scheduling with different SCS
* [FG18-5c for DL cross-carrier scheduling with different SCS and PDSCH processing capability 2]
* [FG18-5d for UL cross-carrier scheduling with different SCS and PUSCH processing capability 2]

**Agreements:**

* A new FG [Support of SCell dormancy indication without data scheduling within active time] is added with bracket

# **FG18-1/18-1a/18-1b: UL power sharing for DC**

Based on [1] and agreements made in [100b-e-NR-UEFeatures-MRDCCA-01], FG18-1/1a/1b can be defined as below.

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| 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**  **( 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 |
| 18. MR-DC/CA enhancement | 18-1 | Basic UL power sharing for DC | Semi-static power sharing mode1 between MCG and SCG cells of same FR for NR dual connectivity. | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A | [Absence means intra-FR DC is not supported. ] | Optional with capability signalling |
| 18-1a | Semi-static UL power sharing mode 2 for DC | Semi-static power sharing mode 2 between MCG and SCG cells of same FR for NR dual connectivity. | 18-1 (TBD) | Yes | N/A |  | Per band combination | N/A | N/A | N/A | Semi-static power sharing mode 2 between MCG and SCG cells of same FR is applicable only for synchronous NR dual connectivity | Optional with capability signalling |
| 18-1b | Dynamic UL power sharing for DC | Dynamic power sharing between MCG and SCG cells of same FR for NR dual connectivity.   1. T\_offset | 18-1 (TBD) | Yes | N/A |  | Per band combination | N/A | N/A | N/A | 1) {short, long} | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| Company | Comment |
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Following views are provided in contributions for the RAN1#100bis-e meeting.

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| [3] | MediaTek Inc. | For the current RAN1 UE feature table of MR-DC/CA, we think the alternative 18-1/1a/1b structure marked in [ ] for intra-FR DC UL power control is more clear. Hence, we support the alternative ones.  **Proposal 1: Adopt the alternative 18-1/1a/1b structure marked in [ ] for intra-FR DC UL power control in current RAN1 UE feature table.**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  | | 18-1 | Synchronous NR-DC operation | NR-DC operation with synchronization between MCG and SCG  Power-sharing mode within the frequency range   1. semi-static power-sharing mode 1 2. semi-static power-sharing mode 2 3. dynamic power-sharing and the value of T\_offset |  |  |  |  | Per band combination | N/A | N/A |  | Absence means synchronous NR-DC operation for the given band combination is not supported.  1) {Supported}  2) {not supported, supported}  3) {not supported, short, long} | Optional with capability signalling | | 18-1a | Non-SFN synchronous NR-DC operation | Operation with non-zero slot offset between MCG and SCG  Power-sharing mode within the frequency range   1. semi-static power-sharing mode 1 2. semi-static power-sharing mode 2 3. dynamic power-sharing and the value of T\_offset | 18-1 |  |  |  | Per band combination | N/A | N/A |  | Absence means non-SFN synchronous NR-DC operation for the given band combination is not supported.  1) {Supported}  2) {not supported, supported}  3) {not supported, short, long} | Optional with capability signalling | | 18-1b | Asynchronous NR-DC operation | Operation with no slot alignment between MCG and SCG  Power-sharing mode within the frequency range   1. semi-static power-sharing mode 1 2. dynamic power-sharing and the value of T\_offset | 18-1 |  |  |  | Per band combination | N/A | N/A |  | Absence means asynchronous NR-DC operation for the given band combination is not supported.  1) {Supported}  2) {not supported, supported}  3) {not supported, short, long} | Optional with capability signalling | |
| [4] | Intel Corporation | According to [1], two alternatives are proposed for features on power control. i.e.   * Alt-1: FG 18-1/18-1a/18-1b; * Alt-2: FG [18-1]/[18-1a]/[18-1b]   The key difference is which information is used to organize the features, the type of power control mode (Alt-1) or the type of synchronization (Alt-2). We prefer Alt-1 since it is aligned with the way to define UE features for power control for other cases, e.g. EN-DC.  Based on Alt-1, further information needs to be added under 18-1/18-1a/18-1b for the behavior related to synchronization, look-ahead, etc. we provide our views below.   * 18-1a: since semi-static PS mode 2 only applies to synchronized NN-DC, a clarification is needed * 18-1b: it is not clear if T\_offset only applies to dynamic PS with look-ahead or applies to dynamic PS in general. A clarification is needed   **Proposal 1: Adopt FG18-1/18-1a/18-1b for dynamic power sharing of NN-DC**   * **FG 18-1a, to clarify it is limited to synchronized NN-DC** * **FG 18-1b: to clarify T\_offset is only used for dynamic PS with look-ahead** |
| [5] | Ericsson | * Proposed FGs [18-1], [18-1a], [18-1b],   + SFN sync between MCG and SCG is related to Rel15 parameter *sfn-SyncNRDC*. Since discussion related to this issue is ongoing in RAN (i.e., as per [2]), we propose to treat any related Rel16 discussion in RAN plenary instead of RAN1.   + If specifying a separate UE capability for synchronous NR-DC and asynchronous NR-DC, we propose to define ‘synchronous’ and ‘asynchronous’ according to requirements in 38.133 (i.e., NR-DC can have similar requirements as that of sync and async EN-DC currently captured in 38.133). |
| [6] | Nokia, Nokia Shanghai Bell | **18-1/1a/1b:** The suggested restructuring along Synchronous and Asynchronous DC does not seem necessary as the differentiation is not meaningful with all PC modes. Still it appears relevant to clarify the scenarios supported with each PC mode as follows:   |  |  |  |  |  | | --- | --- | --- | --- | --- | | 18-1 | Basic UL power sharing for DC | Semi-static power sharing mode1 between MCG and SCG cells of same FR for NR dual connectivity for both synchronous and asynchronous NR-DC scenarios. |  | Absence means intra-FR DC is not supported. | | 18-1a | Semi-static UL power sharing mode 2 for DC | Semi-static power sharing mode 2 between MCG and SCG cells of same FR for NR dual connectivity for synchronous NR-DC scenario. | 18-1 |  | | 18-1b | Dynamic UL power sharing for DC | Dynamic power sharing between MCG and SCG cells of same FR for NR dual connectivity.   1. Supported scenario for dynamic power sharing 2. T\_offset | 18-1 | 1) {Synch DC only, Sync and Async DC}  2) {short, long} | |
| [7] | Qualcomm Incorporated | We believe the original 18-1, 18-1a, and 18-1b, should be replaced by the proposed [18-1], [18-1a], and [18-1b]. |
| [8] | Huawei, HiSilicon | The new added FG [18-1] with bracket should be removed. FG [18-1] is about Synchronous NR-DC operation, which should not be separated from FG18-1a since it is a special case of FG18-1a (non-SFN sync NR-DC), and RAN plenary decision RP-192345 mandates all Rel-16 UEs to support non-SFN sync NR-DC.  ***Proposal 1:*** *The new added FG 18-1 with bracket should be removed*   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  | |

# **FG18-4/18-4a/[18-4b]: SCell dormancy indication**

Based on [1] and the agreements, FG18-4/4a/[4b] can be defined as below.

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| 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**  **( 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 |
| 18. MR-DC/CA enhancement | 18-4 | SCell dormancy within active time | Support for SCell dormancy indication sent within the active time on PCell with DCI format 0\_1/1\_1 | TBD | Yes | N/A |  | Per UE | No | No | N/A |  | Optional with capability signalling |
| 18-4a | SCell dormancy outside active time | Support for SCell dormancy indication sent outside the active time on PCell with DCI format 2\_6 | [19-1] (TBD) | Yes | N/A |  | Per UE | No | No | N/A |  | Optional with capability signalling |
| [18-4b] | [Support of SCell dormancy indication without data scheduling within active time] | [Support of SCell dormancy indication without data scheduling within active time] | TBD | Yes | N/A |  | [Per UE] | [No] | [No] | [N/A] |  | [Optional with capability signaling] |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| Company | Comment |
| Qualcomm | Our preference is “per band combination”. Most of the FGs here are already “Per band combination”. |
| Huawei, HiSi | Per BC for -4/-4a. We don’t prefer to have -4b so no input for this row. |
| Ericsson | Prefer Per UE with FR1/FR2 differentiation |
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Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

**Based on the feedbacks, at least following points should be discussed.**

* **whether FG18-4/4a are per band combination or per UE**

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| [3] | MediaTek Inc. | For FG 18-4, two Cases of SCell dormancy indication are supported when the indication is sent within DRX Active Time.   * Case 1 SCell dormancy indication:   + DCI format 0\_1 and 1\_1 with additional bit field “SCell dormancy indication” are used.   + Case 1 DCI can still schedule PDSCH/PUSCH, and the timeline for HARQ-ACK information feedback is the same as N1 in Rel-15.   + 1 bit in “SCell dormancy indication” indicates SCell dormancy/non-dormancy for a group of SCells. * Case 2 SCell dormancy indication:   + DCI format 1\_1 with some repurposed bit fields is used.   + Case 2 DCI cannot schedule PDSCH but UE still needs to report HARQ-ACK information. Its HARQ-ACK report timeline is tighter than in Case 1. (working assumption: timeline is the same as in HARQ-ACK information report for SPS PDSCH release).   + 1 bit of SCell dormancy indication indicates SCell dormancy/non-dormancy for a SCell.   Because of many differences between Case 1 and Case 2 SCell dormancy indication, it is more reasonable to have separated FGs for them. We suggest the following revisions:  **Proposal 2:**   * **FG 18-4: SCell dormancy indication with data scheduling within active time**   + **Support for SCell dormancy indication sent within the active time on PCell with DCI format 0\_1/1\_1 scheduling PUSCH/PDSCH** * **Add FG 18-4b: SCell dormancy indication without data scheduling within active time**   + **Support for SCell dormancy indication sent within the active time on PCell via DCI format 1\_1 without PDSCH scheduling**  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 18-4 | SCell dormancy indication with data scheduling within active time | Support for SCell dormancy indication sent within the active time on PCell with DCI format 0\_1/1\_1 scheduling PUSCH/PDSCH |  |  | N/A |  | Per UE | No | No |  |  | Optional with capability signalling | | 18-4a | SCell dormancy outside active time | Support for SCell dormancy indication sent outside the active time on PCell with DCI format 2\_6 | 19-1 |  |  |  | Per UE | No | No |  |  | Optional with capability signalling | | 18-4b | SCell dormancy indication without data scheduling within active time | Support for SCell dormancy indication sent within the active time on PCell via DCI format 1\_1 without PDSCH scheduling |  |  | N/A |  | Per UE | No | No |  |  | Optional with capability signaling | |
| [4] | Intel Corporation | FG 18-4: There is no PDCCH/PDSCH transmission for a dormant BWP. A UE supporting one dormant BWP plus one non-dormant BWP is not equal to support two BWPs with PDCCH/PDSCH transmissions. Therefore, it is better to clarify that a prerequisite condition is UE capability of supporting at least 2 BWPs. Otherwise, it is not clear regarding the relation between SCell dormancy and multi-BWP operation.  **Proposal 3: for SCell dormancy,**   * **FG 18-2, component 3, to clarify that a prerequisite condition is UE capability of supporting at least 2 BWPs.** |
| [6] | Nokia, Nokia Shanghai Bell | **18-4:**   * Should be clear that there are two cases, the DCI format scheduling PUSCH/PDSCH and the DCI format not scheduling PDSCH. We do not propose this to be split in separate capabilities but clarify that both cases are supported.  |  |  |  | | --- | --- | --- | | 18-4 | SCell dormancy within active time | Support for SCell dormancy indication sent within the active time on PCell with DCI format 0\_1/1\_1   1. DCI format 1\_1 without scheduling PDSCH 2. DCI format 0\_1/1\_1 with scheduling PUSCH/PDSCH | |
| [7] | Qualcomm Incorporated | On FG 18-4 and 18-4a, there was a comment “Rapporteur: see comments above” to our previous proposal for email discussion. This comment seems to refer to a similar proposal form Huawei. However, there was no comments under Huawei’s proposal either.  We prefer “per band combination” so that it provides more flexibility to UE to selectively support Scell dormancy. Besides we observed that most of the feature groups in MR/DC-CA enhancement are also “Per band combination” which is aligned with our proposal for Scell dormancy.   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 18-4 | Scell dormancy within active time | Support for Scell dormancy indication sent within the active time on Pcell with DCI format 0\_1/1\_1 |  |  | N/A |  | Per band combination | No | No |  |  | Optional with capability signalling | | 18-4a | Scell dormancy outside active time | Support for Scell dormancy indication sent outside the active time on Pcell with DCI format 2\_6 | [19-1] |  | N/A |  | Per band combination | No | No |  |  | Optional with capability signalling | |
| [8] | Huawei, HiSilicon | * **FG 18-4/4a**   FG 6-5/6-6 should be as pre-requisite  Change the reporting type from ‘per UE’ to ‘per BC’, and at this stage please put per UE in bracket.  ***Proposal 5:*** *FG 6-5/6-6 should be as pre-requisite and Change the reporting type from ‘per UE’ to ‘per BC’ in FG 18-4/4a*   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 18-4 | SCell dormancy within active time | Support for SCell dormancy indication sent within the active time on PCell with DCI format 0\_1/1\_1 | *FG 6-5/6-6* | *Per BC* | No | No |  | Optional with capability signalling | | 18-4a | SCell dormancy outside active time | Support for SCell dormancy indication sent outside the active time on PCell with DCI format 2\_6 | [19-1] , *FG 6-5/6-6* | *Per BC* | No | No |  | Optional with capability signalling | |

# **FG18-5/5a/5b/[5c]/[5d]: Cross carrier scheduling with different SCS**

Based on [1] and agreements, FG18-5/5a/5b/[5c]/[5d] can be defined as below.

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| 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**  **( 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 |
| 18. MR-DC/CA enhancement | 18-5 | DL cross-carrier scheduling with different SCS | 1. The UE supports DL cross carrier scheduling for the different numerologies with carrier indicator field (CIF) in DL carrier aggregation where numerologies for the scheduling cell and scheduled cell are different  {Scheduling cell of lower SCS and scheduled cell of higher SCS, Scheduling cell of higher SCS and scheduled cell of lower SCS, both}  [2. Processing up to X unicast DCI scheduling for DL per scheduled CC ]  X is based on pair of (scheduling CC SCS, scheduled CC SCS):  X=[4] for (15,120), (15,60), (30,120),  X=[2] for (15,30), (30,60), (60,120 kHz),  [3. Default QCL assumption for cross-carrier scheduling with different SCS] | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A | crossCarrierScheduling-OtherSCS    Note: This applies also to the case where there is a single span in the slot for the scheduling CC.  In case UE supports 3-5b, the limits apply for each span for FDD scheduling cell and TDD scheduling cell. | Optional with capability signalling |
| 18-5a | Default QCL assumption for cross-carrier scheduling | [Indicates whether the UE can be configured with *enabledDefaultBeamForCCS* for default QCL assumption for cross-carrier scheduling.] | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A |  | Optional with capability signalling |
| 18-5b | UL cross-carrier scheduling with different SCS | 1. The UE supports UL cross carrier scheduling for the different numerologies with carrier indicator field (CIF) in UL carrier aggregation where numerologies for the scheduling cell and scheduled cell are different  {Scheduling cell of lower SCS and scheduled cell of higher SCS, Scheduling cell of higher SCS and scheduled cell of lower SCS, both}  [2. Processing up to X unicast DCI scheduling for UL per scheduled CC ]  X is based on pair of (scheduling CC SCS, scheduled CC SCS):  X=[4] for (15,120), (15,60), (30,120),  X=[2] for (15,30), (30,60), (60,120 kHz), | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A | crossCarrierScheduling-OtherSCS    Note: This applies also to the case where there is a single span in the slot for the scheduling CC.  In case UE supports 3-5b, the limits apply for each span for FDD scheduling cell and TDD scheduling cell. | Optional with capability signalling |
| [18-5c] | [DL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | [DL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | TBD | Yes | N/A |  | [Per band combination] | N/A | N/A | N/A |  | [Optional with capability signaling] |
| [18-5d] | [UL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | [UL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | TBD | Yes | N/A |  | [Per band combination] | N/A | N/A | N/A |  | [Optional with capability signaling] |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| Company | Comment |
| Apple | We support to have 18-5b, we have the following comments   * Without PDSCH/PUSCH processing capability 2 related CCS capability, we assume that no UE in Rel-16 will support PDSCH/PUSCH processing capability 2 for CCS, regardless if the SCS relationship between the scheduling DCI and scheduled PDSCH/PUSCH * Component 2 of 18-5/18-5b should be removed, furthermore PDCCH monitoring related capability should be a separate FG for CCS   + Component 2 is not well defined, is it per slot or per PDCCH monitoring occasion?   + There are many different types of PDCCH monitoring capability, FG3-1, FG3-5a, FG3-5b and the new span based Rel-16 URLLC design. Which PDCCH monitoring capability component 2 is referring to and why we limit the UE capability to be that? * If we keep 18-5a, then component 3 can be removed from 18-5a. We can further discuss the following   + Differentiate same or different SCS   + Differentiate QCL-TypeD for DL and spatial relation for UL   We prefer as starting point   * FG 18-5 and 18-5b, per FS (per band per BC). But we prefer to separate FR1<-> FR2 * FG 18-5a, per band |
| MTK | * Remove the component 2 of 18-5 “Processing up to X unicast DCI scheduling (DL and UL) per scheduled CC” is kept or removed * Move component 3 from 18-5 to FG[18-5a] * Do not define the maximum number of unicast DCIs in one scheduling slot/span across all scheduled cells |
| Qualcomm | Our preference is:   * Add ‘Per band’ to FG18-5/5a/5b. * PDCCH monitoring related capability is not defined within other capabilities. * Keep FG 18-5a separate. Do not add FG 18-5a to FG18-5. |
| Ericsson | * Keep component 2 - The main point is to allow full scheduling when low-SCS carrier schedules high SCS without running into DCI limitations. Can clarify - “X applies per span in a slot of scheduling CC. There is also info in the note. * Prefer per-UE with FR1/FR2 differentiation |

Following feedback is provided in a contribution for the RAN1#100bis-e meeting.

**Based on the feedback, at least following point should be discussed for FG18-5/5a/5b.**

* **Whether per band is added for FG18-5/5a or not**
* **Whether the component 2 of 18-5 “Processing up to X unicast DCI scheduling (DL and UL) per scheduled CC” is kept or removed**
* **Whether the component 3 of 18-5 is added to FG[18-5a] or not**
* **Whether or not to define the maximum number of unicast DCIs in one scheduling slot/span across all scheduled cells**

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| [2] | ZTE Corporation | According to RAN1#98bis meeting, UE vendors may have the concern that too many unicast DCIs are placed within one monitoring occasion if one scheduling cell cross-carrier schedules a large number of scheduled cells. In this case, the maximum number of unicast DCIs in one scheduling slot/span across all scheduled cells can be defined.  ***Proposal 1:***  *Increase the number of valid DCIs in a PDCCH monitoring occasion to at least 4;*  *Define the maximum number of unicast DCIs in one scheduling slot/span across all scheduled cells.*  The current Rel-15 DAI counting mechanism assumes that only up to one unicast DL DCI is in each monitoring occasion for each scheduled cell, which doesn’t cover the case that more than one unicast DL DCI is received for the same scheduled cell. More than one unicast DL DCI for one scheduled cell is a typical case for cross-carrier scheduling with smaller SCS for the scheduling cell. For example, the scheduling cell is of 15 KHz SCS and the scheduled cell is of 120 KHz SCS, where one 15 KHz slot equals to 8 120 KHz slots. For full flexibility, up to 8 unicast DCIs may need to be transmitted within one MO. Thus, the new DAI counting order shall also take this case into account. For PDSCHs scheduled from the same MO for the same scheduled cell, the PDSCH starting time can be used for DAI counting. Combined with the Rel-15 DAI counting order, the new DAI counting order can be summarized as below:   1. First in ascending order of PDSCH starting time; 2. Second in ascending order of serving cell index; 3. Third in ascending order of MO index.   ***Proposal 2****: If the maximum number of unicast DCIs per MO is increased, the PDSCH starting time in addition to the existing MO and Cell index is introduced to order the HARQ-ACK feedback.*    **Figure 2.** DAI count order if more than one DCI is received within one MO. |
| [3] | MediaTek Inc. | For FG 18-5: Cross-carrier scheduling with different SCS, it is sufficient to reuse the Rel. 16 FG 3-5b PDCCH monitoring to have multiple DCIs in one slot of the scheduling cell with lower SCS than the scheduled cell. This has the benefit of avoiding introducing additional impact to the spec (e.g., new design for HARQ-ACK codebook). We think the value of X is not needed. Besices, it is recommended to add ‘Per band’ to support the feature for CA within certain bands or not.  **Proposal 3: RAN1 agree to reuse the Rel. 16 FG 3-5b PDCCH monitoring to have multiple DCIs in one slot of the scheduling cell with lower SCS than the scheduled cell. Delete the descriptions related to value X. Add ‘Per band’ to FG 18-5 to support the feature for CA within certain bands or not.**  For FG [18-5a]: Default QCL assumption for cross-carrier scheduling with same SCS, we support to keep this capability for better UE implementation flexibility.  **Proposal 4: Keep “18-5a Default QCL assumption for cross-carrier scheduling with same SCS” in current RAN1 UE feature table.**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 18-5 | Cross-carrier scheduling with different SCS | 1) The UE supports cross carrier scheduling for the different numerologies with carrier indicator field (CIF) in DL carrier aggregation where numerologies for the scheduling cell and scheduled cell are different  [2 Default QCL assumption for cross-carrier scheduling with different SCS] |  |  | N/A |  | Per band combination | No | No |  | crossCarrierScheduling-OtherSCS    1) {Scheduling cell of lower SCS and scheduled cell of higher SCS, Scheduling cell of higher SCS and scheduled cell of lower SCS, both} | Optional with capability signalling | | 18-5a | Default QCL assumption for cross-carrier scheduling with same SCS | Indicates whether the UE can be configured with *enabledDefaultBeamForCCS* for default QCL assumption for cross-carrier scheduling with same SCS. | 6-10 |  |  |  | Per band combination |  |  |  |  | Optional with capability signalling | |
| [4] | Intel Corporation | FG 18-5 component 2): it is not clear which interpretation is correct.   * Interpretation #1: X DL DCI + X UL DCI, i.e. gNB can transmit up to 2X DCI per scheduled cell * Interpretation #2: totally X DCIs, i.e. gNB can transmit up to X DCI per scheduled cell   As discussed in [2], the main motivation for X>1 is for the case that the scheduling cell has a SCS shorter than scheduled cell. For better scheduling flexibility on the scheduled cell, the number of PDCCH detections needs to be increased. Another limitation is the maximum number of DL DCIs that schedule PDSCH on a same cell. If the maximum number is more than 4, it is not enough to rely on C-DAI as additional dimension in HARQ-ACK bit ordering for Type1 HARQ-ACK codebook. Some alternative options were proposed in early meetings. However, it is not likely to converge on any option. Therefore, we prefer to define . The current value of X in [1] is OK.  FG 18-5a: it could be a separate feature since all 3 components in FG 18-1 are related to cross-carrier scheduling with different SCS.  **Proposal 4: for *Cross-carrier scheduling with different numerology,***   * **FG 18-5 component 2): it is not clear which interpretation is correct.**   + **Interpretation #1: X DL DCI + X UL DCI, i.e. gNB can transmit up to 2X DCI per scheduled cell**   + **Interpretation #2: totally X DCIs, i.e. gNB can transmit up to X DCI per scheduled cell** * **To confirm that**   + **X=4 for (15,120), (15,60), (30,120),**   + **X=2 for (15,30), (30,60), (60,120 kHz**), * **FG 18-5a can be separate feature** |
| [5] | Ericsson | * Propose to add new FG 18-5b for UL CA with mixed numerologies   + The feature for cross-carrier scheduling with mixed numerology for uplink carrier aggregation is missing since 18-5 describes only DL CA. Introduce a new feature 18-5b for supporting UL CA, mirroring 18-5 with following changes:     - * Change DL CA to UL CA in component 1)       * Delete component 3) * FG 18-5   + Regarding component 2     - We propose to confirm the text in square brackets around component 2. For improved scheduling flexibility (e.g. contiguous scheduling) and efficient operation, especially in case of low SCS scheduling high SCS, it is desirable to allow increasing number of DCIs within a span.   + Regarding component 3     - Propose to confirm the text in square brackets as default beam for different SCS case does not need separate capability. * FG 18-5a   + Prefer to define this capability only for same SCS as different SCS can be handled by 18-5. |
| [6] | Nokia, Nokia Shanghai Bell | **18-5:**   * Component 2: support the proposal where the X is based on the scheduling/scheduled carrier SCS combination as currently written in the table. The proposed values for X are reasonable. The component should be clarified that the X is defined per span. * Component 3: This should be included as a basic component as always supported when UE indicates support for 18-5   **18-5a:** OK to have this new FG. Add pre-requisite 6-10 Cross carrier scheduling for the same numerology |
| [7] | Qualcomm Incorporated | On FG 18-5, we propose to add ‘Per band’ to selectively support the feature for CA within certain bands.  On component 2 of FG 18-5, based on early RAN1 discussions, we observed that it is sufficient to use the Rel. 16 FG 3-5b PDCCH monitoring to have multiple DCIs in one slot of the scheduling cell with a lower SCS than the scheduled cell. There are discussions on whether a UE should support all components in an FG if the UE supports any. At least for FG 18-5, we think the UE should not be required to automatically support component 2 because the UE reports to support cross-carrier scheduling with different SCS as described by component 1.  On component 3 of FG 18-5, similar to component 2, we would like to clarify whether a UE must support all components in an FG if the UE supports any.  On FG 18-5a, we support to include this FG in the UE features. It can be further discussed whether 18-5a and 18-5 compnent 3 can be merged together. If they are merged together, compnent 3 of FG 18-5 is added to FG 18-5a, but not the other way round.  ~  We can calrify more on our proposals. The intent is not to differentiate UE behaviours between DCI formats 0\_1/1\_1 and DCI formats 0\_2/1\_2 but to differentiate UE behaviours between eURLLC and eMBB. It is not clear to us how eURLLC benefits from the feature. It is also too restrictive if a UE must support cross-carrier scheduling with different SCS for both or neither of eMBB and eURLLC simultaneously. In the updated proposals below, DCI formats are removed from the “components” field.   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 18-5 | Cross-carrier scheduling with different SCS | | 1) The UE supports cross carrier scheduling for the different numerologies with carrier indicator field (CIF) in DL carrier aggregation where numerologies for the scheduling cell and scheduled cell are different  [2] Processing up to X unicast DCI scheduling (DL and UL) per scheduled CC ]  [3 Default QCL assumption for cross-carrier scheduling with different SCS] |  |  | N/A |  | Per band and per band combination | No | No |  | crossCarrierScheduling-OtherSCS    1) {Scheduling cell of lower SCS and scheduled cell of higher SCS, Scheduling cell of higher SCS and scheduled cell of lower SCS, both}  [2] ]  X is based on pair of (scheduling CC SCS, scheduled CC SCS):  [4] for (15,120), (15,60), (30,120),  [2] for (15,30), (30,60), (60,120 kHz),  Note: This applies also to the case where there is a single span in the slot for the scheduling CC.  In case UE supports 3-5b, the limits apply for each span for FDD scheduling cell and TDD scheduling cell. | Optional with capability signalling | | [18-5a] | Default QCL assumption for cross-carrier scheduling | Indicates whether the UE can be configured with *enabledDefaultBeamForCCS* for default QCL assumption for cross-carrier scheduling with same SCS. | |  |  |  |  | Per band and per band combination |  |  |  | FFS if this is needed or if it should cover also component 3 of 18-5 | Optional with capability signalling | | 18-5b | Cross-carrier scheduling with different SCS for URLLC | The UE supports cross-carrier scheduling with different SCS for URLLC | |  | Yes | N/A |  | Per band and per band combination | No | No |  | 1) {Scheduling cell of lower SCS and scheduled cell of higher SCS, Scheduling cell of higher SCS and scheduled cell of lower SCS, both} | Optional with capability signalling | |

# **FG18-6/6a: Cross carrier A-CSI-RS triggering with different SCS**

Based on [1] and agreements, FG18-6/6a can be defined as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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**  **( 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 |
| 18. MR-DC/CA enhancement | 18-6 | Cross-carrier A-CSI RS triggering with different SCS | Cross-carrier A-CSI RS triggering with different SCS | 2-33 (TBD) | Yes | N/A |  | Per band combination | N/A | N/A | N/A | 1) {PDCCH cell of lower SCS and A-CSI RS cell of higher SCS, PDCCH cell of higher SCS and A-CSI-RS of lower SCS, both} . | Optional with capability signalling |
| 18-6a | Default QCL assumption for cross-carrier A-CSI-RS triggering | Indicates whether the UE can be configured with *enabledDefaultBeamForCCS* for default QCL assumption for cross-carrier A-CSI-RS triggering. | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A |  | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

|  |  |
| --- | --- |
| Company | Comment |
| Apple | We prefer as starting point   * FG 18-6, per FS (per band per BC). But we prefer to separate FR1<-> FR2 * FG 18-6a, per band |
| Qualcomm | Our preference is:   * Keep FG 18-6 * Keep FG 18-6a * Add ‘Per band’ to FG 18-6/6a |
| Huawei, HiSi | Per BC for both |
| Ericsson | Prefer per-UE with FR1/FR2 differentiation |

Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

**Based on the feedback, at least following point should be discussed for FG18-6/6a.**

* **Whether per band is added for FG18-6/6a or not**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [3] | MediaTek Inc. | For FG [18-6a]: Default QCL assumption for cross-carrier A-CSI-RS triggering, we support to keep this capability for better UE implementation flexibility.  **Proposal 5: Keep “18-6a Default QCL assumption for cross-carrier A-CSI-RS triggering” in current RAN1 UE feature table.**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 18-6a | Default QCL assumption for cross-carrier A-CSI-RS triggering | Indicates whether the UE can be configured with *enabledDefaultBeamForCCS* for default QCL assumption for cross-carrier A-CSI-RS triggering. |  |  |  |  | Per band combination |  |  |  |  | Optional with capability signalling | |
| [6] | Nokia, Nokia Shanghai Bell | **18-6a**: This should be made a mandatory component of 18.6. No need for a separate capability |
| [7] | Qualcomm Incorporated | One FG 18-6   * We propose to update feature type same as FG 18-5. * Minor changes were made by adding “cell” and replaing a “-” with space for the second A-CSI RS to keep wording consistency.   On FG 18-6a, we propose to remove the FFS.  ~  We can calrify more on our proposals. The intent is not to differentiate UE behaviours between DCI formats 0\_1/1\_1 and DCI formats 0\_2/1\_2 but to differentiate UE behaviours between eURLLC and eMBB. It is not clear to us how eURLLC benefits from the feature. It is also too restrictive if a UE must support cross-carrier scheduling with different SCS for both or neither of eMBB and eURLLC simultaneously. In the updated proposals below, DCI formats are removed from the “components” field.   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 18-6 | Cross-carrier A-CSI RS triggering with different SCS | Cross-carrier A-CSI RS triggering with different SCS | 2-33 |  | N/A |  | Per band and per combination | No | No |  | 1) {PDCCH cell of lower SCS and A-CSI RS cell of higher SCS, PDCCH cell of higher SCS and A-CSI RS cell of lower SCS, both} . | Optional with capability signalling | | [18-6a] | Default QCL assumption for cross-carrier A-CSI-RS triggering | Indicates whether the UE can be configured with *enabledDefaultBeamForCCS* for default QCL assumption for cross-carrier A-CSI-RS triggering. |  |  |  |  | Per band and per combination |  |  |  | FFS if this is needed | Optional with capability signalling | | 18-6b | Cross-carrier A-CSI RS triggering with different SCS for URLLC | The UE supports cross-carrier A-CSI RS triggering with different SCS for URLLC |  | Yes | N/A |  | Per band and per band combination | No | No |  | 1) {PDCCH cell of lower SCS and A-CSI RS cell of higher SCS, PDCCH cell of higher SCS and A-CSI-RS cell of lower SCS, both}. | Optional with capability signalling | |

# **FG18-7: CA with non-aligned frame boundaries**

Based on [1] and the agreements, FG18-7 can be defined as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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**  **( 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 |
| 18. MR-DC/CA enhancement | 18-7 | CA with non-aligned frame boundaries | CA with non-aligned frame boundaries for inter-band CA | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A | Defines whether the UE supports carrier aggregation operation where the frame boundaries of the Pcell and the Scell are not aligned, while the slot boundaries are. | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSi | Per BC |
|  |  |
|  |  |
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Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

**Based on the feedback, at least following point should be discussed for FG18-7.**

* **Whether/how to define a signaling structure where the UE can indicate the grouping of cells across which the UE is capable of applying time offsets**

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| --- | --- | --- |
| [7] | Qualcomm Incorporated | * There should be a signaling structure recommended to RAN2, where the UE can indicate the grouping of cells across which the UE is capable of applying time offsets. For example, the UE can only apply offset between TDD bands but not between FDD bands, etc. |

# **FG18-8: HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group**

Based on [1] and the agreements, FG18-8 can be defined as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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**  **( 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 |
| 18. MR-DC/CA enhancement | 18-8 | HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group | HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group | 6-7 | Yes | N/A |  | Per UE | No | No | N/A | Support HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group.  Rel-15 had this per cell group | [Optional with capability signalling or Mandatory conditioned to support for multiple PUCCH groups 6-7] |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSi | Assuming pre-requisite will be discussed at next stage, this can be per-UE reported without FRx/xDD differentiation. |
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Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [3] | MediaTek Inc. | For FG 18-8: HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group, since this is a new Rel-16 feature, it should be optional with capability signaling.  **Proposal 6: FG “18-8 HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group” should be optional with capability signaling.**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 18-8 | HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group | HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group | 6-7 |  | N/A |  | Per UE | No | No |  | Support HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group.  Rel-15 had this per cell group | Optional with capability signalling | |
| [6] | Nokia, Nokia Shanghai Bell | **18-8**: Support that this is a mandatory feature for Rel-16 UEs supporting FG6-7 |
| [8] | Huawei, HiSilicon | * **FG 18-8**   There is no need to restrict to same SCS case only with only 6-7 as the pre-requisite, so 6-8 can also be pre-requisite FG and/or the condition for mandatory support.  ***Proposal 6:*** *There is no need to restrict to same SCS case only with only 6-7 as the pre-requisite in FG 18-8* |

# **Conclusion**

TBD

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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**  **( 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 |
| 18. MR-DC/CA enhancement | 18-1 | Basic UL power sharing for DC | Semi-static power sharing mode1 between MCG and SCG cells of same FR for NR dual connectivity. | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A | [Absence means intra-FR DC is not supported. ] | Optional with capability signalling |
| 18-1a | Semi-static UL power sharing mode 2 for DC | Semi-static power sharing mode 2 between MCG and SCG cells of same FR for NR dual connectivity. | 18-1 (TBD) | Yes | N/A |  | Per band combination | N/A | N/A | N/A | Semi-static power sharing mode 2 between MCG and SCG cells of same FR is applicable only for synchronous NR dual connectivity | Optional with capability signalling |
| 18-1b | Dynamic UL power sharing for DC | Dynamic power sharing between MCG and SCG cells of same FR for NR dual connectivity.   1. T\_offset | 18-1 (TBD) | Yes | N/A |  | Per band combination | N/A | N/A | N/A | 1) {short, long} | Optional with capability signalling |
| 18-4 | SCell dormancy within active time | Support for SCell dormancy indication sent within the active time on PCell with DCI format 0\_1/1\_1 | TBD | Yes | N/A |  | Per UE | No | No | N/A |  | Optional with capability signalling |
| 18-4a | SCell dormancy outside active time | Support for SCell dormancy indication sent outside the active time on PCell with DCI format 2\_6 | [19-1] (TBD) | Yes | N/A |  | Per UE | No | No | N/A |  | Optional with capability signalling |
| [18-4b] | [Support of SCell dormancy indication without data scheduling within active time] | [Support of SCell dormancy indication without data scheduling within active time] | TBD | Yes | N/A |  | [Per UE] | [No] | [No] | [N/A] |  | [Optional with capability signaling] |
| 18-5 | DL cross-carrier scheduling with different SCS | 1. The UE supports DL cross carrier scheduling for the different numerologies with carrier indicator field (CIF) in DL carrier aggregation where numerologies for the scheduling cell and scheduled cell are different  {Scheduling cell of lower SCS and scheduled cell of higher SCS, Scheduling cell of higher SCS and scheduled cell of lower SCS, both}  [2. Processing up to X unicast DCI scheduling for DL per scheduled CC ]  X is based on pair of (scheduling CC SCS, scheduled CC SCS):  X=[4] for (15,120), (15,60), (30,120),  X=[2] for (15,30), (30,60), (60,120 kHz),  [3. Default QCL assumption for cross-carrier scheduling with different SCS] | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A | crossCarrierScheduling-OtherSCS    Note: This applies also to the case where there is a single span in the slot for the scheduling CC.  In case UE supports 3-5b, the limits apply for each span for FDD scheduling cell and TDD scheduling cell. | Optional with capability signalling |
| 18-5a | Default QCL assumption for cross-carrier scheduling | [Indicates whether the UE can be configured with enabledDefaultBeamForCCS for default QCL assumption for cross-carrier scheduling.] | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A |  | Optional with capability signalling |
| 18-5b | UL cross-carrier scheduling with different SCS | 1. The UE supports UL cross carrier scheduling for the different numerologies with carrier indicator field (CIF) in UL carrier aggregation where numerologies for the scheduling cell and scheduled cell are different  {Scheduling cell of lower SCS and scheduled cell of higher SCS, Scheduling cell of higher SCS and scheduled cell of lower SCS, both}  [2. Processing up to X unicast DCI scheduling for UL per scheduled CC ]  X is based on pair of (scheduling CC SCS, scheduled CC SCS):  X=[4] for (15,120), (15,60), (30,120),  X=[2] for (15,30), (30,60), (60,120 kHz), | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A | crossCarrierScheduling-OtherSCS    Note: This applies also to the case where there is a single span in the slot for the scheduling CC.  In case UE supports 3-5b, the limits apply for each span for FDD scheduling cell and TDD scheduling cell. | Optional with capability signalling |
| [18-5c] | [DL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | [DL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | TBD | Yes | N/A |  | [Per band combination] | N/A | N/A | N/A |  | [Optional with capability signaling] |
| [18-5d] | [UL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | [UL cross-carrier scheduling with different SCS and PDSCH processing capability 2] | TBD | Yes | N/A |  | [Per band combination] | N/A | N/A | N/A |  | [Optional with capability signaling] |
| 18-6 | Cross-carrier A-CSI RS triggering with different SCS | Cross-carrier A-CSI RS triggering with different SCS | 2-33 (TBD) | Yes | N/A |  | Per band combination | N/A | N/A | N/A | 1) {PDCCH cell of lower SCS and A-CSI RS cell of higher SCS, PDCCH cell of higher SCS and A-CSI-RS of lower SCS, both} . | Optional with capability signalling |
| 18-6a | Default QCL assumption for cross-carrier A-CSI-RS triggering | Indicates whether the UE can be configured with enabledDefaultBeamForCCS for default QCL assumption for cross-carrier A-CSI-RS triggering. | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A |  | Optional with capability signalling |
| 18-7 | CA with non-aligned frame boundaries | CA with non-aligned frame boundaries for inter-band CA | TBD | Yes | N/A |  | Per band combination | N/A | N/A | N/A | Defines whether the UE supports carrier aggregation operation where the frame boundaries of the Pcell and the Scell are not aligned, while the slot boundaries are. | Optional with capability signalling |
| 18-8 | HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group | HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group | 6-7 | Yes | N/A |  | Per UE | No | No | N/A | Support HARQ-ACK codebook type and HARQ-ACK spatial bundling configuration per PUCCH group.  Rel-15 had this per cell group | [Optional with capability signalling or Mandatory conditioned to support for multiple PUCCH groups 6-7] |

# **References**

[1] R1-2001484 RAN1 UE features list for Rel-16 NR after RAN1#100-E Moderator (AT&T, NTT DOCOMO, INC.)

[2] R1-2001631 Discussion on UE feature for MR-DC CA ZTE

[3] R1-2001833 Views on Rel-16 UE features for MR-DC/CA MediaTek Inc.

[4] R1-2002024 UE feature for MR-DC Intel Corporation

[5] R1-2002426 Discussion on UE features for MR-DC Ericsson

[6] R1-2002477 On UE features for MR-DC/CA Nokia, Nokia Shanghai Bell

[7] R1-2002571 Discussion on UE features for MR-DC/CA Qualcomm Incorporated

[8] R1-2002595 Rel-16 UE features for MR-DC/CA Huawei, HiSilicon