**3GPP TSG RAN WG1 #105-e R1-21xxxxx**

**e-Meeting, May 10th – 27th, 2021**

**Agenda Item:** 8.2.5

**Source:** Moderator (LG Electronics)

**Title:** Summary #1 of PDSCH/PUSCH enhancements (Scheduling/HARQ)

**Document for:** Discussion and decision

# Introduction

This is the summary document for 8.2.5 on PDSCH/PUSCH enhancements (especially for scheduling and HARQ) for NR above 52.6 GHz, based on the contributions listed in reference section.

The following email thread is assigned for discussion of this topic:

[105-e-NR-52-71GHz-03] Email discussion/approval on scheduling particularly w.r.t. multi-PDSCH/PUSCH with a single DCI, HARQ, with checkpoints for agreements on May 24, May 27 – Seonwook (LGE)

# Multi-PDSCH/PUSCH scheduling

## Aspects common to PDSCH and PUSCH

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| Company | Views |
| [1] Futurewei | Proposal 2. Reuse the legacy Rel-17 maximum schedulable PDSCHs with a single DCI, i.e., 8, as the upper bound of number of slots in a multi-PDSCH/PUSCH for both the SCS 480kHz and SCS 960kHz. No further restriction is needed for SCS 480kHz.Proposal 3. Extend the RRC TDRA configuration table to include multiple SLIVs, mapping types, and slot offsets for each scheduled PUSCH/PDSCH in a multi-PUSCH/PDSCH. Observation 1: The number of rows of an enhanced TDRA configuration table might need to surpass 16 as configured for the legacy Rel-15/16, and thus increased DCI bit-width is expected.Observation 2. User-multiplexing is of lower priority due to narrow-beam in 52.6GHz to 71GHz band, thus UE may occupy larger number of PRBs, which allows increased RBG size.Proposal 5: CBGTI/CBGFI is not applicable in a DCI format that schedules multi-PDSCH for SCSs including 480kHz/960kHz; but can be applied to cases under the SCS 120kHz.Proposal 10: Only DCI format 1\_1 is extended for scheduling multi-PDSCH. |
| [2] Huawei | Proposal 1: The maximum number of PDSCHs/PUSCHs scheduled by a single DCI is 4 for 480 kHz SCS.Proposal 3: Support at least DCI format 1-1/0-1 for multi-slot PDSCH/PUSCH scheduling with a single DCI. No support of DCI format 0-0 and 1-0 for multi-slot PDSCH/PUSCH scheduling.Observation 1: Further enhancements of FDRA are not essential for both multi-slot PDSCH scheduling and multi-slot PUSCH scheduling.Observation 2: Configure rate matching pattern to support non-continuous resource mapping in time domain needs no additional specification effort. Non-continuous PDSCHs (resp. PUSCHs) allocation can be signaled by a k0 (resp. k2) value for each SLIV in each row of the RRC-configured TDRA table.Proposal 5: CBG (re)transmission is not supported for multi-slot PDSCH/PUSCH scheduling. |
| [3] vivo | Proposal 1: For a DCI that can schedule multiple PDSCHs/PUSCHs, it should be studied how to configure K0/K2, and the following options could be considered:- Option 1: Each PDSCH/PUSCH has a separate K0/K2.- Option 2: Each row has a single K0/K2.Proposal 2: Legacy frequency domain scheduling in NR Rel-15/16 is reused for multi-PUSCH/PDSCH scheduling.Proposal 3: It can be clarified that the URLLC related fields in the DCI scheduling multiple PUSCHs are applied equally to each scheduled PUSCH, including priority indicator and open-loop power control parameter set indication.Proposal 4: For CBG based scheduling, the same solution adopted in Rel-16 NR-U multi-PUSCH scheduling can be reused for multi-PUSCH scheduling, i.e., CBG based scheduling is supported only when a DCI schedules a single PUSCH.Proposal 5: For scheduling DCI format, the same solution adopted in Rel-16 NR-U can be reused, i.e., the same DCI format is used for both single PUSCH scheduling and multi-PUSCH scheduling. |
| [4] Spreadtrum | Proposal 2: CBG (re)transmission should not be supported when more than one PDSCHs/PUSCHs are scheduled.Proposal 3: Apply same method rule compared to Rel-16 NR-U for FDRA. |
| [5] Nokia | Proposal 1: The multi-PUSCH scheduling defined in Rel-16 NR-U is used as the baseline for designing multi-PxSCH scheduling. Maximize the similarity between multi-PDSCH and multi-PUSCH· Do not introduce new DCI format for multi-PDSCH/PUSCH scheduling.· Use DCI format 0\_1 to schedule multiple PUSCHs with a single DCI· Use DCI format 1\_1 to schedule multiple PDSCHs with a single DCI.Proposal 2: The maximum number of PxSCH that can scheduled with a single DCI in Rel-17 is 8 also for 480 kHz SCS. All UEs need to support at maximum 8 PxSCH for both 480 kHz and 960 kHz SCSs.Proposal 5: For TDRA, PUSCHTimeDomainAllocationListForMultiPxSCH indicates only contiguous slots.• Invalid slots are determined based on RateMatchPattern(s)• Non-contiguous transmission covers contiguous HARQ processes.Proposal 7: For other multi-PxSCH enhancements:• FDRA enhancements and frequency hopping enhancements are considered as secondary topics for multi-PxSCH transmission and they are considered only if time allows. • CBGTI is not applicable to multi-PDSCH scheduling• For URLLC related fields, one value of each field is applied for all scheduled PUSCHs |
| [6] Ericsson | Proposal 2: No further restriction or UE capability for 120 and 480 kHz SCS on the maximum number of PDSCHs that can be scheduled with a single DCI.Proposal 3: No further restriction or UE capability for 120 and 480 kHz SCS on the maximum number of PUSCHs that can be scheduled with a single DCI.Proposal 5: For TDRA table that supports multi-PDSCH/PUSCH scheduling, each row contains up to 8 multiple PDSCHs/PUSCHs that can be non-contiguous on slot level.Proposal 6: For TDRA table that supports multi-PDSCH/PUSCH scheduling, each row contains up to 8 PDSCH/PUSCH, with separate SLIV, mapping type, and scheduling offset K0/K2 for each scheduled PDSCH/PUSCH.Proposal 7: Introduce new RBG configuration for PDSCH/PUSCH frequency resource allocation Type 0 to reduce FDRA granularity and DCI size.Proposal 8: Support configurable Resource Allocation Granularity (P) up to 32 for DCI Format 0\_1 and 1\_1 with PUSCH/PDSCH frequency resource allocation Type 1 to reduce FDRA granularity and DCI size.Proposal 13: When multi-PDSCH is configured, the CBGTI/CBGFI fields in DCI Format 1\_1 should not be included. The saved bits can be re-used for indicating RV/NDI for multiple PDSCHs.Observation 11: There are no real technical advantages for supporting multi-PDSCH/PUSCH and CBG transmission simultaneously.Proposal 15: When DCI Format 0\_1 is used for scheduling multiple PUSCHs, priority indicator and open-loop power control parameter set indication fields in the DCI should apply to all PUSCHs being scheduled.Proposal 17: Do not support scheduling of multiple PDSCHs with a single DCI where the TB(s) corresponding to one or more of the PDSCHs is(are) mapped over multiple slots by legacy TB repetition (semi-statically configured by pdsch-AggregationFactor or dynamically indicated by repetitionNumber in TDRA table).Proposal 18: As in Rel-16, do not support scheduling of multiple PUSCHs with a single DCI where one or more of the PUSCHs is(are) mapped over multiple slots by legacy TB repetition (Type A or B repetition).Proposal 19: Support multi-PDSCH scheduling with a single DCI for multi-TRP transmission in Rel-17 except for the case where the TB(s) corresponding to one or more of the scheduled PDSCHs is(are) mapped over multiple slots by legacy TB repetition.Proposal 25: Do not support CBG transmission for multi-PUSCH in Rel-17 when multi-PUSCH is configured and when DCI Format 1\_0 is used to schedule multiple PUSCHs (same as multi-PUSCH in Rel-16).Proposal 26: Do not support simultaneous configuration of multi-PDSCH scheduling and CBG transmission in Rel-17. |
| [7] CATT | Proposal 4: For multiple PDSCH/PUSCH scheduling, no more than one PUSCH/PDSCH shall be transmitted in one slot.Proposal 5: Non-continuous time-domain allocation is indicated by invalid SLIV value in the configuration.Proposal 6: When the scheduled PDSCH/PUSCH overlaps with unavailable slots/symbols, the corresponding SLIV value can be regarded as invalid.Proposal 7: Whether the HARQ process ID is still consecutive when one or more SLIVs value is invalid can be further discussed.Proposal 8: For SCS of 480 KHz, it is not needed to restrict the maximum number of PDSCHs to 4. |
| [8] Qualcomm | Proposal 2: A UE capability to be defined per SCS, to indicate the maximum number of supported PDSCHs/PUSCHs per single DCI for SCS 120kHz and 480kHz.Proposal 9: For multi-PDSCH/PUSCH DCI fields enhancements:* CBGTI: Not to be supported for more than one PDSCH/PUSCH
* FDRA optimization can be deprioritized

Proposal 10: For TDRA filed of multi-PDSCH/PUSCH grants with single DCI, each row contains a single value of k0/k1 and multiple SLIVs, and new rules are needed to be defined • For overlapping SLIVs: the second SLIV to be allocated in the next slot.• Allow SLIV ‘0’ to indicate slot level gaps between the adjacent allocations.Proposal 11: Introduce new default TDRA PDSCH and PUSCH tables depending on the used SCS, e.g., 960kHz and 480kHz SCS, to be able to schedule all the resources between any two adjacent PDCCH monitoring occasions. The slot offsets in these tables should cover up to the PDCCH monitoring periodicity. For the slots without PDCCH monitoring, L=14 can be considered. |
| [9] OPPO | Proposal 4: The maximum number of PDSCHs/PUSCHs that can be scheduled with a single DCI should be 8 for all the supported SCSs. |
| [10] ZTE | Proposal 1: The CBG (re)transmission should be supported when more than one PUSCHs are scheduled and the CBGTI field should be per re-transmitted PUSCH in the multiple PUSCHs scheduling DCI. |
| [11] Intel | Proposal 1: For multi-PUSCH scheduling, * Support CBG based scheduling when 2 PUSCHs are scheduled.
* Do not support enhancement on FDRA.

Proposal 2: For multi-PDSCH scheduling, supported CBG based scheduling.* Maximum number of PDSCHs for CBG based scheduling is 2.
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| [12] Fujitsu | Proposal 1: For 120, 480 and 960 kHz SCS, the maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI in Rel-17 is 8. |
| [13] Apple | Proposal 1: For Rel-17 multi-PUSCH transmission• The maximum number of PUSCHs that can be scheduled for 120 kHz and 480 kHz SCS can be further restricted based on UE capabilities. • A clear use case should be made for CBG support for multi-PUSCH transmission.• The FDRA size should be optimized to reduce the FDRA overhead. • a single URLLC priority should be assigned to a single DCIProposal 2: For multi-PUSCH scheduling with a single DCI the following fields are signaled: • Per DCI: FDRA, MCS, HARQ\_process\_number• Per PUSCH: TDRA-K2, TDRA-(S,L), TDRA-Mapping\_type, NDI, RV• FFS: Uplink TDAIProposal 4: For Rel-17 multi-PDSCH transmission• The maximum number of PDSCHs that can be scheduled for 120 kHz and 480 kHz SCS can be further restricted based on UE capabilities. • A clear use case should be made for CBG support for multi-PDSCH transmission.• The FDRA size should be optimized to reduce the FDRA overhead. • a single URLLC priority should be assigned to a single DCIProposal 5: For multi-PDSCH scheduling with a single DCI the following fields are signaled: • Per DCI: FDRA, 1st MCS, 2nd MCS, HARQ\_process\_number, and PRB bundling size• Per PDSCH: TDRA-K0, TDRA-(S,L), TDRA-Mapping\_type, 1st NDI, 1st RV, 2nd NDI, 2nd RV, rate matching indicator, and ZP CSI-RS trigger• FFS: c-DAI, Downlink T-DAI, CGBTI/CBGFI, K1, and PRI. |
| [14] Sony | Proposal 1: CBG-based transmission should not be supported for multi-PUSCH scheduling.Proposal 3: URLLC related fields should be supported for multi-PUSCH scheduling• Further study whether single or multiple fields related to URLLC are applied to multiple PUSCH scheduled by single DCI.Proposal 10: No new DCI format is needed for multi-PUSCH/PDSCH scheduling.• The same DCI format is used for both single PUSCH/PDSCH scheduling and multi-PUSCH/PDSCH scheduling.Proposal 11: At least DCI format 0\_1 should be supported for multi-PUSCH scheduling.Proposal 12: At least DCI format 1\_1 should be supported for multi-PDSCH scheduling.Observation 2: DCI enhancement may need to be additionally considered in the case that a lot of DCI overhead for multi-PDSCH/PUSCH scheduling is required. |
| [15] NEC | Proposal 1: CBG based (re)transmission is not supported for multi-PDSCH scheduling with a single DCI |
| [16] Samsung | Proposal 1: The maximum number of PDSCHs/PUSCHs scheduled by a single DCI can be 4 or 8 for 120KHz and 480KHz, which is based on UE capability.Proposal 2: Rel-16 NR-U multi-PUSCH scheduling DCI can be reused for multi-PUSCH in 52.6~71GHz with at least the following enhancement: - PUSCH TDRA: separate k0, SLIV and mapping type to support non-continuous PUSCH transmissions. - PUSCH FDRA: larger RRC configured range for RBG. - URLLC related field: same priority for all PUSCHs scheduled by a single DCIProposal 3: For multi-PDSCH scheduling, the bit field common for DL and UL grant use the same design as multi-PUSCH scheduling, and at least following DL-specific bit field should be specified,- CBG-based transmission is not applicable to multi-PDSCH scheduling, including CBGTI/CBGFIProposal 4: Support single DCI for single or multi-PDSCH/PUSCH scheduling as Rel-16 NR-U. |
| [17] MediaTek | Proposal 8: To improve gNB scheduling flexibility, reinterpret CGBTI field to indicate which scheduled PDSCHs corresponding to a DCI are transmitted/retransmitted. |
| [18] Panasonic | Proposal 1: The specification supports 8 as the maximum number of PDSCHs and PUSCH respectively in any SCS in licensed/unlicensed band usage. The UE capability should be discussed later.Proposal 3: No support CBG-based (re)transmission for multi-PDSCH/PUSCH scheduling by a DCI.Proposal 5: No need to have the optimization of FDRA size. |
| [19] LG Electronics | Proposal #1: Do not restrict the maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI to less than 8 for 120 and/or 480 kHz SCS.Proposal #3: Do not introduce a new DCI format for multi-PDSCH/PUSCH scheduling.Proposal #4: Do not use DCI format 0\_0/1\_0 for multi-PDSCH/PUSCH scheduling.Proposal #5: Use DCI format 0\_1 to schedule multiple PUSCHs with a single DCI.Proposal #6: Use DCI format 1\_1 to schedule multiple PDSCHs with a single DCI.Proposal #7: For the multi-PUSCH scheduling in Rel-17,* TDRA: Support slot-level gap between PUSCHs.
	+ Signalling details: A row index of TDRA table is signalled with {K2, SLIV, mapping type} for the first PUSCH and {D, SLIV, mapping type} for each of next PUSCH(s) where D corresponds to slot level gap between adjacent PUSCHs.
* URLLC related fields such as priority indicator and/or open loop power control parameter set indication
	+ Alt 1: Apply to all of scheduled PUSCHs.
	+ Alt 2: Present if only a single PUSCH is scheduled, but absent otherwise.
* CBGTI: The same rule with Rel-16 is supported, i.e., CBG (re)transmission is not supported if more than one PUSCHs are scheduled but supported otherwise.

Proposal #8: For multi-PDSCH scheduling with a single DCI,* TDRA: Support slot-level gap between PDSCHs.
	+ Signalling details: A row index of TDRA table is signalled with {K0, SLIV, mapping type} for the first PDSCH and {D, SLIV, mapping type} for each of next PDSCH(s) where D corresponds to slot level gap between adjacent PDSCHs.
* CBGTI/CBGFI: CBGTI/CBGFI field is not present when more than one PDSCHs are scheduled, but present when a single PDSCH is scheduled.
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| [20] Lenovo | Proposal 2: For NR operation between 52.6 GHz and 71 GHz with 480 kHz, support scheduling up to 4 PDSCHs by single DCI.Proposal 3: For NR operation between 52.6 GHz and 71 GHz with 120 kHz and 480 kHz, support scheduling up to 8 PUSCHs by single DCI, similar to 960 kHz SCS. |
| [21] Xiaomi | Proposal 6: Support dynamic indication by DCI to determine the number of scheduled TTIs.Observation 1: The current DCI 0-2/1-2 can be reused to allow frequency domain resource by multi-PRB granularity. |
| [22] InterDigital | Observation 1: To support cases where only small amount of data to be transmitted, enabling single-slot scheduling with slot-based monitoring for all the SCS configurations can be useful. Proposal 1: Single-slot scheduling with slot-based monitoring is supported for all the SCS values, i.e. 120 kHz, 480 kHz, and 960 kHz. Observation 2: As the symbol duration scales with the SCS, naturally the number of PDSCHs/PUSCHs that can be supported should also be scaled.Observation 3: Defining the different maximum number of PDSCH/PUSCHs for 480 kHz based on UE capability introduces additional gNB implementation complexity to handle fragmented UE implementations without clear performance benefits.Proposal 2: The maximum number of PDSCHs or PUSCHs schedules by a single DCI depends on the SCS.Proposal 3: The maximum number of PDSCHs or PUSCHs schedules by a single DCI for 480 kHz SCS is 4. Proposal 4: UE capability on the maximum number of PDSCHs or PUSCHs scheduled by a single DCI for 480 kHz is not supported.Proposal 5: The benefits of increasing the size of TDRA tables for PDSCH and PUSCH to support multiple PDSCHs/PUSCHs scheduling by single DCI should be carefully evaluated.Observation 4: It is observed that required payloads of DCI for frequency domain resource allocation do not increase as maximum number of RBs does not increase.Observation 5: Larger RB size reduces frequency domain resource allocation flexibility, and this may be a crucial disadvantage as higher SCSs occupies larger bandwidths than lower SCSs within the same RBG size.Proposal 7: The benefits from frequency domain resource allocation enhancements should be carefully evaluated. |
| [24] NTT DOCOMO | Proposal 1: For multi-PDSCH/PUSCH scheduling,- No need to restrict the maximum number of scheduled PDSCHs/PUSCHs to be smaller than 8 for 480 kHz and/or 120 kHz SCS.Proposal 2: * For multi-PUSCH scheduled by single DCI,
	+ Discuss whether/how a DCI format supporting multi-PUSCH scheduling can support scheduling single PUSCH with repetition.
	+ CBG based scheduling is not supported when multiple PUSCHs are scheduled by one DCI.
	+ Support FDRA enhancement to reduce DCI overhead.
	+ For URLLC related fields, one value of each related field is applied for all scheduled PUSCHs.
* For multi-PDSCH scheduled by single DCI,
	+ Similar consideration on CBG based transmission, FDRA and URLLC fields as multi-PUSCH scheduling can be applied to multi-PDSCH scheduling.
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| [25] Charter | Proposal 1: No further SCS-dependent restrictions are necessary on the maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI.Proposal 3: CBGFI/CBGTI is not supported for multi-PDSCH scheduling. |

### Summary (on the maximum number of scheduled PDSCHs/PUSCHs):

Company views on the maximum number (=N\_max) of PDSCHs or PUSCHs that can be scheduled by a single DCI:

* N\_max =8 for all SCSs
	+ Supported by Futurewei, Nokia, Ericsson, CATT, OPPO, Fujitsu, Panasonic, LG Electronics, Lenovo (for PUSCH), NTT DOCOMO, Charter
* Additional restriction for 120 kHz SCS or 480 kHz SCS
	+ Supported by Huawei (4 for 480 kHz SCS), Lenovo (4 PDSCHs for 480 kHz SCS), InterDigital (4 for 480 kHz SCS)
* UE capability
	+ Supported by Qualcomm, Apple, Samsung

[Moderator’s note] 10 companies suggest not to further restrict N\_max to less than 8 for 120 and/or 480 kHz SCS. 3 companies suggest to restrict N\_max to 4 for 480 kHz SCS. 3 companies suggest to define UE capability on how many N\_max can be supported by a UE. Therefore, it is proposed to deprioritize this issue in this meeting.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
| DOCOMO | Fine with the proposal. |
| Qualcomm  | We are okay with deprioritizing this discussion for this meeting. |
| MediaTek | Agree with the Moderator’s proposal |

### Summary (on DCI format for multi-PDSCH/PUSCH scheduling):

Company views on DCI format for multi-PDSCH/PUSCH scheduling:

* Do not use fallback DCI
	+ Supported by Huawei, Nokia, LG Electronics
* Use DCI format 0\_1 or 1\_1
	+ Supported by Futurewei, Huawei, vivo?, Nokia, Sony, Samsung, LG Electronics

[Moderator’s note] 7 companies suggest to use DCI format 0\_1 for multi-PUSCH scheduling and 1\_1 for multi-PDSCH scheduling. 3 companies suggest not to use fallback DCI for multi-PDSCH/PUSCH scheduling. We can discuss this issue in this meeting.

### Proposal #1 (DCI format):

* Do not use fallback DCI (i.e., DCI formats 0\_0 and 1\_0) for multi-PDSCH/PUSCH scheduling.
* Use DCI format 0\_1 to schedule multiple PUSCHs with a single DCI.
* Use DCI format 1\_1 to schedule multiple PDSCHs with a single DCI.

Companies are encouraged to provide views on Proposal #1.

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| Company | Views |
| DOCOMO | Agree with the Proposal.We think DCI format 0\_1/1\_1 is enough for scheduling multiple PUSCHs/PDSCHs. |
| Qualcomm  | We agree with the Moderator’s proposal  |
| MediaTek | Agree with the Moderator’s proposal |
| Huawei, HiSilicon | Support proposal #1 |

### Summary (on TDRA enhancement):

Company views on TDRA enhancement to support discontinuous allocation for multi-PDSCH/PUSCH scheduling:

* Option 1: {SLIV, mapping type, scheduling offset K0/K2} for each PDSCH/PUSCH in a row of TDRA table
	+ Supported by Furutrewei, Huawei, vivo, Apple, Samsung
* Option 1a: {SLIV, mapping type, distance between PXSCHs} for each PDSCH/PUSCH in a row of TDRA table
	+ Supported by LG Electronics
* Option 2: Based on rate-matching pattern indicator (for PDSCH) or invalid symbol pattern indicator (for PUSCH)
	+ Supported by Huawei, Nokia, CATT
* Option 3: When n-th SLIV is overlapped with (n+1)-th SLIV, (n+1)-th SLIV is allocated in the next slot from the slot corresponding to n-th SLIV.
	+ Supported by vivo, Qualcomm
* Option 4: Based on invalid SLIV
	+ Supported by CATT, Qualcomm (using SLIV=0)

[Moderator’s note] Several options are identified to support discontinuous allocation for multi-PDSCH/PUSCH scheduling. We can discuss (and possibly down-select) this issue in this meeting.

### Proposal #2 (TDRA):

* In order to support non-continuous resource allocation in time-domain, the following options can be considered for TDRA enhancements:
	+ Option 1: {SLIV, mapping type, scheduling offset K0/K2} for each PDSCH/PUSCH in a row of TDRA table
	+ Option 1a: {SLIV, mapping type, distance between PXSCHs} for each PDSCH/PUSCH in a row of TDRA table
	+ Option 2: Based on rate-matching pattern indicator (for PDSCH) or invalid symbol pattern indicator (for PUSCH)
	+ Option 3: When n-th SLIV is overlapped with (n+1)-th SLIV, (n+1)-th SLIV is allocated in the next slot from the slot corresponding to n-th SLIV.
	+ Option 4: Based on invalid SLIV (e.g., SLIV=0)

Companies are encouraged to provide views on Proposal #2. According to companies’ preference, hopefully we can choose one (or some) of those options in this meeting.

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| Company | Views |
| DOCOMO | We support option 1 which is the most flexible. |
| Qualcomm  | It will be helpful, if we agreed on general points at the beginning before diving in the signaling details. For instance, companies should share their views on allowing slot level gaps and the longest allowed gap between to allocations. In addition, whether we will allow multiple SLIVs to occupy the same slot. This will make sure that companies reach similar understandings about the non-continuous resource allocation. After, this discussion, we may be able to reorganize the options as some of the options can work together while some of them may be only needed based on the choice of number of offsets in each row of the TDRA table. For example, we can decide on the number of offsets in each row * + Option 1: k0/k2 per SLIV
	+ Option 1a: a single value of k0/k2 per row and distance between PXSCHs
	+ Option 2: A single value of k0/k2 per row

Then, the remaining options will be only needed to define the gaps under Option 2.  |
| MediaTek | We have similar comment with Qualcomm. First of all, it should be clarified whether the definition of non-continuous resource allow slot level discontinuity, i.e., does it allow the scheduled PDSCHs to be allocated in a set of slots which are not consecutive in time? If not, then option1, option1a, and option2 might not be needed. If it allows, then the range of gap should be discussed.Second, if achieving slot level gap is the intention of this proposal, then all the options can work. However, we are not sure we should optimize such slot level gap over the continuous resource allocation deployment. Therefore, we prefer not to support option 1, option 1a, option3, and option4. Regarding option 2, in our view, it follows Rel-15/16 rate-matching pattern rule specified in TS 38.214 (clause 5.1.4) and it should be supported naturally. Also, the TDD configuration can also be used as a tool to achieve non-continuous resource, which is related to the discussion in the Q2 in section 3.1.  |
| Huawei, HiSilicon | We would suggest decoupling the questions because the list of options includes solutions that provide a number of symbols less than one slot as gap between two PDSCHs in consecutive slots (option 3), and solutions that provide a gap of one slot between two PDSCHs. We think that the second question should be addressed first (how to provide a gap of one or more slots between two PDSCHs). In this case we should first discuss between option 1, option 1a, option 2 and option 4.Another question is whether to allow more than one PDSCH in a slot, which may be the intention of option 3. In our view this flexibility is not necessary given the already very short duration of slots with 480 or 960 kHz SCS. Such decision is also needed before progressing on HARQ feedback aspects. |

### Summary (on FDRA enhancement):

Company views on FDRA enhancement:

* Same as in Rel-16 (i.e., no enhancement): Huawei, vivo, Spreadtrum, Qualcomm, Intel, Panasonic
* FDRA field enhancement to reduce DCI overhead
	+ Supported by Futurewei, Ericsson, Apple, Samsung, NTT DOCOMO

[Moderator’s note] 5 companies suggest to enhance FDRA field to reduce DCI overhead while 6 companies are against FDRA enhancement. Therefore, it is proposed to deprioritize this issue in this meeting.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
| DOCOMO | Fine with the proposal. |
| Qualcomm | We think that this discussion can be deprioritized  |
| MediaTek | Agree with the Moderator’s proposal |

### Summary (on CBG-based (re)transmission support of multi-PDSCH/PUSCH scheduling DCI):

Company views on CBG-based (re)transmission support of multi-PDSCH/PUSCH scheduling DCI:

* CBG (re)transmission is NOT supported for multi-PDSCH/PUSCH scheduling DCI
	+ Supported by Futurewei (for 480/960 kHz SCS), Huawei, Nokia, Ericsson (for PDSCH), Sony, NEC, Samsung, Panasonic, Charter
* CBG-related field (e.g., CBGTI or CBGFI) is not present when more than one PDSCHs or PUSCHs are scheduled, i.e., similar to Rel-16
	+ Supported by vivo, Spreadtrum, Ericsson (for PUSCH), Qualcomm, MediaTek, LG Electronics, NTT DOCOMO
* CBG-related field (e.g., CBGTI or CBGFI) is present when TWO PDSCHs or PUSCHs are scheduled
	+ Supported by Intel
* CBG-related field (e.g., CBGTI or CBGFI) is always present
	+ Supported by ZTE

[Moderator’s note] Most companies expressed their views on this issue, so we can discuss this issue in this meeting.

### Proposal #3 (CBG):

* For a DCI that can schedule multiple PDSCHs,
	+ CBG-based (re)transmission is not supported for the DCI.
	+ Note: Multi-PDSCH scheduling for the case of 120 kHz SCS is still FFS as per prior agreement. This case can be addressed after this FFS has been decided.
* For a DCI that can schedule multiple PUSCHs,
	+ For a serving cell configured with 480 or 960 kHz SCS, CBG-based (re)transmission is not supported for the DCI.
	+ For a serving cell configured with SCS other than 480 and 960 kHz SCSs, CBG-based (re)transmission is supported as in Rel-16, i.e., CBG (re)transmission is not supported if more than one PUSCHs are scheduled but supported otherwise.

Companies are encouraged to provide views on Proposal #3.

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| Company | Views |
| DOCOMO | We are fine with the principle of the proposal. For the FFS under the first bullet on DCI for scheduling multiple PDSCHs, we think the principle should also be applied to 120kHz SCS if the 120kHz SCS is supported.  |
| Qualcomm | We found the proposal confusing in the sense that it is not clear whether we will not support CBG-based re(transmission) in the case of more than a single PDSCH/PUSCH is scheduled by the same DCI or the DCI format itself that can schedule multi-PDSCH/PUSCH grant will not have CBG related fields  |
| MediaTek | We support the proposal in principle. We have same confusion as Qualcomm. Is the proposal to not support CBG-based transmission for 120/480/960 kHz multi-PDSCH/PUSCH scheduling but to support CBG-based transmission for 120 kHz single PDSCH/PUSCH scheduling? If so, we can support. However, then the case of 480/960 kHz single PDSCH/PUSCH scheduling should be FFS.  |
| Huawei, HiSilicon | Question for the first bullet point: a DCI that can schedule multiple PDSCHs means that the TDRA table contains at least one row with multiple SLIVs. If this is the correct understanding, this means that CBG-based re(transmission) is not supported even if this DCI is used to schedule a single PDSCH. With this understanding, we support the proposal. |

### Summary (on URLLC related field enhancement):

Company views on enhancement for URLLC related field such as priority indicator and open-loop power control parameter set indication:

* Apply commonly to all PDSCHs or PUSCHs
	+ Supported by vivo, Nokia, Ericsson, Samsung, LG Electronics, NTT DOCOMO
* Present if only a single PDSCH or PUSCH is scheduled, but absent otherwise
	+ Supported by LG Electronics

[Moderator’s note] 6 companies commonly suggest to apply URLLC related fields to all scheduled PDSCHs or PUSCHs, but this issue can be deprioritized in this meeting given a small number of inputs.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
| DOCOMO | We think to apply the field commonly to each PDSCH/PUSCH is the simplest solution. If absent for others, default values may need to be defined, which is very limited (e.g. the priority of PDSCHs/PUSCHs except the first PDSCH is default as low priority).  |
| Qualcomm  | The URLLC fields should be applied to all allocations. In case of multi-PDSCH grant, not applying the URLLC field to allocations, will strictly imply that multiple PUCCHs should be triggered by the same DCI and it is opposed by several companies.Also, we are okay with deprioritizing this discussion for this meeting |
| MediaTek | Agree with the Moderator’s proposal |

## PUSCH-specific issues

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| Company | Views |
| [2] Huawei | Observation 7: Further enhancements of frequency hopping for multi-slot PUSCH scheduling are not essential. Proposal 8: Same multiplexing rule for aperiodic CSI report in multi PUSCH scheduling in Rel-16 should be applied at least in shared spectrum operation. |
| [3] vivo | Proposal 7: For A-CSI reporting, the same solution adopted in Rel-16 NR-U multi-PUSCH scheduling can be reused, i.e. A-CSI is multiplexed in the M-th or (M-1)-th scheduled PUSCH based on the value of M. |
| [4] Spreadtrum | Proposal 1: Frequency hopping should be supported for scheduled PUSCH.Proposal 3: Apply same rule compared to Rel-16 NR-U for CSI request. |
| [5] Nokia | Proposal 7: For other multi-PxSCH enhancements:• FDRA enhancements and frequency hopping enhancements are considered as secondary topics for multi-PxSCH transmission and they are considered only if time allows. • The PUSCH that carries the AP-CSI feedback, the same solution adopted in Rel-16 NR-U multi-PUSCH scheduling is reused. |
| [6] Ericsson | Proposal 9: Support intra- and inter-slot frequency hopping for multi-PUSCH scheduling with a single DCI. For inter-slot hopping, consider modifying the hopping counter such that it increments across the scheduled PUSCHs rather than being tied to the slot number within the radio frame.Proposal 14: When a DCI schedules M PUSCHs and an aperiodic CSI report with a valid CSI request field, the PUSCH that carries the aperiodic CSI feedback is M-th scheduled PUSCH for M <= 2, or (M-1)-th scheduled PUSCH for M > 2. |
| [8] Qualcomm | Proposal 9: For multi-PDSCH/PUSCH DCI fields enhancements:* Frequency hopping for multi-PUSCH: supported for single PUSCH grant, and FFS: support intra-slot hopping for two or more PUSCHs
 |
| [10] ZTE | Proposal 2: For CSI request, the same design as in Rel-16 NRU can be considered for above 52.6GHz at least for unlicensed band. * When a DCI schedules M PUSCHs, the PUSCH that carries the aperiodic CSI feedback is M-th scheduled PUSCH for M <= 2, or (M-1)-th scheduled PUSCH for M > 2.
 |
| [11] Intel | Proposal 1: For multi-PUSCH scheduling, * Support intra-slot frequency hopping for scheduled PUSCHs.
* Do not support enhancement on CSI request.
 |
| [13] Apple | Proposal 1: For Rel-17 multi-PUSCH transmission• Re-use the CSI-request mechanism in Rel-16 NR-U• Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHzProposal 2: For multi-PUSCH scheduling with a single DCI the following fields are signaled: • Per DCI: FDRA, MCS, HARQ\_process\_number• Per PUSCH: TDRA-K2, TDRA-(S,L), TDRA-Mapping\_type, NDI, RV• FFS: Uplink TDAI |
| [14] Sony | Proposal 2: For AP-CSI feedback, the same rule as Rel-16 multi-PUSCH should be applied to Rel-17 multi-PUSCH scheduling. |
| [16] Samsung | Proposal 2: Rel-16 NR-U multi-PUSCH scheduling DCI can be reused for multi-PUSCH in 52.6~71GHz with at least the following enhancement: - A-CSI feedback: A-CSI in first PUSCH for licensed band (as Rel-15/16 licensed band), and A-CSI in last or penult PUSCH for unlicensed band (as Rel-16 NR-U).- Frequency hopping: intra-PUSCH hopping.- HARQ process number: whether HARQ process number increments only for valid PUSCHs (no collision with semi-static DL symbol) |
| [18] Panasonic | Proposal 4: Support to reuse the existing rule for CSI-request specified in Rel. 16 for multi-PDSCH/PUSCH scheduling by a DCI. |
| [19] LG Electronics | Proposal #7: For the multi-PUSCH scheduling in Rel-17,* CSI-request: The same rule with Rel-16 is applied to both of licensed and unlicensed bands, i.e., when a DCI schedules M PUSCHs, the PUSCH that carries the aperiodic CSI feedback is M-th scheduled PUSCH for M <= 2, or (M-1)-th scheduled PUSCH for M > 2.
 |
| [21] Xiaomi | Proposal 7: Support to study intra-TTI frequency hopping and its enabling mechanism for multi-TTI scheduling.Proposal 8: Support to indicate more than one channel access types in a single DCI. |
| [24] NTT DOCOMO | Proposal 2: * For multi-PUSCH scheduled by single DCI,
	+ A-CSI reporting on PUSCH rule in Rel-16 should be reused.
	+ Support frequency hopping for multi-PUSCH scheduling. Newly introduced frequency hopping scheme for multi-PUSCH scheduling can be considered.
 |

### Summary (on frequency hopping enhancement):

Company views on frequency hopping enhancement:

* Intra-PUSCH hopping: Samsung, Xiaomi, NTT DOCOMO
* Inter-PUSCH hopping: NTT DOCOMO
* Intra-slot hopping: Ericsson, Intel
	+ Objected by Apple
* Inter-slot hopping: Ericsson, Apple
* NO further enhancement: Huawei

[Moderator’s note] Company views are diverged, so it is proposed to deprioritize this issue in this meeting.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
| DOCOMO | Firstly, we think PUSCH frequency hopping can be supported for multi-PUSCH scheduling since interlaced allocation is not applied in 60GHz. It can be further discussed whether existing frequency hopping schemes are reused, or new frequency hopping scheme may be introduced. |
| Qualcomm  | We are okay with deprioritizing this discussion for this meeting |
| MediaTek | Agree with the Moderator’s proposal |
| Huawei, HiSilicon | Question for clarification: The field frequencyHopping applies to DCI format 0\_0 and 0\_1 for 'pusch-RepTypeA'. It is not clear which intra-slot frequency hopping is referred to for PUSCH when PUSCH is scheduled without repetition, which is the case for a DCI configured for multi-slot PUSCH scheduling as in Rel-16. So why is Intra-slot hopping listed here?Question for clarification on inter-slot frequency hopping: It is our understanding that when multi-slot PUSCH is configured, then such DCI schedules different TBs in different slots without repetitions. In this case, there is no benefit of inter-slot hopping. In the case where PUSCH is scheduled with repetition, inter-slot hopping can be used. But multi-slot/multi-TB and multi-slots with repetitions cannot be used at the same time. |

### Summary (on CSI-request enhancement):

Company views on CSI-request enhancement:

* Same as in Rel-16 NR-U
	+ Supported by Huawei (at least in shared spectrum operation), vivo, Spreadtrum, Nokia, ZTE, Intel, Apple, Sony, Samsung (for unlicensed band), Panasonic, LG Electronics, NTT DOCOMO
* In the first PUSCH for licensed band
	+ Supported by Samsung (as in Rel-15/16 licensed band)

[Moderator’s note] At least 10 companies suggest to keep the same rule for licensed and unlicensed bands as in Rel-16 NR-U while 1 company suggests to apply different rules for licensed and unlicensed bands. However, according to the excerpt from TS 38.214 Clause 5.2.3 as below, aperiodic CSI reporting rule is applied regardless of licensed band or unlicensed band.

|  |
| --- |
| 5.2.3 CSI reporting using PUSCHA UE shall perform aperiodic CSI reporting using PUSCH on serving cell c upon successful decoding of a DCI format 0\_1 or DCI format 0\_2 which triggers an aperiodic CSI trigger state.When a DCI format 0\_1 schedules two PUSCH allocations, the aperiodic CSI report is carried on the second scheduled PUSCH. When a DCI format 0\_1 schedules more than two PUSCH allocations, the aperiodic CSI report is carried on the penultimate scheduled PUSCH. |

Therefore, we can make a conclusion as follows:

### Proposed conclusion #1 (CSI-request):

* For a DCI that can schedule multiple PDSCHs,
	+ CSI-request: When the DCI schedules M PUSCHs, the PUSCH that carries the aperiodic CSI feedback is M-th scheduled PUSCH for M <= 2, or (M-1)-th scheduled PUSCH for M > 2.

Companies are encouraged to provide views on proposed conclusion #1.

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| Company | Views |
| DOCOMO | Support the proposal.One correction for the main bullet: * For a DCI that can schedule multiple ~~PDSCHs~~ PUSCHs
 |
| Qualcomm | Support the proposal and DOCOMO’s correction  |
| MediaTek | Agree with the Moderator’s proposal with DOCOMO’s correction. |
| Huawei, HiSilicon | We support conclusion #1 with the correction from Docomo |

## PDSCH-specific issues

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| Company | Views |
| [1] Futurewei | Proposal 1. Only single-PDSCH is supported for SCS 120kHz for reason that the duration of a multi-slot can be larger the channel coherence time consideration for cases of moderate speed. Proposal 4: Decide the maximum number of layers that should be supported for 52.6GHz to 71GHz band before deciding whether the MCS/RV/NDI fields for the 2nd TB is needed or not. The legacy rule that the MCS/RV/NDI fields for the 2nd TB is only relevant for >4 layers transmissions still apply here. |
| [2] Huawei | Proposal 2: Multi-PDSCH scheduling by a single DCI is not supported for 120 kHz SCS.Proposal 4: Support scheduling 2nd TB for multi-slot PDSCH/PUSCH scheduling, and MCS for the 2nd TB is applied commonly to all the scheduled PDSCHs/PUSCHs, while NDI and RV are indicated individually for each scheduled PDSCH/PUSCH.Observation 3: The interleaved VRB-to-PRB mapping for 120 kHz SCS can be reused for 480 kHz and 960 kHz SCS.Observation 4: PRB bundling mechanism defined in Rel-15 can be reused as a baseline for multi-PDSCH scheduling in this new frequency range.Observation 5: The existing configuration and indication related to RateMatchPattern can be reused.Observation 6: Triggering scheme defined in Rel-15/16 can be reused directly for aperiodic ZP CSI-RS. Proposal 6: Support periodic/semi-persistent ZP CSI-RS for 480 and 960 kHz SCS with periodicity up to 80 ms.Proposal 7: Support gNB to mute PDSCH transmissions belonging to the indicated row of TDRA table if symbols of the corresponding PDSCH(s) are overlapped with the UL symbols configured by TDD DL/UL configuration when multi-slot PDSCH(s) is scheduled by single DCI. |
| [3] vivo | Proposal 8: Two codewords should be supported for multi-PDSCH scheduling.Proposal 9: Each of resource allocation related fields in the DCI scheduling multiple PDSCHs is applied equally to each scheduled PDSCH, including VRB-to-PRB mapping, PRB bundling size indicator, rate matching indicator, and ZP CSI-RS trigger. |
| [4] Spreadtrum | Proposal 4: Support to indicate the MCS/NDI/RV for the 2nd TB for multi-PDSCH scheduling. |
| [5] Nokia | Proposal 3: Consider dynamic indication of the number of repetitions also for PDSCH. Proposal 4: Support multi-PDSCH also for 120 kHz SCS* Consider multi-PDSCH also for FR2.

Proposal 6: Support only one TB with multi-slot PxSCH |
| [6] Ericsson | Proposal 1: Support multiple PDSCH scheduling for 120 kHz SCS.Observation 1: When multiple PDSCHs are scheduled by a single DCI with DCI Format 1\_1, it is not necessary to explicitly prohibit the MCS/NDI/RV fields for the second transport blocks in the specification. These fields can be disabled via existing RRC configuration.Proposal 10: When multiple PDSCHs are scheduled by a single DCI with DCI Format 1\_1, the triggered ZP CSI-RS field applies to all the PDSCHs scheduled by the DCI.Proposal 11: When multiple PDSCHs are scheduled by a single DCI with DCI Format 1\_1, the VRB-to-PRB mapping and PRB bundling size indicator fields apply to all the PDSCHs scheduled by the DCI.Proposal 12: When multiple PDSCHs are scheduled by a single DCI with DCI Format 1\_1, the Rate Matching Indicator field applies to all the PDSCHs scheduled by the DCI. |
| [8] Qualcomm | Proposal 1: Multi-PDSCH or multi-PUSCH scheduling with the same DCI should be applicable to 120kHz as well as 480 and 960kHz, though we don’t need to introduce multi-slot monitoring capability for 120KHz.Proposal 9: For multi-PDSCH/PUSCH DCI fields enhancements:* Second TB can be supported for each PDSCH
	+ MCS for the 2nd TB: This appears only once in the DCI and applies commonly to the second TB of each PDSCH
	+ NDI for the 2nd TB: This is signaled per PDSCH and applies to the second TB of each PDSCH
	+ RV for the 2nd TB: This is signaled per PDSCH, with 2 bits if only a single PDSCH is scheduled or 1 bit for each PDSCH otherwise and applies to the second TB of each PDSCH
* VRB-to-PRB mapping and PRB bundling size indicator: to be applied for all granted data allocations by the same DCI
* ZP CSI trigger: to be applied to all the slots granted by the same DCI.
 |
| [9] OPPO | Proposal 5: UE is not expected to be scheduled with more than one PDSCHs in one slot for both 480 kHz and 960 kHz SCS. |
| [11] Intel | Proposal 3: For multi-PDSCH scheduling * Scheduling of 2nd TB is supported.
* For 2nd TB, separate MCS, NDI and RV are signaled from 1st TB.
* For 2nd TB, similar mechanisms for signaling of MCS, NDI and RV for 1st TB are reused.
* Carrier indicator, BWP indicator, frequency domain resource allocation, DMRS configuration including antenna port, DMRS sequence initialization, etc., can be commonly applied for scheduled PDSCHs.
 |
| [13] Apple | Proposal 4: For Rel-17 multi-PDSCH transmission• Multiple PDSCH scheduling applies to 120 kHz SCS in addition to 480 and 960 kHz SCS• Support inter-slot frequency hopping and NOT intra-slot frequency hopping for 480 kHz and 960 kHz• New signaling may be needed for the PRI, K1, priority, DAI, CBGTI and CBGFI fields to support HARQ compared with multi-PUSCH transmission.Proposal 5: For multi-PDSCH scheduling with a single DCI the following fields are signaled: • Per DCI: FDRA, 1st MCS, 2nd MCS, HARQ\_process\_number, and PRB bundling size• Per PDSCH: TDRA-K0, TDRA-(S,L), TDRA-Mapping\_type, 1st NDI, 1st RV, 2nd NDI, 2nd RV, rate matching indicator, and ZP CSI-RS trigger• FFS: c-DAI, Downlink T-DAI, CGBTI/CBGFI, K1, and PRI. |
| [16] Samsung | Proposal 3: For multi-PDSCH scheduling, the bit field common for DL and UL grant use the same design as multi-PUSCH scheduling, and at least following DL-specific bit field should be specified,- MCS/RV/NDI for 2nd TB is not applicable to multi-PDSCH scheduling (only support single TB case)- HARQ-ACK relevant bit field is applicable to all PDSCHs and single PUCCH |
| [18] Panasonic | Proposal 2: No support MCS/NDI/RV for the 2nd TB for each PDSCH in multi-PDSCH scheduling by a DCI. |
| [19] LG Electronics | Proposal #2: Apply scheduling multiple PDSCHs by single DL DCI to all SCSs including 480 and 960 kHz.Proposal #8: For multi-PDSCH scheduling with a single DCI,* MCS for the 2nd TB: This appears only once in the DCI and applies commonly to the second TB of each PDSCH.
* NDI: For 2-TB case, this can be signalled per each TB. Alternatively, NDI per TB for up to N-scheduled PDSCHs and TB-common NDI for more than N-scheduled PDSCHs (e.g., N=1) can be considered.
* RV: For 2-TB case, this can be signalled with 2 bits per TB if a single PDSCH is scheduled, TB-common 1 bit (i.e., 1 bit per PDSCH) if more than one PDSCHs are scheduled.
* Rate matching indicator and ZP-CSI-RS trigger: This can be applied to all or part of scheduled PDSCHs (e.g., the first PDSCH).
 |
| [20] Lenovo | Proposal 1: For NR operation between 52.6 GHz and 71 GHz with 120 kHz, multi-PDSCH scheduling enhancements are not considered in NR Rel-17, i.e. only single PDSCH can be scheduled by single DCI for 120 kHz SCS |
| [22] InterDigital | Observation 7: Supporting a second TB per each PDSCH when multiple PDSCHs are scheduled by a single DCI can have a significant specification impact and increase the signalling overhead, UE processing time and complexity. Proposal 12: scheduling of the 2nd TB for each PDSCH when multiple PDSCHs are scheduled by a single DCI is not supported. |
| [24] NTT DOCOMO | Proposal 1: For multi-PDSCH/PUSCH scheduling,- Multi-PDSCH scheduling can apply to 120 kHz in addition to 480 kHz and 960 kHz SCS.Proposal 2: * For multi-PDSCH scheduled by single DCI,
	+ Not support two TBs in one PDSCH when multiple PDSCHs are scheduled by one DCI.
	+ VRB-to-PRB mapping, PRB bundling size indicator, rate matching indicator, and ZP CSI-RS trigger are applied to all slots of scheduled PDSCHs.
 |
| [25] Charter | Proposal 2: Reuse the 1st TB framework as much as possible for the 2nd TB, as well as apply same settings commonly to all multiple PDSCHs. |

### Summary (on the applicability of multi-PDSCH scheduling to SCSs other than 480/960 kHz SCS):

Company views on the applicability of multi-PDSCH scheduling to SCSs other than 480/960 kHz SCS:

* Support to apply it to SCSs other than 480/960 kHz SCS
	+ Nokia, Ericsson, Apple, LG Electronics, NTT DOCOMO
* Object to apply it to SCSs other than 480/960 kHz SCS
	+ Futurewei, Huawei, Lenovo

[Moderator’s note] 5 companies suggest to apply multi-PDSCH scheduling also to SCSs other than 480/960 kHz SCS while 3 companies are against applying it to SCSs other than 480/960 kHz SCS. Therefore, it is proposed to deprioritize this issue in this meeting.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
| DOCOMO | We are fine to deprioritize the issue in this meeting. But we prefer to support multi-PDSCH scheduling in 120kHz SCS. Considering multi-PUSCH scheduling supported in 120kHz SCS, and no additional specification impact is needed compared to agreed 490/960kHz SCS, we think it is straightforward to also support multi-PDSCH scheduling for 120kHz SCS. |
| Qualcomm  | We support multi-PDSCH grant for SCS 120kHz based on UE capability, i.e., a UE may only support single PDSCH grant for SCS 120kHz and we are okay with deprioritizing this discussion for this meeting |
| MediaTek | We don’t support applying multi-PDSCH scheduling for SCS 120kHz case but we agree with the Moderator’s proposal. |

### Summary (on MCS/NDI/RV for the 2nd TB):

Company views on MCS/NDI/RV for the 2nd TB:

* 2-TB scheduling
	+ Supported by Huawei, vivo, Spreadtrum, Ericsson, Qualcomm, Intel, Apple, LG Electronics, Charter
	+ Objected by Nokia, Samsung, Panasonic, InterDigital, NTT DOCOMO
* MCS for the 2nd TB
	+ This appears only once in the DCI and applies commonly to the second TB of each PDSCH
		- Supported by Huawei, Qualcomm, Intel, LG Electronics
* NDI for the 2nd TB
	+ This is signaled per PDSCH and applies to the second TB of each PDSCH
		- Supported by Huawei, Qualcomm, Intel, LG Electronics
	+ NDI per TB for up to N-scheduled PDSCHs and TB-common NDI for more than N-scheduled PDSCHs (e.g., N=1)
		- Supported by LG Electronics
* RV for the 2nd TB
	+ This is signaled per PDSCH and applies to the second TB of each PDSCH
		- Supported by Huawei, Qualcomm (with 2 bits if only a single PDSCH is scheduled or 1 bit for each PDSCH otherwise), Intel, LG Electronics (with 2 bits per TB if a single PDSCH is scheduled, TB-common 1 bit (i.e., 1 bit per PDSCH) if more than one PDSCHs are scheduled)

[Moderator’s note] 9 companies suggest to support 2-TB scheduling by a DCI that can schedule multiple PDSCHs while 5 companies are against 2-TB scheduling by the DCI. Nevertheless, it seems quite restrictive to disallow 2-TB scheduling for multi-PDSCH scheduling DCI. Furthermore, proponents of 2-TB scheduling seem to be mostly aligned on how to signal MCS/NDI/RV for the second TB, so we can minimize relevant specification impact by following approaches similar to the first TB which was agreed in the last meeting.

### Proposal #4 (2-TB scheduling):

* For a DCI that can schedule multiple PDSCHs,
	+ MCS for the 2nd TB: This appears only once in the DCI and applies commonly to the second TB of each PDSCH
	+ NDI for the 2nd TB: This is signaled per PDSCH and applies to the second TB of each PDSCH
	+ RV for the 2nd TB: This is signaled per PDSCH, with 2 bits if only a single PDSCH is scheduled or 1 bit for each PDSCH otherwise, and applies to the second TB of each PDSCH

Companies are encouraged to provide views on Proposal #4.

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| Company | Views |
| DOCOMO | We can accept the proposal even though we think the probability of scheduling two TBs (i.e. rank>4) is not typical in 60GHz. |
| Qualcomm | We support the proposal  |
| MediaTek | We don’t support the proposal. As pointed out by many companies, it is unlikely to apply more than 4 layer for transmission in this frequency range and we don’t see the need on the enhancement of enabling the 2nd TB in multi-PDSCH scheduling. If the 2nd TB is needed, then single PDSCH scheduling can work.  |
| Huawei, HiSilicon | We support proposal #4. It is not clear why high rank statistics would be different depending on single PDSCH or multiple PDSCH scheduling by a single DCI. Can Mediatek or others explain? |

### Summary (on resource allocation related fields such as VRB-to-PRB mapping, PRB bundling size indicator, rate matching indicator, and ZP CSI-RS trigger):

Company views on resource allocation related fields such as VRB-to-PRB mapping, PRB bundling size indicator, rate matching indicator, and ZP CSI-RS trigger:

* VRB-to-PRB mapping
	+ Applies to all the PDSCHs scheduled by the DCI: vivo, Ericsson, Qualcomm, NTT DOCOMO
* PRB bundling size indicator
	+ Applies to all the PDSCHs scheduled by the DCI: vivo, Ericsson, Qualcomm, Apple, NTT DOCOMO
* Rate matching indicator
	+ Applies to all the PDSCHs scheduled by the DCI: vivo, Ericsson, LG Electronics, NTT DOCOMO
	+ Per PDSCH: Apple
	+ Applies to part of scheduled PDSCHs (e.g., the first PDSCH): LG Electronics
* ZP CSI-RS trigger
	+ Applies to all the PDSCHs scheduled by the DCI: vivo, Ericsson, Qualcomm, LG Electronics, NTT DOCOMO
	+ Per PDSCH: Apple
	+ Applies to part of scheduled PDSCHs (e.g., the first PDSCH): LG Electronics

[Moderator’s note] Given a small number of inputs, this issue can be deprioritized in this meeting.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
| DOCOMO | We are fine to deprioritize the issue in this meeting.We think the simplest method is to apply the fields to all the PDSCH(s), which is the same handling as PDSCH repetition case in Rel-16. |
| Qualcomm  | We support applying these fields for all PDSCHs and we are okay with deprioritizing this discussion for this meeting  |
| MediaTek | Agree with the Moderator’s proposal |
| Huawei, HiSilicon | It may be possible to conclude on the VRB-to-PRB mapping, and PRB bundling size indicator. |

# HARQ

## Type-1 (semi-static) HARQ-ACK codebook

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| Company | Views |
| [1] Futurewei | Proposal 6: Option 1 is preferred over Option 1a for determine the candidate PDSCH occasion for type-1 HARQ-ACK codebook to be established. All slot offsets are included in the TDRA table for multi-PDSCH such that the extended K1 set is obtainable for contiguous and non-contiguous multi-PDSCH configurations. Observation 3: Option 2 may not have the equal flexibility to handle non-contiguous multi-PDSCH as with Option 1 and can suffer from DL/UL collision. Proposal 7: For the non-continuous multi-PDSCH, restrict the maximum allowable gaps to maximally 2 slots between individual PDSCHs to limit the size of the extended K1 set. |
| [2] Huawei | Observation 8: Extension of K1 set is redundant when slot offset between each PDSCH(s) for each row of TDRA can be calculated by each K0(s) values in TDRA table.Observation 9: Option 2 has more impact on the specification when different PDSCH(s) occasions within one slot are from different rows of TDRA tableProposal 9: Support option 1a to determine the candidate PDSCH reception occasions for multi-PDSCH scheduling by single DCI. |
| [3] vivo | Proposal 12: For semi-static codebook enhancement Option 1, the K1 set is extended to accommodate all the DL slots determined not only by K1 but also by DL slots occupied by a row in the TDRA table.Proposal 13: For semi-static codebook enhancement Option 1, the set of SLIVs associated with a candidate DL slot involved in the extended K1 set contains every SLIV ending in the candidate DL slot when scheduling the TDRA row containing the SLIV and applying a certain K1 in the K1 set.Proposal 14: For semi-static codebook enhancement Option 2, HARQ-ACK information of multiple PDSCHs scheduled by one DCI will be mapped to a same PDSCH candidate occasion, which is determined by the last scheduled PDSCH among the multiple PDSCHs originally.Proposal 15: For semi-static codebook enhancement Option 2, the number of HARQ-ACK bits for a PDSCH candidate occasion in the semi-static codebook can be determined by the maximum number of SLIVs of those rows mapped to the PDSCH candidate occasion.Proposal 16: For semi-static codebook enhancement, support Option 1, i.e. extending K1 set.Proposal 17: Study semi-static HARQ-ACK codebook in conjunction with time domain bunding for multi-PDSCH scheduling. |
| [5] Nokia | Proposal 12: For Type-1 codebook, option 1: the set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set, is supported. |
| [6] Ericsson | Observation 9: There are a number of open issues around Option 2 for semi-static HARQ-ACK codebook enhancement to support multi-PDSCH scheduling that need to be clarified. Furthermore, it is not clear what potential advantage Option 2 offers compared to Option 1.Observation 10: For Option 1a for semi-static HARQ-ACK codebook enhancement to support multi-PDSCH scheduling, it is unclear how a set of Candidate PDSCH reception occasions can be determined according to each SLIV of each row in the TDRA table without taking the configured K1 values into account. If the configured K1 values are taken into account, it is not clear how this is different from Option 1.Proposal 21: Support Option 1 for semi-static HARQ-ACK codebook enhancement for multi-PDSCH scheduling.Proposal 22: For each configured K1 value, the sets of candidate PDSCH reception occasions corresponding to different rows in the TDRA table should be pruned to generate a set of unique PDSCH candidate occasions for the K1 value.Proposal 23: The sets of candidate PDSCH reception occasions corresponding to different configured K1 values should be pruned to generate a set of unique PDSCH candidate for semi-static HARQ-ACK codebook generation.Proposal 24: If any occasion(s) in a set of candidate PDSCH reception occasions, derived from a row in the TDRA table and a configured K1 value, collide with any UL symbols indicated by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated, the entire set of candidate PDSCH reception occasions should be dropped in the generation of the semi-static HARQ codebook. |
| [7] CATT | Proposal 6: When the scheduled PDSCH/PUSCH overlaps with unavailable slots/symbols, the corresponding SLIV value can be regarded as invalid.Proposal 10: The enhancement mechanism for discarding candidate PDSCH reception occasions and HARQ-ACK feedback information shall be studied before determination on the options for Type-1 HARQ-ACK can be made. |
| [8] Qualcomm | Proposal 5: Support Option 1, i.e., the set of the candidate PDSCH reception occasions can be determined based on each SLIV of each row in the TDRA table, extension of K1 can be discussed separately to avoid confusion. Proposal 7: When some PDSCHs/PUSCHs are skipped due to conflict between multi-PDSCH/PUSCH grant and UL/DL TDD configurations, the HARQ increment process will be applied over all PDSCHs/PUSCHs carried by the same DCI, then the corresponding HARQ IDs corresponding to the skipped PDCSHs/PUSCHs should be cancelled and ignored when constructing the type-1 codebook. |
| [9] OPPO | Proposal 1: Support option 1 or option 2 for Type-1 HARQ-ACK codebook construction.* For option 1, the candidate DL slots are determined by the union of DL slot sets, where each DL slot set is determined by each row in the TDRA table and based on extension of one K1 value in K1 set.
* For option 2, the number of HARQ-ACK bits corresponding to one candidate PDSCH reception occasion is determined by the maximum number of PDSCHs which can be scheduled with a single DCI according to the configured TDRA table.
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| [10] ZTE | Proposal 3: For enhancements of generating type-1 HARQ-ACK codebook, we support option 1:* The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set.
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| [11] Intel | Proposal 4* For Type-1 HARQ-ACK codebook generation, to allocate the occasion(s) for the candidate PDSCH transmissions corresponding to the multiple rows in TDRA table, the overlap of any SLIV of a row should be considered.

Proposal 5* For Type-1 HARQ-ACK codebook generation, the DL slots for PDSCH transmissions that are determined by the set of K1 values. For each determined DL slot, a set of (K1, row) are derived, then the overlap of any SLIV of different (K1, row) should be considered.
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| [12] Fujitsu | Observation 1: For Option 1 of determining set of candidate PDSCH reception occasions, besides extension of set of $K\_{1}$, it would require additional effort at least to determine the associated SLIVs for each $K\_{1}^{'} $in the set of $K\_{1}^{'}$ (based on extension of set of $K\_{1}$), which may need a significant change to the current structure of pseudo-code.Observation 2: For Option 1a or Option 2 for determining the set of candidate PDSCH reception occasions, besides change on pruning based on TDD DL/UL configuration, it requires to specify the number of HARQ-ACK information bits for a candidate PDSCH reception occasion. * Compared with Option 1a, Option 2 would bring extra restriction on scheduling.

Proposal 2: For Option 1a or Option 2 for determining the set of candidate PDSCH reception occasions, regarding the number of HARQ-ACK information bits for a candidate PDSCH reception occasion, the following 2 alternatives can be considered. * Alt.1. The number of HARQ-ACK information bits for a candidate PDSCH reception occasion can be determined according to corresponding valid SLIVs.
* Alt.2: Support bundling of HARQ-ACK information bits for multiple PDSCHs. Then the the number of HARQ-ACK information bits for a candidate PDSCH reception occasion is determined based on the number of bundled PDSCHs.

Observation 3: For determining the set of candidate PDSCH reception occasions, compared with Option 1 and Option 2, Option 1a provides a good trade-off between the complexity of generating the codebook and scheduling flexibility.Proposal 3: Support Option 1a for determining the set of candidate PDSCH reception occasions. |
| [13] Apple | Observation 2: The use of Option 1 to construct the semi-static HARQ-ACK codebook results in a smaller codebook size than Option 2.Proposal 8: For enhancement of the semi-static HARQ-ACK codebook for multi-PDSCH transmission, the set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set. |
| [14] Sony | Proposal 7: Support Option 1 (The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set) |
| [15] NEC | Proposal 3: For type-1 HARQ-ACK codebook determination, we prefer option1. |
| [16] Samsung | Proposal 6: For Type-1 codebook, the set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set (Option 1). - K1 set is extended based on K1 and slot offset between last PDSCH and other PDSCHs in a row in the TDRA table. - Collison between candidate PDSCH reception occasion and TDD UL/DL configuration is handled per single PDSCH SLIV.- Further study how to reduce redundant HARQ-ACK bit with joint consideration of multiple PDSCHs in multiple slots.- Further study how to reduce redundant HARQ-ACK bit with the consideration of validity of PDCCH MO. |
| [17] MediaTek | Proposal 1: For Type-1 codebook construction, support Option1 or Option1a together with the Rel-16 per-slot pruning operation which is based on TDD configuration and UE capability on number of PDSCH reception per slot. |
| [18] Panasonic | Proposal 8: For type-1 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, • The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set. |
| [19] LG Electronics | Proposal #9: Three options agreed in RAN1#104bis-e can be rephrased as follows and Option 1 is preferred considering HARQ-ACK codebook size and specification impact.* Option 1: The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set
	+ K1\_set (=set of K1 values) is extended to K1\_ext based on K1 and slot offset between last PDSCH and other PDSCHs in a row in the TDRA table.
	+ R (=set of row indexes) is extended to R\_ext such that each of the multiple SLIVs in a row index of R is separated by a row in R\_ext and each of row indexes in R\_ext has a single SLIV.
	+ To determine the set of candidate PDSCH reception occasions, all of row indexes in R\_ext is used when the corresponding K1 value is included in K1\_set and also included in K1\_ext, but the row indexes in R\_ext associated only with multiple SLIVs in R are used when the corresponding K1 value is not included in K1\_set but included in K1\_ext.
* Option 1a: The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table
	+ Alt 1: For a K1 value (in K1\_set) and DL slot n corresponding to the K1 value, pruning procedure is performed for each slot from DL slot n-M+1 to DL slot n, where M is defined as the configured maximum number of DL slots that can be scheduled by a single DCI.
	+ Alt 2: For a K1 value (in K1\_set) and DL slot n corresponding to the K1 value, after pruning procedure is performed for DL slot n, P-1 PDSCH reception occasions are added where P is defined as the configured maximum number of PDSCHs that can be scheduled by a single DCI.
* Option 2: The set of candidate PDSCH reception occasions is determined according to the last SLIV of each row in the TDRA table
	+ Pseudo code to determine the set of PDSCH reception occasions can be reused by performing pruning procedure with the last SLIV of each row in the TDRA table.
	+ In pseudo code to assign HARQ-ACK bit(s) for each PDSCH reception occasion, Q HARQ-ACK bits are assigned for each PDSCH reception occasion, where Q depends on the configured maximum number (=P) of PDSCHs that can be scheduled by a single DCI (e.g., Q=P for 1 TB case and Q=2P for 2 TB case).

Proposal #10: Further discuss whether or not to allow the case where some of PDSCHs scheduled by a multi-PDSCH scheduling DCI overlap with semi-static UL symbol(s). |
| [20] Lenovo | Proposal 5: For NR operation between 52.6 GHz and 71 GHz, in order to generate type-1 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, the set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set. |
| [21] Xiaomi | Proposal 2: Prefer Option 1 for Type 1 HARQ-ACK codebook. |
| [22] InterDigital | Proposal 10: Support Option 1 for candidate PDSCH reception occasions determining, i.e., the set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set. |
| [23] Convida | Proposal 1. For type-1 codebook HARQ-ACK generation, Option 1 can be supported for single DCI scheduling multi-PDSCH for reducing specification impact and how to determine (expansion) K1 set can be further studied. |
| [24] NTT DOCOMO | Proposal 3: Support option 2 with following procedure for type 1 HARQ-ACK CB construction for multi-PDSCH scheduling.* Step 1: Determine PDSCH slot window for the HARQ-ACK based on configured K1 set.
* Step 2: Determine candidate PDSCH reception occasions for each slot in the PDSCH slot window, based on TDD DL/UL configuration and last SLIV of each TDRA row.
* Step 3: Generate HARQ-ACK information for each candidate PDSCH reception occasion in the set. The number of HARQ-ACK bits for one candidate PDSCH reception occasion needs to consider possible multiple PDSCHs.

Discuss further on the number of HARQ-ACK bits for each candidate PDSCH reception occasion* Alt 1: Determined according to the maximum number of PDSCHs can be scheduled by one DCI on the serving cell.
* Alt 2: Determined according to the number of SLIVs in TDRA row(s) whose last SLIV corresponds to the current candidate PDSCH reception occasion.
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| [26] WILUS | Proposal 2: For Type-1 HARQ-ACK codebook construction for multi-PDSCH scheduling by a single DCI, we support option 1.* Option 1: The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set.
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### Summary (on Type-1 HARQ-ACK codebook generation):

Company views on Type-1 HARQ-ACK codebook generation:

* Option 1: The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set
	+ Supported by Futurewei, vivo, Nokia, Ericsson, Qualcomm, OPPO, ZTE, Intel, Apple, Sony, NEC, Samsung, MediaTek, Panasonic, LG Electronics, Lenovo, Xiaomi, InterDigital, Convida, WILUS
* Option 1a: The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table
	+ Supported by Huawei, Intel, Fujitsu, MediaTek
* Option 2: The set of candidate PDSCH reception occasions is determined according to the last SLIV of each row in the TDRA table
	+ Supported by OPPO, NTT DOCOMO

[Moderator’s note#1] 20 companies prefer Option 1, 4 companies prefer Option 1a, and 2 companies prefer Option 2. Given that most companies prefer Option 1, we may narrow it down to Option 1. Even if we go with Option 1, still there seem to be further issues to finalize type-1 codebook design.

### Q1: Would it be acceptable to go with Option 1? If not, please provide the reason.

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| Company | Views |
| DOCOMO | We can accept the proposal for progress. But we hope more clarifications of option 1 before we go into an agreement. For example, for each PDSCH slot determined based on the extended K1 set, is the candidate PDSCH occasion in the slot determined considering all possible SLIVs in each row of the TDRA table, or only SLIVs that are possible to be located in the slot? For the former option, large redundancy is possible. For the latter option, UE complexity will be increased if there are many rows and many different SLIVs. |
| Qualcomm | We support Option 1 |
| MediaTek | We share the similar view with DOCOMO that all the options are lack of details and they are all the same at the level of finding the initial candidate PDSCH occasions. However, how to prune those candidate PDSCHs should be discussed together in order to down select those options. |
| Huawei, HiSilicon | We also think that alternatives for K1 set extensions should be better understood and listed before diving into agreeing to support Option 1. Perhaps the proponents can each describe their detailed method for K1 set extension for further discussion. |

[Moderator’s note#2] In addition, companies have different views on whether or not to allow the case where some of PDSCHs scheduled by a multi-PDSCH scheduling DCI overlap with semi-static UL symbol(s). This issue should be resolved since it will affect type-1 codebook generation process.

### Q2: Is it allowed to schedule multiple PDSCHs where any of scheduled PDSCHs is collided with uplink symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*? If YES, is it also allowed to schedule multiple PUSCHs where any of scheduled PUSCHs is collided with downlink symbol(s) indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*?

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| Company | Views |
| DOCOMO | From perspective of flexibility, we think it is possible to schedule a PDSCH overlapping with uplink symbol. However, it is not expected that each PDSCH overlapping with UL symbol, i.e. it is expected that at least one PDSCH doesn’t overlap with UL symbol. |
| Qualcomm  | Following the legacy behaviour of slot aggregation, the overlapped PDSCHs with semi-static UL TDD symbols should be skipped (Not all the granted allocations)The HARQ increment process will be applied over all PDSCHs/PUSCHs carried by the same DCI, then the corresponding HARQ IDs corresponding to the skipped PDCSHs/PUSCHs should be cancelled and ignored when constructing the type-1 codebook.We don’t see a necessity for cancelling all PDSCHs in case of conflict as this will limit the scheduling options especially when have 8 PDSCHs that can be scheduled by the same DCI  |
| MediaTek | We support to allow any scheduled PDSCHs from a single DCI to collide with UL patterns indicated by TDD configuration. Also, we support to treat each scheduled PDSCHs individually and apply the legacy behavior on each scheduled PDSCH separately. |
| Huawei, HiSilicon | We don’t see the need to complicate the configuration of TDRA table by requiring to configure many rows in order to avoid any collision with UL slots when the starting slot can have any offset with the UL/DL configuration. It is simpler to define a rule such that if a PDSCH is signaled in TDRA and collides with an UL symbol in tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated, then the PDSCH is considered not scheduled by the UE and by the gNB. This way the size of the TDRA table doesn’t need to be very large. |

## Type-2 (dynamic) HARQ-ACK codebook

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| Company | Views |
| [1] Futurewei | Proposal 9: Two sub-codebooks can be adopted with Alt 1 to reduce HARQ-ACK codebook size. While multi-PDSCH and CBG should not be jointly configured for HARQ-ACK codebook generation for multi-PDSCH.Observation 5: The time-domain bundling size can be $2^{l}$, $0\leq l\leq log\_{2}\left(N\right)$ for Alt 1 and a fixed value 2 for Alt 2a. Time-domain Bundling is appliable by all alternatives. Proposal 11: Reuse the legacy carrier-first time-second ordering of DAI counting for multi-PDSCH. Observation 6: Whether using two sub-codebooks for Alt 3 when 1 < M < N could serve to reduce notably the number of HARQ-ACK bits depends on the actual scheduled value M. Proposal 12: Use two sub-codebooks for Alt 3 for cases when for 1 < M ≤ N if two sub-codebooks is agreed under Alt 1. |
| [2] Huawei | Proposal 10: Support Alt 2a (C-DAI/T-DAI is counted per PDSCH with a single codebook) for type-2 HARQ-ACK codebook with extension of DAI field in non-fallback DCI.Proposal 11: For type-2 HARQ-ACK codebook generation, ordering of the PDSCHs for DAI counting is counted per PDSCH in time domain first and then frequency domain.Observation 10: Alt 3 is problematic when the number of scheduled PDSCHs is smaller than configured M value.Proposal 12: When time domain bundling of HARQ-ACK feedback per DCI is configured with Alt2a, C-DAI/T-DAI could be configured to be counted per DCI. |
| [3] vivo | Proposal 18: For dynamic HARQ-ACK codebook for multi-PDSCH scheduling, support Alt 2, i.e. C-DAI/T-DAI is counted per PDSCH.Proposal 19: For DAI counting Alt 2, it should be discussed and determined to what extent the DAI counting can help to detect missed PDSCH(s), before determining whether/how to increase the number of DAI bits.Proposal 20: For the ordering of DAI counting for Alt 2, PDSCH(s) scheduled by a single DCI is counted firstly, serving cell(s) in the same PUCCH cell group is counted secondly, and PDCCH monitoring occasion(s) is counted thirdly.Proposal 21: Study dynamic HARQ-ACK codebook in conjunction with time domain bunding for multi-PDSCH scheduling. |
| [4] Spreadtrum | Proposal 5: Regarding the generation of type 2 codebook, C-DAI/T-DAI should be counted per PDSCH. |
| [5] Nokia | Proposal 9: Alt.3 is supported, that is, C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable. Proposal 10: Number of DAI bits is determined based on the configured M value and the maximum number of schedulable PDSCHs. Proposal 11: Configurable time domain bundling of HARQ-ACK feedback over M consecutive PDSCHs scheduled by the same DCI can be supported. |
| [6] Ericsson | Observation 5: Fundamental redefinition of DAI can have a large impact on the current NR specs, and also affects DAI counting related to DCIs not used for multi-PDSCH scheduling. This can cause conceptual chaos among different 3GPP releases, hence should definitely be avoided.Observation 6: To maintain the same robustness against DCI misdetection as in Rel-15/16 NR, Alt-2 and Alt-3 require increasing the bit-width of DAI values. Due to the use of a single- codebook for single/multi-PDSCH scheduling, this increment of DAI bit-widths applies to all relevant DL and UL DCI formats (DCI Format 1\_0, 1\_1, 1\_2, 0\_1 and 0\_2) and, in the case of carrier aggregation, to all component carriers.Observation 7: Alt-1 reuses the same DAI counting mechanism as in Rel-15/16 NR. It requires neither re-definition of DAI counting mechanism nor extension of the bit-width of DAI values. Hence, Alt-1 has the minimum impact on the current NR specs and implementations among the three identified alternatives for dynamic HARQ-ACK codebook enhancement.Observation 8: Applying time domain HARQ-ACK bundling on top of Alt-1 can reduce the HARQ-ACK codebook size, thus achieving a configurable balance with retransmission efficiency depending on the deployment scenario. Proposal 20: Support DAI counting Alt-1 in combination with separate HARQ-ACK codebook for single/multi-PDSCH scheduling and configurable time domain HARQ-ACK bundling for dynamic HARQ codebook enhancement for multi-PDSCH scheduling. |
| [7] CATT | Proposal 11: Considering the motivation of introducing multiple PDSCHs scheduling is that PDCCH monitoring period is based on multiple slots, Alt-1 for Type-2 HARQ-ACK codebook generation is preferred. |
| [8] Qualcomm | Proposal 8: • Regarding the DAI counting, we support Alt 2, i.e., C-DAI/T-DAI is counted per PDSCH • Support increasing the field size of the DAI based on RRC configuration to increase the reliability against the missed DCIs. However, the field size increase should be subject to gNB configuration.• Allow adjusting the resolution of the DAI counter based on the greatest common divisor of the number of the SLIVs, among the rows of the TDRA, i.e., each increment of the DAI indicates that a number of PDSCHs equal to the greatest common divisor has been sent.• Introduce new rule on how to place the virtual DCIs: * Option 1: According to a defined symbol level offset for each additional PDSCH
* Option 2: At the start symbol of each PDSCH allocation

• DAI counting follows the legacy approach after introducing the virtual DCIs. |
| [9] OPPO | Proposal 2: Support alt 1 or alt 2a for Type-2 HARQ-ACK codebook construction.* For alt 1, two sub-codebooks should be considered.
* For alt 2a, a single codebook should be considered.
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| [10] ZTE | Proposal 4: Considering the effect on the HARQ-ACK codebook generation process, Alt 2: C-DAI/T-DAI is counted per PDSCH can be selected. |
| [11] Intel | Proposal 6: For Type-2 HARQ-ACK codebook generation, only Alt. 1 is supported.Proposal 7For Type-2 HARQ-ACK codebook generation, * If CBG based transmission is configured, HARQ-ACK feedback for multi-PDSCH scheduling is included in the second sub-codebook.
* If CBG based transmission is not configured, HARQ-ACK feedback for multi-PDSCH scheduling is included in
	+ the first sub-codebook if up to two PDSCHs are scheduled;
	+ otherwise, the second sub-codebook.

Proposal 8: Time domain bundling among some/all of the PDSCH transmissions that are scheduled by the same DCI is supported to reduce the HARQ-ACK codebook size. |
| [12] Fujitsu | Proposal 4: To generate the type-2 HARQ-ACK codebook for DCI scheduling multiple PDSCHs, Alt. 1 should be supported where C-DAI/T-DAI is counted per DCI. For Alt. 1, it should be supported that the Type-2 HARQ-ACK codebook includes two sub-codebooks.- The 1st sub-codebook includes HARQ-ACK bits for PDSCHs scheduled in a single-PDSCH and TB-based manner among all the CCs.- The 2nd sub-codebook includes HARQ-ACK bits for PDSCHs scheduled in a single-PDSCH and CBG-based manner, and PDSCHs scheduled in a multi-PDSCH manner. |
| [13] Apple | Proposal 9: Reusing the existing C-DAI and T-DAI definition in Rel-15/6, i.e., counting per DCI. Proposal 10: Introduce signaling mechanism to enable generating a HARQ-ACK bit per ‘M’ scheduled PDSCHs in a multi-PDSCH scheduling by performing HARQ-ACK bundling to compress the HARQ-ACK bits overhead. |
| [14] Sony | Proposal 8: C-DAI/T-DAI for multi-PDSCH scheduling should be counted per PDSCH. |
| [15] NEC | Proposal 4: For type-2 HARQ-ACK codebook determination, support both Alt 1 and Alt 2a. |
| [16] Samsung | Proposal 7: For Type-2/enhanced type-2 HARQ-ACK codebook, Alt -1 (DAI is counted per DCI, and single and multi-PDSCHs scheduled by a DCI are associated with different sub-codebook) should be supported.Proposal 8: If HARQ-ACK bundling is supported, bundling is performed within PDSCHs scheduled by a single DCI. Down-select one of the following alternatives:* Alt a: gNB configures a number of HARQ-ACK bundling groups (Nb) per DCI
* Alt b: gNB configures a number of PDSCHs per HARQ-ACK bundling groups (Npb)
* Alt c: gNB configures time duration of one HARQ-ACK bundling group (Tb).
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| [17] MediaTek | Proposal 2: For Type-2 codebook construction based on the principle of DAI per DCI, support the following PDSCH grouping and HARQ-ACK bit reporting to manage the codebook size.* When a UE is configured for multi-PDSCH scheduling in a cell c, the scheduled PDSCHs from one DCI are grouped into $M$ PDSCH groups
	+ $M=min⁡(N,C)$, where N is the maximum number of PDSCH groups per DCI configured by network and C is the number of scheduled PDSCHs in the DCI.
	+ Let $M\_{1}=mod\left(C,M\right), K\_{1}=\left⌈C/M\right⌉, K\_{2}=\left⌊C/M\right⌋$
	+ Each PDSCH group in the first $M\_{1}$ PDSCH groups contains $K\_{1}$ scheduled PDSCHs and each PDSCH group in the remaining PDSCH groups contains $K\_{2}$ scheduled PDSCHs.
	+ UE reports one HARQ-ACK bit for each PDSCH group
		- If all PDSCHs within a PDSCH group are decoded correctly, UE reports “ACK”
		- Else, UE reports “NACK”
	+ If $M<N$, UE will append $N-M$ “NACK” bits after the M HARQ-ACK bits from the $M$ TB groups to construct the codebook

Proposal 3: For Type-2 codebook construction based on the principle of DAI per PDSCH, consider the scheduling restriction such that at most $X$ PDSCHs can be scheduled by any 3 consecutive DCIs.* + The corresponding bit filed length of DAI will be $\left⌈log\_{2}(X+1)\right⌉$.

Proposal 4: For Type-2 codebook construction, consider the principle of DAI per HARQ-ACK bit and consider the restriction on the number of HARQ-ACK bits such that at most $X$ HARQ-ACKs are corresponding to a DCI* + When the number of PDSCHs $C$ scheduled by a DCI is less than $X$, UE only needs to report $C$ HARQ-ACK bits instead of $X$ HARQ-ACK bits.
	+ When the number of PDSCHs $C$ scheduled by a DCI is greater or equal to $X$, UE only needs to report $X$ HARQ-ACK bits instead of $C$ HARQ-ACK bits
		- The $X$ HARQ-ACK bits can be generated based on Rel-16 CBG-like grouping among the scheduled PDSCH.
	+ DAI bit field length is $\left⌈log\_{2}(3X+1)\right⌉$
	+ $X$ can be configured by gNB

Proposal 6: CBG transmission is not supported with multi-PDSCH scheduling feature. |
| [18] Panasonic | Proposal 9: For generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, C-DAI/T-DAI is counted per PDSCH, i.e., Alt. 2a.Propose 10: For C-DAI/T-DAI is counted per PDSCH in Alt. 2a, when multi-PDSCH scheduling is configured,* If only C-DAI is necessary, the DAI field size is $2+log\_{2}N\_{Max}$,
* If both T-DAI and C-DAI are necessary, the DAI field size is $2×(2+log\_{2}N\_{Max}$),
* If both T-DAI and C-DAI are necessary and non-scheduled PDSCH group is configured, the DAI field size is $3×(2+log\_{2}N\_{Max}$),
 |
| [19] LG Electronics | Proposal #11: For (enhanced) type-2 HARQ-ACK codebook,* If Alt 1 (C-DAI/T-DAI is counted per DCI) is adopted, two sub-codebooks where one is for single PDSCH scheduling case and the other is for multi-PDSCH scheduling case are introduced.
	+ If CBG is additionally configured, the number of sub-codebooks is kept as two and HARQ-ACK corresponding to CBG-based PDSCH scheduling and multi-PDSCH scheduling cases is merged into the same sub-codebook.
* If Alt 2 (C-DAI/T-DAI is counted per PDSCH) is adopted, two sub-codebooks where one is for single PDSCH scheduling case and the other is for multi-PDSCH scheduling case are introduced to prevent from increasing C-DAI size in DCI format 1\_0.
	+ If CBG is additionally configured, the number of sub-codebooks is increased to three where first sub-codebook is for TB-based single-PDSCH scheduling case, second sub-codebook is for CBG-based PDSCH scheduling case, and third sub-codebook is for multi-PDSCH scheduling case.
 |
| [20] Lenovo | Proposal 6: For NR operation between 52.6 GHz and 71 GHz, for dynamic (type-2) HARQ-ACK codebook, support C-DAI/T-DAI counting per DCI.Proposal 7: For NR operation between 52.6 GHz and 71 GHz, for dynamic (type-2) HARQ-ACK codebook, if C-DAI/T-DAI counting per DCI is agreed, the one of the following two options should be agreed for HARQ-ACK codebook construction:- Option 1: Different sub HARQ-ACK codebook is generated for numerology corresponding to which different number of maximum PDSCHs can be scheduled. For example, if up to 1 PDSCH is scheduled for 120 kHz, then first sub HARQ-ACK codebook is constructed for 120 kHz, if up to 4 PDSCHs are scheduled for 480 kHz, then second sub HARQ-ACK codebook is constructed for 480 kHz, and if up to 8 PDSCHs are scheduled for 960 kHz, then third sub HARQ-ACK codebook is constructed for 960 kHz- Option 2: Same HARQ-ACK codebook is applied for multi-PDSCH scheduling DCI, even if the maximum allowed PDSCH scheduling is different and codebook size alignment can be done by time-domain bundling. For example if up to PDSCHs can be scheduled with 480 kHz and up to 8 PDSCHs can be scheduled with 960 kHz, then 4 HARQ-ACK bits are expected to be generated per DCI for both cases, where time-domain bundling for every 2 PDSCHs is applied for 960 kHz in order to limit the size to 4, similar to 480 kHz |
| [21] Xiaomi | Proposal 1: Support Alt.1 for Type 2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs. |
| [22] InterDigiatl | Proposal 9: For counting C-DAI/T-DAI for generating type-2 HARQ-ACK codebook, Alt 3: C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable (e.g., 1, 2, 4, …). |
| [23] Convida | Proposal 2. For type-2 codebook HARQ-ACK generation, Alt-3 seems a flexible option for consideration and the details of Alt-3 can be further studied. |
| [24] NTT DOCOMO | Proposal 4: For HARQ-ACK feedback for multiple PDSCHs scheduled by one DCI if HARQ-ACK bundling among different PDSCHs is not applied,* Support Alt. 2 (C-DAI/T-DAI is counted per PDSCH) for type 2 HARQ-ACK CB construction.

Proposal 5: For HARQ-ACK feedback for multiple PDSCHs scheduled by one DCI,* Support HARQ-ACK bundling among PDSCHs scheduled by single DCI.
* Support Alt. 1 or Alt. 3 if HARQ-ACK bundling is applied.
 |

### Summary (on Type-2 HARQ-ACK codebook generation):

Company views on Type-2 HARQ-ACK codebook (CB) generation:

* Alt 1 (C-DAI/T-DAI is counted per DCI)
	+ Supported by Futurewei (2 sub-CBs), Ericsson (2 sub-CBs + time domain bundling), CATT, OPPO (2 sub-CBs), Intel (2 sub-CBs), Fujitsu (2 sub-CBs), Apple, NEC, Samsung (2 sub-CBs), MediaTek, LG Electronics (2 sub-CBs), Lenovo, Xiaomi (2 sub-CBs), NTT DOCOMO (if time domain bundling is applied)
* Alt 2 (C-DAI/T-DAI is counted per PDSCH)
	+ Supported by Huawei (extension of DAI field in non-fallback DCI), vivo, Spreadtrum, Qualcomm, OPPO, ZTE, Sony, NEC, MediaTek, Panasonic, LG Electronics (2 sub-CBs), NTT DOCOMO
* Alt 3 (C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable)
	+ Supported by Furturewei (for 1< M≤N, 2 sub-CBs), Nokia, InterDigital, Convida, NTT DOCOMO (if time domain bundling is applied)

[Moderator’s note#1] 14 companies prefer Alt 1, 12 companies prefer Alt 2, and 5 companies prefer Alt 3. Given the preference and considering Alt 3 includes Alts 1 and 2, it seems reasonable to focus on Alts 1 and 2. Instead of narrowing it down to a specific alternative, we may first try to agree on more details of each alternative.

### Proposal #5 (Type-2 HARQ-ACK CB Alt 1):

* If Alt 1 (C-DAI/T-DAI is counted per DCI) is adopted for generating type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs,
	+ Two sub-codebooks are generated, where the HARQ-ACK bits in the first sub-codebook correspond to PDSCH(s) scheduled by a DCI that schedules a single PDSCH and the HARQ-ACK bits in the second sub-codebook correspond to PDSCHs scheduled by a DCI that schedules more than one PDSCHs.
	+ If CBG is configured, the HARQ-ACK bits corresponding to CBG-based PDSCH receptions are included in the second sub-codebook.

Companies are encouraged to provide views on Proposal #5.

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| Company | Views |
| DOCOMO | We are fine with the proposal. But we don’t prefer Alt 1 considering large PUCCH redundancy. |
| Qualcomm | We do not believe that this option should be restricted to the two sub-codebook case. In addition, it should be clarified that this feature will always assume either A/N bundling or padding to ensure the alignment of the codebook sizes, this will be needed even if we agreed on supporting this feature with multiple sub-codebooks.  |
| MediaTek | Agree with Qualcomm. We are not sure including multi-PDSCH HARQ-ACK information with CBG codebook is feasible without aligning the number of HARQ-ACK bits corresponding to one DCI with CBG transmission. In our understanding, there is a notion of max CBG group size which determines the number of HARQ-ACK bits corresponding to one DCI with CBG transmission and that size might not be the same as the number of HARQ-ACK bits corresponding to one DCI scheduling multiple PDSCHs. Is this scenarios is allowed, then how to merge CBG and multi-PDSCH HARQ information in one codebook is not clear to us.We do agree that there should be separate codebooks for single PDSCH scheduling and multi-PDSCHs scheduling. One clarification question is, if a DCI only schedules one PDSCH under the multi-PDSCH feature, e.g., one row of TDRA table only has one SLIV, which codebook should this HARQ-ACK bit belong to? |
| Huawei, HiSilicon | Proposal #3 (on whether to allow CBG (re)transmissions for PDSCH in a DCI that can schedule multiple PDSCHs) should be addressed first before discussing proposal #5.We would like to understand the relation between Alt1 and time-domain bundling. If it is assumed that time-domain bundling is applied within the PDSCHs scheduled by one DCI, then it is not clear why two sub-codebooks are needed. |

### Proposal #6 (Type-2 HARQ-ACK CB Alt 2):

* If Alt 2 (C-DAI/T-DAI is counted per PDSCH) is adopted for generating type-2 HARQ-ACK codebook corresponding to a DCI that can schedule multiple PDSCHs,
	+ PDSCH(s) scheduled by a single DCI is counted firstly, serving cell(s) in the same PUCCH cell group is counted secondly, and PDCCH monitoring occasion(s) is counted thirdly.
	+ DAI field in fallback DCI (i.e., DCI formats 0\_0 and 1\_0) is not extended.
	+ The number of bits for each of counter DAI and total DAI in non-fallback DCI is extended by
		- Alt A: 2 + ceiling{log2(N\_max)} where N\_max is determined by the maximum configured number of PDSCHs for multi-PDSCH scheduling DCI across serving cells belonging to the same PUCCH cell group
		- Alt B: 2 + N\_conf where N\_conf is configured by new RRC parameter

Companies are encouraged to provide views on Proposal #6.

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| Company | Views |
| DOCOMO | We are fine with the proposal and we prefer Alt 2 to Alt 1. |
| Qualcomm  | We want to add adjusting the resolution of the DAI increment based on the greatest common divisor of the number of the SLIVs among the different rows in the TDRA table, as this can significantly reduce the number of DAI bits in many cases. For example, consider a TDRA table that only contains rows with 4 or 8 SLIVs, then every four PDSCHs can increment the DAI counter by 1, i.e., a grant of 4 PDSCHs will increment the DAI once, and a grant of 8 PDSCHs will increment the DAI twice. By doing this, there is no need to increase the number of DAI bits in the DCI based on the maximum number of the SLIVs in the TDRA table, which can save some DCI overhead while maintaining the same level of reliability of the missed grants. |
| MediaTek | Few clarification questions below:For the second sub-bullet* + DAI field in fallback DCI (i.e., DCI formats 0\_0 and 1\_0) is not extended.

is this bullet necessary if we can agree on the Proposal #1?Regarding the number of bits for each C-DAI/T-DAI, if Alt B is adopted, then does the C-DAI/T-DAI still counted per PDSCH or per group of PDSCH? If so, then we suggest to somehow capture the relation between N\_conf and the group of PDSCH and FFS on the grouping rule associated with Alt B. If not, can Moderator clarify the meaning of N\_conf? is it related to some scheduling restriction like the maximum number of scheduled PDSCHs in any three consecutive DCIs?  |
| Huawei, HiSilicon | Proposal #3 (on whether to allow CBG (re)transmissions for PDSCH in a DCI that can schedule multiple PDSCHs) should be addressed first before discussing proposal #5.We are ok with proposal #6 to clarify Alt2. The option to have 2 sub-codebooks for Alt2 can be kept if companies have concerns with not extending the DCI field in fallback DCI. |

## HARQ timing

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| Company | Views |
| [1] Futurewei | Observation 4: It can be beneficial to study coverage loss if a larger size type-1 HARQ-ACK codebook is carried by UCI of certain PUCCH format. Proposal 8: Study if there is benefit of adopting multi-PUCCH for multi-PDSCH for either mitigation of coverage loss or reduce idle slot if HARQ starvation is a significant issue for the higher SCSs. |
| [3] vivo | Proposal 10: For multi-PDSCH scheduling, support reporting HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI on different PUCCH(s).Proposal 11: For reporting HARQ-ACK feedback on different PUCCHs, further study how to divide the PDSCHs scheduled by a single DL DCI, as well as indicate or determine more than one PUCCH carrying HARQ-ACK feedback. |
| [6] Ericsson | Proposal 27: Do not support HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI to be carried by different PUCCH occasions. |
| [8] Qualcomm | Proposal 4: All HARQ-ACK information corresponding to different PDSCHs scheduled by the same DCI to be carried by the same PUCCH. |
| [9] OPPO | Proposal 3: Separate the scheduled PDSCHs into two groups, consider two PUCCH resources allocated for the two PDSCH groups, an earlier PUCCH is used to report HARQ-ACK information of the earlier PDSCH group. |
| [10] ZTE | Observation 1: HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s) considering HARQ-ACK feedback delay. |
| [11] Apple | Observation 1: HARQ-ACK information corresponding to different PDSCHs scheduled by a single DCI carried by different PUCCHs affects the UE complexity, signaling overhead and transmission latency but may be affected by channel access within or across COTs.Proposal 6: RAN1 should decide whether a multi-PxSCH transmission can occur across multiple COTs and the specify the UE HARQ-ACK feedback behavior in the case that one or more of the PDSCH transmissions occurs outside a valid COT.Proposal 7: RAN1 should support a single HARQ-ACK feedback for Multi-PDSCH transmissions within a single COT only. |
| [14] Sony | Proposal 6: If PDSCH processing time is long, at least one of the following solutions should be considered1. Multiple HARQ feedback timing indication by one DCI2. Multiple DCI in a slot3. Increasing the number of HARQ process |
| [15] NEC | Proposal 2: HARQ-ACK information corresponding to the PDSCHs scheduled by a single DCI can be carried in an uplink slot or at most 2 uplink slots. |
| [16] Samsung | Proposal 5: HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI carried by different PUCCH(s) is not supported in Rel-17. |
| [17] MediaTek | Proposal 5: The HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI should only be carried by single PUCCH to simplify Type-2 codebook design. |
| [18] Panasonic | Proposal 7: Support HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s). |
| [19] LG Electronics | Proposal #12: Further discuss whether or not HARQ-ACK information corresponding to different PDSCHs scheduled by a single DCI can be carried by two different PUCCHs, at least considering the follows:* How to separately allocate resource for two PUCCHs (e.g., K1, PRI, etc)
* How to signal individual DAI values corresponding to two PUCCHs
* Under which condition(s) two PUCCHs are indicated by the DCI (e.g., in case more than N PDSCHs are scheduled)
 |
| [20] Lenovo | Proposal 4: For NR operation between 52.6 GHz and 71 GHz, for HARQ-ACK information corresponding to PDSCHs scheduled by the DCI, different PUCCH(s) can be used where the PUCCH carrying the HARQ-ACK can be transmitted in the middle of non-contiguous PDSCHs transmissions to allow earlier/faster transmission of HARQ-ACK associated with earlier PDSCHs |
| [21] Xiaomi | Proposal 3: For latency sensitive service, separate HARQ-ACK PUCCH resources for multiple PDSCHs scheduled by single DCI can be considered. |
| [22] InterDigital | Observation 6: Configuring one PUCCH transmission with HARQ-ACK for all the PDSCHs scheduled by one DCI can introduce excessive HARQ-ACK round trip delay and negatively impact on the expected performance gains. Proposal 8: When multiple PDSCH are scheduled using single DCI, support multiple sub-codebooks each carrying HARQ-ACK information of a sub-set of scheduled PDSCHs. Proposal 11: To support multiple PUCCHs each carrying HARQ-ACK information of a group of PDSCHs scheduled by a single DCI, extend TDRA table such that each row indicates multiple slot offsets (K0 values) corresponding to multiple HARQ-ACK sub codebooks. |
| [24] NTT DOCOMO | Proposal 6: Support transmitting HARQ-ACKs for multiple PDSCHs scheduled by one DCI on different PUCCHs. |

### Summary (on whether or not HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s)):

Company views on whether or not HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s):

* Supported by vivo, OPPO, ZTE, Sony, NEC, Panasonic, Lenovo, Xiaomi, InterDigital, NTT DOCOMO
* Objected by Ericsson, Qualcomm, Apple, Samsung, MediaTek, LG Electronics

[Moderator’s note] 10 companies suggest to support that HARQ-ACK information corresponding to different PDSCHs scheduled by a DCI is carried by different PUCCHs while 6 companies are against it. Therefore, it is proposed to deprioritize this issue in this meeting.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
| DOCOMO | Fine to deprioritize the issue in this meeting. |
| Qualcomm  | We don’t see significant benefit from carrying the feedback of PDSCHs scheduled by the same DCI over two PUCCHs in terms of latency. This is because the expected timeline of PDSCH decoding will be relatively large. For example, with 960kHz, N1 will be around 11 slots, using SCS 120kHz absolute timeline as a baseline. With 8 PDSCHs at maximum scheduled by the same DCI, the offset between any PDSCH reception and its feedback has to be larger than N1, i.e., 11 slots, i.e., counting this offset from a slot of PDCSH at the middle of the allocation or the slot of the last PDSCH will not lead to a significant reduction in the latency of the feedback. For example, if we allow the first 4 PDSCHs to be feedback separately before the last 4 PDSCHs, the first feedback will be transmitted at most 4 slots before the second feedback, this will count for ~56us latency enhancement for SCS 960kHz which is not significant. |
| MediaTek | We also don’t see the need for introducing more PUCCHs for the multi-PDSCH scheduling and we agree to deprioritize the discussion. |
| Huawei, HiSilicon | We are open to discuss if time allows. This could allow getting HARQ feedback earlier for the first group of PDSCHs, i.e. immediately after the last PDSCH, while the second group of PDSCHs require more processing time. If there are available UL slots in between the multiple DL slots scheduled by a single DCI, then this could be allowed by the network. |

## HARQ process

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| Company | Views |
| [3] vivo | Proposal 6: There is no need to increase the maximum number of HARQ processes due to multi-PDSCH/PUSCH scheduling. |
| [5] Nokia | Proposal 8: If up to 32 DL HARQ processes are supported for 960 kHz SCSs, it is enough to support single transmission of HARQ feedback per multi-PDSCH DCI. |
| [6] Ericsson | Proposal 4: Increase maximum number of DL and UL HARQ processes in Rel-17 from 16 to 32. |
| [8] Qualcomm | Proposal 3: In the case of increasing the HARQ processes to 32 for SCSs 480kHz and 960kHz, a UE capability should be defined such that X HARQ processes can be supported, and Y of them can do soft combining where X and Y ≥ 16. |
| [21] Xiaomi | Proposal 4: Tx/Rx HARQ buffer capacity will need to be enhanced if HARQ process number increases for SCS 480/960 kHz.Proposal 5: Not support CBG (re)transmission when more than one PUSCHs are scheduled especially when the total HARQ processes is extended to 64/128. |

### Summary (on the number of HARQ processes):

Company views on increasing the number of HARQ processes:

* Supported by Ericsson, Qualcomm (subject to UE capability)
* Objected by vivo

[Moderator’s note] Given a small number of inputs, this issue can be deprioritized in this meeting.

Please feel free to express views on Moderator’s note, if any.

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| Company | Views |
| sSS | Fine to deprioritize the issue in this meeting. |
| Qualcomm  | We are okay with increasing the HARQ processes based on UE capability  |
| MediaTek | Agree to deprioritize the discussion. |
| Huawei, HiSilicon | Proposals were already provided at the last meeting so it is unclear if more companies will contribute in later meetings. We think that a decision could be made in this meeting. Given that NTN already agreed to increase to 32 HARQ processes, at least the same could be agreed in this WI. |

## Others

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| Company | Views |
| [10] ZTE | Proposal 5: Further enhancement on enhanced dynamic HARQ-ACK codebook construction should be considered. |
| [14] Sony | Proposal 9: NR-U HARQ enhancement features (Non-numerical K1, enhanced Type-2 HARQ CB, and Type-3 HARQ CB) for multi-PDSCH scheduling should be supported.• Further study how to indicate/determine PDSCH group if multiple PUCCH for multi-PDSCH scheduling is supported. |
| [17] MediaTek | Proposal 7: The UCI information bits including HARQ-ACK information bits should reuse the existing PUCCH payload size limit 1706. |

# Reference

1. R1-2104212 Enhancements to support PDSCH/PUSCH for Beyond 52.6GHz FUTUREWEI
2. R1-2104274 PDSCH/PUSCH enhancements for 52-71GHz spectrum Huawei, HiSilicon
3. R1-2104350 Discussions on multi-PDSCH/PUSCH scheduling for NR operation from 52.6GHz to 71GHz vivo
4. R1-2104418 Discussion on PDSCH and PUSCH enhancements for above 52.6GHz Spreadtrum Communications
5. R1-2104454 PDSCH/PUSCH enhancements Nokia, Nokia Shanghai Bell
6. R1-2104462 PDSCH-PUSCH Enhancements Ericsson
7. R1-2104509 PDSCH/PUSCH enhancements for up to 71GHz operation CATT
8. R1-2104661 PDSCH/PUSCH enhancements for NR in 52.6 to 71GHz band Qualcomm Incorporated
9. R1-2104767 Discussion on PDSCH/PUSCH enhancements OPPO
10. R1-2104835 Discussion on the PDSCH/PUSCH enhancements for 52.6 to 71GHz ZTE, Sanechips
11. R1-2104896 Discussion on PDSCH/PUSCH enhancements for extending NR up to 71 GHz Intel Corporation
12. R1-2105062 Considerations on multi-PDSCH/PUSCH with a single DCI and HARQ for NR from 52.6GHz to 71 GHz Fujitsu
13. R1-2105094 Discussion on multi-PxSCH and HARQ Codebook Enhancements Apple
14. R1-2105158 PDSCH/PUSCH enhancements for NR from 52.6 GHz to 71 GHz Sony
15. R1-2105259 Discussion on PDSCH enhancements supporting NR from 52.6GHz to 71 GHz NEC
16. R1-2105299 PDSCH/PUSCH enhancements for NR from 52.6 GHz to 71 GHz Samsung
17. R1-2105372 HARQ codebook design for 52.6-71 GHz NR operation MediaTek Inc.
18. R1-2105396 Discussion on PDSCH/PUSCH enhancements for NR 52.6-71 GHz Panasonic Corporation
19. R1-2105421 PDSCH/PUSCH enhancements to support NR above 52.6 GHz LG Electronics
20. R1-2105497 PDSCH/PUSCH scheduling enhancements for NR from 52.6 GHz to 71GHz Lenovo, Motorola Mobility
21. R1-2105556 PDSCH and PUSCH enhancements for NR 52.6-71GHz Xiaomi
22. R1-2105583 Enhancing PDSCH/PUSCH Scheduling for 52.6 GHz to 71 GHz Band InterDigital, Inc.
23. R1-2105596 PDSCH Considerations for Supporting NR from 52.6 GHz to 71 GHz Convida Wireless
24. R1-2105690 PDSCH/PUSCH enhancements for NR from 52.6 to 71 GHz NTT DOCOMO, INC.
25. R1-2105784 PDSCH-PUSCH Enhancement for NR beyond 52.6 GHz Charter Communications
26. R1-2105870 Discussion on multi-PDSCH/PUSCH scheduling for NR from 52.6GHz to 71GHz WILUS Inc.

# Appendix: Previous agreements

Agreement: (RAN1#104-e)

* For a UE and for a serving cell, scheduling multiple PDSCHs by single DL DCI and scheduling multiple PUSCHs by single UL DCI are supported.
	+ Each PDSCH or PUSCH has individual/separate TB(s) and each PDSCH/PUSCH is confined within a slot.
	+ FFS: The maximum number of PDSCHs or PUSCHs that can be scheduled with a single DCI
	+ FFS: Whether multiple PDSCH scheduling applies to 120 kHz in addition to 480 and 960 kHz
	+ At least for 120 kHz SCS, single-slot scheduling with slot-based monitoring will still be supported as specified in Rel-15/Rel-16
* The followings will not be considered in this WI.
	+ Single DCI to schedule both PDSCH(s) and PUSCH(s)
	+ Single DCI to schedule one or multiple TBs where any single TB can be mapped over multiple slots, where mapping is not by repetition
	+ Single DCI to schedule N TBs (N>1) where a TB can be repeated over multiple slots (or mini-slots)
* Note: This does not imply that existing slot aggregation and/or repetition for PDSCH and PUSCH by single DCI is precluded for the serving cell.

Agreement: (RAN1#104-e)

* For a DCI scheduling multiple PDSCHs, HARQ-ACK information corresponding to PDSCHs scheduled by the DCI is multiplexed with a single PUCCH in a slot that is determined based on K1,
	+ where K1 (indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI or provided by *dl-DataToUL-ACK* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI) indicates the slot offset between the slot of the last PDSCH scheduled by the DCI and the slot carrying the HARQ-ACK information corresponding to the scheduled PDSCHs.
		- It is noted that granularity of K1 can be separately discussed.
* FFS: If needed, further discuss whether or not HARQ-ACK information corresponding to different PDSCHs scheduled by the DCI can be carried by different PUCCH(s)

Agreement: (RAN1#104-e)

For generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, the following alternatives can be considered to DAI counting and will be down-selected in RAN1#104bis-e.

* Alt 1: C-DAI/T-DAI is counted per DCI.
* Alt 2: C-DAI/T-DAI is counted per PDSCH.
* Alt 3: C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable (e.g., 1, 2, 4, …).
* FFS: Codebook generation details
* FFS: How to signal DAI values (e.g., increase of DAI bits for Alt 2 and Alt 3)
* FFS: Whether to apply time domain bundling of HARQ-ACK feedback

Agreement: (RAN1#104-e)

The multi-PUSCH scheduling defined in Rel-16 NR-U is the baseline for multi-PUSCH scheduling in Rel-17.

* FFS: Applicability to multi-PDSCH scheduling.

Agreement: (RAN1#104-e)

* For the multi-PUSCH scheduling in Rel-17, study the enhancement of the following in addition to Rel-16 multi-PUSCH scheduling.
	+ CBGTI: Whether or not CBG (re)transmission is supported when more than one PUSCHs are scheduled (Already supported when only one PUSCH is scheduled).
	+ CSI-request: Whether to apply same or different rule compared to Rel-16 (e.g., the PUSCH that carries the AP-CSI feedback is the first PUSCH that satisfies the multiplexing timeline).
	+ TDRA: Down-select among
		- Alt 1: TDRA table is extended such that each row indicates up to [X, FFS for X] multiple PUSCHs (continuous in time-domain). Each PUSCH has a separate SLIV and mapping type. The number of scheduled PUSCHs is signalled by the number of indicated valid SLIVs in the row of the TDRA table signalled in DCI.
		- Alt 2: TDRA table is extended such that each row indicates up to [X, FFS for X] multiple PUSCHs (that can be non-continuous in time-domain). Each PUSCH has a separate SLIV and mapping type. The number of scheduled PUSCHs is signalled by the number of indicated valid SLIVs in the row of the TDRA table signalled in DCI.
		- Alt 3: TDRA table is extended such that each row indicates up to 8 multiple PUSCH groups (that can be non-continuous between PUSCH groups). Each PUSCH group has a separate SLIV, mapping type and number of slots/PUSCHs N. Within each PUSCH group, N PUSCHs occupy the same OFDM symbols indicated by the SLIV and mapping type. The number of scheduled PUSCHs is the sum of number of PUSCHs in all PUSCH groups in the row of the TDRA table signalled in DCI.
	+ FDRA: Whether/how to enhance FDRA e.g., by increasing RBG size or changing allocation granularity
	+ Frequency hopping: Whether/how to support frequency hopping for scheduled PUSCHs, e.g., inter-PUSCH/intra-PUSCH hopping
	+ URLLC related fields such as priority indicator and open-loop power control parameter set indication: Whether/how to apply URLLC related fields for scheduled PUSCHs
	+ Applicability to multi-PDSCH scheduling in Rel-17.
	+ Note: Other enhancements are not precluded.

Agreement: (RAN1#104bis-e)

* The maximum number of PDSCHs that can be scheduled with a single DCI in Rel-17 is 8 for SCS of 480 and 960 kHz.
	+ FFS: Further restrictions for 480 kHz to 4
	+ FFS: A UE capability to select between 4 and 8 for 480 kHz SCS
	+ Note: Multi-PDSCH scheduling for the case of 120 kHz SCS is still FFS as per prior agreement. This case can be addressed after this FFS has been decided.
* The maximum number of PUSCHs that can be scheduled with a single DCI in Rel-17 is 8.
	+ FFS: Further restrictions for 120 kHz and 480 kHz SCS
	+ FFS: A UE capability to select between different values for 120 kHz and 480 kHz SCS

Agreement: (RAN1#104bis-e)

For a DCI that can schedule multiple PDSCHs,

* MCS for the 1st TB: This appears only once in the DCI and applies commonly to the first TB of each PDSCH
* NDI for the 1st TB: This is signaled per PDSCH and applies to the first TB of each PDSCH
* RV for the 1st TB: This is signaled per PDSCH, with 2 bits if only a single PDSCH is scheduled or 1 bit for each PDSCH otherwise and applies to the first TB of each PDSCH
* HARQ process number: This applies to the first scheduled PDSCH and is incremented by 1 for subsequent PDSCHs (with modulo operation, if needed)
* FFS:
	+ MCS/NDI/RV for the 2nd TB for each PDSCH, including whether scheduling of the 2nd TB for each PDSCH can be supported or not
	+ Details of resource allocation related fields such as VRB-to-PRB mapping, PRB bundling size indicator, rate matching indicator, and ZP CSI-RS trigger
	+ Whether/how to signal CBGFI/CBGTI if CBGFI/CBGTI is supported for multi-PDSCH scheduling
	+ Details of fields that are common with multi-PUSCH scheduling, e.g., TDRA, FDRA, priority indicator, including potential enhancements

Agreement: (RAN1#104bis-e)

* For a DCI that can schedule multiple PUSCHs,
	+ TDRA: Alt 2 (TDRA table is extended such that each row indicates up to 8 multiple PUSCHs (that can be non-continuous in time-domain). Each PUSCH has a separate SLIV and mapping type. The number of scheduled PUSCHs is implicitly indicated by the number of indicated valid SLIVs in the row of the TDRA table signalled in DCI.), as per agreement made in RAN1#104-e
		- FFS: signaling details
	+ Note: Alt 2 does not preclude continuous resource allocation in time-domain.
* For a DCI that can schedule multiple PDSCHs,
	+ TDRA: TDRA table is extended such that each row indicates up to 8 multiple PDSCHs (that can be non-continuous in time-domain). Each PDSCH has a separate SLIV and mapping type. The number of scheduled PDSCHs is implicitly indicated by the number of indicated valid SLIVs in the row of the TDRA table signalled in DCI.
		- FFS: signaling details
	+ Note: This does not preclude continuous resource allocation in time-domain.
	+ Note: Multi-PDSCH scheduling for the case of 120 kHz SCS is still FFS as per prior agreement. This case can be addressed after this FFS has been decided.

Agreement: (RAN1#104bis-e)

For enhancements of generating type-1 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs, the following options can be considered,

* Option 1: The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table and based on extension of K1 set
* Option 1a: The set of candidate PDSCH reception occasions is determined according to each SLIV of each row in the TDRA table
* Option 2: The set of candidate PDSCH reception occasions is determined according to the last SLIV of each row in the TDRA table
* FFS: Codebook generation details, including how to handle the collision with TDD DL/UL configuration and whether/how to extend K1 set based on K1 and slot offset between last PDSCH and other PDSCHs in a row in the TDRA table

Conclusion: (RAN1#104bis-e)

The following is observed for alternative 1 from prior agreement.

* For Alt 1 (C-DAI/T-DAI is counted per DCI) of generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs,
	+ C-DAI/T-DAI in DL DCI: Same DAI overhead with Rel-16 single-PDSCH DCI
	+ T-DAI in UL DCI:
		- In case of single codebook handling feedback for both single and multi-PDSCH scheduling, same DAI overhead with Rel-16 UL DCI
		- In case of separate sub-codebooks, need additional DAI field (with same bit-width of DAI with Rel-16 UL DCI), in UL DCI for all serving cells including a serving cell not configured with multi-PDSCH DCI
			* Note that DAI field increment for this case is similar for the case in Rel-15 where CBG is configured
	+ HARQ-ACK codebook generation:
		- A separate sub-codebook can be generated when multi-PDSCH DCI is configured for a serving cell, similar to the way as 2nd sub-codebook is defined to handle CBG-based scheduling
			* FFS: whether single codebook or separate sub-codebooks is(are) generated when multi-PDSCH DCI is configured for a serving cell
			* FFS: how many sub-codebooks are generated when multi-PDSCH DCI is configured for a serving cell and CBG is configured for the serving cell and/or the other serving cell(s)
		- HARQ-ACK payload size is increased compared to single PDSCH scheduling only, since the number of HARQ-ACK bits corresponding to each DAI of the (sub-)codebook for multi-PDSCH DCI in case of separate sub-codebooks (or for all DL DCIs in case of single codebook) depends on the maximum configured number of PDSCHs for multi-PDSCH DCI across serving cells belonging to the same PUCCH cell group.
		- The number of HARQ-ACK bits for multi-PDSCH DCI in case of separate sub-codebooks, or for all DL DCIs in case of single codebook, does not depend on the number of actually scheduled PDSCHs, rather, it is fixed as the maximum configured number of PDSCHs.
		- FFS: time domain bundling of HARQ-ACK feedback, as per agreement in RAN1#104-e
	+ Note that multi-PDSCH DCI refers to a DL DCI where at least one entry of the TDRA table allows scheduling more than one PDSCH

Conclusion: (RAN1#104bis-e)

The following is observed for alternative 2 from prior agreement.

* For Alt 2a (C-DAI/T-DAI is counted per PDSCH with a single codebook) of generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs,
	+ C-DAI/T-DAI in DL DCI: Bit-width can be increased (FFS: by how much), in DL DCI not only for multi-PDSCH DCI but also for single-PDSCH DCI for all serving cells including a serving cell not configured with multi-PDSCH DCI
	+ T-DAI in UL DCI: Bit-width can be increased (FFS: by how much), in UL DCI for all serving cells including a serving cell not configured with multi-PDSCH DCI
	+ C-DAI/T-DAI in DL DCI and T-DAI in UL DCI shall be designed such that at most 3 consecutive DCI missing can be resolved, same as in Rel-15/16 NR.
		- FFS: details on increment of DAI field size
		- FFS: whether/how to handle the case where different DCI formats (e.g., DCI format 1\_0 and DCI format 1\_1) have different field sizes for C-DAI/T-DAI
	+ HARQ-ACK codebook generation:
		- The number of HARQ-ACK bits depends on the number of scheduled PDSCHs.
		- FFS: ordering of the PDSCHs for DAI counting
		- FFS: time domain bundling of HARQ-ACK feedback, as per agreement in RAN1#104-e
	+ Note that multi-PDSCH DCI refers to a DL DCI where at least one entry of the TDRA table allows scheduling more than one PDSCH

Conclusion: (RAN1#104bis-e)

The following is observed for alternative 3 from prior agreement.

* For Alt 3 (C-DAI/T-DAI is counted per M scheduled PDSCH(s), where M is configurable) of generating type-2 HARQ-ACK codebook corresponding to DCI that can schedule multiple PDSCHs,
	+ If M equals to the maximum configured number of PDSCHs, Alt 3 is the same with Alt 1, if the same number of codebooks is assumed.
	+ Else if M equals to 1, Alt 3 is the same with Alt 2.
	+ Otherwise (i.e., 1<M<the maximum configured number of PDSCHs), Alt 3 is similar to Alt 2, except that
		- The number of HARQ-ACK bits corresponding to each DAI increases by M times.
		- NACK bits may be padded if the number of scheduled PDSCHs is not an integer multiple of M.
		- FFS: details on DAI field size
		- FFS: whether single codebook or separate sub-codebooks is(are) generated when multi-PDSCH DCI is configured for a serving cell
	+ In addition, new RRC parameter to configure M needs to be introduced.
	+ Note that multi-PDSCH DCI refers to a DL DCI where at least one entry of the TDRA table allows scheduling more than one PDSCH