**3GPP TSG RAN WG1 #112bis-e R1-23xxxxx**

**e-Meeting, April 17th – April 26th, 2023**

**Agenda item:** 9.17.14

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

**Title:** [draft] Summary #1 on UE features for eDSS

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 9.17.14 regarding UE features for eDSS and captures the following email discussion.

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| [112bis-e-R18-UE\_features-03] Email discussion on UE features for eDSS by April 26 – Shinya (DOCOMO)* Check points: April 21, April 26
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According to the initial UE features list from rapporteur [1], there are following feature groups for eDSS.

* FGs for NR PDCCH reception in symbols with LTE CRS REs
	+ 52-1 Reception of NR PDCCH candidates overlapping with LTE CRS Res
	+ 52-3 FFS: Support reception of NR PDCCH candidates overlapping with LTE CRS REs when two LTE-CRS overlapping rate matching patterns are configured
* FGs for UE support for two overlapping CRS rate matching patterns
	+ 52-2 Two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz overlapping with a LTE carrier (regardless of support or configuration of multi-TRP)

Similar to Rel-17, the first priority is to stabilize the signaling structure so that RAN2 can start their work. To this end, in this RAN1 meeting, we focus on the FG structure to have common understanding among companies on how to split the WID into FGs and how to group components/features into rows, while controversial contents can be kept as FFS or […]. Other issues, such as reporting type, can be discussed in future meetings.

# **FGs for NR PDCCH reception in symbols with LTE CRS REs**

In [1], FGs for NR PDCCH reception in symbols with LTE CRS REs are captured as below.

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 52. NR\_DSS\_enh | 52-1 | Reception of NR PDCCH candidates overlapping with LTE CRS REs | Reception of NR PDCCH candidates that overlap with LTE CRS REs within a NR carrier using 15 kHz SCS1) Reception of NR PDCCH candidates in REs that overlap with LTE CRS when UE is provided with LTE CRS RM pattern(s) by configuration of one CRS rate matching pattern or multiple non-overlapping CRS rate matching patterns2) PDCCH-DMRS channel estimation Value 1: PDCCH-DMRS channel estimation based on legacy CE assumptionValue 2: for CORESET duration greater than 1 symbol, PDCCH-DMRS channel estimation based on PDCCH-DMRS REs in symbols not overlapping with LTE CRSOther values FFS3) Symbols in which reception of NR PDCCH candidates that overlap with LTE CRS REs is supportedValue 1: 2nd OFDM symbol (s1)Other values FFS | 5-28, 14-1 (only for case of multiple non-overlapping CRS RM patterns) | Yes | N/A | UE not required to support reception of NR PDCCH candidates overlapping with LTE CRS REs when it is provided with LTE CRS RM pattern(s) by higher layers  | [Per Band] | No | No | N/A | Component 2 candidate value set: {Value 1, Value2, other values FFS}Component 3 candiddate value set: {Value 1, other values FFS}[Note: From UE perspective, PDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15] [Note: For component 2, RAN1 consider support legacy CE only if no RAN4 performance requirements are defined for this option] |  |
| 52. NR\_DSS\_enh | 52-3 | FFS: Support reception of NR PDCCH candidates overlapping with LTE CRS REs when two LTE-CRS overlapping rate matching patterns are configured |  | 52-1, at least one of 52-2 or 14-1a | Yes | N/A |  | [Per Band] | No  | No  | N/A |  |  |

Following inputs are provided in contributions for the RAN1#112bis-e meeting.

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| [2] | vivo | As usual, UE capability is needed to help NW identify whether UE supports R18 DSS, as well as the supported CE options for R18 DSS. The following proposal [2] was discussed in the previous meeting.

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| Proposal-2: Introduce UE capability (or capabilities) to indicate supported channel estimation for the reception of NR PDCCH candidates that overlap with LTE CRS REs* details to be discussed during UE capability discussions (e.g. CE on all PDCCH-DMRS symbols, CE on clean symbol(s) PDCCH-DMRS only)
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As RAN4 has so far not verified any additional requirements for legacy CE (RAN4 work is scheduled to start in Q4), RAN1 can discuss whether separate capabilities or a single capability with multiple candidate CE option is required to indicate the following cases:* option1. Support CE on all PDCCH-DMRS symbols
* option2. Support CE on clean symbol(s) PDCCH-DMRS only
* option3. option1 and option2

If RAN1 does not consider legacy CE, at least option2 should be supported. However, if the capability only includes option2, and RAN4 subsequently determines that option1 can be supported without additional requirements in Q4, the UE feature signaling would need to be revised. To address this, one possible solution is to allow a set of candidate values for the supported PDCCH-DMRS channel estimation in the reported UE capability. Additionally, according to the previous simulation results, the PDCCH performance not only depends on the receiver type and CE, but also relies on the ratio of PSD ratio of CRS and PDCCH. When the PSD ratio of CRS and PDCCH is 1:1, the PDCCH performance of legacy receivers (i.e., legacy PDCCH decoding+legacy CE) deteriorates significantly compared with R17, thus CE based on clean symbol(s) PDCCH-DMRS only is preferred in this case. However, when the CRS PSD is relatively low, legacy receivers may have better performance. Thus, UE may need to support ‘both’ CE options so that NW can further indicate which to be used according to its deployment. The following design can be considered.**Proposal 1. Regarding UE capability(s) for PDCCH reception on CRS symbol(s), RAN1 adopts the following FG:** **- FG: Indicate the support of NR PDCCH reception in symbols with LTE CRS REs, and the supported CE mechanism(s) (e.g., including CE on all PDCCH-DMRS symbols, CE on the clean symbol(s) PDCCH-DMRS only, both).**

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| Feature group | Components | Prerequisite FG | Field name in TS 38.331 | Parent IE | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Note | Mandatory/Optional |
| NR PDCCH reception in symbols with LTE CRS REs | 1. support NR PDCCH reception in symbols with LTE CRS REs | 5-28 (Rate-matching around LTE CRS) | *pdcchReceptionOnCRS-r18* | *BandNR* | n/a | n/a (FR1 only) | Component 1:{‘channel estimation on clean symbol(s) PDCCH-DMRS only’, ‘Legacy channel estimation: channel estimation on all PDCCH-DMRS symbols’, ‘both’}Note: ‘channel estimation on all PDCCH-DMRS symbols’ is legacy CE assumption, and shall not require any new performance requirement. | Optional with capability signaling |

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| [3] | OPPO | First of all, it is already agreed in RAN1 #110 that the Rel-18 support of PDCCH monitoring in overlapping with LTE CRS is dependent on UE capability and is applicable for SCS=15kHz only. Further, according to the current TS38.822, the most of UE features relating to NR behaviors in presence of LTE CRS and relating to Rel-16 DSS are “optional with UE capability signaling”. Therefore, the following proposals look straightforward. ***Proposal 1: A new FG is defined for Rel-18 support of PDCCH monitoring in overlapping with LTE CRS.*** * ***The new FG is optional with UE capability signaling.***
* ***The new FG is for FR1 only, with a note to further clarify as being applicable to 15kHz SCS only.***
* ***The new FG does not differentiate between FDD and FDD.***

Although the new FG can have FG3-1 (Basic DL control channel) as a prerequisite FG, which includes capability for *precoderGranularity=sameAsREG-bundle*, it may or may not require FG3-7 (Precoder-granularity of CORESET size) as a prerequisite which targets the capability on *precoderGranularity=allContiguousRBs*. The different prerequisites may drive two separate instances of new FG in Proposal 1. As for the FG components inside the above new FG, one of the key components should be able to differentiate whether the “clean symbol” is to be identified and used in the PDCCH reception, especially the channel estimation based on PDCCH DMRS. The RAN1 agreement in the WI phase mentions two types of channel estimation:

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| *Following options can be used for PDCCH-DMRS channel estimation** *legacy CE assumption*
	+ *RAN1 consider support this, if no RAN4 performance requirements are defined*
* *CE on clean symbol(s) only (this channel estimation option does not apply for 1 symbol CORESET)*

*Note: Restriction on the symbols and/or LTE CRS patterns applicable for above agreements can be considered during UE capability session.* |

 Our understanding for the above agreement includes: * The legacy CE assumption does not need to identify “clean symbol”, while the clean-symbol-dependent CE does.
* From viewpoints of UE implementation and specification, the legacy CE and the clean-symbol-dependent CE are not mutually exclusive to each other, i.e., UE hardware is not prevented from supporting both.
* Theoretically the legacy CE and the clean-symbol-dependent CE are just two typical implementation examples for channel estimation. The specification should not assume there can be only these two implementation possibilities. Meanwhile, there is no standardized rule to tell whether a PDCCH reception step, e.g., channel phase adjustment/compensation due to suspicious DMRS RE, should be classified as a step inside channel estimation or not. It is also pointless for the specification to try to enumerate all the potential ways for UE to perform channel estimation.

The above reasoning leads to a logic that the FG components should not be made CE-specific, but should translate the “clean symbol” requirement to a general condition for PDCCH reception. In summary, we have the following proposal. ***Proposal 2: The new FG in Proposal 1 has two FG instances in the UE feature list:**** ***The 1st FG instance has FG3-1 as prerequisite FG, and contains following FG components.***
	+ ***Support of reception of a PDCCH candidate having a DMRS RE overlapping with LTE CRS RE, with assumption by UE that the RE overlapping between the PDCCH candidate and LTE CRS did not occur.***
	+ ***Support of reception of a PDCCH candidate having a DMRS RE overlapping with LTE CRS RE, by requiring the existence of at least one OFDM symbol, in which at least one PDCCH DMRS RE associated with the PDCCH candidate presents but none of them overlaps with any configured LTE CRS RE.***
* ***The 2nd FG instance has FG3-1 and FG3-7 as prerequisite FGs, and contains following FG components.***
	+ ***Support of reception of PDCCH in a CORESET that has a DMRS RE overlapping with LTE CRS RE, with assumption by UE that the RE overlapping between the CORESET RE and LTE CRS RE did not occur.***
	+ ***Support of reception of PDCCH in a CORESET that has a DMRS RE overlapping with LTE CRS RE, by requiring the existence of at least one OFDM symbol, in which at least one PDCCH DMRS RE associated with the CORESET presents but none of them overlaps with any configured LTE CRS RE.***

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| Feature group | Components | Prerequisite feature groups | Need of FDD / TDD differentiation | Need of FR1 / FR2 differentiation | Note | Mandatory / Optional |
| [PDCCH\_CRS\_FG1] | 1. Support of reception of a PDCCH candidate having a DMRS RE overlapping with LTE CRS RE, with assumption by UE that the RE overlapping between the PDCCH candidate and LTE CRS did not occur.
2. Support of reception of a PDCCH candidate having a DMRS RE overlapping with LTE CRS RE, by requiring the existence of at least one OFDM symbol, in which at least one PDCCH DMRS RE associated with the PDCCH candidate presents but none of them overlaps with any configured LTE CRS RE.
 | 3-1 | No | FR1 only | For DSSApply to SCS=15kHz only | Optional with capability signalling |
| [PDCCH\_CRS\_FG2] | 1. Support of reception of PDCCH in a CORESET that has a DMRS RE overlapping with LTE CRS RE, with assumption by UE that the RE overlapping between the CORESET RE and LTE CRS RE did not occur.
2. Support of reception of PDCCH in a CORESET that has a DMRS RE overlapping with LTE CRS RE, by requiring the existence of at least one OFDM symbol, in which at least one PDCCH DMRS RE associated with the CORESET presents but none of them overlaps with any configured LTE CRS RE.
 | 3-1, 3-7 | No | FR1 only | For DSSApply to SCS=15kHz only | Optional with capability signalling |

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| [4] | Spreadtrum | In RAN1#110 meeting [1], the following agreements were reached for support NR PDCCH reception in symbols with LTE CRS REs [2].

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| AgreementIf the feature “Reception of NR PDCCH candidates that overlap with LTE CRS REs “is supported, it is RAN1 understanding that the feature is supported by UE performing channel estimation with a regular legacy DMRS pattern in frequency dimension, i.e., no change to UE assumption on PDCCH DMRS RE positions/pattern in a symbol that are used for the purpose of channel estimation.AgreementReception of NR PDCCH candidates that overlap with LTE CRS REs is supported by Rel18 UEsPDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side.Note: depends on UE capability Following options can be used for PDCCH-DMRS channel estimation* legacy CE assumption
	+ RAN1 consider support this, if no RAN4 performance requirements are defined
* CE on clean symbol(s) only (this channel estimation option does not apply for 1 symbol CORESET)

Note: Restriction on the symbols and/or LTE CRS patterns applicable for above agreements can be considered during UE capability session.ConclusionRAN1 understands above agreements applies to 15kHz SCS only. |

FG X-1 can be a basic feature group to indicate the support of “reception of NR PDCCH candidates that overlap with LTE CRS REs”. It includes a set of capability components, including restriction on symbols, applicable search space, and applicable LTE CRS patterns, etc. FG 5-28 (Rate-matching around LTE CRS) and FG 3-1(Basic DL control channel) should be the prerequisite feature groups of this feature. According to agreement in RAN1#110-e meeting, it is RAN1 understanding that the feature is supported by UE performing channel estimation with a regular legacy DMRS pattern in frequency dimension. In addition, PDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side. There are two options can be used for PDCCH-DMRS channel estimation: legacy CE assumption, CE on clean symbol(s) only. These should be considered components of UE feature.There is no conclusion about symbol restriction about this feature. It is not clear whether or not NR PDCCH can extend to symbol#0. RAN1 never evaluated the overlapped symbol on Symbol#0 and this case should be excuded. Otherwise, the PDCCH decoding performance will deteriorate. Another issue is whether additional restriction is needed, e.g., the feature is for NR PDCCH overlapping with LTE CRS within the first 3 symbols only, or can be any symbol contains LTE CRS in a slot. We think the former can be supported.For the restriction on LTE CRS pattern lists, if two CRS patterns overlapping in frequency can be configured to puncture NR PDCCH, it will have a great impact on decoding performance. Thus, we think only one LTE CRS pattern is applicable to NR PDCCH candidate. For the CSS such as Type 0/0A/1/2, it is typically cell specific and they might be shared by a group of UEs such as UE is before RRC connection setup. Thus, it is not feasible to do LTE CRS puncture NR PDCCH associated with Type 0/0A/1/2 CSS. Thus, NR PDCCH in Type 0/0A/1/2 CSS should be transmitted using legacy PDCCH/CORESET on non-LTE CRS symbol(s).Given the agreement in RAN1#110b-e clearly states that “Reception of NR PDCCH candidates that overlap with LTE CRS REs” applies to 15kHz SCS only, this should be reflected in UE feature framework. Thus, the feature should be based on the granularity of per band. The FR1/FR2 differentiation of the eDSS feature list should be “yes”. Regarding the “Mandatory/Optional” for the feature of NR PDCCH reception in symbols with LTE CRS REs, it is suggested to be “Optional with capability signalling”. Based on the discussion and analysis above, the feature “NR PDCCH reception in symbols with LTE CRS REs” may contain the following components: 1. UE performing channel estimation with a regular legacy DMRS pattern in frequency dimension
2. PDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side
3. PDCCH-DMRS channel estimation methods: legacy CE assumption, CE on clean symbol(s) only
4. Symbol restriction: reception of NR PDCCH overlapped with LTE CRS Res on symbol#1
5. LTE CRS pattern lists restriction: only one LTE CRS pattern
6. Search space restrictions: PDCCH on USS
7. PDCCH monitoring occasion(s) is within the first 3 OFDM symbols

***Proposal 1. For the UE feature on eDSS, the following aspects should be considered**** + ***Prerequisite feature groups of X-1 include 5-28, 3-1***
	+ ***The granularity of the NR-PDCCH recepetion with LTE-CRS is per Band***
	+ ***“Need for FR1/FR2 differentiation” should be “Applicable to FR1 only”***
	+ ***“Mandatory/Optional” should be “Optional with capability signalling”***
	+ ***Consider following components***
* ***PDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side***
* ***UE performing channel estimation with a regular legacy DMRS pattern in frequency dimension***
* ***PDCCH-DMRS channel estimation methods: legacy CE assumption, CE on clean symbol(s) only***
* ***Symbol restriction: reception of NR PDCCH overlapped with LTE CRS REs on symbol#1***
* ***LTE CRS pattern lists restriction: only one LTE CRS pattern***
* ***Search space restrictions: PDCCH on USS***
* ***PDCCH monitoring occasion(s) is within the first 3 OFDM symbols***

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| eDSS | X-1 | Reception of NR PDCCH candidates that overlap with LTE CRS REs | Support of Reception of NR PDCCH candidates that overlap with LTE CRS REs1. UE performing channel estimation with a regular legacy DMRS pattern in frequency dimension
2. PDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side
3. PDCCH-DMRS channel estimation methods: legacy CE assumption, CE on clean symbol(s) only
4. Symbol restriction: reception of NR PDCCH overlapped with LTE CRS Res on symbol#1
5. LTE CRS pattern lists restriction: only one LTE CRS pattern
6. Search space restrictions: PDCCH on USS
7. PDCCH monitoring occasion(s) is within the first 3 OFDM symbols
 | 5-28, 3-1 | Yes | N/A | Reception of NR PDCCH candidates that overlap with LTE CRS REs is not supported | Per Band | No | Applicable to FR1 only | No |  | Optional with capability signalling |

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| [5] | ZTE | In RAN1#110 meeting, the following agreements were agreed for NR PDCCH reception for eDSS [1]. And 9 remaining issues have been discussed in RAN1#110bis-e without any consensus reached [2].

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| **Agreement**Reception of NR PDCCH candidates that overlap with LTE CRS REs is supported by Rel18 UEsPDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side.Note: depends on UE capability Following options can be used for PDCCH-DMRS channel estimation* legacy CE assumption
	+ RAN1 consider support this, if no RAN4 performance requirements are defined
* CE on clean symbol(s) only (this channel estimation option does not apply for 1 symbol CORESET)

Note: Restriction on the symbols and/or LTE CRS patterns applicable for above agreements can be considered during UE capability session.ConclusionRAN1 understands above agreements applies to 15kHz SCS only. |

Given there are still many aspects unclear for this topic, we provide our general views on the necessities of corresponding UE capabilities first. More details can be discussed later. * **Whether to introduce UE capability for supported CE methods**

In RAN1#110bis-e, whether/how to introduce UE capability for supported CE methods for the PDCCH reception in symbols with LTE CRS REs was discussed. The proposal is listed below as suggested by the moderator.

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| **Issue#** | **Description** |
| 4 | Introduce UE capability to indicate one or more supported channel estimation abilities for the reception of NR PDCCH candidates that overlap with LTE CRS REs• details to be discussed during UE capability discussions (e.g. CE on all PDCCH-DMRS symbols, CE on clean symbol(s) PDCCH-DMRS only) |

According to the agreement made in RAN1#110, legacy CE assumption can be supported if no RAN4 performance requirements are defined. Apparently, legacy CE does NOT require a new UE capability. Therefore, legacy CE should be a mandatory feature for a UE supporting Rel-18 DSS if no RAN4 performance requirements are defined. A UE can report whether it can support CE on clean symbols only. ***Observation 1:*** *Legacy CE should be a mandatory feature for a UE supporting Rel-18 DSS if no RAN4 performance requirements for legacy CE are defined.* In case RAN4 decides that new RAN4 performance requirements are needed for legacy CE, legacy CE assumption will not be considered in RAN1 according to RAN1 agreement. In such case, A UE can only support CE on clean symbols only, which should be a basic UE capability for Rel-18 DSS. ***Observation 2:*** *‘CE on clean symbols only’ should be a mandatory feature for a UE supporting Rel-18 DSS if RAN4 concludes that new RAN4 performance requirements are needed for legacy CE assumption.* With above, we have the following proposal.***Proposal 1:*** *A basic UE capability of reception of NR PDCCH candidates overlapped with LTE CRS REs is supported.** *If no RAN4 performance requirements are defined, legacy CE should be a mandatory feature for a UE supporting Rel-18 DSS, i.e., included in the basic UE FG, and a UE can additionally report whether it supports ‘CE on clean symbols only’.*
* *If RAN4 concludes that new RAN4 performance requirements are needed for legacy CE, ‘CE on clean symbols only’ should be a mandatory feature for a UE supporting Rel-18 DSS, i.e., included in the basic UE FG.*
* **Restriction on the symbols**

In RAN1#110bis-e, whether to limit the symbols supporting PDCCH reception in symbols with LTE CRS REs were discussed. Two options are listed below suggested by the moderator, while some companies prefer not to limit the symbols during the discussion.

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| **Issue#** | **Description** |
| 5 | Alt-1: Specify restrictions on certain symbols where reception of NR PDCCH overlapped with LTE CRS Res is not supported e.g. symbol#0Alt-2: Specify NW indication of location of LTE PDCCH |

The main reason to limit on symbol #0 is that worse performance is expected than that on other symbols. While such performance issue could be acceptable and leave to implementation, especially when there are only 4 additional REGs occupied on symbol#0 by PCFICH and PHICH duration is configured as extended. As a result, performance loss may be minor on symbol#0 compared with other symbols, i.e. symbol#2, #3. On the other hand, any enhancement for PDCCH reception overlapping with CRS on symbol #0 should be avoided. So, we may no need to explicitly impose such restrictions and therefore we have the following proposal.***Proposal 2****: No restriction on the symbols for reception of NR PDCCH candidates overlapped with LTE CRS REs is introduced.** **Whether to limit the number of LTE CRS patterns**

In RAN1#110bis-e, whether to limit the number of LTE CRS patterns or pattern lists for the PDCCH reception in symbols with LTE CRS REs were discussed. Two options are listed below suggested by the moderator, while some companies preferred to change ‘list’ to ‘pattern’ during the discussion.

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| **Issue#** | **Description** |
| 2 | Alt-1: Reception of NR PDCCH candidates overlapped with LTE CRS REs from only one configured LTE CRS pattern list is supportedAlt-2: Reception of NR PDCCH candidates overlapped with LTE CRS REs from either one or two configured LTE CRS pattern lists is supported |

In RAN1#110, PDCCH reception in symbols with LTE CRS REs is agreed, and UE support for two overlapping CRS rate matching patterns are also agreed with introducing two new RRC parameters *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18.*Further combining with current RRC signalling listed below for CRS rate matching pattern, the non-overlapping CRS rate matching patterns in one *LTE-CRS-PatternList* can be up to 3, and up to 2 *lte-CRS-PatternList* can be configured regardless of *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* configured or not. That is, a UE could be configured with up to 6 CRS rate matching patterns no matter in Rel-16 or Rel-18.

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| *lte-CRS-PatternList1-r16 SetupRelease { LTE-CRS-PatternList-r16 } OPTIONAL, -- Need M* *lte-CRS-PatternList2-r16 SetupRelease { LTE-CRS-PatternList-r16 } OPTIONAL, -- Need M* *LTE-CRS-PatternList-r16 ::= SEQUENCE (SIZE (1..maxLTE-CRS-Patterns-r16)) OF RateMatchPatternLTE-CRS**maxLTE-CRS-Patterns-r16 INTEGER ::= 3 -- Maximum number of additional LTE CRS rate matching patterns* |
| *lte-CRS-PatternList1* *A list of LTE CRS patterns around which the UE shall do rate matching for PDSCH. The LTE CRS patterns in this list shall be non-overlapping in frequency. The network does not configure this field and lte-CRS-ToMatchAround simultaneously.* |
| *lte-CRS-PatternList2* *A list of LTE CRS patterns around which the UE shall do rate matching for PDSCH scheduled with a DCI detected on a CORESET with CORESETPoolIndex configured with 1. This list is configured only if CORESETPoolIndex configured with 1. The first LTE CRS pattern in this list shall be fully overlapping in frequency with the first LTE CRS pattern in lte-CRS-PatternList1, The second LTE CRS pattern in this list shall be fully overlapping in frequency with the second LTE CRS pattern in lte-CRS-PatternList1, and so on. Network configures this field only if the field lte-CRS-ToMatchAround is not configured and there is at least one ControlResourceSet in one DL BWP of this serving cell with coresetPoolIndex set to 1.* |

Firstly, reception of NR PDCCH candidates that overlap with more than one non-overlapping LTE CRS rate matching patterns from one LTE CRS pattern list should be supported. Because the frequency resource of a CORESET could be overlapped with more than one non-overlapping LTE CRS rate matching patterns from one LTE CRS pattern list due to the larger bandwidth of NR than LTE. Secondly, for PDCCH reception in symbols with LTE CRS REs, whether to support it together with two overlapping CRS rate matching patterns from two LTE CRS pattern lists should be determined. It is preferred to support this due to the following reasons.* In current spec, a UE is not required to monitor the PDCCH candidate if at least one RE of a PDCCH candidate for the UE on the serving cell overlaps with at least one RE of *lte-CRS-ToMatchAround*, or of *LTE-CRS-PatternList*. And *LTE-CRS-PatternList* can be set by both *lte-CRS-PatternList1* and *lte-CRS-PatternList2*. As a result, if UE could monitor PDCCH candidate in symbols with LTE CRS REs in Rel-18, it is no need to further restrict only one LTE CRS pattern list which will lead to non-unified UE implementations.
* Even in the worst case, i.e., the REs indicated by both two overlapping lists (list 1&2 or list 3&4) are punctured for NR PDCCH, it may still potentially have better performance. Because there are still some non-punctured REs (i.e. 4 REs with one PRB in symbol with LTE CRS) can be used for NR PDCCH and a higher aggregation level can still be used by using two OFDM symbols with using the same frequency resources for NR PDCCH. Therefore, there is no need to preclude PDCCH reception in symbols with LTE CRS REs in this case.

***Proposal 3****: Reception of NR PDCCH candidates overlapped with LTE CRS REs from either one or two configured LTE CRS pattern lists is supported.* |
| [6] | Nokia, NSB | RAN1 has discussed over several meetings during the WI phase, whether the specifications should allow the possibility to configure the UE with a CORESET that does not have a “clean” symbol, i.e. there is no symbol that doesn’t overlap with LTE CRS. However, we do not see this as a UE capability differentiator per-se; it is clear that the all UEs have the ability to demodulate and decode a PDCCH, and this ability is still there even if the PDCCH is overlapping (fully or partially) with LTE CRS. Already with Rel-15 UEs can be configured with a CORESET that doesn’t have clean symbols as long as the UE is not aware of the presence of the LTE CRS in the system, in which case the UE would happily process the PDCCH candidate without ever bothering to worry about what the CRS REs are doing to the PDCCH channel estimate or demodulation performance. Making the UE aware of the LTE CRS presence should not eliminate this UEs ability of handling the fully CRS-overlapping CORESET.**Observation 1:** Legacy PDCCH CE is able to process PDCCH with all symbols overlapping with LTE CRS**Proposal 1:** Basic UE capability for PDCCH overlapping with LTE CRS supports CORESET configuration with all symbols overlapping with LTE CRS REsThe UE’s support for processing a PDCCH candidate that has REs overlapping with LTE CRS REs configured to the UE is obviously a new UE capability as the legacy UEs are expected to drop the PDCCH candidates that it knows overlap with LTE CRS. This regardless from the fact that the legacy UEs would possess the ability to process the PDCCH candidate, but due to unfortunate overspecification are supposed to drop such a candidate.Furthermore, as shown in [[R1-2206432](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206432.zip)] (Nokia, Nokia Shanghai Bell), the UE that optimizes its PDCCH demodulator/decoder may reach different performance than one that exploits the “legacy” PDCCH demodulator/decoder that doesn’t take the PDCCH/CRS collisions into account. Specifically, for a given receiver type, the gNB could avoid using or even configuring the PDCCH candidates that it knows have a very high SNR requirement or can be expected to fail no matter what the SNR when colliding with REs. In addition it would be useful for the UE could drop the PDCCH AL2 that are known to fail with very high probability and not count these PDCCH candidates in the PDCCH blind decodin budget.**Observation 2:** It is beneficial for the gNB to know to what the UE is capable of in terms of PDCCH processing when overlapping with LTE CRSDifferent UE capabilities helping the network to decide what to do with the colliding REs are:* Is the PDCCH channel estimator using the DMRS of the symbol with the LTE CRS REs
* Is the PDCCH channel estimator using the DMRS REs colliding with the LTE CRS REs
* Is the PDCCH decoder always puncturing the PDCCH REs colliding with the LTE CRS RE
* Is the PDCCH channel estimator and decoder able to leverage relative power difference information between the PDCCH and the LTE CRS REs

Knowing the above capabilities allows the gNB to decide what to do with the PDCCH/PDCCH DMRS REs that collide with the LTE CRS REs. These can be expressed as 4 separate capabilities as outlined in table 1:**Proposal 2:** Take the table 1 as the basis for UE capability discussion for the PDCCH overlapping with LTE CRSTable 1: Set of new Rel-18 UE capabilities for PDCCH overlapping LTE CRS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| FG | FG name | Components | Value range | Note |
| X-1 | Support for PDCCH monitoring on LTE CRS | The UE is capable of monitoring a PDCCH candidate that overlaps with LTE CRS RE(s) using all the PDCCH DMRS REs nominally present with the candidate | {Supported} | Basic capability for this feature. Can be supported with the PDCCH channel estimator as implemented in earlier releases. |
| X-2a | Optimized PDCCH CE for PDCCH overlapping with LTE CRS #1 | Support for ignoring the PDCCH DMRS REs colliding with LTE CRS | {Supported} | X-1 is a pre-requisite capability |
| X-2b | Optimized PDCCH CE for PDCCH overlapping with LTE CRS #2 | Support for ignoring the PDCCH DMRS REs of a symbol colliding with LTE CRS and base the PDCCH channel estimate on the symbol(s) with no overlap with LTE CRS, if at least one present | {Supported} | X-1 is a pre-requisite capability |
| X-3 | Optimized PDCCH decoding for PDCCH overlapping with LTE CRS | Support for ignoring the PDCCH REs colliding with LTE CRS | {Supported} | X-1 is a pre-requisite capability |
| X-4 | PDCCH to LTE CRS configuration | Support for PDCCH and PDCCH DMRS to LTE CRS power ratio configuration | {Supported} | X-1 is a pre-requisite capability |

 |
| [6] | Samsung | The baseline UE capability for DSS is whether a UE can receive a PDCCH candidate when REs used for the PDCCH candidate overlap with LTE CRS REs. At the most basic realization, the UE can operate by ignoring the presence of LTE CRS REs. It is noted that such operation can also be achieved for a Rel-15 UE by the network indicating 2 CRS ports (symbol 0), when there are actually 4 CRS ports (symbols 0 and 1), for example for a CORESET located in symbols 1 and 2. A problem with such approach is that PDSCH BLER will be affected, especially for QAM modulations. That problem can be avoided by eDSS as the pattern with 4 CRS ports can be indicated. The impact on PDCCH BLER is under the control of the network and can be addressed by a lower code rate for the DCI or even, at least in principle, by reducing LTE CRS power in affected REs or symbols of a PDCCH transmission. To improve PDCCH BLER with reduced requirements on network operation, a first UE capability is to receive/decode DCI formats by adjusting the LLRs for symbols in REs overlapping with LTE CRS REs (e.g. exclude those LLRs from use in decoding). Another UE capability is to do the same for channel estimation – adjust the weighting of DM-RS symbols in REs overlapping with LTE CRS REs (e.g. excluding those DM-RS symbols from use in channel estimation). To enable a simplified implementation for channel estimation that essentially re-uses the legacy channel estimator, another UE capability was agreed for a UE can perform channel estimation using only DM-RS REs in symbols where no DM-RS RE overlaps with LTE CRS RE. It is noted that PDCCH BLER based on channel estimation using DM-RS REs only in symbols where no DM-RS RE overlaps with LTE CRS RE will be worse than using all DM-RS REs except for those overlapping with CRS REs and, therefore, if a UE meets BLER requirements defined for the former channel estimator, the UE will meet those BLER requirements using the later channel estimator. Finally, the gNB needs to be aware of each UE capability in order to be able to determine link budget requirements for a DCI format detection with a desired BLER by the UE.  **Proposal 1: Consider the UE FGs in Table 1 for eDSS.** **Table 1: UE FGs for eDSS**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| N-1 | PDCCH monitoring on REs with LTE CRS | Support PDCCH reception on REs that overlap with LTE CRS REs  |  | Yes | Does not support PDCCH receptions in symbols with LTE CRS | Per UE  | No | N/A | N/A | Only in FR1, only for 15 kHz SCS  | Optional without capability signalling |
| N-2 | Optimized DCI format decoding | Support decoding without using DCI symbols in REs that overlap with LTE CRS REs | N-1 | Yes | Larger DCI BLER | Per UE | No | N/A | N/A |  | Optional with capability signalling |
| N-3-1 | Optimized channel estimation 1 | Support channel estimation without using DM-RS in REs that overlap with LTE CRS REs | N-1 | Yes | Larger DCI BLER | Per UE | No | N/A | N/A |  | Optional with capability signalling |
| N-3-2 | Optimized channel estimation 2 | Support channel estimation without using DM-RS in symbols where DM-RS REs overlap with LTE CRS REs | N-1 | Yes | Larger DCI BLER | Per UE | No | N/A | N/A |  | Optional with capability signalling |

 |
| [7] | MediaTek | In RAN1 #110 meeting, it has been agreed that reception of NR PDCCH candidates that overlap with LTE CRS REs is supported in Rel-18 and PDCCH candidates and PDCCH-DMRS RE mapping follow the same mapping as legacy, i.e., PDCCH are not rate-matched around LTE CRS. Furthermore, to resolve companies concern on the channel estimation complexity based on punctured PDCCH DMRS by LTE CRS, two channel estimation assumptions are supported for Rel-18 eDSS feature from RAN1 point of view, which are legacy channel estimation assumption and channel estimation on PDCCH symbols not overlapped with LTE CRS. In addition, legacy channel estimation is considered to be supported only if RAN4 provide no requirement for such case.Based on the current agreements, there can be two possible outcomes for legacy channel estimation assumption depending on RAN4 discussion. One outcome is RAN4 define no requirement for the case and the legacy channel estimation is considered for Rel-18 eDSS feature. The other outcome could be RAN4 define the associated requirement and whether legacy channel estimation can be configured needs further RAN1 discussion. To avoid pending feature design based on RAN4 discussion, we propose to consider channel estimation based on clean symbol should be assumed as baseline for Rel-18 eDSS feature. However, it is not typical to report UE capability on the channel estimation method and we suggest to reflect the channel estimation assumption by CORESET configuration. Proposal 1: For the support of reception of a NR PDCCH candidate that overlaps with LTE CRS REs, at least one PDCCH symbol of the NR PDCCH is not overlapped with LTE CRS |
| [8] | Apple | Regarding the NR PDCCH reception with colliding LTE CRS REs, the following agreements were reached in RAN1#110 meeting.

|  |
| --- |
| **Agreement**[2]Reception of NR PDCCH candidates that overlap with LTE CRS REs is supported by Rel18 UEsPDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side.Note: depends on UE capability Following options can be used for PDCCH-DMRS channel estimation* legacy CE assumption
	+ RAN1 consider support this, if no RAN4 performance requirements are defined
* CE on clean symbol(s) only (this channel estimation option does not apply for 1 symbol CORESET)
* Note: Restriction on the symbols and/or LTE CRS patterns applicable for above agreements can be considered during UE capability session.
 |

With the above agreements, whether it is allowed to receive the PDCCH in all LTE CRS symbols is to be discussed in UE capability session. For LTE, the PCFICH and PHICH are transmitted in symbol#0. Normally, PHICH duration is configured with one symbol, i.e., in symbol#0. So even if the PCFICH decoding is failure, the PHICH decoding is not impacted. Thus, if NR PDCCH is allowed to be configured in symbol #0, it would have negative impacts on PCFICH and PHICH detection. It’s not desirable to define a NR feature but impact LTE performance.**Proposal 1: eDSS capable UE doesn’t expect the NR PDCCH configured in symbol#0.** For the number of LTE CRS patterns overlapping with NR PDCCH, according to the WID, the objective is to investigate the performance gain of NR PDCCH punctured by LTE CRS. In the performance evaluation, only one LTE CRS pattern was considered. If NR PDDCH REs are punctured by two CRS pattern, only one-third of REs in the LTE CRS symbol are available for NR PDCCH transmission. It will result in a higher aggregation level for decoding the PDCCH correctly. In another word, the capacity gain of supporting two CRS patterns was not well justified. **Proposal 2: eDSS capable UE is not required to monitor PDCCH candidate with the REs overlapping with CRS REs from more than one LTE CRS pattern list.**Regarding the PDCCH DMRS channel estimation, two channel estimation methods are considered if PDCCH REs are punctured by LTE CRS REs. The legacy channel estimation assumption is that all the PDCCH DMRS REs are used for channel estimation, and this is the basic capability and mandatory feature for UE implementation. It’s not necessary to introduce it again for eDSS. For channel estimation on the clean symbol, it could be a new UE capability, which is depending on the UE implementation. The question is whether there are any scheduling impacts to gNB if this capability is reported by UE. gNB still can configure one symbol CORESET, as the legacy channel estimation will be applied in this case.**Proposal 3: No UE capability is defined for eDSS channel estimation.** |
| [9] | Qualcomm | RAN1 made following agreements:

|  |
| --- |
| AgreementIf the feature “Reception of NR PDCCH candidates that overlap with LTE CRS REs “is supported, it is RAN1 understanding that the feature is supported by UE performing channel estimation with a regular legacy DMRS pattern in frequency dimension, i.e., no change to UE assumption on PDCCH DMRS RE positions/pattern in a symbol that are used for the purpose of channel estimation.AgreementReception of NR PDCCH candidates that overlap with LTE CRS REs is supported by Rel18 UEsPDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side.Note: depends on UE capability Following options can be used for PDCCH-DMRS channel estimation* legacy CE assumption
	+ RAN1 consider support this, if no RAN4 performance requirements are defined
* CE on clean symbol(s) only (this channel estimation option does not apply for 1 symbol CORESET)

Note: Restriction on the symbols and/or LTE CRS patterns applicable for above agreements can be considered during UE capability session.ConclusionRAN1 understands above agreements applies to 15kHz SCS only. |

Since the legacy UEs that do not support NR-PDCCH reception overlapping LTE CRS REs, network should not configure Type-0/0A/2 CSS sets and Type-1 CSS set without dedicated configuration such that NR-PDCCH overlaps with LTE CRS REs. Therefore, we propose to limit the feature for USS set and Type-3 CSS set with dedicated configuration.**Proposal 1:*** NR PDCCH reception that overlaps with LTE CRS REs is limited to Type-1 CSS set with dedicated RRC configuration, Type-3 CSS set, and USS set

Regarding the restriction on the symbols and/or LTE CRS patterns applicable for the agreements, we have the following views.* For NR-PDSCH rate-matching around LTE-CRS REs, LTE-CRS pattern(s) or LTE-CRS pattern lists(s) can be configured using various parameters. For NR-PDCCH reception overlapping with LTE CRS REs, we assume no new parameter for indicating LTE-CRS pattern(s)/pattern list(s) is introduced, and the existing LTE-CRS pattern(s)/pattern list(s) parameters are re-used. The UE should be able to report which parameter(s) the UE can take into account for NR-PDCCH reception.
* In time-domain, NR-PDCCH reception overlapping with LTE-CRS REs should be limited to the first 3 (or 4) OFDM symbols. If a UE supports NR-PDCCH reception anywhere in a slot (e.g., FG3-2), the benefit of supporting NR-PDCCH reception overlapping with LTE CRS REs must be quite limited (or even be zero). The restriction can be part of UE features same as for FG3-1 and FG22-12.

**Proposal 2:*** UE should be able to indicate support for one or multiple of the following:
	+ R15 parameter for single LTE-CRS pattern (*lte-CRS-ToMatchAround*)
	+ R16 parameter for single LTE-CRS pattern list (*lte-CRS-PatternList1-r16*)
	+ R16 parameters for two overlapping LTE-CRS pattern lists for m-DCI m-TRP (*lte-CRS-PatternList1-r16 and lte-CRS-PatternList2-r16*) with two different values of *coresetPoolIndex*
	+ R18 parameters for two overlapping LTE-CRS pattern lists (*lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*) without two different values of *coresetPoolIndex*
	+ R18 parameters for two overlapping LTE-CRS pattern lists for m-DCI m-TRP (*lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*) with two different values of *coresetPoolIndex*
* Separate UE feature groups for NR PDCCH reception that overlaps with LTE CRS REs for:
	+ The first 3 OFDM symbols in a slot
	+ Within a single span of 3 consecutive OFDM symbols that is within the first 4 OFDM symbols in a slot (prerequisite: FG22-12)

A UE may support m-DCI m-TRP and maybe configured with CORESETs with different values of *coresetPoolIndex*. For PDSCH rate-matching, in this case the UE uses an LTE-CRS pattern list associated with the CORESET with a value of coresetPoolIndex. In other words, one of two LTE CRS rate-matching pattern lists is dynamically selected for PDSCH rate-matching. For NR-PDCCH reception with LTE CRS REs, the same rule can apply. More specifically, if a UE is configured with CORESETs with different *coresetPoolIndex*, for NR-PDCCH reception with a CORESET with one value of *coresetPoolIndex*, the UE assumes LTE-CRS pattern list associated with the *coresetPoolIndex* for NR-PDCCH reception. This should be clarified for the case where a UE is configured with CORESETs with different values of *coresetPoolIndex*, and *LTE-CRS-PatternList1-r16* and *LTE-CRS-PatternList2-r16*, or *LTE-CRS-PatternList3-r18* and *LTE-CRS-PatternList4-r18*.**Proposal 3:*** Clarify following:
	+ If a UE is not configured with two different values of *coresetPoolIndex* for CORESETs, the UE takes into account all the LTE-CRS patterns/pattern lists configured by RRC
	+ If a UE is configured with two different values of *coresetPoolIndex* for CORESETs, the UE takes into account LTE-CRS patterns/pattern lists configured by *lte-CRS-PatternList1-r16* or *lte-CRS-PatternList3-r18* for NR PDCCH reception in CORESET with *coresetPoolIndex* =0 and by *lte-CRS-PatternList2-r16* or *lte-CRS-PatternList4-r18* for NR PDCCH reception in CORESET with *coresetPoolIndex* = 1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| x. NR\_DSS\_enh | x-1 | NR PDCCH reception that overlaps with LTE CRS within the first 3 OFDM symbols of a slot | 1. Support of NR PDCCH reception that overlaps with LTE CRS REs configured by one or multiple LTE-CRS rate matching patterns from the following:
	* (1) lte-CRS-ToMatchAround
	* (2) lte-CRS-PatternList1-r16
	* (3) lte-CRS-PatternList1-r16 and lte-CRS-PatternList2-r16 with two values of coresetPoolIndex
	* (4) lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18
	* (5) lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18 with two values of coresetPoolIndex
2. NR PDCCH that overlaps with LTE CRS REs is in Type-1 CSS with dedicated RRC configuration, Type-3 CSS, and/or USS that are monitored within the first 3 OFDM symbols of a slot

Note: if a UE is not configured with two different values of coresetPoolIndex in ControlResourceSet, the UE takes into account all the LTE-CRS rate-matching patterns provided by either from (1) – (4) for NR PDCCH receptionNote: if a UE is configured with two different values of coresetPoolIndex in ControlResourceSet, the UE takes into account LTE-CRS rate-matching patterns provided by lte-CRS-PatternList1-r16 or lte-CRS-PatternList3-r18 for NR PDCCH reception in CORESET with coresetPoolIndex =0 and by lte-CRS-PatternList2-r16 or lte-CRS-PatternList4-r18 for NR PDCCH reception in CORESET with coresetPoolIndex = 1Following options can be used for PDCCH-DMRS channel estimation:* + Legacy CE assumption
	+ CE on clean symbol(s) only
 | 5-28 for (1)14-1 for (2)14-1a & 16-2a-5 for (3)x-3 for (4)x-4 for (5) |  |  |  | Per Band | n/a | FR1 only |  | For 15kHz only | Optional with capability signallingComponent 1: one or multiple from (1) – (5) |
|  | x-2 | NR PDCCH reception that overlaps with LTE CRS within a single span of 3 consecutive OFDM symbols that is within the first 4 OFDM symbols in a slot | 1. NR PDCCH that overlaps with LTE CRS REs is in Type-1 CSS with dedicated RRC configuration, Type-3 CSS, and/or USS that are monitored within a single span of 3 consective OFDM symbols that is within the first 4 OFDM symbols in a slot
 | x-1, 22-12 |  |  |  | Per UE |  | FR1 only |  | For 15kHz only |  |

 |
| [10] | DOCOMO | At the RAN1#110 meeting, following agreement regarding supported channel estimation (CE) scheme options was made.

|  |
| --- |
| **Agreement**Reception of NR PDCCH candidates that overlap with LTE CRS REs is supported by Rel18 UEsPDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side.Note: depends on UE capability Following options can be used for PDCCH-DMRS channel estimation* legacy CE assumption
	+ RAN1 consider support this, if no RAN4 performance requirements are defined
* CE on clean symbol(s) only (this channel estimation option does not apply for 1 symbol CORESET)

Note: Restriction on the symbols and/or LTE CRS patterns applicable for above agreements can be considered during UE capability session. |

At the RAN1#110bis-e meeting, it was discussed whether to introduce a UE capability to report supported CE schemes, but no agreement was reached [1]. As in the above agreement, there are two options for PDCCH-DMRS channel estimation, and one of them is same as legacy CE assumption/behaviour while another one is clearly new assumption/behaviour as UE performs CE on clean symbol(s) only even if PDCCH is also on symbol(s) with LTE CRS REs.Accordingly, possible gNB transmission schemes are followings.* puncturing DMRS REs overlapping with CRS (while no puncturing for PDCCH REs overlapping with CRS)
* superposition transmission of DMRS/PDCCH and CRS

In case that UE supports “legacy CE assumption” but does not support “CE on clean symbol(s) only”, gNB should apply “superposition transmission of DMRS/PDCCH and CRS”. Since the UE will perform legacy CE on both clean symbol(s) and non-clean symbol(s) where LTE CRS REs exist, “puncturing DMRS REs overlapping with CRS” will degrade the performance due to the lack of DMRS REs on non-clean symbol(s). On the other hand, if UE supports “CE on clean symbol(s) only”, gNB can apply either “puncturing DMRS REs overlapping with CRS” or “superposition transmission of DMRS/PDCCH and CRS” since anyway the UE in this case performs CE on clean symbol(s) only and above possible gNB transmission schemes (i.e., whether DMRS REs overlapping with CRS are transmitted or punctured) do not have any impact on the CE. However, in order to avoid unnecessary transmission, gNB may select “puncturing DMRS REs overlapping with CRS” instead of “superposition transmission of DMRS/PDCCH and CRS” if gNB is aware of the UE support for “CE on clean symbol(s) only”.Therefore, the UE capability reporting on the optional support of “CE on clean symbol(s) only” would be necessary. There seems no need to support any other feature as prerequisite for the support of “CE on clean symbol(s) only”. The reporting type can be per UE without any differentiation.**Proposal 1: Support UE capability reporting on the support of “CE on clean symbol(s) only”.*** **No prerequisite FG is necessary**
* **Reporting type is per UE without any differentiation**
* **Optional with capability signalling**
 |
| [11] | Ericsson | Following was agreed in RAN1#110:**Agreement**Reception of NR PDCCH candidates that overlap with LTE CRS REs is supported by Rel18 UEsPDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side.Note: depends on UE capability Following options can be used for PDCCH-DMRS channel estimation* legacy CE assumption
	+ RAN1 consider support this, if no RAN4 performance requirements are defined
* CE on clean symbol(s) only (this channel estimation option does not apply for 1 symbol CORESET)

Note: Restriction on the symbols and/or LTE CRS patterns applicable for above agreements can be considered during UE capability session.ConclusionRAN1 understands above agreements applies to 15kHz SCS only.AgreementIf the feature “Reception of NR PDCCH candidates that overlap with LTE CRS REs “is supported, it is RAN1 understanding that the feature is supported by UE performing channel estimation with a regular legacy DMRS pattern in frequency dimension, i.e., no change to UE assumption on PDCCH DMRS RE positions/pattern in a symbol that are used for the purpose of channel estimation.Some aspects related to UE capabilities were discussed in [110bis-e-R18-Others-01] email thread but no agreements/conclusions were made [1]. One aspect is restriction on symbols in which reception of NR PDCCH candidates that overlap with LTE CRS REs is supported. As discussed in [2] (and shown in Figure 2-1 below), supporting this feature in second OFDM symbol (s1) enables (2sym + 11sym) or (3sym+10sym) combination of (NR PDCCH symbols +NR PDSCH symbols). Therefore, the feature should be supported at least for s1. Among other candidates (s0, s4, s7, s8, s11), we see some benefit in supporting the feature also for s0 and s4 as they enable additional (LTE PDCCH+ NR PDCCH + NR PDSCH) combinations. These can be supported via additional capability indications.**Proposal 1*** A capability indication for UE support of reception of NR PDCCH candidates that overlap with LTE CRS REs in 2nd OFDM symbol (s1) of a slot should be supported.
* Separate capability indication for UE support in {s0,s1}, {s1,s4}, {s0,s1,s4} can be additionally supported.

**Figure 2-1 – Example configuration of LTE and NR transmissions on a DSS carrier with Rel18 Enhancement.**Another aspect discussed in [1] was restriction on Type 0/0A/1/2 CSS sets from being used with this feature. We do not see need to introduce such a restriction. Even from UE perspective, there is little/no impact to implementation if legacy CE is used. Even with clean symbol CE, if the UE can support the feature for USS there no additional complexity to support it for other SS sets as well. Two channel estimation (CE) options (‘legacy CE’ and ‘clean symbol based CE’) for supporting the feature were included in the agreement. In [2] we provided performance evaluations for different CORESET durations and channel estimation options and summary of results is included in Annex A for reference. Supporting the feature with 1-symbol CORESET and legacy CE provides the highest capacity gain among all the evaluated scenarios. Therefore, the feature should be supported at least for this combination. Typically, channel estimation is considered as UE receiver implementation aspect and is transparent to the specifications. However, the case of ‘clean symbol based CE’ can only be supported with 2-symbol or 3-symbol CORESET durations while the ‘legacy CE’ is applicable to all possible CORESET durations. Given this, if UEs that support only ‘clean symbol CE’ are to be supported, a capability indication to distinguish them from UEs supporting ‘legacy CE’ is required.**Proposal 2*** A capability indication for UE support of reception of NR PDCCH candidates that overlap with LTE CRS REs using ‘legacy channel estimation’ (and all possible CORESET durations) should be supported.
* If there are UEs that only support the ‘clean symbol CE’ channel estimation option, separate capability indication for this should be supported.

As also discussed in [3], if UE capability signalling is introduced such that a UE can indicate that it supports the feature with two channel estimation methods (‘legacy CE’ and ‘clean symbol CE’), then an RRC parameter would be needed to explicitly configure the UE to use one of the two supported channel estimation methods.On the applicable CRS patterns, the straightforward option is to support the feature for the case of non-overlapping CRS patterns (one pattern for case of Rel15 FG 5-28 and up to 3 non-overlapping patterns for case of Rel16 FG 14-1). Then support for the feature with overlapping CRS patterns (introduced in Rel16 or Rel18) can be considered separately. **Proposal 3*** A capability indication for UE support of reception of NR PDCCH candidates that overlap with LTE CRS REs using one or multiple non-overlapping CRS patterns should be supported.
* Separate capability indication for UE support with two overlapping CRS patterns can be additionally supported .
 |
| [12] | Huawei, HiSilicon | The related agreements and conclusions of previous meeting are as follows [1]:

|  |
| --- |
| RAN1#110 AgreementReception of NR PDCCH candidates that overlap with LTE CRS REs is supported by Rel18 UEsPDCCH candidates and PDCCH-DMRS RE mapping are based on that of R15 from UE side.Note: depends on UE capability Following options can be used for PDCCH-DMRS channel estimation* legacy CE assumption
	+ RAN1 consider support this, if no RAN4 performance requirements are defined
* CE on clean symbol(s) only (this channel estimation option does not apply for 1 symbol CORESET)

Note: Restriction on the symbols and/or LTE CRS patterns applicable for above agreements can be considered during UE capability session.RAN1#110 ConclusionRAN1 understands above agreements applies to 15kHz SCS only. |

Based on above agreements, we propose the following UE features. Table 1 UE feature for NR PDCCH reception in symbols with LTE CRS REs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | Consequence if the feature is not supported by the UE | Type(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC) | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| XX. NR\_DSS\_enh | XX-1 | NR PDCCH reception in symbols with LTE CRS REs | Support of NR PDCCH reception a PDCCH candidate overlaps with at least one RE of LTE CRS REs1. at least one symbol of the PDCCH candidate does not overlap with LTE CRS REs
2. the PDCCH candidate overlaps with LTE CRS REs from one configured LTE CRS pattern
3. the SCS of the PDCCH candidate is 15kHz
 |  | Yes | N/A |  | Per Band | N/A | FR1 only | N/A |  | Optional with capability signalling |

***Proposal 1: Introduce new UE features XX-1 in Table 1 for NR PDCCH reception in symbols with LTE CRS REs in Rel-18 eDSS.*** |

## **Discussion**

**Question 2-1a:**

* **Regarding component 1 of FG 52-1 and FG 52-3, companies are encouraged to provide views on whether to support the reception of NR PDCCH candidates in REs that overlap with LTE CRS when UE is provided with LTE CRS RM patterns by configuration of multiple non-overlapping CRS rate matching patterns, e.g., as a component of FG 52-1 or as a separate capability similar to FG 52-3.**
	+ As a component of FG 52-1: ZTE, E///
	+ As a separate capability: QC
	+ Not support: HW/HiSi?

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| Company | Comment |
| Moderator | Assuming that companies are generally fine to support at least one CRS rate matching pattern as a component of FG 52-1 |
| Qualcomm | Defining separate capabilities is feasible. For PDSCH rate-matching, a UE may indicate support of (1) FG5-28 only or (2) both FG5-28 and FG14-1. As part of FG14-1, a UE reports max no. of LTE-CRS patterns in total within a carrier and max no. of non-overlapping LTE-CRS patterns within a carrier. If there is no separate UE capabilities for PDCCH reception with single LTE CRS pattern and multiple non-overlapping LTE CRS patterns, a UE indicating support of (2) for PDSCH rate-matching cannot declare support of FG52-1 unless it supports and is tested for PDCCH reception with single LTE CRS pattern and multiple non-overlapping LTE CRS patterns.  |
| NTT DOCOMO | We think the case with multiple non-overlapping CRS rate matching patterns should be supported since it is possible scenario as NR could have wider bandwidth than LTE and the gain of this feature is same as in the case with one CRS rate matching pattern.If the case with multiple non-overlapping CRS rate matching patterns is supported, although our first preference is the proposal from ZTE and Ericsson i.e., support of the case for PDCCH reception in symbols with LTE-CRS is part of basic FG, we think Qualcomm proposal is reasonable that it may need to be up to separate UE capability as support of multiple non-overlapping CRS rate matching patterns for rate matching purpose (FG14-1) is optional feature. So, we can live with such approach as well. |
| OPPO | If the question is whether there can be multiple CRS RM patterns involving into the overlapping with NR PDCCH, we think the answer should be NO, because WI phase study mainly focused on overlapping with single LTE pattern at any time, and multiple CRS patterns overlapping with PDCCH would have various impacts to PDCCH data reception even if the number of clean symbols for DMRS does not change. On the other hand, if the question is whether there can be multiple CRS patterns being configured to UE but only one of the patterns is used to test overlapping with NR PDCCH, RAN1 did not have an agreement (about which specific configured CRS pattern to be used) in place to handle this case. So our overall view at current stage is “not to support”.  |
| ZTE | With similar reason as mentioned by DOCOMO, we support the case with multiple non-overlapping CRS rate matching patterns configured. For FG 14-1, the candidate reporting values for number of non-overlapping LTE CRS patterns is {1,2,3}. If separate UE capability is pursued, does that mean we need to define 3 separate UE capabilities for three different values respectively? In our view, a simpler way is to include it as a component of FG 52-1 with adding an FFS point in ‘Note’ column like ‘FFS whether to allow reporting different candidate values for component 1’.  |
| MediaTek | We have similar view with OPPO. In WI phase, we didn’t evaluate whether there is a gain when PDCCH candidates are overlapped with more than 1 LTE CRS pattern. Therefore, we don’t support the reception of NR PDCCH candidates in REs that overlap with more than 1 LTE CRS patterns when UE is provided with LTE CRS RM patterns by configuration of multiple non-overlapping CRS rate matching pattern. In our view, when a PDCCH candidate is overlapped with more than 1 LTE CRS pattern, UE should not perform PDCCH detection on such candidate.  |
| vivo | we don’t think support PDCCH reception in REs that are overlapped with Res from multiple CRS patterns (even for the case of multiple non-overlapping CRS RM patterns) should be Prerequisite for R18 DSS. These two features are not related to each other. Additional sub-FG (e.g., 52-1a) is needed if to support PDCCH reception on NR carrier overlapped with CRS REs from multiple LTE carriers. 52-1: 5-28~~, 14-1 (only for case of multiple non-overlapping CRS RM patterns)~~ 1) Reception of NR PDCCH candidates in REs that overlap with LTE CRS when UE is provided with LTE CRS RM pattern(s) by configuration of one CRS rate matching pattern ~~or multiple non-overlapping CRS rate matching patterns~~52-1a: 14-1 (only for case of multiple non-overlapping CRS RM patterns)1) Reception of NR PDCCH candidates in REs that overlap with LTE CRS when UE is provided with LTE CRS RM pattern(s) by configuration of one CRS rate matching pattern or multiple non-overlapping CRS rate matching patternswe are not convinced why FG 52-3 is necessary, the two features (PDCCH on CRS, two overlapping CRS Lists for PDSCH) are not relevant, and the performance would serious deteriorate when CORESET is overlapped with two overlapping CRS patterns. |
| Xiaomi | We share the similar view with ZTE that a note to indicate the number of supported non-overlapped LTE CRS patterns can be introduced.  |
| Spreadtrum | Only one LTE CRS pattern case had been evaluated by simulation while multiple patterns had never been evaluated by RAN1. We prefer to support Reception of NR PDCCH candidates in REs that overlap with LTE CRS when UE is provided with LTE CRS RM pattern(s) by configuration of only one CRS rate matching pattern. If majority support of multiple non-overlapping CRS rate matching patterns, we are open to discuss it. However, it should not be consider as Prerequisite feature and separate capabilities is necessary. |
| Nokia, NSB | It seems more appropriate to have component 1) as a separate capability, as it is an extra functionality that may or may not be supported by UEs supporting the basic functionality of this 52-1. Note, there is no component 1) in current description of 52-3, so it is unclear what the question regarding that part means exactly.  |
| Huawei/HiSi | Same view as OPPO, MediaTek, and vivo. As far as we know, no company submitted simulation results on the degradation of performance with two CRS patterns (which we believe mush be worse than one overlapping CRS patter). In addition, it has additional complexity of UE to receive the PDCCH with two puncturing patterns. Therefore, 14-1 should not be the assumed as the Prerequisite for 52-1. BTW, in our understanding, even 5-28 may not need to be the Prerequisite for 52-1 since 52-3 is relevant to PDCCH instead of PDSCH. But we can live with 5-28 as Prerequisite.UE is not expected to be configured with these two functionalities (14-1 and 52-1). |
| Qualcomm | @ DOCOMO: It is true that NR could have wider bandwidth than LTE, but this can still be supported by single LTE-CRS pattern. Therefore, this is independent issue from whether to mandate multiple non-overlapping LTE CRS patterns in FG52-1.Configuration of multiple non-overlapping LTE CRS patterns may require a UE to handle (1) 2-port CRS vs 4-port CRS in different frequency portion of a NR carrier, (2) different v-shift values in different frequency portion of a NR carrier, etc. We still think single LTE CRS pattern should be for basic feature and multiple non-overlapped LTE CRS patterns should be for advanced feature.@ OPPO, MTK, Huawei: Regarding whether the WI supports multiple LTE-CRS patterns, our understanding is multiple patterns should be supported (with separate capability). Otherwise, network cannot handle a UE supporting PDCCH reception with single LTE-CRS pattern and PDSCH rate-matching with multiple LTE-CRS patterns. RAN1 already agree to support configuring LTE-CRS-PatternList1, LTE-CRS-PatternList1 and LTE-CRS-PatternList2, LTE-CRS-PatternList3 and LTE-CRS-PatternList4. For these case, it is unclear which LTE-CRS pattern from the list(s) to use for PDCCH reception. |
| Ericsson1 | Reception of NR PDCCH candidates in REs that overlap with LTE CRS when UE is configured with multiple non-overlapping CRS rate matching patterns should be supported. We are OK with approach suggested by Qualcomm. |
| Apple | Our understanding of moderator’s question is whether support more than one RM pattern for non-overlapping CRS RM patterns in frequency domain. As discussed in the work item phase, only one RM pattern was investigated. Supporting more than one pattens would require additional handling from UE side and pre-condition is supporting FG14-1. In this sense, it could be better to have a separate capability for supporting multiple non-overlapping CRS RM patterns. |
| Moderator | Summary of companies’ view* + As a component of FG 52-1: ZTE (with candidate values {1,2,3}), E///, DCM, Xiaomi (with candidate values {1,2,3}),
	+ As a separate capability: QC. [DCM], vivo, SPRD, Nokia/NSB, [E///], Apple
	+ Not support: HW/HiSi, OPPO, MTK,

If the component of FG 52-1 has candidate values for the max supported number of non-overlapping CRS rate matching patterns {1,2,3} (i.e., possible to indicate one or multiple non-overlapping CRS rate matching pattern(s)), it is almost same as separate capability. Assuming this, following proposal is made**Proposal 2-1a:*** **Regarding component 1 of FG 52-1,**
	+ **Component 1 of FG 52-1 is revised to “Reception of NR PDCCH candidates in REs that overlap with LTE CRS when UE is provided with LTE CRS RM pattern~~(s)~~ by configuration of one CRS rate matching pattern ~~or multiple non-overlapping CRS rate matching patterns~~”**
	+ **Introduce a separate FG to indicate the support of reception of NR PDCCH candidates in REs that overlap with LTE CRS when UE is provided with LTE CRS RM patterns by configuration of multiple non-overlapping CRS rate matching patterns**
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**Question 2-1b:**

* **Regarding component 1 of FG 52-1 and FG 52-3, companies are encouraged to provide views on whether to support the reception of NR PDCCH candidates overlapping with LTE CRS REs when two LTE-CRS overlapping rate matching patterns are configured, e.g., as a component of FG 52-1 or as a separate FG 52-3.**
	+ As a component of FG 52-1: ZTE
	+ As a separate capability: E///, QC
	+ Not support: SPRD, Apple, HW/HiSi?

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| Company | Comment |
| Moderator | Assuming that companies are generally fine to support at least one CRS rate matching pattern as a component of FG 52-1 |
| Qualcomm | Defining separate UE capabilities is feasible. The reason is the same as our answer to Question 2-1a. |
| NTT DOCOMO | Different from the case with multiple non-overlapping CRS rate matching patterns in Question 2-1a, we think that whether to support PDCCH reception in symbols with LTE-CRS in case with two overlapping CRS rate matching patterns should be discussed with considering the gain of this feature in such case.We have no strong view on this case, but if this case is supported, it should be up to separate UE capability from the basic capability for PDCCH reception in symbols with LTE-CRS. |
| OPPO | Our view for Question 2-1a applies here as well.  |
| ZTE | Even more than one non-overlapping CRS patterns are configured, it expects there is still performance gain by allowing PDCCH reception on LTE-CRS symbols. Because there are still some non-punctured REs (i.e. 4 REs with one PRB in symbol with LTE CRS) can be used for NR PDCCH and a higher aggregation level can still be applied by using two OFDM symbols with using the same frequency resources for NR PDCCH.Similar as above, we prefer to include as a component of FG 52-1.  |
| MediaTek | Similar comment to our reply to Question 2-1b. |
| vivo | Not sure about the benefits of 52-3. the two features(PDCCH on CRS, two overlapping CRS Lists for PDSCH) are not relevant, and the PDCCH decoding performance would seriously deteriorate when the CORESET is overlapped with two overlapping CRS patterns in a same LTE carrier.  |
| Xiaomi | Support the content of FG 52-3. Besides, we do not think two overlapping CRS patterns always result in poor performance. Actually, the number of occupied REs according to the two LTE CRS patterns may be same as that of single LTE CRS pattern, e.g., 4-port CRS & 1-port CRS on symbol#1, as shown in following figure. For UEs to support FG 52-3, the performance can be guaranteed by gNB configuration. |
| Spreadtrum | There would be limited REs (i.e., 4 RE) besides LTE CRS if two CRS patterns overlapping in frequency can be configured to puncture NR PDCCH, which will have a great impact on NR PDCCH decoding performance. RAN1 never evaluated the two overlapping CRS pattern case and this case should be excluded. We don’t support PDCCH reception overlapping with LTE CRS REs when two LTE-CRS overlapping rate matching patterns are configured. |
| Nokia, NSB | We think a separate capability is needed, i.e. 52-3. |
| Huawei/HiSi | Same view as 2-1a. Besides the reasons we provide for 2-1a, in addition, from the motivation perspective, the two CRS patterns is applicable to cell edge UEs, which SNR is already deteriorated; why do we still pursue the capacity in that case?Therefore, 52-3 is not needed.@Xiaomi If one CRS pattern is fully overlapped with another, then gNB only needs to configure one CRS pattern? |
| Qualcomm | Multiple overlapping LTE CRS patterns creates a new pattern for NR-PDCCH puncturing. Therefore, handling of multiple overlapping LTE CRS patterns require separate FGs.For PDSCH rate-matching purpose, RAN1 agreed to introduce LTE-CRS-PatternList3 and LTE-CRS-PatternList4 in Rel-18. It does not make sense these parameters cannot be used for PDCCH reception for the other feature in the same WI. |
| Ericsson1 | OK to have as separate capability i.e., as in 52-3 |
| Apple | The eDSS work was almost finished in RAN1, it’s not appropriate to extend the work item scope at maintenance phase. FG52-3 is not needed.  |
| Moderator | Summary of companies’ view* + As a component of FG 52-1: ZTE
	+ As a separate capability: E///, QC, [DCM], Xiaomi, Nokia/NSB
	+ Not support: SPRD, Apple, HW/HiSi, OPPO, MTK, vivo

Given there is divergent view for the support of this capability, following question is made:**Question 2-1b-1:*** **Companies are encouraged to provide views on which option you have strong concern.**
	+ **Opt1: FG 52-3 is introduced as a separate FG from FG 52-1**
	+ **Opt2: FG 52-3 is removed (i.e., not support the case when two LTE-CRS overlapping rate matching patterns are configured)**
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**Question 2-2:**

* **Regarding component 2 of FG 52-1, companies are encouraged to provide views on whether/how to support PDCCH-DMRS channel estimation.**
	+ Opt.1: support of FG52-1 includes support of legacy CE: ZTE (if no new RAN4 requirement is necessary for legacy CE i.e., legacy CE is mandatory), Nokia, Samsung, DCM, E///
		- Opt.1-1: separately report whether CE on clean symbol only is supported or not: ZTE (if no new RAN4 requirement is necessary for legacy CE i.e., legacy CE is mandatory), Nokia, Samsung, DCM, E/// (if there is UE supporting only “clean symbol only”)
		- Opt.1-2: further separately report whether optimized CE scheme(s) is supported or not: Nokia, Samsung
		- Opt.1-3: further separately report whether UE supports PDCCH-CRS power ratio configuration: Nokia
	+ Opt.2: report (legacy CE) or (clean symbol only) or (both): vivo
	+ Opt.3: no need to report supported CE scheme(s): Apple, OPPO (expect at least one clean symbol is configured), QCM, HW/HiSi (expect at least one clean symbol is configured), MTK (expect at least one clean symbol is configured), SPRD?

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| Company | Comment |
| Qualcomm | With the current formulation of UE feature lists for Edss, we prefer not to report any information of supported CE scheme(s). More specifically, we think the component 2 can be deleted. |
| NTT DOCOMO | Although multiple companies have a concern on reporting supported CE scheme(s) as UE capability, there is a clear performance degradation if Gnb is not aware of UE’s supported CE schemes. If UE supporting the basic capability of this feature (FG52-1) will support both legacy CE and CE on clean symbols only, the capability reporting on CE schemes is not necessary and it is ok to remove the component 2. But if UE may or may not support the CE on clean symbols only (assuming no new RAN4 requirement is necessary for legacy CE and UE anyway supports legacy CE), we prefer to have a mechanism so that Gnb is aware of UE’s support of the CE on clean symbols only. |
| OPPO | Our view is: 1. Channel estimation should not be explicitly specified as parts of capability structure. What people think here for “Value 1”, “Value 2” and etc, if not being able to cover all CE implementations, would become limitations to the implementation. But RAN1 discussion is not designed to enumerate all implementations.
2. What “channel estimation based on legacy CE assumption” means is not clear, given there is no standardized “legacy CE assumption” in legacy implementations.
3. The signal structure of “Value 1, Value 2…” means UE implementation does not support both Value1 and Value2 at the same time. But what if the UE implementation could?

Our preference is Opt.3, to be more specific, to hide the CE requirements into the general reception capability for PDCCH. To clarify, we do not oppose the component differentiating the general PDCCH receptions (but not CE) by “clean symbol”.  |
| ZTE | Our preference is Opt.1. The default CE method supported by UE depends on RAN4 decision about the requirement of legacy CE, which then impacts the discussion on the separately reported CE methods if needed. Considering RAN1 may not be able to receive RAN4 decision in time, we are also ok to consider Opt.3.  |
| MediaTek | We also prefer not to report any CE schemes as UE capability explicitly. The discussion of legacy CE and CE on clean symbol comes from whether UE can have at least one PDCCH symbol not overlapped with LTE CRS. Therefore, we suggest to remove component 2 of FG52-1 and replace by “reception of a NR PDCCH candidate that overlaps with LTE CRS REs when at least one PDCCH symbol of the NR PDCCH is not overlapped with LTE CRS.”As for whether to introduce the option of all PDCCH symbols overlapped with LTE CRS or legacy CE option in UE feature, we have a general question: suppose we introduce option for legacy CE or allow all PDCCH symbols overlapped with LTE CRS, then what is the consequence if RAN4 specify requirement for such option? Based on agreement, then RAN1 will not considered support such scenario. If that’s the case, then RAN1 might update the UE feature list depending on RAN4 discussion?  |
| Vivo | For Component 2, candidate value set should include ‘both’According to previous discussing, the performance of PDCCH decoding depends on the receiver type and CE as well as the ratio of PSD of CRS and PDCCH. When the ratio is high, legacy receivers show significant deterioration in PDCCH performance, and CE based on clean symbol PDCCH-DMRS is preferred. However, when CRS PSD is low, legacy receivers may perform better. As UE has no idea of what the TX scheme would be like, UE may need to support both CE options, and NW further indicates which one to use based on its deployment. Option1-1 and option2 is clear, in option1-1, legacy CE is always supported and clean CE can be additionally supported. Option2 is the most flexible, and the supported Ces (legacy or clean symbol or both) can be separately indicated. Thus, either option1-1 supporting additionally reported ‘clean DMRS symbol based CE’ and option2 is ok for us.However, Option3 is not clear to us, if UE reports ‘expect at least one clean symbol is configured’, it is not clear whether it only supports ‘clean symbol only’ or both ‘clean symbol only’ and ‘legacy CE’. |
| Xiaomi | Option 2 is fine to us. To be specific, the legacy CE should be defined as there is no CE-related definition in current specification. In our understanding, the legacy CE means that the UE adopts DMRS on all the PDCCH symbols, i.e., including clean symbol and overlapping symbol with LTE CRS to perform CE. |
| Spreadtrum | We support Opt.3. There is no need to report supported CE scheme(s). From our perspective, legacy CE should be a default UE behaviour. If no new RAN4 performance requirements will be defined, it is strange to introduce different CE options as UE capability, which totally can be UE implementation as long as RAN4 performance requirements can be met. From the perspective of UE implementation, there is no difference between these two CE. No additional algorithm complexity are introduced in CE on clean symbol(s) only compared to legacy CE. So the two CE cannot be regarded as two capabilities. If no new RAN4 performance requirements is defined, there is no need to report the CE capability. UE can perform channel estimation based on legacy CE if there is no clean symbol. But it does not mean the UE cannot support CE on clean symbol only. UE can still support CE on clean symbol once clean symbols are available, which totally depends on the UE implementation. Even capability of CE on clean symbol only is reported, 1-symbol CORESET can also be configured because legacy CE can be applied in this case. Thus, whether or not to report CE capability has no impact on gNB scheduling. Thus, it is unreasonable to introduce CE capabilities when no new CE requirement is defined in RAN4. However, CE method can be indicated by gNB to achieve better PDCCH decoding performance. |
| Nokia, NSB | From network point of view it is important to have as much information as possible about what the UE is doing, as in practice UEs often behave better than minimum requirements in any case. Hence, we prefer separate capabilities as indicated by options Opt.1-1, 1-2, and 1-3 above. In addition, it is useful to have separate indication about what UE is doing for channel estimation and actual decoding operation. |
| Huawei/HiSi | As a clarification, we can live with Opt.1-1. But we have sympathy with MediaTek that the CE is UE implementation. “reception of a NR PDCCH candidate that overlaps with LTE CRS REs when at least one PDCCH symbol of the NR PDCCH is not overlapped with LTE CRS.” Is fine to us. Alternatively, “reception of NR PDCCH candidates that overlap with LTE CRS REs and includes at least one clean symbol, under which the CE is performed”. If the UE does not report the capability, how would gNB anticipate the PDCCH reception performance?For Opt1-2, Opt1-3, we do not have agreement on supporting them.For Opt2, whether the legacy receiver is supported or not depends on RAN4, so no need to discuss it now. |
| Ericsson1 | Agree with NTT Docomo comments and OK with Opt 1-1 in FL proposal (support of FG52-1 includes support of legacy CE + separately report whether CE on clean symbol only is supported or not)From our perspective, a capability indication for UE support of reception of NR PDCCH candidates that overlap with LTE CRS REs using ‘legacy channel estimation’ (i.e., possible CORESET durations) should be supported. If there are UEs that only support the ‘clean symbol CE’ channel estimation option, separate capability indication for this should be supported.  |
| Apple | Option 3 is preferred. which channel estimation scheme is used is the implementation issue. Reporting the channel estimation scheme doesn’t help gNB scheduling. So, we don’t see the necessity to report CE scheme. |
| Moderator | Summary of companies’ view* + Opt.1: support of FG52-1 includes support of legacy CE: ZTE (if no new RAN4 requirement is necessary for legacy CE i.e., legacy CE is mandatory), Nokia, Samsung, DCM, E///
		- Opt.1-1: separately report whether CE on clean symbol only is supported or not: ZTE (if no new RAN4 requirement is necessary for legacy CE i.e., legacy CE is mandatory), Nokia, Samsung, DCM, E/// (if there is UE supporting only “clean symbol only”), vivo, [HW/HiSi], E///
		- Opt.1-2: further separately report whether optimized CE scheme(s) is supported or not: Nokia, Samsung
		- Opt.1-3: further separately report whether UE supports PDCCH-CRS power ratio configuration: Nokia
	+ Opt.2: report (legacy CE) or (clean symbol only) or (both): vivo, Xiaomi
	+ Opt.3: no need to report supported CE scheme(s): Apple, OPPO (expect at least one clean symbol is configured), QCM, HW/HiSi (expect at least one clean symbol is configured), MTK (expect at least one clean symbol is configured), SPRD, [ZTE]

Given there is divergent view for the support of this capability, following question is made:**Question 2-2-1:*** **Companies are encouraged to provide views on which option you have strong concern.**
	+ **Opt1-1:**
		- **If no new RAN4 requirement is necessary for legacy CE,**
			* **support of FG 52-1 includes support of legacy CE**
			* **Introduce a separate capability to report whether CE on clean symbol only is supported or not**
		- **Otherwise, support of FG 52-1 includes CE on clean symbol only**
	+ **Opt3: Component 2 in FG 52-1 is deleted (i.e., no need to report supported CE scheme(s))**
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**Question 2-3:**

* **Regarding component 3 of FG 52-1, companies are encouraged to provide views on which symbols should be supported for the reception of NR PDCCH candidates that overlap with LTE CRS REs.**
	+ Support sumbol#0:
		- Yes: ZTE, E/// (as separate capability)
		- No: SPRD, Apple
	+ Limit to the first 3 OFDM symbols in a slot
		- Yes: SPRD, QC (as basic FG)
			* Separate FG within a single span of 3 consecutive OFDM symbols that is within the first 4 OFDM symbols in a slot (prerequisite: FG22-12) : QC
		- No: E///

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| Company | Comment |
| Qualcomm | We would like to make sure that PDCCH reception with LTE CRS pattern(s) is not impacted by MBSFN subframe configuration. It makes sense to limit the PDCCH reception with LTE CRS pattern(s) within the first 3 OFDM symbols in a slot. We are OK to have an optional capability for first 4 OFDM symbols (similar to FG22-12). |
| NTT DOCOMO | We have no strong view on the support of this feature for symbol#0.Regarding the limitation to first 3 OFDM symbols in a slot, we prefer to not have such limitation, and at least the case with 3 consecutive symbols within first 4 OFDM symbols in a slot should be supported in addition to the case with first 3 OFDM symbols in a slot (even as separate capability). |
| OPPO | No strong view on support of Symbol #0. For the limit of first 3 symbols, in our view, if either LTE CRS or NR PDCCH can be outside the first 3 symbols per slot, this WI task is not quite necessary. That limitation is the condition for this feature to be meaningful, so we support to have such limitation in capability structure.  |
| ZTE | Depending on the configuration on symbol#0 from LTE side, it could be still beneficial to support symbol#0, and we see no need to explicitly exclude this.  |
| MediaTek | For support of symbol #0, does it mean that NR PDCCH may also collide with LTE PHICH? If so, then we are not sure what is the benefit to support symbol#0 overlapping.For limit to the first 3 OFDM symbols in a slot, we support such restriction.  |
| vivo | Not sure about the benefits of supporting symbol#0 as symbol#0 is for LTE PDCCH and PHICH |
| Xiaomi | We share the similar view with vivo. Considering the coexistence of PHICH、PCFICH and LTE CRS, the available REs for PDCCH on symbol#0 may be very limited. |
| Spreadtrum | RAN1 never evaluated the overlapped symbol on Symbol#0 by simulation and this case should be excluded. Otherwise, the PDCCH decoding performance and LTE performance will be degraded if NR PDCCH extend to symbol#0 and symbol #1. We think NR PDCCH can be allowed to overlap with LTE CRS on symbol#1, but not allowed to symbol#0. Considering motivation of this WI is to improve the PDCCH capacity, so support reception PDCCH candidate overlapping LTE CRS pattern within the first 3 OFDM symbols is more in line with the motivation of the WI. In addition, we think reception of NR PDCCH candidates that overlapping with LTE CRS REs can only apply to USS. For USS, the monitoring occasion is within the first 3 OFDM symbols of a slot. |
| Nokia, NSB | We think it should be a separate capability.  |
| Huawei/HiSi | On sumbol#0: slightly prefer not to support.Limit to the first 3/4 OFDM symbols in a slot: Support. Otherwise it is tangled with other UE capabilities. |
| Ericsson1 | For overlap in symbol s1, at least below two cases should be supportedPrefer to have possibility for UEs to indicate support for symbol s0 and also s4 as separate capabilities. |
| Apple | For support synmbol#0, it’s better not to configure NR PDCCH on symbol#0 to avoid the impacts on LTE.For the limit to the first 3symobls, it seems this restriction is not necessary. NR PDCCH configuration is flexible. PDCCH configured with other than the first 3symbol could still get the benefits with this feature. |
| Moderator | Summary of companies’ view* + Support sumbol#0:
		- Yes: ZTE, E/// (as separate capability), Nokia/NSB? (as separate capability)
		- No: SPRD, Apple, MTK, vivo, Xiaomi, HW/HiSi
	+ Limit to the first 3 OFDM symbols in a slot
		- Yes: SPRD, QC (as basic FG), OPPO, MTK, HW/HiSi
			* Separate FG within a single span of 3 consecutive OFDM symbols that is within the first 4 OFDM symbols in a slot (prerequisite: FG22-12) : QC, DCM, Nokia/NSB?, HW/HiSi
		- No: E///

Based on the above, following proposal is made (Note that 2nd bullet can be refined based on the discussion in **Question 2-5**)**Proposal 2-3:*** **Component 3 in FG 52-1 is revised to “Symbols in which reception of NR PDCCH candidates that overlap with LTE CRS REs is supported ~~Value 1~~: 2nd OFDM symbol (s1) ~~Other values FFS~~”**
* **Add a component in FG 52-1: NR PDCCH that overlaps with LTE CRS REs is in [Type-1 CSS with dedicated RRC configuration, Type-3 CSS, and/or] USS that are monitored within the first 3 OFDM symbols of a slot**
* **Introduce a separate FG to indicate the support of NR PDCCH that overlaps with LTE CRS REs is in [Type-1 CSS with dedicated RRC configuration, Type-3 CSS, and/or] USS that are monitored within a single span of 3 consecutive OFDM symbols that is within the first 4 OFDM symbols in a slot**
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**Question 2-4:**

* **Companies are encouraged to provide views on whether to separate FG 52-1 by supported precoder granularity size (FG 3-1 or FG3-7).**
	+ Yes: OPPO

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| Company | Comment |
| Qualcomm | It is reasonable to have separate FG, if the precoder granularity of ‘*allContiguousRBs*’ is supported for PDCCH reception with LTE-CRS pattern(s). Current version of 38.211 CR from Editor seems excluding the CORESET with the precoder granularity of ‘*allConfiguousRBs*’ from the support of PDCCH reception with LTE CRS pattern(s), according to our reading. This should be discussed as well. |
| NTT DOCOMO | As this feature is about PDCCH reception, whether combination with existing optional capability related to PDCCH reception should be clarified.In addition, even if a certain combination is supported, it may be reported by combination of existing capability and basic capability for the Rel-18 eDSS PDCCH reception in symbols with LTE-CRS if the support of the existing capability in Rel-18 eDSS scenario and other existing scenarios does not need to be distinguished. We think precoder granularity size can be handled in such a way if the precoder granularity of ‘*allContiguousRBs*’ is supported for PDCCH reception in symbols with LTE-CRS. |
| OPPO | We said YES by assuming the precoder granularity of ‘*allContiguousRBs*’ is supported (given the RAN1 did not say no so far). We are open if the majority want to open the functionality discussion first.  |
| ZTE | Suggest to defer the discussion until a clear conclusion made for support of precoder granularity of ‘*allContiguousRBs*’.  |
| MediaTek | We also prefer to discuss the support of ‘*allContiguousRBs*’ first and discuss the available precoder granularity in UE feature discussion. |
| vivo | ok |
| Spreadtrum | We share same view as ZTE.  |
| Nokia, NSB | It is not clear why we would need a separate capability for this.  |
| Huawei/HiSi | Fine with it. |
| Ericsson1 | precoder granularity of ‘*allContiguousRBs*’ is not excluded by any agreements. Do not see need for separate capability indication for this.but OK to discuss further. |
| Moderator | Summary of companies’ view* + Yes: OPPO, QC (depend on CR), OPPO (depend on CR), vivo, HW/HiSi
	+ No: DCM, Nokia/NSB, E///
	+ Wait for the CR discussion: ZTE, MTK, SPRD

As suggested by some companies, it would be better to wait for the CR discussion on whether to support the precoder granularity of ‘*allConfiguousRBs*’. Come back after some progress is made there. |

**Question 2-5:**

* **Companies are encouraged to provide views on whether to limit the supported SS sets for FG 52-1.**
	+ Limit to Type-1 CSS set with dedicated RRC configuration, Type-3 CSS set, and USS set: QC
	+ Limit to USS set: SPRD

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| Company | Comment |
| Qualcomm | Yes. We are also fine with USS set only. |
| NTT DOCOMO | We agree that supported SS sets should be defined as for FG3-1, and it should be limited to dedicated configuration as Qualcomm proposed. |
| OPPO | We prefer USS set only.  |
| ZTE | Prefer QC’s proposal.  |
| MediaTek | Prefer to limit to USS set. |
| vivo | prefer USS set only.  |
| Xiaomi | We also prefer USS set only. |
| Spreadtrum | We support USS set only. |
| Nokia, NSB | We support the original Qualcomm proposal, i.e. limit to Type-1 CSS set with dedicated RRC configuration, Type-3 CSS set, and USS set. |
| Huawei/HiSi | USS set only is fine. |
| Ericsson1 | OK with Qualcomm proposal. |
| Apple | Either one is fine for us. |
| Moderator | Summary of companies’ view* + Limit to Type-1 CSS set with dedicated RRC configuration, Type-3 CSS set, and USS set: QC, DCM, ZTE, Nokia/NSB, E///
	+ Limit to USS set: SPRD, [QC], OPPO, MTK, vivo, Xiaomi, HW/HiSi,

All companies are fine with at least USS set. Further discuss following question.**Question 2-5-1:*** **Companies are encouraged to provide views on which option you have strong concern.**
	+ **Opt1: FG 52-1 is limited to Type-1 CSS set with dedicated RRC configuration, Type-3 CSS set, and USS set**
	+ **Opt2: FG 52-1 is limited to USS set**
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**Question 2-6:**

* **Companies are encouraged to provide views on whether to clarify following (proposed by Qualcomm) in AI 9.17.14.**
	+ If a UE is not configured with two different values of *coresetPoolIndex* for CORESETs, the UE takes into account all the LTE-CRS patterns/pattern lists configured by RRC
	+ If a UE is configured with two different values of *coresetPoolIndex* for CORESETs, the UE takes into account LTE-CRS patterns/pattern lists configured by *lte-CRS-PatternList1-r16* or *lte-CRS-PatternList3-r18* for NR PDCCH reception in CORESET with *coresetPoolIndex* =0 and by *lte-CRS-PatternList2-r16* or *lte-CRS-PatternList4-r18* for NR PDCCH reception in CORESET with *coresetPoolIndex* = 1

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| Company | Comment |
| Moderator | Unclear whether this should be discussed in maintenance agenda or here (i.e. spec impact) |
| Qualcomm | We are OK to capture either in UE feature or in spec. Important to make a common understanding. |
| NTT DOCOMO | As in our comment for Question 2-1b, we have no strong view on the support of the case with two overlapping CRS rate matching patterns (especially for the case where both patterns need to be considered and gain may be limited). But the proposal from Qualcomm looks reasonable clarification for that case (if supported) as well as for another case where one of the overlapping patterns needs to be considered. Regarding moderator’s question, we basically think that whether or not to support the cases should be discussed in maintenance agenda i.e., as part of discussion on CRs. |
| OPPO | In our understanding, 1. Question 2-6 seems dependable upon outcomes of Questions 2-1a/b.
2. What the sub-bullets provided are new functional behaviors, and should be discussed in maintenance.
 |
| ZTE | Ok to discuss in maintenance.  |
| vivo | the benefits of supporting reception of PDCCH overlapped with two overlapping CRS patterns are not justified. If two overlapping CRS Lists are not supported for PDCCH reception on CRS symbols, we don’t need to consider the above two bullets |
| Spreadtrum | Same commented as Question 2-2, we don’t support PDCCH reception overlapping with LTE CRS REs when two LTE-CRS overlapping rate matching patterns are configured.  |
| Nokia, NSB | This doesn’t seem to be a UE capability discussion, hence it needs to be coordinated with maintenance.  |
| Huawei/HiSi | We prefer not to support the co-existence with two CRS patterns, so let’s first have consensus on 2-1a/2-1b before handling this issue. |
| Ericsson1 | OK to clarify this after converging further on FG 52-3 discussion. |
| Apple | This can be discussed after the progress of whether supports two overlapped CRS RM patterns. |
| Moderator | As suggested by some companies, this should be discussed after some progress is made in Question 2-1a/2-1b. Come back after some progress is made there. |

# **FGs for UE support for two overlapping CRS rate matching patterns**

In [1], FGs for UE support for two overlapping CRS rate matching patterns are captured as below.

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 52. NR\_DSS\_enh | 52-2 | Two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz overlapping with a LTE carrier (regardless of support or configuration of multi-TRP) | Support of two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz overlapping with a LTE carrier (regardless of support or configuration of multi-TRP) | [14-1] | Yes | N/A | UE support for two overlapping LTE-CRS RM patterns within a part of NR carrier using 15 kHz overlapping with a LTE carrier when UE is not supporting or configured with multi-TRP is not enabled | [Per Band] | No  | No | N/A |  |  |

Following inputs are provided in contributions for the RAN1#112bis-e meeting.

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| [2] | vivo |

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| Working AssumptionIntroduce two new RRC parameters (i.e., list3 and list4). gNB **cannot** configure legacy list1/2 and new list3/4 simultaneously. If new list3/4 are configured, UE applies list3/4 regardless of whether CORESETPoolIndex= 1 is configured for any of DL BWPs of the serving cell.**Agreement** * Introduce new UE capability(ies) for support of two overlapping LTE CRS patterns in Rel-18 DSS ~~if the UE is NOT configured by higher layer parameter~~ *~~PDCCH-Config~~* ~~with two different values of~~ *~~coresetPoolIndex~~* ~~in~~ *~~ControlResourceSet~~.*
	+ NW can configure two LTE-CRS overlapping rate matching patterns without *coresetPoolIndex* only if the UE indicates support of the new capability(ies).
* Clarify that the Rel-16 UE capability *overlapRateMatchingEUTRA-CRS-r16* is subject to support of *multiDCI-Multi-TRP-r16*.
* Maximum number of LTE-CRS rate matching patterns for PDSCH supported by a UE (i.e., *maxNumberPatterns-r16* and *maxNumberNon-OverlapPatterns-r16*) is kept unchanged.

**Agreement*** + Introduce two new RRC parameters *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* in *ServingCellConfig* around which the UE shall do rate matching for PDSCH scheduled by PDCCH with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI, or PDSCHs with SPS.
		- The network does not configure *lte-CRS-PatternList3-r18* and any of *lte-CRS-ToMatchAround, lte-CRS-PatternList1-r16* and *lte-CRS-PatternList2-r16* simultaneously. *Lte-CRS-PatternList4-r18* is configured only if *lte-CRS-PatternList3-r18* is configured in *ServingCellConfig.*
		- For case when UE is not configured with two different values of *coresetPoolIndex* in *ControlResourceSet*, and configured with *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*, both *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applied
		- For case when UE is configured with two different values of *coresetPoolIndex* in *ControlResourceSet*, and configured with *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*
			* If UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, *lte-CRS-PatternList3-r18* is applied if the PDSCH is associated with c*oresetPoolIndex* set to ‘0’, and *lte-CRS-PatternList4-r18* is applied if the PDSCH is associated with c*oresetPoolIndex* set to ‘1’
			* Otherwise, both *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applied.
		- The legacy configuration rule in TS 38.331 is applied in Rel-18 DSS, i.e.,
			* “The first LTE CRS pattern in *lte-CRS-PatternList4* shall be fully overlapping in frequency with the first LTE CRS pattern in *lte-CRS-PatternList*3, The second LTE CRS pattern in this list shall be fully overlapping in frequency with the second LTE CRS pattern in lte-CRS-PatternList3, and so on.”

**Agreement** ***lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applicable to 15 kHz SCS PDSCH only.** |

Regarding the two overlapping CRS rate matching patterns, the above agreements are achieved. It can be seen that this feature is quite similar to per band reported feature *overlapRateMatchingEUTRA-CRS-r16* for MTRP. As such, this R18 feature can also be reported per-band basis. The following design can be considered.**Proposal 2. Regarding the two overlapping CRS rate matching patterns, introduce the following FG**:

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| Feature group | Components | Prerequisite FG | Field name in TS 38.331 | Parent IE | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Note | Mandatory/Optional |
| Two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz overlapping with a LTE carrier | Support of two LTE-CRS overlapping rate matching patterns provided by *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* within a part of NR carrier using 15 kHz SCS overlapping with a LTE carrier | 14-1  | *overlapRateMatchingEUTRA-CRS-r18* | *BandNR* | n/a | n/a (FR1 only) | For DSS:The number of the additional CRS rate matching patterns reported in Rel-18 is accounted in the total number of rate matching pattern reported by the UE for Rel-15 by using pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot and pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlotThe maximum number of LTE-CRS rate matching patterns for PDSCH supported by a UE (i.e., maxNumberPatterns-r16 and maxNumberNon-OverlapPatterns-r16) is kept unchanged. | Optional with capability signaling |

 |
| [3] | OPPO | Our understanding to the Rel-18 eDSS support of two CRS patterns for PDSCH reception includes:* The functionalities that can be done with CRS patterns {list1, list2} are also supported by CRS patterns {list3, list4}. As far as these functionalities are concerned, {list1, list2} and {list3, list4} are inter-changeable. So it is reasonable to create a new Rel-18 FG by cloning existing FG14-1a that was designed for {list1, list2}.
* Besides what can be commonly supported by {list1,list2} and {list3,list4}, {list3, list4} can additionally support the PDSCH rate matching around LTE CRS for the non-multi-TRP case, i.e., when “UE is not configured with two different values of coresetPoolIndex in ControlResourceSet”. Therefore, even though there is already a FG16-2a-5 for “Separate CRS rate matching” based on CORESETPoolIndex, this FG16-2a-5 cannot be directly used given it is intended for multi-TRP only due to its prerequisite relation to FG16-2a. Then the design choice for new FG is to copy the FG component-1 of FG16-2a-5 into the new Rel-18 FG.

***Proposal 3: The Rel-18 UE feature for supporting PDSCH reception in overlapping with two CRS patterns is cloned from existing FG14-1a, with one more component copied from component-1 in existing FG16-2a-5.***

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| Feature group | Components | Prerequisite feature groups | Need of FDD / TDD differentiation | Need of FR1 / FR2 differentiation | Note | Mandatory / Optional |
| [PDSCH\_CRS\_FG1] | 1. Support of two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz SCS overlapping with a LTE carrier.
2. Whether the UE can rate match around configured CRS patterns which is associated with CORESETPoolIndex (if configured) and are applied to the PDSCH scheduled with a DCI detected on a CORESET with the same value of CORESETPoolIndex.
 | 14-1 | No | FR1 only | For DSS The number of the additional CRS rate matching patterns reported in Rel-16 is accounted in the total number of rate matching pattern reported by the UE for Rel-15 by using pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot and pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot.Apply to SCS=15kHz only | Optional with capability signalling |

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| [4] | Spreadtrum | In RAN1#110 meeting [1], the following agreements were reached for support of two overlapping CRS patterns for Rel-18 DSS.

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| **Agreement** ***lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applicable to 15 kHz SCS PDSCH only.****Agreement****The following TP for sub-clause 5.1.4.2 of TS 38.214 h20 is endorsed in principle.** **5.1.4.2 PDSCH resource mapping with RE level granularity**<omitted text>A UE may be configured with any of the following higher layer parameters:*-* REs indicated by the '*RateMatchPatternLTE-CRS*'in *lte-CRS-ToMatchAround* in *ServingCellConfig* or *ServingCellConfigCommon* configuring cell-specific RS, in 15 kHz subcarrier spacing applicable only to 15 kHz subcarrier spacing PDSCH, of one LTE carrier in a serving cell are declared as not available for PDSCH. *-* REs indicated by *'RateMatchPatternLTE-CRS'* in *lte-CRS-PatternList1-r16* or *lte-CRS-PatternList3-r18* in *ServingCellConfig* configuring cell-specific RS, in 15 kHz subcarrier spacing applicable only to 15 kHz subcarrier spacing PDSCH, of one LTE carrier in a serving cell are declared as not available for PDSCH.- For the UE for broadcast reception, REs indicated by *'RateMatchPatternLTE-CRS'* in *PDSCH-Config-MCCH* or *PDSCH-Config-MCCH* configuring cell-specific RS, in 15 kHz subcarrier spacing applicable only to 15 kHz subcarrier spacing PDSCH, of one LTE carrier in a serving cell are declared as not available for PDSCH.- Each *RateMatchPatternLTE-CRS* configuration contains *v-Shift* consisting of LTE-CRS-vshift(s), *nrofCRS-Ports* consisting of LTE-CRS antenna ports 1, 2 or 4 ports, *carrierFreqDL* representing the offset in units of 15 kHz subcarriers from (reference) point A to the LTE carrier centre subcarrier location, *carrierBandwidthDL* representing the LTE carrier bandwidth, and may also configure *mbsfn-SubframeConfigList* representing MBSFN subframe configuration. A UE determines the CRS position within the slot according to Clause 6.10.1.2 in [15, TS 36.211], where slot corresponds to LTE subframe. - If the UE is configured by higher layer parameter *PDCCH-Config* with two different values of *coresetPoolIndex* in *ControlResourceSet* and is also configured by the higher layer parameter *lte-CRS-PatternList1-r16* and *lte-CRS-PatternList2-r16* in *ServingCellConfig*, the following REs are declared as not available for PDSCH:- if the UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, REs indicated by the CRS pattern(s) in *lte-CRS-PatternList1-r16* if the PDSCH is associated with *coresetPoolIndex* set to ‘0’, or the CRS pattern(s) in *lte-CRS-PatternList2-r16* if PDSCH is associated with *coresetPoolIndex* set to ‘1’;- otherwise, REs indicated by *lte-CRS-PatternList1-r16* and *lte-CRS-PatternList2-r16,* in *ServingCellConfig*.- If the UE is not configured by higher layer parameter PDCCH-Config with two different values of *coresetPoolIndex* in *ControlResourceSet*, and if the UE is configured by higher layer parameter *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* in *ServingCellConfig*, REs indicated by *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are declared as not available for PDSCH.- If the UE is configured by higher layer parameter *PDCCH-Config* with two different values of *coresetPoolIndex* in *ControlResourceSet* and is also configured by the higher layer parameter *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* in *ServingCellConfig*, the following REs are declared as not available for PDSCH:- if the UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, REs indicated by the CRS pattern(s) in *lte-CRS-PatternList3-r18* if the PDSCH is associated with *coresetPoolIndex* set to ‘0’, or the CRS pattern(s) in *lte-CRS-PatternList4-r18* if PDSCH is associated with *coresetPoolIndex* set to ‘1’;- otherwise, REs indicated by *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18,* in *ServingCellConfig*.<omitted text> |

FG X-2 can be a basic feature group to indicate the support of “support of two overlapping CRS patterns for Rel-18 DSS”. It includes a set of capability components, including support for two overlapping CRS rate matching patterns Rel-18 DSS and restriction on configuration of lte-CRS-PatternList3 andlte-CRS-PatternList3, etc. Prerequisite feature groups of X-2 should include 14-1 only.Accordign to the agreement in RAN1#110, lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18 are applicable to 15 kHz SCS PDSCH only. Thus, the granularity of feature should be per Band. “Need for FR1/FR2 differentiation” should be “Applicable to FR1 only”. “Mandatory/Optional” should be “Optional with capability signalling” in feature X-2.***Proposal 2. For the UE feature on support of two overlapping CRS patterns for Rel-18 DSS, the following aspects should be considered**** + ***Prerequisite feature groups of X-1 include 14-1***
	+ ***The granularity of the support of two overlapping CRS patterns for Rel-18 DSS is per Band***
	+ ***“Need for FR1/FR2 differentiation” should be “Applicable to FR1 only”***
	+ ***“Mandatory/Optional” should be “Optional with capability signalling”***
	+ ***Consider following components***
* ***Support for two overlapping CRS rate matching patterns***
* ***Not configure lte-CRS-PatternList3 and lte-CRS-ToMatchAround, or this field and lte-CRS-PatternList1, or this field and lte-CRS-PatternList2 simultaneously.***
* ***Configure lte-CRS-PatternList4 only if the field lte-CRS-ToMatchAround is not configured and the field lte-CRS-PatternList3 is configured***
* ***The first LTE CRS pattern in lte-CRS-PatternList4 shall be fully overlapping in frequency with the first LTE CRS pattern in lte-CRS-PatternList3. The second LTE CRS pattern in this list shall be fully overlapping in frequency with the second LTE CRS pattern in lte-CRS-PatternList3, and so on***
* ***If the UE is not configured by higher layer parameter PDCCH-Config with two different values of coresetPoolIndex in ControlResourceSet, and if the UE is configured by higher layer parameter lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18 in ServingCellConfig, REs indicated by lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18 are declared as not available for PDSCH.***
* ***If the UE is configured by higher layer parameter PDCCH-Config with two different values of coresetPoolIndex in ControlResourceSet and is also configured by the higher layer parameter lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18 in ServingCellConfig, the following REs are declared as not available for PDSCH:***

***- if the UE is configured with crs-RateMatch-PerCoresetPoolIndex, REs indicated by the CRS pattern(s) in lte-CRS-PatternList3-r18 if the PDSCH is associated with coresetPoolIndex set to ‘0’, or the CRS pattern(s) in lte-CRS-PatternList4-r18 if PDSCH is associated with coresetPoolIndex set to ‘1’;******- otherwise, REs indicated by lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18, in ServingCellConfig.***

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| eDSS | X-2 | Two overlapping LTE-CRS rate matching patterns | 1. Support for two overlapping CRS rate matching patterns
2. Not configure lte-CRS-PatternList3 and lte-CRS-ToMatchAround, or this field and lte-CRS-PatternList1, or this field and lte-CRS-PatternList2 simultaneously
3. Configure lte-CRS-PatternList4 only if the field lte-CRS-ToMatchAround is not configured and the field lte-CRS-PatternList3 is configured
4. The first LTE CRS pattern in lte-CRS-PatternList4 shall be fully overlapping in frequency with the first LTE CRS pattern in lte-CRS-PatternList3. The second LTE CRS pattern in this list shall be fully overlapping in frequency with the second LTE CRS pattern in lte-CRS-PatternList3, and so on
5. If the UE is configured by higher layer parameter PDCCH-Config with two different values of coresetPoolIndex in ControlResourceSet and is also configured by the higher layer parameter lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18 in ServingCellConfig, the following REs are declared as not available for PDSCH:

- if the UE is configured with crs-RateMatch-PerCoresetPoolIndex, REs indicated by the CRS pattern(s) in lte-CRS-PatternList3-r18 if the PDSCH is associated with coresetPoolIndex set to ‘0’, or the CRS pattern(s) in lte-CRS-PatternList4-r18 if PDSCH is associated with coresetPoolIndex set to ‘1’;- otherwise, REs indicated by lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18, in ServingCellConfig. | 14-1 | Yes | N/A | Two overlapping LTE-CRS rate matching patterns is not supported | Per Band | No | Applicable to FR1 only | No | For eDSSThe number of the additional CRS rate matching patterns reported in Rel-18 is accounted in the total number of rate matching pattern reported by the UE for Rel-15 by using pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot and pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot | Optional with capability signalling |

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| [5] | ZTE | In RAN1#109 meeting, the following agreements were agreed for two overlapping CRS patterns for DSS [3].

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| **Agreement*** Introduce new UE capability(ies) for support of two overlapping LTE CRS patterns in Rel-18 DSS ~~if the UE is NOT configured by higher layer parameter~~ *~~PDCCH-Config~~* ~~with two different values of~~ *~~coresetPoolIndex~~* ~~in~~ *~~ControlResourceSet~~.*
	+ NW can configure two LTE-CRS overlapping rate matching patterns without *coresetPoolIndex* only if the UE indicates support of the new capability(ies).
* Clarify that the Rel-16 UE capability *overlapRateMatchingEUTRA-CRS-r16* is subject to support of *multiDCI-Multi-TRP-r16*.
* Maximum number of LTE-CRS rate matching patterns for PDSCH supported by a UE (i.e., *maxNumberPatterns-r16* and *maxNumberNon-OverlapPatterns-r16*) is kept unchanged.
 |

According to the second bullet of above agreements, it needs to clarify the Rel-16 UE capability *overlapRateMatchingEUTRA-CRS-r16* is subject to support of *multiDCI-MultiTRP-r16* (i.e., FG 16-2a). As a result, we have the following proposal. ***Proposal 4****: Clarify the Rel-16 UE capability overlapRateMatchingEUTRA-CRS-r16 is subject to support of multiDCI-MultiTRP-r16 as follows.*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 14-1a | Two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz overlapping with a LTE carrier  | 1. Support of two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz SCS overlapping with a LTE carrier | 14-1, 16-2a  | *overlapRateMatchingEUTRA-CRS-r16* | *BandNR* | n/a | n/a (FR1 only) | For DSSThe number of the additional CRS rate matching patterns reported in Rel-16 is accounted in the total number of rate matching pattern reported by the UE for Rel-15 by using pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot and pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot | Optional with capability signaling |

As shown in Section 6, the existing FG 14-1 and 14-1a are used for support of multiple overlapping CRS rate matching patterns. Basically, FG 14-1 is to report the total number of supported CRS rate matching patterns including both non-overlapping and overlapping ones. FG 14-1a is to report whether the UE support two overlapping patterns in multi-DCI M-TRP case. Since the Rel-16 UE capability *overlapRateMatchingEUTRA-CRS-r16* is subject to support of *multiDCI-Multi-TRP-r16*, a new Rel-18 UE capability similar as FG 14-1/1a should be introduced for all kinds of PDSCH transmission in Rel-18, i.e., single-TRP, single-DCI or multi-DCI based MTRP PDSCH transmission in Rel-18. According to the agreement, the maximum number of LTE-CRS rate matching patterns for PDSCH supported by a UE is kept unchanged. Therefore, we have the following proposal.***Proposal 5****: Adopt the following UE FG on maximum number of LTE-CRS rate matching patterns for Rel-18 DSS.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| xx-1 | Multiple LTE-CRS rate matching patterns | For a UE configure with *lte-CRS-PatternList3-r18,*1)Maximum number of LTE-CRS rate matching patterns in total within a NR carrier using 15 kHz SCS2)Maximum number of LTE-CRS non-overlapping rate matching patterns within a NR carrier using 15 kHz SCS | 5-28 (Rate-matching around LTE CRS) | Per band  | n/a | n/a (FR1 only) | For DSSThe number of the additional CRS rate matching patterns reported in Rel-18 is accounted in the total number of rate matching pattern reported by the UE for Rel-15 by using pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot and pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlotUE reporting component 1 for xx-1 also reports component 2.Reporting of values of Component 1 larger than two is only applicable when reporting values of Component 2 larger than one. | Optional with capability signallingComponent 1:{2, 3, 4, 5, 6}Component 2: {1, 2, 3} |

Based on the agreement made in RAN1#110 below, when Rel-18 RRC parameters *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* configured, UE supports two overlapping CRS rate matching patterns regardless of Multi-DCI based MTRP or not.

|  |
| --- |
| **Agreement*** + Introduce two new RRC parameters *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* in *ServingCellConfig* around which the UE shall do rate matching for PDSCH scheduled by PDCCH with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI, or PDSCHs with SPS.
		- The network does not configure *lte-CRS-PatternList3-r18* and any of *lte-CRS-ToMatchAround, lte-CRS-PatternList1-r16* and *lte-CRS-PatternList2-r16* simultaneously. *Lte-CRS-PatternList4-r18* is configured only if *lte-CRS-PatternList3-r18* is configured in *ServingCellConfig.*
		- For case when UE is not configured with two different values of *coresetPoolIndex* in *ControlResourceSet*, and configured with *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*, both *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applied
		- For case when UE is configured with two different values of *coresetPoolIndex* in *ControlResourceSet*, and configured with *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*
			* If UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, *lte-CRS-PatternList3-r18* is applied if the PDSCH is associated with c*oresetPoolIndex* set to ‘0’, and *lte-CRS-PatternList4-r18* is applied if the PDSCH is associated with c*oresetPoolIndex* set to ‘1’
			* Otherwise, both *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applied.
		- The legacy configuration rule in TS 38.331 is applied in Rel-18 DSS, i.e.,
			* “The first LTE CRS pattern in *lte-CRS-PatternList4* shall be fully overlapping in frequency with the first LTE CRS pattern in *lte-CRS-PatternList*3, The second LTE CRS pattern in this list shall be fully overlapping in frequency with the second LTE CRS pattern in lte-CRS-PatternList3, and so on.”
 |

With above, a similar FG as FG 14-1a can be introduced. ***Proposal 6****: Adopt the following UE FG on two overlapping LTE-CRS rate matching patterns for Rel-18 DSS.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| xx-1a | Two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz overlapping with a LTE carrier | For a UE configure with *lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18,*1. Support of two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz SCS overlapping with a LTE carrier | xx-1  | Per FSPC | n/a | n/a (FR1 only) | For DSSThe number of the additional CRS rate matching patterns reported in Rel-18 is accounted in the total number of rate matching pattern reported by the UE for Rel-15 by using pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot and pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot | Optional with capability signaling |

 |
| [9] | Qualcomm | RAN1 made following agreements.

|  |
| --- |
| Agreement* Introduce two new RRC parameters *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* in *ServingCellConfig* around which the UE shall do rate matching for PDSCH scheduled by PDCCH with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI, or PDSCHs with SPS.
	+ The network does not configure *lte-CRS-PatternList3-r18* and any of *lte-CRS-ToMatchAround, lte-CRS-PatternList1-r16* and *lte-CRS-PatternList2-r16* simultaneously. *Lte-CRS-PatternList4-r18* is configured only if *lte-CRS-PatternList3-r18* is configured in *ServingCellConfig.*
	+ For case when UE is not configured with two different values of *coresetPoolIndex* in *ControlResourceSet*, and configured with *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*, both *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applied
	+ For case when UE is configured with two different values of *coresetPoolIndex* in *ControlResourceSet*, and configured with *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*
		- If UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, *lte-CRS-PatternList3-r18* is applied if the PDSCH is associated with c*oresetPoolIndex* set to ‘0’, and *lte-CRS-PatternList4-r18* is applied if the PDSCH is associated with c*oresetPoolIndex* set to ‘1’
		- Otherwise, both *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applied.
	+ The legacy configuration rule in TS 38.331 is applied in Rel-18 DSS, i.e.,
		- “The first LTE CRS pattern in *lte-CRS-PatternList4* shall be fully overlapping in frequency with the first LTE CRS pattern in *lte-CRS-PatternList*3, The second LTE CRS pattern in this list shall be fully overlapping in frequency with the second LTE CRS pattern in lte-CRS-PatternList3, and so on.”
 |

For this, we think separate UE features are necessary for single and two different values configured for *coresetPoolIndex* of the CORESETs. Other than this, it would be possible to refer to the legacy R16 FG.**Proposal 4:*** Separate UE features are necessary for:
	+ Two overlapping LTE-CRS patterns for the case where two different values of *coresetPoolIndex* are not configured
	+ Two overlapping LTE-CRS patterns for the case where two different values of *coresetPoolIndex* are configured

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | x-3 | Two overlapping CRS rate matching patterns for a NR carrier using 15kHz overlapping with a LTE carrier | 1. Support of two overlapping LTE-CRS rate matching patterns according to lte-CRS-PatternList3 and lte-CRS-PatternList4 for PDSCH reception without two different values of coresetPoolIndex in ControlResourceSet
2. Maximum number of LTE-CRS rate matching patterns in total within a NR carrier using 15kHz SCS
3. Maximum number of LTE-CRS non-overlapping rate matching patterns within a NR carrier using 15kHz SCS
 | 5-28 |  |  |  | Per Band | n/a | n/a (FR1 only) |  | For DSSThe number of the additional CRS rate matching patterns reported in Rel-18 is accounted in the total number of rate matching pattern reported by the UE for Rel-15 by using pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot and pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlotReporting of values of component 2 larger than two is only applicable when reporting values of compoentn 3 is larger than one. | Optional with capability signallingComponent 1: {yes}Component 2: {2, 3, 4, 5, 6}Component 3: {1, 2, 2} |
|  | x-4 | Two overlapping CRS rate matching patterns with two different values of coresetPoolIndex for a NR carrier using 15kHz overlapping with a LTE carrier | 1. Support of two overlapping LTE-CRS rate matching patterns according to lte-CRS-PatternList3 and lte-CRS-PatternList4 for PDSCH reception with two different values of coresetPoolIndex in ControlResourceSet
 | 5-28, 16-2a, x-3 |  |  |  | Per Band | n/a | n/a (FR1 only) |  | For DSSThe number of the additional CRS rate matching patterns reported in Rel-18 is accounted in the total number of rate matching pattern reported by the UE for Rel-15 by using pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot and pdsch-RE-MappingFR1-PerSymbol/pdsch-RE-MappingFR1-PerSlot | Optional with capability signalling |

 |
| [10] | DOCOMO | There is Rel-16 capability on support of two overlapping CRS rate matching patterns for multi-TRP (i.e., overlapRateMatchingEUTRA-CRS-r16). RAN1 sent LS to RAN2 to clarify that the Rel-16 UE capability overlapRateMatchingEUTRA-CRS-r16 is subject to support of multiDCI-Multi-TRP-r16 in Rel-18 ASN.1 [2]. In addition, following RRC parameters were also informed to RAN2 in the LS and RAN1 have assumed that there will be UE capability for Rel-18 eDSS.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **WI code** | **Sub-feature group** | **Parameter name in the spec** | **New or existing?** | **Description** | **Value range** | **Per (UE, cell, TRP, …)** | **UE-specific or Cell-specific** | **Specification** |
| NR\_DSS\_enh | Support for two overlapping CRS rate matching patterns | *lte-CRS-PatternList3* | New | A list of LTE CRS patterns around which the UE shall do rate matching for PDSCH. The LTE CRS patterns in this list shall be non-overlapping in frequency. This list can be configured if [Rel-18 DSS capability(ies)] specified in TS 38.306 [26] is indicated. The network does not configure this field and lte-CRS-ToMatchAround, or this field and lte-CRS-PatternList1, or this field and lte-CRS-PatternList2 simultaneously. | *LTE-CRS-PatternList-r16* | *ServingCellConfig* | UE-specific | 38.331 |
| NR\_DSS\_enh | Support for two overlapping CRS rate matching patterns | *lte-CRS-PatternList4* | New | A list of LTE CRS patterns around which the UE shall do rate matching for PDSCH. The LTE CRS patterns in this list shall be non-overlapping in frequency. This list can be configured if [Rel-18 DSS capability(ies)] specified in TS 38.306 [26] is indicated. The first LTE CRS pattern in this list shall be fully overlapping in frequency with the first LTE CRS pattern in lte-CRS-PatternList3. The second LTE CRS pattern in this list shall be fully overlapping in frequency with the second LTE CRS pattern in lte-CRS-PatternList3, and so on. Network configures this field only if the field lte-CRS-ToMatchAround is not configured and the field lte-CRS-PatternList3 is configured. | *LTE-CRS-PatternList-r16* | *ServingCellConfig* | UE-specific | 38.331 |

Therefore, for supporting two overlapping CRS rate matching patterns for Rel-18 eDSS, new capability signalling is necessary. The capability signalling structure for Rel-18 eDSS can reuse that of overlapRateMatchingEUTRA-CRS-r16.**Proposal 2: Support UE capability reporting on the support of “two overlapping CRS rate matching patterns”.*** **Prerequisite FG is FG14-1 (multipleRateMatchingEUTRA-CRS-r16)**
* **Reporting type is per band, and it is applicable to FR1 only**
* **Optional with capability signalling**
 |
| [11] | Ericsson | On the applicable CRS patterns, the straightforward option is to support the feature for the case of non-overlapping CRS patterns (one pattern for case of Rel15 FG 5-28 and up to 3 non-overlapping patterns for case of Rel16 FG 14-1). Then support for the feature with overlapping CRS patterns (introduced in Rel16 or Rel18) can be considered separately. **Proposal 3*** A capability indication for UE support of reception of NR PDCCH candidates that overlap with LTE CRS REs using one or multiple non-overlapping CRS patterns should be supported.
* Separate capability indication for UE support with two overlapping CRS patterns can be additionally supported .
 |
| [12] | Huawei, HiSilicon | The related agreements of previous meeting are as follows [1][2]:

|  |  |
| --- | --- |
| RAN1#109-e Agreement* Introduce new UE capability(ies) for support of two overlapping LTE CRS patterns in Rel-18 DSS
	+ NW can configure two LTE-CRS overlapping rate matching patterns without *coresetPoolIndex* only if the UE indicates support of the new capability(ies).
* Clarify that the Rel-16 UE capability *overlapRateMatchingEUTRA-CRS-r16* is subject to support of *multiDCI-Multi-TRP-r16*.
* Maximum number of LTE-CRS rate matching patterns for PDSCH supported by a UE (i.e., *maxNumberPatterns-r16* and *maxNumberNon-OverlapPatterns-r16*) is kept unchanged.

RAN1#110 AgreementThe following TP for sub-clause 5.1.4.2 of TS 38.214 h20 is endorsed in principle.

|  |
| --- |
| **5.1.4.2 PDSCH resource mapping with RE level granularity**<omitted text>A UE may be configured with any of the following higher layer parameters:*-* REs indicated by the '*RateMatchPatternLTE-CRS*'in *lte-CRS-ToMatchAround* in *ServingCellConfig* or *ServingCellConfigCommon* configuring cell-specific RS, in 15 kHz subcarrier spacing applicable only to 15 kHz subcarrier spacing PDSCH, of one LTE carrier in a serving cell are declared as not available for PDSCH. *-* REs indicated by *'RateMatchPatternLTE-CRS'* in *lte-CRS-PatternList1-r16* or *lte-CRS-PatternList3-r18* in *ServingCellConfig* configuring cell-specific RS, in 15 kHz subcarrier spacing applicable only to 15 kHz subcarrier spacing PDSCH, of one LTE carrier in a serving cell are declared as not available for PDSCH.- For the UE for broadcast reception, REs indicated by *'RateMatchPatternLTE-CRS'* in *PDSCH-Config-MCCH* or *PDSCH-Config-MCCH* configuring cell-specific RS, in 15 kHz subcarrier spacing applicable only to 15 kHz subcarrier spacing PDSCH, of one LTE carrier in a serving cell are declared as not available for PDSCH.- Each *RateMatchPatternLTE-CRS* configuration contains *v-Shift* consisting of LTE-CRS-vshift(s), *nrofCRS-Ports* consisting of LTE-CRS antenna ports 1, 2 or 4 ports, *carrierFreqDL* representing the offset in units of 15 kHz subcarriers from (reference) point A to the LTE carrier centre subcarrier location, *carrierBandwidthDL* representing the LTE carrier bandwidth, and may also configure *mbsfn-SubframeConfigList* representing MBSFN subframe configuration. A UE determines the CRS position within the slot according to Clause 6.10.1.2 in [15, TS 36.211], where slot corresponds to LTE subframe. - If the UE is configured by higher layer parameter *PDCCH-Config* with two different values of *coresetPoolIndex* in *ControlResourceSet* and is also configured by the higher layer parameter *lte-CRS-PatternList1-r16* and *lte-CRS-PatternList2-r16* in *ServingCellConfig*, the following REs are declared as not available for PDSCH:- if the UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, REs indicated by the CRS pattern(s) in *lte-CRS-PatternList1-r16* if the PDSCH is associated with *coresetPoolIndex* set to ‘0’, or the CRS pattern(s) in *lte-CRS-PatternList2-r16* if PDSCH is associated with *coresetPoolIndex* set to ‘1’;- otherwise, REs indicated by *lte-CRS-PatternList1-r16* and *lte-CRS-PatternList2-r16,* in *ServingCellConfig*.- If the UE is not configured by higher layer parameter PDCCH-Config with two different values of *coresetPoolIndex* in *ControlResourceSet*, and if the UE is configured by higher layer parameter *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* in *ServingCellConfig*, REs indicated by *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are declared as not available for PDSCH.- If the UE is configured by higher layer parameter *PDCCH-Config* with two different values of *coresetPoolIndex* in *ControlResourceSet* and is also configured by the higher layer parameter *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* in *ServingCellConfig*, the following REs are declared as not available for PDSCH:- if the UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, REs indicated by the CRS pattern(s) in *lte-CRS-PatternList3-r18* if the PDSCH is associated with *coresetPoolIndex* set to ‘0’, or the CRS pattern(s) in *lte-CRS-PatternList4-r18* if PDSCH is associated with *coresetPoolIndex* set to ‘1’;- otherwise, REs indicated by *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18,* in *ServingCellConfig*.<omitted text> |

 |

Based on above agreements, we propose the following UE features. If the UE supports this feature and 16-2a-5 (Separate CRS rate matching), then the UE can rate match around lte-CRS-PatternList3-r18 for corset pool Index 0 and lte-CRS-PatternList4-r18 for corset pool index 1 separately. And if the UE supports this feature but does not support 16-2a-5, then the UE can rate match around both lte-CRS-PatternList3-r18 and lte-CRS-PatternList4-r18.Table 2 UE feature for two LTE-CRS overlapping rate matching patterns

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | Consequence if the feature is not supported by the UE | Type(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC) | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| XX. NR\_DSS\_enh | XX-2 | Two LTE-CRS overlapping rate matching patterns within a part of NR carrier using 15 kHz overlapping with a LTE carrier | 1. Support of two LTE-CRS overlapping rate matching patterns (i.e. *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*) within a part of NR carrier using 15 kHz SCS overlapping with a LTE carrier | 14-1 | Yes | N/A |  | Per Band | N/A | FR1 only | N/A | Maximum number of LTE-CRS rate matching patterns for PDSCH supported by a UE (i.e., *maxNumberPatterns-r16* and *maxNumberNon-OverlapPatterns-r16*) is kept unchanged.The UE can rate match around configured CRS patterns which is associated with CORESETPoolIndex (if configured) and are applied to the PDSCH scheduled with a DCI detected on a CORESET with the same value of CORESETPoolIndex if the UE also supports 16-2a-5. | Optional with capability signalling |

***Proposal 2: Introduce new UE features XX-2 in Table 2 for two overlapping CRS rate matching patterns in Rel-18 eDSS.*** |

## **Discussion**

**Question 3-1:**

* **Companies are encouraged to provide views on whether to separate FG 52-2 for the case** **where two different values of coresetPoolIndex are configured.**
	+ Yes: Qualcomm

|  |  |
| --- | --- |
| Company | Comment |
| Qualcomm | Yes. In addition, we prefer to describe which parameters the FG52-2 corresponds to. In our understanding, the proposal here is for lte-CRS-PatternList3 and lte-CRS-PatternList4. The current FG52-2 is confusing because there are lte-CRS-PatternList1 and lte-CRS-PatternList2 as well. |
| NTT DOCOMO | According to the RAN1 agreement made at RAN1#110 as below, the case where two different values of coresetPoolIndex are configured should be considered for the Rel-18 CRS rate matching feature. Although simple approach is to define separate new capability for the case from FG 52-2, there may be other possible approach e.g., reusing existing capability 16-2a-5 as proposed by Huawei.* + For case when UE is not configured with two different values of *coresetPoolIndex* in *ControlResourceSet*, and configured with *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*, both *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applied
	+ For case when UE is configured with two different values of *coresetPoolIndex* in *ControlResourceSet*, and configured with *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18*
		- If UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, *lte-CRS-PatternList3-r18* is applied if the PDSCH is associated with c*oresetPoolIndex* set to ‘0’, and *lte-CRS-PatternList4-r18* is applied if the PDSCH is associated with c*oresetPoolIndex* set to ‘1’

Otherwise, both *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are applied. |
| OPPO | We are ok to have either two split FGs or two separate FG components in a single FG (by taking component from FG16-2a-5 into FG52-2).  |
| ZTE | Prefer a single FG.  |
| vivo | Ok to have separate capabilities if the majority perceive the need for them |
| Spreadtrum | Prefer two separate FG components in a single FG. |
| Nokia, NSB | In principle, it seems that separate capabilities could be more appropriate, but more discussion may be needed with a more precise formulation of those FGs.  |
| Huawei, HiSilicon | For two separate FG, it should be that, one FG is rate matching for both list3 and list4 no matter two different values of *coresetPoolIndex* are configured or not. Another FG is rate matching for list3 for one TRP and rate matching for list4 for another TRP, i.e. similar as FG16-2a-5 separate CRS rate matching below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| FG52-2a | Separate CRS rate matching | 1. Whether the UE can rate match around configured CRS patterns which is associated with CORESETPoolIndex (if configured) and are applied to the PDSCH scheduled with a DCI detected on a CORESET with the same value of CORESETPoolIndex | [FG52-2] | Yes | N/A |  | [per band] | No | No | N/A |  |  |

If the separation is based on only whether two different values of coresetPoolIndex are configured or not, then for two different values of coresetPoolIndex configuration, further separation is needed for separate CRS rate matching. This would have three FGs.So we prefer a single FG by adding FG16-2a-5 in this FG52-2 (e.g. the UE can rate match around configured CRS patterns which is associated with CORESETPoolIndex (if configured) and are applied to the PDSCH scheduled with a DCI detected on a CORESET with the same value of CORESETPoolIndex if the UE also supports 16-2a-5), and also fine for only two separate FGs, one is rate matching for both list, another is rate matching separately.For the consequence if the feature is not supported by the UE, it is confusing and should be removed. Our understanding is that if the UE does not support this feature, then the gNB should not configure list3 and list4 for this UE, so the UE will not have list3 and list4 CRS patterns. |
| Vivo2 | Either the FG52-2a proposed by Huawei or reusing FG16-2a-5 is fine for us.In addition to separate CRS rate matching, we think some further clarifications are also needed on FG related to CRS including FG2-6b additional DMRS location, and FG14-2 PDSCH Type B mapping of length 9 and 10 OFDM symbols.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 2-6bThis FG applies to FR1 only and 15kHz SCS. This applies to one additional DMRS case only | Support alternative additional DMRS location | Support alternative additional DMRS position for co-existence with LTE CRS | 2-5 and 5-28 | *additionalDMRS-DL-Alt* |
| 14-2For DSSFG10-8 covers PDSCH type B mapping without DMRS shift due to CRS collision. | PDSCH Type B mapping of length 9 and 10 OFDM symbols | 1. support of PDSCH Type B scheduling of length 9 and 10 OFDM symbols2. support of DMRS shift for length-10 symbols | 5-6a (PDSCH mapping type B)  | *pdsch-MappingTypeB-Alt-r16* |

These FGs are supported for *lte-CRS-ToMatchAround*, *lte-CRS-PatternList1* and *lte-CRS-PatternList2.* if alternative additional DMRS location and PDSCH Type B mapping of length 9 and 10 OFDM symbols can be supported in R18 eDSS with *lte-CRS-PatternList3* and *lte-CRS-PatternList4*, do we also need to define separate FG(e.g., 52-2b,52-2c) for them similar as that for separate CRS rate matching, Or we simply reuse these existing capability with FG 52-2. |
| Ericsson1 | OK to have separate FG for the case where two different values of coresetPoolIndex are configured. |
| Apple | We are open to discuss whether it should be one or two FGs. From implementation perspective, there is no big difference whether mTRP is configured or not.  |
| Moderator | Summary of companies’ view* + Yes: Qualcomm, [DCM], [OPPO], [vivo], [Nokia/NSB], E///, [Apple]
	+ No (taking component from FG16-2a-5 into FG52-2): [DCM], [OPPO], ZTE, SPRD, HW/HiSi, [Apple]

Given there is divergent view for this capability, following question is made:**Question 3-1-1:*** **Companies are encouraged to provide views on which option you have strong concern.**
	+ **Opt1: FG 52-2 is separated for the case where two different values of coresetPoolIndex are configured**
	+ **Opt2: Add a component in FG 52-2: UE can rate match around configured CRS patterns which is associated with CORESETPoolIndex (if configured) and are applied to the PDSCH scheduled with a DCI detected on a CORESET with the same value of CORESETPoolIndex if the UE also supports 16-2a-5**

Vivo raised another aspect whether to define separate FG for FGs 2-6b/14-2 or reuse them.**Question 3-1-2:*** **Companies are encouraged to provide views on which option you have strong concern.**
	+ **Opt1: Introduce separate FGs for FGs 2-6b/14-2 for the case when UE supports FG 52-2**
	+ **Opt2: Reuse FGs 2-6b/14-2 to indicate the support of these capabilities for FG 52-2**
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**Question 3-2:**

* **Companies are encouraged to provide views on whether followings can be separately reported from FG 14-1 (i.e., whether to include FG14-1 as a prerequisite FG for FG 52-2).**
	+ **Maximum number of LTE-CRS rate matching patterns in total within a NR carrier using 15 kHz SCS: {2,3,4,5,6}**
	+ **Maximum number of LTE-CRS non-overlapping rate matching patterns within a NR carrier using 15 kHz SCS: {1,2,3}**
		- Yes: ZTE, QC
		- No: vivo, OPPO, SPRD, DCM, HW/HiSi

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| --- | --- |
| Company | Comment |
| Qualcomm | Yes. FG14-1 is for lte-CRS-PatternList1 and lte-CRS-PatternList2 while FG52-2 is for lte-CRS-PatternList3 and lte-CRS-PatternList4. So, we are not sure how FG14-1 can be prerequisite for FG52-2. RAN1 introduced FG52-2 in Rel-18 because RAN1 noticed that R16 multi CRS patterns does not work without multi-TRP feature. Therefore, it does not make sense to couple the R16 FG14-1 and R18 FG52-2. |
| NTT DOCOMO | We think reported values for number of rate matching patterns in FG 14-1 can be reused as Rel-18 rate matching feature is just removing m-TRP restriction on the case with overlapping rate matching patterns. Regarding Qualcomm’s comment, our understanding is that R16 FG14-1 is not only for Mtrp case while FG14-1a is the support of overlapping rate matching patterns for Mtrp case.  |
| OPPO | Same understanding as from DOCOMO.  |
| ZTE | For lte-CRS-PatternList3 and lte-CRS-PatternList4, it supports both single TRP case and multi-TRP case. And FG 14-1 only considers multi-TRP case when two overlapping LTE CRS patterns are configured. In addition, in the ‘Note’ column of FG14-1, it is clearly mentioned that only Rel-16 CRS patterns are accounted for the supported max # of RE mapping patterns (FG 2-33a). So, we may have to have a separate UE FG similar as FG 14-1.  |
| vivo | If the maximum numbers of LTE-CRS in FG14-1 and the maximum numbers of LTE-CRS in FG 52-2 are reported independently, how to understand the following agreement? If FG14-1 reports 6 and FG 52-2 reports 6, it means UE supports up to 12 LTE-CRS rate matching patterns in total? We prefer not to introduce more CRS patterns compared with R16. It would be acceptable for us to either include FG14-1 as a prerequisite FG for FG 52-2, or to add a note that if 14-1 and 52-2 are independent and if both capabilities are reported, the total maximum number of LTE-CRS rate matching patterns and the total maximum number of LTE-CRS non-overlapping rate matching patterns should not exceed {2,3,4,5,6} and {1,2,3} respectively * Maximum number of LTE-CRS rate matching patterns for PDSCH supported by a UE (i.e., *maxNumberPatterns-r16* and *maxNumberNon-OverlapPatterns-r16*) is kept unchange
 |
| Spreadtrum | We are open to either include FG14-1 as a prerequisite FG for FG 52-2, or to have a separate UE FG similar as FG 14-1. We share same view as vivo that the total maximum number of LTE-CRS rate matching patterns and the total maximum number of LTE-CRS non-overlapping rate matching patterns should be unchanged compared R16. |
| Nokia, NSB | While FG 52-2 and 14-1 are well related to each other, and one could even consider 52-2 as a natural extension of 14-1, there is no need to force that relationship in the UE capabilities.  |
| Huawei, HiSilicon | Same understanding as from DOCOMO. We only clarified that FG14-1a is for M-TRP according to the agreement below.AgreementClarify that the Rel-16 UE capability *overlapRateMatchingEUTRA-CRS-r16* is subject to support of *multiDCI-Multi-TRP-r16*. |
| Qualcomm | Still, we agree with ZTE and Nokia. We are not sure what a benefit is to mandate FG14-1 for a UE to support LTE-CRS PDSCH rate-matching using Rel-18 parameters List3 and List4. This just increase the burden (need to pass the test using the Rel-16 parameter List1 to support Rel-18 PDSCH rate-matching). |
| Ericsson1 | We are OK with either approach. 52-2 + 14-1 as prerequisite seems simplest approach from our perspective (this would similar to 14-1a+14-1). |
| Apple | We slight prefer to have separate capability from FG14-1, it’s clearer and not bundling it to mTRP feature. |
| Moderator | Summary of companies’ view* + - Yes: ZTE, QC, [vivo] (with clarification for the maximum supported number), [SPRD] (with clarification for the maximum supported number), Nokia/NSB, [E///]
		- No: vivo, OPPO, SPRD, DCM, HW/HiSi, [vivo], [SPRD], HW/HiSi, [E///]

Given there is divergent view for this capability, following question is made:**Question 3-2-1:*** **Companies are encouraged to provide views on which option you have strong concern.**
	+ **Opt1: Following capabilities in FG 52-2 are separately reported from FG 14-1**
		- **Maximum number of LTE-CRS rate matching patterns in total within a NR carrier using 15 kHz SCS: {2,3,4,5,6}**
			* **FFS: total number reported by UE in FG 14-1 and FG 52-2 shall not exceed 6**
		- **Maximum number of LTE-CRS non-overlapping rate matching patterns within a NR carrier using 15 kHz SCS: {1,2,3}**
			* **FFS: total number reported by UE in FG 14-1 and FG 52-2 shall not exceed 3**
	+ **Opt2: FG14-1 is included as a prerequisite FG for FG 52-2**
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# **Conclusions**

To be updated

# **References**

[1] R1-2303763 Initial UE feature list for Rel18 DSS Enhancements WI WI Rapporteur (Ericsson)

[2] R1-2302516 Discussion on UE features for eDSS vivo

[3] R1-2302578 Discussion on UE features for Rel-18 eDSS OPPO

[4] R1-2302626 Discussion on UE features for eDSS Spreadtrum Communications

[5] R1-2302764 Discussion on UE feature for eDSS ZTE

[6] R1-2302896 Initial views on UE features for eDSS Nokia, Nokia Shanghai Bell

[7] R1-2303160 Discussion on UE features for eDSS Samsung

[8] R1-2303342 UE feature discussion for Rel-18 eDSS MediaTek Inc.

[9] R1-2303513 On Rel-18 eDSS UE features Apple

[10] R1-2303622 UE features for eDSS Qualcomm Incorporated

[11] R1-2303737 Discussion on UE features for eDSS NTT DOCOMO, INC.

[12] R1-2303764 UE features for Rel18 DSS Enhancements Ericsson

[13] R1-2303864 UE features for eDSS Huawei, HiSilicon