**3GPP TSG RAN WG1 #100bis R1-2001868**

**e-Meeting, April 20th – 30th, 2020**

**Agenda Item: 7.2.11.6**

**Source: Moderator (AT&T)**

**Title: Summary on UE features for eMIMO**

**Document for:** **Discussion/Decision**

# Introduction

This document was drafted by the moderator of the agenda item under the direction of the RAN1 Chairman following the below guidance whose purpose it serves:

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| * + April 13-17: preparation phase
		- April 13th – 14th: FLs to prepare summary
		- April 15th – 17th: FLs to lead the discussion identifying the set of email threads
		- **Note:** PLEASE KEEP THE EMAIL DISCUSSION **SCOPE** PER EMAIL THREAD **REASONABLE!**
			* **Too much scope will force Chairman/Vice Chairman to step in to do the necessary cut down using the best judgement** à **if so, no complain please.**
 |

All Sections except Section 3 were exclusively prepared by the moderator of the agenda item. Specifically, Section 2 is the moderator’s summary of contributions submitted to RAN1 #100bis-e in this agenda item according to the Chairman’s guidance. During the preparation phase, companies were given the opportunity to revise their views in the moderator’s summary in Section 2 using revision marks as shown below, if any. Section 3 was jointly drafted by the moderator and contributing companies during the preparation phase of RAN1 #100bis-e whereby companies present their views on the moderator’s proposals according to the Chairman’s guidance above in the respective tables. After conclusion of the preparation phase, the moderator submitted the final document as input to RAN1 #100bis-e with recommendations captured in Section 4.

The following will be removed from the final document, however, in the meantime, please take note of this guidance of the RAN1 MCC technical officer:

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| W.r.t the naming convention, the following suggestion […] may be helpful to keep the previous company’s name (only the most recent one) in the filename, so that we can easily tell which previous version this is based on, and may solve the issue when there are crossing emails.e.g. something like the following:5\_Incoming\_Liaison\_Statements/Summary-1\_v1-LG5\_Incoming\_Liaison\_Statements/Summary-1\_v2-LG-CATT5\_Incoming\_Liaison\_Statements/Summary-1\_v2-LG-vivo5\_Incoming\_Liaison\_Statements/Summary-1\_v3-CATT-HWHiSi |

# Summary on UE features for eMIMO

The following table represents the version of the NR UE feature list for eMIMO used by RAN1 as reference for RAN1 #100bis-e [1].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 16. NR\_eMIMO | ~~16-1~~ | ~~Multi-beam operation~~  | 1. ~~The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS whether to be a separate UE feature, e.g. 16-1a)~~
2. ~~FFS: Support of group-based reporting for L1-SINR~~
3. ~~Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH (FFS whether to be a separate UE feature, e.g. 16-1b)~~
4. ~~Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS (FFS whether to be a separate UE feature, e.g. 16-1c)~~
5. ~~The maximum number of PUCCH resources per BWP for simultaneous spatial relation update (FFS whether to be a separate UE feature, e.g. 16-1c)~~
6. ~~Support of default spatial relation pathloss reference RS for dedicated-PUCCH/SRS and PUSCH scheduled by DCI format 0\_0~~
7. ~~[Support of / The maximum number of] spatial relation update for AP-SRS via MAC CE (FFS whether to be a separate UE feature, e.g. 16-1c)~~
8. ~~The maximum number of configured pathloss reference RS update for PUSCH/SRS/PUCCH via MAC CE (FFS whether to be a separate UE feature, e.g. 16-1c)~~
9. ~~FFS: The maximum number of activated pathloss reference RS update for PUSCH/SRS/PUCCH [across CCs, within a slot across all CCs] (FFS whether to be a separate UE feature, e.g. 16-1c)~~
10. ~~The maximum number of SCells for SCell beam failure recovery (FFS whether to be a separate UE feature, e.g. 16-1d)~~
11. ~~FFS: Support of PUCCH-BFR (FFS whether to be a separate UE feature, e.g. 16-1d)~~
12. ~~FFS: The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs, within a slot across all CCs] (FFS whether to be a separate UE feature, e.g. 16-1d)~~
13. ~~FFS: Densigy of CSI-RS for SCell BFR~~

The components in FG 16-1 are separated into individual FGs from 16-1a to 16-1g as follows. | ~~TBD for #1~~~~2-1, 2-4 for #2~~ ~~2-53, 2-59 for #3-#6~~~~8-2 for #7~~~~2-31 for #8~~ |  | ~~N/A~~ |  | ~~TBD~~~~[Per band for #1, #2, #5, #6~~~~Per UE for , #7, #8~~~~Per BC for #3, #4]~~ | ~~N~~ | ~~N for #1, #2, #7, #8~~~~Y for #3 - #6~~ |  |  | ~~Optional~~ |
| 16-1a | L1-SINR reporting | 1. The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)
2. FFS: Support of group-based reporting for L1-SINR
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |
| 16-1b | TCI state activation and spatial relation update | 1. [Support of / maximum number of lists for] Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH ~~(FFS whether to be a separate UE feature, e.g. 16-1b)~~
2. [Support of / maximum number of lists for] Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
3. [Support of / The maximum number of] PUCCH resource groups per BWP for simultaneous spatial relation update
4. FFS: details on whether/how to indicate band pairs which can share the same DL TCI state
5. FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info
 | Component 1: 2-1, 2-4Component 2: 2-59, 2-60Component 3: 2-53, 2-59, 4-24 |  | N/A |  | TBD[Per BC or per band] | N | Y |  |  | TBD |
| 16-1c | Default spatial relation | Support of default spatial relation and pathloss reference RS for dedicated-PUCCH/SRS and PUSCH scheduled by DCI format 0\_0 | 2-53, 2-59 |  | N/A |  | TBD[Per band] | N | Y |  |  | TBD |
| 16-1d | MAC CE spatial relation update for AP-SRS | [Support of / The maximum number of] spatial relation update for AP-SRS via MAC CE ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~ | 2-53, 2-59 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. The maximum number of configured pathloss reference RSs for PUSCH/SRS~~/PUCCH via MAC CE~~ by RRC for MAC-CE based pathloss reference RS update ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
2. FFS: The maximum number of activated pathloss reference RS update for PUSCH/SRS/PUCCH [across CCs / within a slot across all CCs / per CC] ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
3. FFS: Number of measurement samples N to apply newly activated pathloss reference RS
 | ~~8-2,~~ 8-3 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |
| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
2. FFS: Support of PUCCH-BFR ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
3. FFS: The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC] ~~(FFS to replace this component to 14)~~
4. FFS: ~~Densigy~~ Density of CSI-RS for new beam identification for SCell BFR
 | 2-31 |  | N/A |  | TBD | N |  |  |  | TBD |
| 16-1g | FFS: Resources for beam management, pathloss measurement, and BFR | 1. FFS: The maximum number of SSB/CSI-RS resources across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, and new beam identification.
2. FFS: The maximum number of SSB/CSI-RS resources across all CCs for pathloss measurement
3. FFS: The maximum number of SSB/CSI-RS resources across all CCs for BFD
4. FFS: The maximum number of SSB/CSI-RS resources across all CCs for new beam identification
 |  |  | N/A |  | TBD | N |  |  |  | TBD |
| ~~16-2~~ | ~~Multi-TRP operation~~  | ~~Multi-DCI-based: (FFS whether to be a separate UE feature, e.g. 16-2a)~~1. ~~The maximum number of CORESETs configured per “PDCCH-Config”~~
2. ~~The maximum number of CORESETs configured per CORESETPoolIndex (if configured) per “PDCCH-Config”~~
3. ~~The value of R=[1,2] for BD/CCE~~
4. ~~Whether the UE shall 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~~
5. ~~The maximum number of PUCCH transmissions within a slot~~
6. ~~Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain) and out of HARQ process.~~
7. ~~Support of two PDSCH scrambling sequences per serving cell~~
8. ~~Support of default QCL assumption per CORESETPoolIndex~~
9. ~~The maximum number of activated TCI states~~
10. ~~FFS: The maximum number of MIMO layers of scheduled PDSCHs~~
11. ~~Support of separate HARQ-ACK and/or joint HARQ-ACK~~

~~Single-DCI-based: (FFS whether to be a separate UE feature, e.g. 16-2b)~~1. ~~Whether supporting two PTRS ports~~
2. ~~Support of new DMRS entries~~
3. ~~Support of default QCL assumption with two TCI states~~
4. ~~FFS: Support of URLLC scheme 1a~~
5. ~~Support of FDMSchemeA~~
6. ~~Support of FDMSchemeB~~
7. ~~Support of TDMSchemeA~~
8. ~~Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16~~
9. ~~For FDMSchemeB, whether the UE can support CW soft combining~~
10. ~~Supported maximum TBS size for TDMSchemeA~~
11. ~~Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation~~
12. ~~FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)~~

The previous components in FG 16-2 are separated into individual FGs from 16-2a to 16-2b-5 as follows. | ~~TBD~~ |  | ~~N/A~~ |  | ~~TBC~~~~[Per band]~~ | ~~N~~ | ~~TBD~~ |  |  | ~~TBD~~ |
| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config”
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config”
3. The value of R=[1,2] for BD/CCESupport of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
4. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
5. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
6. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
7. FFS: The maximum number of activated TCI states
8. FFS: The maximum number of MIMO layers of scheduled PDSCHs
9. FFS: the maximum number of CCs supporting multi-DCI based multi-TRP

Optional components:1. Whether the UE shall 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
2. FFS: Support of two PDSCH scrambling sequences per serving cell
3. Support of default QCL assumption per CORESETPoolIndex
4. Support of separate HARQ-ACK
5. Support of joint HARQ-ACK
6. Support of two TDMed long PUCCHs in a slot
 | TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2b | Single-DCI based multi-TRP | Basic component(s):1. FFS: Support of MAC CE to activate multiple TCI states for a TCI codepoint
2. FFS: Number of CCs supporting single-DCI based multi-TRP operation

Optional components:1. Support of default QCL assumption with two TCI states
 | TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| 16-2b-1 | Single-DCI based SDM scheme | 1. FFS: Support of DCI indication of of 2 TCI states by a codepoint and DMRS ports within two CDM groups
2. Whether supporting two PTRS ports
3. FFS Support of DMRS entry {0, 2, 3}
 | 16-2b, TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| 16-2b-2 | Single-DCI based FDMSchemeA | Support of FDMSchemeA | 16-2b, TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| 16-2b-3 | Single-DCI based FDMSchemeB | 1. Support of FDMSchemeB
2. For FDMSchemeB, whether the UE can support CW soft combining
 | 16-2b, TBD |  | N/A |  | TBD [per FSPC] | N | TBD |  |  | TBD |
| 16-2b-4 | Single-DCI based TDMSchemeA | 1. Support of TDMSchemeA
2. Supported maximum TBS size for TDMSchemeA
 | 16-2b, TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation
3. FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)
 | 16-2b, TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| ~~16-3~~ | ~~eType-II codebook~~  | ~~Regular eType-II (FFS whether to be a separate UE feature, e.g. 16-3a)~~1. ~~FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II~~
2. ~~8 parameter combinations (FFS: Value of L per the number of antenna ports)~~
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~
4. ~~Rank 1 to 4~~
5. ~~CBSR~~
6. ~~Rank restriction~~
7. ~~FFS: UCI omission~~
8. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
9. ~~FFS: Support of mixed codebook types~~

~~Port selection eType-II (FFS whether to be a separate UE feature, e.g. 16-3b)~~1. ~~FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II~~
2. ~~6 parameter combinations (combos with L=6 don’t apply) (FFS: Value of L per the number of antenna ports)~~
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~
4. ~~Rank 1 to 4~~
5. ~~Rank restriction~~
6. ~~FFS: UCI omission~~
7. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
8. ~~FFS: Support of mixed codebook types~~

The components in FG 16-3 are separated into individual FGs 16-3a and 16-3b as follows. | ~~TBD~~ |  | ~~N/A~~ |  | ~~FFS: Per band or Per band per BC~~ | ~~N~~ | ~~N~~ |  |  | ~~Optional~~ |
| 16-3a | Regular eType-II | Basic components:1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 8 parameter combinations (FFS: Value of L per the number of antenna ports)
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with value R=1
4. Rank restriction
5. ~~FFS:~~ UCI omission

Optional components1. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with R=2
2. ~~Rank 1 to 4~~ Support of rank 3,4
3. CBSR
4. FFS: The maximum number of configured aperiodic CSI Report Settings
5. FFS: Support of mixed codebook types
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b | Port selection eType-II | Basic components:1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 6 parameter combinations (combos with L=6 don’t apply) (FFS: Value of L per the number of antenna ports)
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with value R=1
4. Rank restriction
5. ~~FFS:~~ UCI omission

Optional components:1. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with R=2
2. ~~Rank 1 to 4~~ Support of rank 3,4
3. FFS: The maximum number of configured aperiodic CSI Report Settings
4. FFS: Support of mixed codebook types
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-4 | Low PAPR DMRS for DL | Low PAPR DMRS for PDSCH | TBD  |  | N/A |  | Per UE | N | N |  |  | [Optional] |
| ~~16-5~~ | ~~Power-efficient UL transmission~~ | ~~UL full power transmission (mode [0], 1, 2)~~1. ~~Supported UL full power transmission mode ([mode 0], mode 1, mode 2, [mode1AndMode2])~~
2. ~~FFS: New UL codebook set(s) per supported mode~~
3. ~~The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]~~
4. ~~FFS: Number of ports per SRS resource~~
5. ~~FFS: Maximum number of different spatial relationship info for all SRS resources for usage set to ‘codebook’ in a resource set~~
6. ~~TPMI group which delivers full power~~

~~Note: UE indicating mode 2 shall support full power transmission for 1 antenna port~~The components in FG 16-5 are separated into individual FGs from 16-5a to 16-5c as follows. |  ~~[2-13, 2-14] for #1-#3~~ |  | ~~N/A~~ |  | ~~Per UE~~ | ~~N~~ | ~~N~~ |  |  | ~~TBD~~  |
| 16-5a | UL full power transmission mode 0 | 1. Supported UL full power transmission ~~[~~mode 0~~]~~
2. Number of Tx to support mode 0: {2Tx, 4Tx, 2Tx\_4Tx}
 | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N | N |  |  | TBD |
| 16-5b | UL full power transmission mode 1 | 1. Supported UL full power transmission mode 1
2. Number of Tx to support mode 1: {2Tx, 4Tx, 2Tx\_4Tx}
3. FFS: New UL codebook set(s) ~~per supported mode~~ per supported Tx
 | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N | N |  |  | TBD |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of Tx to support mode 2: {2Tx, 4Tx, 2Tx\_4Tx}
3. The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.
4. FFS: Number of ports per SRS resource
5. FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set
6. TPMI group which delivers full power. FFS on details for supported number of Tx.

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N | N |  |  | TBD |
| ~~16-6~~ | ~~Low PAPR DMRS for UL~~ | 1. ~~For PUSCH without transform precoding~~
2. ~~For PUSCH with transform precoding and with pi/2 BPSK modulation~~
3. ~~For PUCCH format 3 and/or PUCCH format 4 with transform precoding and with pi/2 BPSK modulation~~

The components in FG 16-6 are separated into individual FGs 16-6a and 16-6b as follows. | ~~TBD for #1-#3~~ |  | ~~N/A~~ |  | ~~Per UE~~ | ~~N~~ | ~~N~~ |  |  | ~~TBD~~ |
| 16-6a | Low PAPR DMRS for PUSCH | 1. For PUSCH without transform precoding
2. For PUSCH with transform precoding and with pi/2 BPSK modulation
 | TBD |  | N/A |  | FFS: Per band | N | N |  |  |  FFS: Optional with capability signalling |
| 16-6b | Low PAPR DMRS for PUCCH | For PUCCH format 3 and/or PUCCH format 4 with transform precoding and with pi/2 BPSK modulation | TBD |  | N/A |  | FFS: Per band | N | N |  |  |  FFS: Optional with capability signalling |
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The following table is the moderator’s summary of contributions submitted to RAN1 #100bis-e in this agenda item.

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| --- | --- |
| Company | Comments/Questions/Suggestions |
| ZTE [2] | **Component-2 in 16-1a: FFS: Support of group-based reporting for L1-SINR** ZTE proposes to introduce UE capability reporting of support of group-based reporting for L1-SINR as a separate feature group

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |
| 16-1h | Group-based reporting for L1-SINR | Support of group-based reporting for L1-SINR | 16-1a |  |  |  |  |  |  |  |  |  |

**16-1b: TCI state activation and spatial relation update**ZTE suggests to define this FG as whether to support these features directly rather than the maximum values, and the maximum values are based on the existing agreements or Rel-15 UE capability reporting- The maximum number of simultaneous TCI state activation across multiple CCs is determined according to Component 2-4: TCI states for PDSCH- The maximum number of simultaneous spatial relation update across multiple CCs is determined according to Component 2-59: Configured spatial relations- The maximum number of PUCCH resource groups is 4 according to agreementsZTE further argues that the above three features are independent and FG-16-1b should be split into three FGs separately for active TCI/spatial relation in a single CC

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1b-1 | TCI state activation and spatial relation update | 1. Support of Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH ~~(FFS whether to be a separate UE feature, e.g. 16-1b)~~
2. FFS: details on whether/how to indicate band pairs which can share the same DL TCI state
 | Component 1: 2-1, 2-4 |  | N/A |  | TBD[Per BC or per band] | N | Y |  |  | TBD |
| 16-1b-2 | Spatial relation update across multiple CCs | 1. Support of Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
2. FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info
 | Component 1: 2-59, 2-60 |  | N/A |  | TBD[Per BC or per band] | N | Y |  |  | TBD |
| 16-1b-3 | Spatial relation update for PUCCH group | Support of PUCCH resource groups per BWP for simultaneous spatial relation update | 2-53, 2-59, 4-24 |  | N/A |  | TBD[Per BC or per band] | N | Y |  |  | TBD |

**16-1d: [Support of / The maximum number of] spatial relation update for AP-SRS via MAC CE**ZTE prefers to update the component as "Support of spatial relation update for AP-SRS via MAC CE" as is done for other components for TCI/spatial relation update. The maximum number of spatial relation update for AP-SRS via MAC CE is based on the recent Component 2-59: Configured spatial relations

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1d | MAC CE spatial relation update for AP-SRS | Support of spatial relation update for AP-SRS via MAC CE ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~ | 2-53, 2-59 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |

**16-1e: Pathloss reference RS activation via MAC CE**ZTE prefers to have a fixed value for maximum number of activated pathloss reference RS(s) rather than according to UE capability. As a baseline, up to 4 activated pathloss reference RS(s) can be supported mandatory without capability signaling, which is the same as in Rel-15

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. The support of pathloss reference RS activation for PUSCH/SRS/PUCCH via MAC CE
 | ~~8-2,~~ 8-3 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |

**Component-5 in 16-1f: FFS: Support of PUCCH-BFR**ZTE proposes the support of PUCCH-BFR shall be mandatory with capability signaling for FR2 and optional for FR1 (as RAN1 did for PCell-BFR), in order to guarantee the effectiveness/low-latency of SCell-BFR. Hence, this component 5 in 16-1f should be removed, and the UE supporting the basic feature group FG 16-1f should support both SR based and PUCCH based-BFR.**Component-7 in 16-1f: FFS: Density of CSI-RS for new beam identification for SCell BFR**For frequency density of CSI-RS for SCell BFR, ZTE prefers to align it with PCell-BFR, i.e., there is not any further restriction for frequency density of CSI-RS for SCell BFR.

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| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
2. FFS: The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC] ~~(FFS to replace this component to 14)~~
 | 2-31 |  | N/A |  | TBD | N |  |  |  | TBD |

**In FG16-2a: Support of out of order**Regarding the component 4-6 about out of order operation in FG 16-2a, ZTE thinks they should be basic components since once Multi-DCI is supported by UE, out of order operation for PDCCH to PDSCH, PDSCH to HARQ-ACK and PDCCH to PUSCH must be supported because of independent scheduling between two TRPs. Otherwise, it is impossible for gNB to implement MTRP in the case of non-ideal backhaul which is the typical scenario for Multi-DCI based MTRP **In FG16-2a: Support of two PDSCH scrambling sequences**ZTE thinks individual capability report is not needed for the support of two scrambling IDs and the support of two scrambling IDs should be a basic feature for Multi-DCI base MTRP. **In FG16-2a: Support of separate HARQ-ACK**Since both separate and joint ACK/NACK feedback are agreed in Rel-16, ZTE believes one of them should be the basic component since otherwise M-DCI based MTRP cannot work if UE does not support both. Because the main scenario is non-ideal backhaul for M-DCI based MTRP, ZTE suggests to make the optional component 4, i.e. support of separate feedback be the basic component.

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| 16-2a | Multi-DCI based multi-TRP | 1. The maximum number of CORESETs configured per “PDCCH-Config”
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config”
3. The value of R=[1,2] for BD/CCE
4. Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
5. Support of out-of-order operation for PDCCH to PDSCH
6. Support of out-of-order operation for PDSCH to HARQ-ACK
7. Support of out-of-order operation for PDCCH to PUSCH
8. FFS: The maximum number of activated TCI states
9. FFS: The maximum number of MIMO layers of scheduled PDSCHs
10. FFS: the maximum number of CCs supporting multi-DCI based multi-TRP
11. Support of two PDSCH scrambling sequences per serving cell
12. Support of separate HARQ-ACK
 | TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
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| 16-2a-4 | Joint HARQ-ACK for multi-DCI based multi-TRP | 1. Support of joint HARQ-ACK
2.
 | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-5 | Two TDMed long PUCCHs in a slot | Support of two TDMed long PUCCHs in a slot | 16-2a |  |  |  |  |  |  |  |  |  |

**Merge 16-2b-1 and 16-2b**ZTE thinks 16-2b-1, i.e., the support of SDM scheme, should be merged into 16-2b. Further, the support of DCI indicating 2 TCI states by a codepoint and DMRS ports within two CDM groups and the support of DMRS entry {0,2,3} should be basic components in the merged FG. The reason is that SDM scheme is the basic functionality of single DCI based MTRP based on Rel-16 discussion, and other schemes including FDM and TDM schemes have been agreed as optional features for single-DCI based MTRP. If UE reports not to support any of these schemes, 16-2b is not supported as well. Further, there is no RRC signaling to disable SDM scheme if UE supports two TCI states indicated by one codepoint. Having the support of two PTRS as an optional feature for FR1 is okay with ZTE, but this feature should be mandatory with capability signaling if 16-2b is supported.**In 16-2b: Support of MAC CE to activate multiple TCI states for a TCI codepoint**ZTE believes activating two TCI states for one TCI codepoint is a basic feature to implement single-DCI based multi-TRP transmission as without this feature, multi-TRP transmission cannot be implemented.

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| 16-2b | Single-DCI based multi-TRP | 1. Support of MAC CE to activate multiple TCI states for a TCI codepoint
2. Support of DCI indication of of 2 TCI states by a codepoint and DMRS ports within two CDM groups
3. Support of DMRS entry {0, 2, 3}
 | TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| 16-2b-1 | Two PTRS ports for single-DCI based multi-TRP | 1. Whether supporting two PTRS ports
 | 16-2b, TBD |  | N/A |  |  | N | TBD |  |  | TBD |

**16-3 eType II codebook**Since it is agreed that eType II codebook and eType II port selection codebook will have separate UE capabilities, ZTE believes it makes more sense to have separate feature groups for eType II and eType II port selection, which is same as Rel-15 and to split 16-3 into two separate feature groups: eType II and eType II port selection.

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| 16-3a | Regular eType-II | 1. Support of parameter combinations 1-6
2. Support of PMI sub-bands with value N3<=19
3. Rank 1 and 2
4. UCI omission
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-1 | CSI-RS and number of PMI subbands for eType-II | For regular eType-II: A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources across all CCs simultaneously, total # of Tx ports across all CCs simultaneously, Max # of PMI subbands N3}, where N3>=19  | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |

**Number of PMI sub-bands in 16-3a and 16-3b**ZTE proposes that the UE signals the maximum N3 value, which shall be larger than 19. Support to report it jointly with the maximum number of CSI-RS ports per resource, the maximum number of active CSI-RS resources per band and the maximum number of active CSI-RS ports per band.ZTE observes that it was agreed previously that for regular eType II, codebook parameter combinations 1-6 are basic components, and codebook parameter combination 7-8 is optional and that this is not reflected in the current UE feature list.ZTE observes that in the current UE feature list, there is a basic component for eType II and eType II PS called rank restriction. ZTE believes that is a mistake. What should be here is the support of rank 1 and 2, since RAN1 have agreed that rank 1 and 2 are basic, and rank 3 and 4 are optional.ZTE observes that it has been agreed that the maximum number of AP CSI settings for one BWP is increased from 4 to 8 and that this is not related to either eType II or eType II port selection. Hence ZTE suggests to add one more FG 16-3c to indicate the support of maximum 8 AP CSI report settings for one BWP, and it does not reply on the support of eType II or eType II port selection.

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| 16-3a-3 | CBSR for eType-II | Support of CBSR for regular eType II | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
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| 16-3a-4 | Codebook parameter combination 7-8 for eType II | Support of codebook parameter combinations 7-8 | 16-3a, TBD |  |  |  |  |  |  |  |  |  |
| 16-3b | Port selection eType-II | 1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 6 parameter combinations (combos with L=6 don’t apply) (FFS: Value of L per the number of antenna ports)
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with value N3<=19
4. Rank restriction
5. UCI omission
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-1 | CSI-RS and number of PMI subbands for port selection eType-II | For port selection eType-II: A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources across all CCs simultaneously, total # of Tx ports across all CCs simultaneously, Max # of PMI subbands N3}, where N3>=19 | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| 16-3c | Number of AP-CSI report settings per BWP | Support up to 8 configured aperiodic CSI report setting per BWP | TBD |  |  |  |  |  |  |  |  |  |

**16-5a/5b/5c: Number of Tx to support mode 0/1/2: {2Tx, 4Tx, 2Tx\_4Tx}**ZTE argues that as a basic principle, for full Tx power transmission, the corresponding PUSCH power scaling factor and extension of UL codebook should be determined only according to the full Tx mode and TPMI-group reporting for full Tx power in mode2 and that components “16-5a/5b/5c: Number of Tx to support mode 0/1/2: {2Tx, 4Tx, 2Tx\_4Tx}” strongly restrict the flexibility of gNB configuration. - For mode 0, all PAs of the UE shall support full Tx power, regardless of 2Tx, or 4Tx.- For mode 1, the scaling factor is the same as Rel-15, and only extension of the UL codebook is supported herein. It does not make sense that the extension of codebook is only applied to a specific number of Tx. - For mode 2, this component is also redundant, considering that the component 16-5-6: TPMI group which delivers full power can fully provide the UE capability of which TPMIs can support full power.**Component-3 in 16-5b: FFS: New UL codebook set(s) per supported Tx**ZTE argues the new UL codebook set(s) are fixed as specified in current specification and hence the bullet should be removed. The new UL codebook sets should be supported if mode 1 is supported.**Component-4 in 16-5c: FFS: Number of ports per SRS resource**ZTE questions why this component is needed**Component-5 in 16-5c: FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set**ZTE thinks this component is needed. ZTE can consider the candidate values of "1", "2" or "4" for this component

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| 16-5a | UL full power transmission mode 0 | 1. Supported UL full power transmission ~~[~~mode 0~~]~~
 | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N | N |  |  | TBD |
| 16-5b | UL full power transmission mode 1 | 1. Supported UL full power transmission mode 1
 | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N | N |  |  | TBD |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.
3. Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set
4. TPMI group which delivers full power. FFS on details for supported number of Tx.

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N | N |  |  | TBD |

**16-6a low PAPR RS for PUSCH**Since the design on Low PAPR DMRS for CP-OFDM and for DFT-S-OFDM are completely different, ZTE thinks FG 16-6a should be split into two FGs. One is for CP-OFDM, the other is for DFT-S-OFDM. The reason is that for CP-OFDM, the enhanced low PAPR DMRS is still inserted in frequency domain, the only change compared with Rel-15 is just on sequence initialization. However, for DFT-S-OFDM, the enhanced low PAPR DMRS is inserted in time domain. Then, DFT process is needed to transform DMRS from the time domain to the frequency domain. The final DMRS sequence in frequency domain is not constant amplitude anymore. Hardware implementation change at both gNB side and UE side may be needed for this feature group. Some UEs with less capability maybe only support the new DMRS for CP-OFDM. Therefore, ZTE suggests to report the UE capability separately on low PAPR DMRS with and without transform precoding. Proposal 5: Split FG16-6a into two FGs separately for CP-OFDM and DFT-s-OFDM.

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| 16-6a | Low PAPR DMRS for PUSCH without transform precoding | For PUSCH without transform precoding | TBD |  | N/A |  | FFS: Per band | N | N |  |  |  FFS: Optional with capability signalling |
| 16-6b | Low PAPR DMRS for PUCCH | For PUCCH format 3 and/or PUCCH format 4 with transform precoding and with pi/2 BPSK modulation  | TBD |  | N/A |  | FFS: Per band | N | N |  |  |  FFS: Optional with capability signalling |
| 16-6c | Low PAPR DMRS for PUSCH with transform precoding and with pi/2 BPSK | For PUSCH with transform precoding and with pi/2 BPSK modulation | TBD |  | N/A |  | FFS: Per band | N | N |  |  |  FFS: Optional with capability signalling |

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| Vivo [3] | **On 16-1b:** Regarding the first two sets of squared brackets, Vivo proposes the following:* The “max number of lists” of simultaneous TCI states and spatial relation update is not necessary to be reported.
* Support to report in 16-1b the max number of unique downlink RS resources in the active TCI states and active spatial relation info per band combination for simultaneous TCI state activation and spatial relation info.

**On 16-1e:** Regarding the squared brackets of component 2. Vivo proposes to limit the total number of active pathloss RS across CCsRegarding the FFS in component 3, Vivo prefers this should be discussed in RAN4 first**On 16-2a:** Vivo proposes to split this into two different parts with one part containing basic components and another part containing optional components.**On 16-2b:** Vivo proposes to move the following component from 16-2b to 16-2b-1: “Support of default QCL assumption with two TCI states”**On 16-5c:** Vivo argues there are two flavors of UL full power transmission mode 2, one flavor is the component 3 where multiple SRS resources in a set are configured with different number of ports for the usage set to ‘codebook’ and another flavor is the component 6 where UE reports TPMI/TPMI group which can deliver full power. Vivo thinks these two are mutually exclusive and propose * Split 16-5c into 2 sub-feature within one containing component 3 and another containing component 6

**On 16-6b:** Vivo proposes to clarify the meaning of “and/or” in component 3: does it mean UE can indicate support of low PAPR RS for PF3 and PF4 individually? |
| OPPO [4] | Oppo proposes that for the TMPI groups for UE capability reporting, an additional group G7 as the union set of G1 and G6 should be supported Oppo notes it is still open whether the TPMI group reporting is optional or mandatory given Mode 2 is reported since the transmission Mode 2 consists of two independent features, antenna virtualization and full power transmission for TPMI with corresponding full-rated PA. Since these two features do not depend on each other and can be used separately, Oppo argues there is no motivation to combine them together and UE should have the flexibility to support one of the following• Antenna virtualization• Full power transmission for TPMI with corresponding full-rated PA• Antenna virtualization and Full power transmission for TPMI with corresponding full-rated PAOppo thus proposes that support the reporting of TMPI groups is optional for a UE reporting the support of Mode 2Regarding the simultaneous support of Mode 1 and Mode 2 for a given UE, Oppo doesn’t see any motivation to support both Mode 1 and Mode 2:* From the perspective of implementation and IoDT test, it is not beneficial to support two totally redundant feature
* From the perspective of network, a network supporting full UL power transmission operations should support both Mode 1 and Mode 2 since either of them is optional

They thus propose that a UE does not support both Mode 1 and Mot 2 and can only report one the following candidates if it supports full power transmission: {Mode 0, Mode 1, Mode 2}Oppo argues that for Mode 0 for a UE with N Tx, it can support M (M<=N) Tx with full power transmission and there is no need to report 2Tx\_4Tx. Moreover, they argue the maximum number of SRS ports reported in Rel-15 already indicates 1Tx, 2Tx or 4 Tx, and hence the current Component 2 is redundant. They mention similar arguments are applicable to Mode 1. For Mode 2, they note the reported TPMI groups in Component 6 are based on 2 ports and/or 4 ports, which also indicates 2Tx, 4Tx, or 2Tx\_4Tx and thus Component 2 for Mode 2 is not needed either.Hence, regarding the full power transmission, they propose to* Remove Component 2 of mode 0 (16-5a)
* Remove Component 2, 3 of mode 1 (16-5b)
* Remove Component 2, 4, 5 of mode 2 (16-5c)

Further, if the above changes are agreed, they argue there is no need to split into 3 feature groups and two feature groups are better* Feature group 1: Mode of full power transmission {mode 0, mode 1, mode 2}
* Feature group 2: Component 3 and 6 of 16-5c (optional, conditioned that Mode 2 is reported)

Oppo proposes that the Rel-15 UE capability “tci-StatePDSCH” is also applied to single DCI based M-TRP transmission in Rel-16Oppo believes support of partially overlapped PDSCHs at time and frequency domain scheduled by multiple PDCCHs should be an optional UE capability for UE supporting multi-DCI based M-TRP transmission and at least two UE capabilities should be defined:• Two PDSCHs are partially overlapped in frequency domain and fully/partially overlapped in time domain.• Two PDSCH are partially overlapped in time domain and fully/partially overlapped in frequency domain.Furthermore, Oppo suggests that support of PDSCH mapping type A+B for simultaneously received PDSCHs is a component UE capability of this featureOppo proposes that for TCI state mapping to PDSCH transmission occasions for scheme 4, cyclical mapping is an optional UE capability and that if the RRC parameter RepTCIMapping is not configured, sequential mapping is usedOppo notes that according to the conclusion of RAN4, the length of required application time for each newly activated path loss RS depends various UE implementation factors. Therefore, they think is not feasible to specify one single value for all the UE and it is preferred for each UE to report UE-specific value, i.e., for MAC CE-based path loss RS activation, the UE reports the minimal application time that the UE requires.Oppo believes R=2 may have limited performance gain for large bandwidth, but when Nsb < 10 the gain of R=2 is marginal. Moreover, they argue, R=2 results some more overhead than R=1 when Nsb<10. From Since the UE has to calculate precoder per half CQI subband for R = 2, which has impact on hardware structure and double the complexity of UE implementation given N3, they propose to support R=1 as mandatory feature regardless of the value of N3, and to make R=2 optional (i.e., same as the latest version of UE feature list) |
| China Unicom [5] | China Unicom proposes to spilt feature group 16-3 into two feature groups:* Feature group 16-3a: Supported Regular eType-II
* Feature group 16-3b: Port selection eType-II

China Unicom believes support of mixed codebook types is critical and necessary. For example, UE can report a list of supported combinations for codebook types and signaled in a form as {codebook A, codebook B, max # ports per resource, max # resource, max # total ports}, where Codebook A is one of {Type I SP, Type I MP}, codebook B is one of {Type II, Type II port-selection, eType II, eType II port-selection}. They thus propose to remove the FFS in “FFS: Support of mixed codebook types” for regular eType-II codebook and eType II port selectionChina Unicom further argues that regarding UCI omission in component 7 for eType II and component 6 for eType II port selection, there is no need of adding this UE capability for either type codebook. They thus propose to remove the component “UCI omission” for these two types of codebooks.Regarding CBSR, for regular eType II, China Unicom argues there are two modes of CBSR. One is just on and off, which indicates whether UE supports CBSR and UE will signal “supported” or not. The other is “soft” amplitude restriction, with choice from 4 amplitude restrictions, as amplitudeSubsetRestriction in 38.214. China Unicom thinks the second mode should be optional even for UE supports CBSR and proposes to modify component 5 to: (1) CBSR (2) If UE supports CBSR, whether UE supports amplitudeSubsetRestriction as in 38.214Regarding the number of PMI sub-bands in component 3 for both eType II and eType II port selection, China Unicom argues the R=2 scheme increases UE operation and computational complexity compared with R=1, e.g., a new subband size for PMI, mismatch subband size on PMI and CQI, as well as increased total number of PMIs. However, R=2 also leads to a finer PMI quantization granularity, which is preferred at the gNB side in their view. In order to tradeoff the advantages and disadvantages, they prefer to set this component(R=2) to be optional for different UE implement. Furthermore, they prefer that component 3 and component 1 can be combined to a quadruple form that can be signaled independently for eType II and eType IIRegarding the maximum number of configured aperiodic CSI Report Settings in component 8 for eType II and component 7 for eType II port selection, China Unicom prefers to address them based on previous agreements, i.e., the maximum number of configured aperiodic CSI Report Settings should be a general feature regardless of codebook type and the max value should be updated from 4 to 8For feature 16-5, China Unicom believes the feature "mode1AndMode2" should be supported for power-efficient UL transmission. China Unicom further observes that some components of feature 16-5 are associated with a specific mode and not in general. For example, for SRS resource and TPMI grouping, the prerequisite is UL full power transmission mode 2. China Unicom thinks this feature should be decoupled into several features according to different modes and prerequisites. As for component 2, the “FFS: New UL codebook set(s) per supported mode” is redundant in China Unicom’s view, as the new UL codebook set is only supported under mode 1. In other words, if mode 1 is supported, then the new UL codebook set is supported, vice versa. Therefore, China Unicom prefers the feature to be listed under the decoupled feature 16-5b “Supported UL full power transmission mode 1”and FFS can be removed. Similarly, as for component 6 and component 4 and component 3, they are associated with mode 2 or mode1andmode 2 only. That is, “TPMI group which delivers full power” is applicable only under mode2 or mode1and mode2. So, supporting mode 2 is the prerequisite for this component and China Unicom proposes:* List the component “PMI group which delivers full power” under the decoupled feature 16-5c“Supported UL full power transmission mode 2”
* Each of the above features cannot be per UE, should be per FS(per feature set per band per band combination)
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| MediaTek Inc. [6] | **FG 16-1a L1-SINR reporting**Add capability component for “Support of group-based reporting for L1-SINR”

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| 16-1a | L1-SINR reporting | 1. The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)
2. ~~FFS:~~ Support of group-based reporting for L1-SINR
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | ~~TBD~~ Optional with capability signaling |

**FG 16-1b TCI state activation and spatial relation update**Add capability component for “Indication of band pairs which can share the same DL TCI state/UL spatial relation info.

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| 16-1b | TCI state activation and spatial relation update | 1. [Support of / maximum number of lists for] Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH ~~(FFS whether to be a separate UE feature, e.g. 16-1b)~~
2. [Support of / maximum number of lists for] Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
3. [Support of / The maximum number of] PUCCH resource groups per BWP for simultaneous spatial relation update
4. ~~FFS: details on whether/how to indicate b~~Band pairs which can share the same DL TCI state
5. ~~FFS: details on whether/how to indicate b~~Band pairs which can share the same UL spatial relation info
 | Component 1: 2-1, 2-4Component 2: 2-59, 2-60Component 3: 2-53, 2-59, 4-24 |  | N/A |  | TBD[Per BC or per band] | N | Y |  |  | ~~TBD~~ Optional with capability signaling |

**FG 16-1e Pathloss reference RS activation via MAC CE**MediaTek suggests to add capability component for “The maximum number of activated pathloss reference RS update for PUSCH/SRS [across CCs / within a slot across all CCs / per CC”. They argue “PUCCH” was removed in the description because this feature is only for PUSCH and SRS. However, this number should include configured pathloss reference RSs for PUCCH as otherwise, total number (activated number for PUSCH/SRS and configured number for PUCCH) can be larger than 4. In addition, MediaTek proposes to add a capability component for the number of measurement samples N for newly activated pathloss reference RS

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| 16-1e | Pathloss reference RS activation via MAC CE | 1. The maximum number of configured pathloss reference RSs for PUSCH/SRS~~/PUCCH via MAC CE~~ by RRC for MAC-CE based pathloss reference RS update ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
2. ~~FFS:~~ The maximum number of activated pathloss reference RSs ~~update~~ for PUSCH/SRS~~/PUCCH~~ and configured pathloss reference RSs for PUCCH [across CCs / within a slot across all CCs / per CC] ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
3. ~~FFS:~~ Number of measurement samples N to apply newly activated pathloss reference RS
 | ~~8-2,~~ 8-3 |  | N/A |  | TBD[Per UE] | N | N |  |  | ~~TBD~~ Optional with capability signaling |

**FG 16-1f SCell beam failure recovery**MediaTek believes capability component for “Support of PUCCH-BFR” is not needed because it is just the same as normal SR transmission.Furthermore, they suggest FG 16-1g can include capability component for “The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC]”. Lastly, the capability component for “Density of CSI-RS for new beam identification for SCell BFR” is unnecessary un MediaTek’s view **FG 16-1g Resources for beam management, pathloss measurement, and BFR**MediaTek proposes to jointly report the capability for the amounts of reference signal resources for various functionsThey note the function ‘BFD’ is missing in the feature group titleMediaTek prefers that the capability for the number of configured resources and for the number of resources to perform measurement in a slot is separately captured since the former corresponds to the capability of the memory size, while the latter is concerned with the capability of computation complexityMediaTek argues that the computation complexity at IMR for L1-SINR measurement and that at other resources such as those for CMR of L1-RSRP/L1-SINR, pathloss measurement, new beam identification, and beam failure detection are quite different. For the former, only measurement on the total received power is sufficient, while for the latter, separate estimation for signal and noise is required. Therefore, MediaTek suggests the corresponding capability should be separately captured for the IMR of L1-SINR and for other purposes. Further, MediaTek notes the aperiodic CSI-RS resource is separated in a different component in FG 2-24. Thus, it is proposed that the same rule is applied to FG 16-1g.

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| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
2. ~~FFS: Support of PUCCH-BFR (FFS whether to be a separate UE feature, e.g. 16-1d)~~
3. ~~FFS: The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC]~~ ~~(FFS to replace this component to 14)~~
4. ~~FFS: Densigy Density of CSI-RS for new beam identification for SCell BFR~~
 | 2-31 |  | N/A |  | ~~TBD~~Per UE | N |  |  |  | ~~TBD~~ Optional with capability signaling |
| 16-1g | ~~FFS:~~ Resources for beam management, pathloss measurement, BFD, and BFR | 1. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, and new beam identification.~~
2. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for pathloss measurement~~
3. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for BFD~~
4. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for new beam identification~~
5. The total number (sum of periodic/semi-persistent/aperiodic) of
	* SSB/NZP-CSI-RS/CSI-IM resources configured for L1-RSRP/L1-SINR, and
	* BFR resources configured for new beam identification, and
	* BFD resources configured for beam failure detection, and
	* Pathloss RS resources configured for pathloss measurement

across all CCs shall not exceed M\_11. The total number of aperiodic NZP-CSI-RS/CSI-IM resources configured for L1-RSRP/L1-SINR across all CCs shall not exceed M\_2
2. The total number (sum of periodic/semi-persistent/aperiodic) of
	* SSB/NZP-CSI-RS resources to perform measurement on CMR for L1-RSRP/L1-SINR, and
	* BFR resources to perform measurement for new beam identification, and
	* BFD resources to perform measurement for beam failure detection, and
	* Pathloss RS resources to perform measurement for pathloss

across all CCs within a slot shall not exceed M\_31. The total number (sum of periodic/semi-persistent/aperiodic) of NZP-CSI-RS/CSI-IM resources to perform measurement on IMR for L1-SINR across all CCs within a slot shall not exceed M\_4
 | 2.24 |  | N/A |  | TBD[Per UE] | N |  |  |  | ~~TBD~~ Optional with capability signaling |

**FG 16-2a Multi-DCI based multi-TRP**MediaTek proposes to move component 4, component 5, and component 6 related to out-of-order from basic components to optional componentsMediaTek proposes to define a basic capability component for M-DCI: “Indication of supporting type(s) of separate/joint HARQ-ACK”, with candidate values {separate, joint, both}To avoid a mismatched behaviour of UE and gNB MediaTek believes supporting a default QCL assumption should be moved to basic components, i.e., “Support of default QCL assumption per CORESETPoolIndex” is a basic component for M-DCI operationIn addition, MediaTek proposes to add the following two components for M-DCI operation in FG16-2a:* Support of simultaneous reception for PDCCH/PDSCH associated with two QCL-Type-D RSs
* Indication of supported “PDSCHs overlapping types”, with bitmap signalling for {fully, partial, non-overlapped TDM, non-overlapped FDM}.”

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| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config”
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config”
3. The value of R=[1,2] for BD/CCESupport of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
4. ~~Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)~~
5. ~~Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)~~
6. ~~Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)~~
7. FFS: The maximum number of activated TCI states
8. FFS: The maximum number of MIMO layers of scheduled PDSCHs
9. FFS: the maximum number of CCs supporting multi-DCI based multi-TRP
10. Indication of supporting type(s) of separate/joint HARQ-ACK
11. Support of default QCL assumption per CORESETPoolIndex

Optional components:1. Whether the UE shall 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
2. FFS: Support of two PDSCH scrambling sequences per serving cell
3. ~~Support of default QCL assumption per CORESETPoolIndex~~
4. ~~Support of separate HARQ-ACK~~
5. ~~Support of joint HARQ-ACK~~
6. Support of two TDMed long PUCCHs in a slot
7. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
8. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
9. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
10. Support of simultaneous reception for PDCCH/PDSCH associated with two QCL-Type-D RSs
11. Indication of supported “PDSCHs overlapping types”, with bitmap signalling for {fully, partial, non-overlapped TDM, non-overlapped FDM}.”
 | TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |

**FG 16-2b Single-DCI based multi-TRP**MediaTek prefers the components of FG 16-2b to be optional or numeric since reporting support of a scheme, e.g., SDM, means all necessary feature components are supported. Second, although the SDM, FDM, and TDM schemes are standalone feature groups and can thus be supported independently, some feature components are applicable to all schemes and can be jointly reported using FG 16-2b according to MediaTek. Following the above principles, they propose not to distinguish the components in FG16-2b as basic or optional. Further, the component “FFS: Support of MAC CE to activate multiple TCI states for a TCI codepoint should be removed in MediaTek’s view since it is necessary for all single-DCI based schemes. Finally, number of CCs should be an optional feature rather than basic according to MediaTek. To address the issue that a UE may not support two simultaneous Rx beams, MediaTek proposes to add the component “Maximum number of QCL Type D RSs indicated in a codepoint of a DCI” in each of FGs 16-2b-1, 16-2b-2, and 16-2b-3. If a UE only supports one Rx beam at a time, it can report a value of one for this component.As for the “FFS” components in FG 16-2b-1 and FG 16-2b-5, since Component 1 in FG 16-2b-1 is how the SDM scheme is captured in the specification, Component 1 should be there as is according to MediaTek. Moreover, MediaTek argues the SDM scheme can work well even if the DMRS entry {0, 2, 3} is not supported, so Component 3 in FG 16-2b-1 should be an optional feature for the SDM scheme. Lastly, there seems no strong motivation to support both TCI state mappings, so a UE can decide which mapping to support for convenience of implementation. For single-DCI based multi-TRP operation, MediaTek suggests all feature groups should be optional and of type at least “per band”. Only FG 16-2b, 16-2b-1, 16-2b-2, and 16-2b-3 require FR1/FR2 differentiation since these feature groups have components related to QCL type D.

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| 16-2b | Single-DCI based multi-TRP | ~~Basic component(s):~~1. ~~FFS: Support of MAC CE to activate multiple TCI states for a TCI codepoint~~
2. FFS: Number of CCs supporting single-DCI based multi-TRP operation

~~Optional components:~~1. Support of default QCL assumption with two TCI states
 | TBD |  | N/A |  | TBD | N | Y |  |  | Optional |
| 16-2b-1 | Single-DCI based SDM scheme | 1. ~~FFS:~~ Support of DCI indication of ~~of~~ 2 TCI states by a codepoint and DMRS ports within two CDM groups
2. Whether supporting two PTRS ports
3. ~~FFS~~ Support of DMRS entry {0, 2, 3}
4. Maximum number of QCL Type D RSs indicated in a codepoint of a DCI
 | ~~16-2b,~~ TBD |  | N/A |  | per band | N | Y |  |  | Optional |
| 16-2b-2 | Single-DCI based FDMSchemeA | 1. Support of FDMSchemeA
2. Maximum number of QCL Type D RSs indicated in a codepoint of a DCI
 | ~~16-2b,~~ TBD |  | N/A |  | per band | N | Y |  |  | Optional |
| 16-2b-3 | Single-DCI based FDMSchemeB | 1. Support of FDMSchemeB
2. For FDMSchemeB, whether the UE can support CW soft combining
3. Maximum number of QCL Type D RSs indicated in a codepoint of a DCI
 | ~~16-2b,~~ TBD |  | N/A |  | per band | N | Y |  |  | Optional |
| 16-2b-4 | Single-DCI based TDMSchemeA | 1. Support of TDMSchemeA
2. Supported maximum TBS size for TDMSchemeA
 | ~~16-2b,~~ TBD |  | N/A |  | per band | N | N |  |  | Optional |
| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation
3. ~~FFS:~~ TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)
 | ~~16-2b,~~ TBD |  | N/A |  | per band | N | N |  |  | Optional |

**16-5b UL full power transmission mode 1**MediaTek believes component 3 is a duplicated component as component 2: for mode 1, indicating number of Tx to support mode 1 equivalent to indicating new codebook sets and proposes to remove it

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| 16-5b | UL full power transmission mode 1 | 1. Supported UL full power transmission mode 1
2. Number of Tx to support mode 1: {2Tx, 4Tx, 2Tx\_4Tx}
3. ~~FFS: New UL codebook set(s) per supported mode per supported Tx~~
 | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N | N |  |  | TBD |

**16-5c UL full power transmission mode 2**In MediaTek’s view, component 3 and component 4 should be considered together. For example, if an UE reports “the maximum number of SRS resources in set with different number of ports” to be 2, and reports “Number of ports per SRS resource” to be 1, it seems [1port, 1port] is the only valid combination, which was not discussed in RAN1. MediaTek thus proposes:Number of SRS resources (NSRS) and number of ports combination supported for mode 2 operation:• For NSRS=x, Nports combination is (multiple) choice of [n1, n2, …, nx], where ni are distinct values for the number of ports in the i-th SRS resource Furthermore, as single port shall always be supported (as in DCI 0\_0), some combinations need not to be reported according to MediaTek, e.g., Nports combination = [1, 2] for 2Tx UE. Lastly, MediaTek proposes to remove component 5 “Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set” in FG16-5c as RAN1 did not discuss to increase or decrease number of spatial relation info

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| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of Tx to support mode 2: {2Tx, 4Tx, 2Tx\_4Tx}
3. ~~The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.~~
4. ~~FFS: Number of ports per SRS resource~~

4. Number of SRS resources and Number of ports combination supported for mode 2 operation :* 4Tx UE
	+ NSRS=2, Nports combination: {[2port, 4port]}

FFS for other candidate values1. ~~FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set~~
2. TPMI group which delivers full power. FFS on details for supported number of Tx.

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port. Nports combination [1,2] shall be supported by 2Tx UE and [1,4] shall be supported by 4Tx UE. | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N | N |  |  | TBD |

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| Intel Corporation [7] | **FG 16-1a (L1-SINR reporting)**Similar to L1-RSRP, CMR for L1-SINR can be based on SSB or NZP CSI-RS. In addition, L1-SINR may include IMR configuration that can be also based on NZP CSI-RS or ZP CSI-RS (CSI-IM) or both. In order to reflect supported reference signals combination for CMR/IMR in L1-SINR measurements that are supported by the UE, Intel prefers to include component with following candidate values:• Support of SSB for both CMR and IMR• Support of NZP CSI-RS for both CMR and IMR• Support of NZP for CMR and CSI-IM for IMR• Support of NZP for CMR and NZP CSI-RS and CSI-IM for IMRIntel also prefers FG 16-1 to allow UE capability indication for the maximum number of SSB, NZP CSI-RS and CSI-IM resources that can be configured for the UE across all CCs as follows:• Maximum number of the NZP CSI-RS and SSB that can be configured for CMR across all CCs• Maximum number of the NZP CSI-RS that can be configured for IMR across all CCs• Maximum number of CSI-IM that can be configured for IMR across all CCIntel further proposes to include additional UE capability components within FG 16-1a indicating the maximum number of CSI-RS and SSB resources that can be configured for CMR and IMR within a slot and across all CCs:• Maximum number of the NZP CSI-RS and SSB that can be configured for CMR within a slot across all CCs• Maximum number of the NZP CSI-RS that can be configured for IMR within a slot across all CCsAccording to Intel, to limit the total reference signal configurations across both measurements, FG 16-1a should include UE capability components indicating the maximum number of the reference signals that can be configured for L1-RSRP and L1-SINR across all CCs for CMR of L1-RSRP and L1-SINR:• Maximum number of the NZP CSI-RS and SSB that can be configured as CMR for L1-RSRP and L1-SINR across all CCs• Maximum number of the NZP CSI-RS and SSB that can be configured as CMR for L1-RSRP and L1-SINR within a slot across all CCsIn summary, they propose to add the following components to FG 16-1aSupported RS combinations for CMR/IMR for L1-SINR• Max. number of reference signal configurations for CMR and IMR for L1-SINR across all CCs• Max. number of reference signal configurations for CMR and IMR for L-SINR within a slot• Max. number of reference signal configurations for CMR for L1-SINR and L1-RSRP• Support of group-based reporting for L1-SINR

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| 16-1a | L1-SINR reporting | 1. Supported RS for CMR/IMR configurations for L1-SINR2. Max. number of reference signal configurations for CMR and IMR for L1-SINR across all CCs3. Max. number of reference signal configurations for CMR and IMR for L-SINR within a slot4. Max. number of reference signal configurations for CMR for L1-SINR and L1-RSRP5. Support of group-based reporting for L1-SINR |

**FG 16-1b (TCI state activation and spatial relation update)**Intel believes there is no strong motivation to include indication of the band pair for simultaneous update of TCI states and spatial relation update and also, there is no strong motivation to include indication of lists for TCI states, spatial relation info and PUCCH group

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| 16-1b | TCI state activation and spatial relation update | 1. Support of Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH (FFS whether to be a separate UE feature, e.g. 16-1b)
2. Support of Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
3. Support of PUCCH resource groups per BWP for simultaneous spatial relation update
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**FG 16-1d (MAC CE spatial relation update for AP-SRS)** In Rel-15 semi-persistent SRS transmission supports spatial relation update using MAC CE without additional capability signaling for the number of such updates. It is, therefore, not fully clear to Intel why such indication is required for aperiodic SRS.

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| 16-1d | MAC CE spatial relation update for AP-SRS | Support of spatial relation update for AP-SRS via MAC CE ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~ |

**FG 16-1e (Pathloss reference RS activation via MAC CE)**Intel believes that for path-loss reference RS activation via MAC CE in FG 16-1e, there is no strong motivation to define UE capability for the number of active PL reference signal considering Rel-15 behavior and the UE capability for the number of measurement samples may be decided by RAN4, if needed

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| 16-1e | Pathloss reference RS activation via MAC CE | 1. The maximum number of configured pathloss reference RSs for PUSCH/SRS~~/PUCCH via MAC CE~~ by RRC for MAC-CE based pathloss reference RS update ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
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**FG 16-1f (SCell Beam Failure Recovery)**Intel proposes to indicate the maximum number of resources per CC in 16-1f-3 while the FFS in 16-1g for indication across all CCs can be removed. The need for a separate UE capability for CSI-RS density for the purposes of SCell BFR is unclear and might not be required in Intel’s view. Moreover, Intel argues the UE capability for the maximum number of SSB and/or CSI-RS resources for new beam identification per CC should be reported. The maximum number of resources for new beam identification across all CCs should also be reported according to Intel and can be done using 16-1g-4 (removing the FFS)

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| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
2. FFS: Support of PUCCH-BFR ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
3. The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR per CC ~~(FFS to replace this component to 14)~~

FFS: ~~Densigy~~ Density of CSI-RS for new beam identification for SCell BFR  |
| 16-1g | FFS: Resources for beam management, pathloss measurement, and BFR | 1. FFS: The maximum number of SSB/CSI-RS resources across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, and new beam identification.
2. FFS: The maximum number of SSB/CSI-RS resources across all CCs for pathloss measurement
3. FFS: The maximum number of SSB/CSI-RS resources across all CCs for BFDThe maximum number of SSB/CSI-RS resources across all CCs for new beam identification
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**FG 16-2a (Multi-DCI based multi-TRP)**Intel makes the following proposals: • Component-1: In Rel-15 the network can configure at most 3 CORESETs per BWP per cell (including UE-specific and common CORESETs). In Rel-16 multi-DCI operation this number is increased to 5. Therefore the candidate values for component-1 should be {3, 4, 5}. • Component-2: Each CORESETPoolIndex represents a cluster of TRPs, therefore a small number here significantly increases RRC reconfiguration overhead. Note that in Rel-15, multi-TRP transmission in the form of DPS is already supported and the maximum number of CORESETs per TRP is 3 in Rel-15. Intel believes the candidate values for this component should be {3, 4, 5} in order to be not worse than Rel-15.• Components 4, 5, 6: RAN1 agreement clearly states that components 4, 5, 6 are subject to UE capability. From a UE perspective, supporting out of order operation for PDCCH – PDSCH, PDSCH – HARQ-ACK and PDCCH – PUSCH would impact the buffering and timeline considerations compared to in-order operation as in Rel-15. In the case of PDCCH – PDSCH, a UE must retain PDCCH/DCI in a long-term buffer in order to make space for PDCCH/DCI arriving later but allocating PDSCH earlier. In the case of PDSCH-HARQ-ACK, a UE must retain the HARQ-ACK feedback for the first PDSCH; and in the case of PDCCH- PUCCH, a UE may delay or retain a prepared (or semi-prepared, up to UE implementation) PUSCH in order to be able to prepare another PUSCH that may be indicated by a later PDCCH. Note also that without such out of order processing, support of non-ideal backhaul multi-TRP is feasible with semi-statically coordinated values of PDCCH-PDSCH, PDSCH-HARQ-ACK and PDCCH-PUSCH between the multiple TRPs. • Component 8, 9: FG 2-3 maxNumberMIMO-LayersPDSCH should be applicable here - adding further restrictions on MIMO layers per TRP limits performance and should be strongly motivated. Also, it can be further discussed whether FG 16-2a is per band, FSPC etc. and it is not clear how component 9 will work when R=2 is reported and BDFactor is configurable

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| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config”.
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config”
3. The value of R=[1,2] for BD/CCE. Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
4. Optional: Support of out-of-order operation for PDCCH to PDSCH ~~(FFS whether to be a basic component)~~
5. Optional: Support of out-of-order operation for PDSCH to HARQ-ACK ~~(FFS whether to be a basic component)~~
6. Optional: Support of out-of-order operation for PDCCH to PUSCH ~~(FFS whether to be a basic component)~~
7. FFS: The maximum number of activated TCI states
8. ~~FFS: The maximum number of MIMO layers of scheduled PDSCHs~~
9. ~~FFS: the maximum number of CCs supporting multi-DCI based multi-TRP~~

Optional components:1. Whether the UE shall 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
2. FFS: Support of two PDSCH scrambling sequences per serving cell
3. Support of default QCL assumption per CORESETPoolIndex
4. Support of separate HARQ-ACK
5. Support of joint HARQ-ACK
6. Support of two TDMed long PUCCHs in a slot
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FG 16-2b (Single-DCI based multi-TRP)The benefit of defining the basic components is not clear to Intel since 16-2b-1 to 16-2b-5 cover all possible cases of single DCI multi-TRP UE features.

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| 16-2b | Single-DCI based multi-TRP | Basic component(s):1. ~~FFS: Support of MAC CE to activate multiple TCI states for a TCI codepoint~~
2. ~~FFS: Number of CCs supporting single-DCI based multi-TRP operation~~

Optional components:1. Support of default QCL assumption with two TCI states
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**FG 16-2b-5 (Single-DCI based schemes 2a, 2b, 3, 4)**According to Intel the FFS for component-1 should be removed in order to define SDM scheme. Furthermore, Intel argue that optionality of DMRS entry {0, 2, 3} was not raised before and they believe it is not needed.

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| 16-2b-1 | Single-DCI based SDM scheme | 1. ~~FFS:~~ Support of DCI indication of 2 TCI states by a codepoint and DMRS ports within two CDM groups
2. Whether supporting two PTRS ports
3. ~~FFS Support of DMRS entry {0, 2, 3}~~
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**FG 16-2b-5 (Single-DCI based inter-slot TDM)**It is not clear to Intel why a TCI state to PDSCH transmission occasion mapping option should be UE capability dependent.

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| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation
3. ~~FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)~~
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**FG 16-2b-2, 16-2b-3, 16-2b-4, 16-2b-5 (Schemes 2a, 2b, 3, 4)**Intel believes some clarification is beneficial on whether the network can assume that the support of MIMO URLLC schemes can be assumed in combination with other URLLC capabilities e.g. PDCCH monitoring (Rel-15 3-5), processing capability 2 (Rel-15 5-5), support for DCI format 1-2 (Rel-16 11-1).**eType-II codebook**Intel makes the following proposals:1. For 16-3a and 16-3b component 1, FFS should be removed;2. For 16-3a and 16-3b basic component 2, supported parameter combinations should be indicated per the number of antenna ports;3. For 16-3a and 16-3b basic component 3 and optional component 1, R = 2 should be optional;4. For 16-3a and 16-3b basic component 5, UCI omission should be mandatory;5. For 16-3a optional component 4 and 16-3b optional component 3, the maximum number of configured aperiodic CSI Report Settings should correspond to a separate UE feature group;6. For 16-3a optional component 5 and 16-3b optional component 4, support of mixed codebook types should correspond to a separate UE feature group.1. Support one of the following solutions addressing issue of UE capabilities for the mixed codebook types
2. Support UE capability signaling parameter which indicates the list of supported combinations of the maximum number of CSI-RS ports, the maximum number of resources, the total number of Tx ports active per band across all the supported codebook types
3. Support UE capabilities on the maximum number of CSI-RS resources and maximum number CSI-RS ports active for each band combination and for each codebook type

|  |  |  |
| --- | --- | --- |
| 16-3a | Regular eType-II | Basic components:1. {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 8 parameter combinations per the number of antenna ports
3. Number of PMI sub-bands (R=1 is mandatory, R=2 is optional) Support of PMI sub-bands with value R=1
4. Rank restriction
5. UCI omission

Optional components1. Number of PMI sub-bands (R=1 is mandatory, R=2 is optional) Support of PMI sub-bands with R=2
2. Rank 1 to 4 Support of rank 3,4
3. CBSR
 |
| 16-3b | Port selection eType-II | Basic components:* {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
* 6 parameter combinations per the number of antenna ports (combos with L=6 don’t apply)
* Number of PMI sub-bands (R=1 is mandatory, R=2 is optional) Support of PMI sub-bands with value R=1
* Rank restriction
* UCI omission

Optional components:1. Number of PMI sub-bands (R=1 is mandatory, R=2 is optional) Support of PMI sub-bands with R=2
2. Rank 1 to 4 Support of rank 3,4
 |

**FG 16-5a (Mode 0) and FG 16-5b (Mode 1)**For full power UL transmission in FG 16-5a, 16-5b and 16-5c, Intel makes the following proposals:1. For FG 16-5a, 16-5b and 16-5c, the component of number of Tx should be changed to the number of SRS antenna ports. And it should be clarified for the relationship with the Rel-15 UE capability parameter maxNumberSRS-Ports-PerResource.2. For component 2 under FG16-5a, the value of 2Tx\_4Tx should be removed.3. For component 2 under FG16-5b, the value of 2Tx\_4Tx should be removed.4. For component 3 under FG16-5b, it is not necessary and can be removed. The code book subset can be configured according to the UE coherence capability for Mode 1.5. For component 4 under FG16-5c, it is redundant and should be removed. The number of ports information can be provided by component 2 under FG16-5c.6. For component 5 under FG16-5c, it is not necessary and can be removed. The Rel-15 UE capability parameter can be reused.1. For FG 16-5a, 16-5b and 16-5c, the granularity should be per Band.

|  |  |  |
| --- | --- | --- |
| 16-5a | UL full power transmission mode 0 | 1. Supported UL full power transmission ~~[~~mode 0~~]~~
2. Number of SRS antenna ports to support mode 0: {2, 4}
 |
| 16-5b | UL full power transmission mode 1 | 1. Supported UL full power transmission mode 1
2. Number of SRS antenna ports to support mode 1: {2, 4}
 |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of SRS antenna ports to support mode 2: {2, 4, 2\_4}
3. The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.
4. TPMI group which delivers full power. FFS on details for supported number of Tx.

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port |

**FG 16-6b (Low PAPR DMRS for PUCCH)**Intel argues that in FG 16-6b, the UE capability for support of Low PAPR DMRS for PUCCH should be for PUCCH format 3 and PUCCH format 4 (if capable) with transform precoding and pi/2 BPSK modulation

|  |  |  |
| --- | --- | --- |
| 16-6b | Low PAPR DMRS for PUCCH | For PUCCH format 3 and PUCCH format 4, if capable, with transform precoding and with pi/2 BPSK modulation |

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| CATT [8] | **16-1a:**

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| --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)
2. FFS: Support of group-based reporting for L1-SINR
 | TBD  |

• On the FFS point, CATT thinks group-based reporting should be included as a of UE capability. **16-1b:**

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| --- | --- | --- | --- |
| 16-1b | TCI state activation and spatial relation update | 1. [Support of / maximum number of lists for] Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH ~~(FFS whether to be a separate UE feature, e.g. 16-1b)~~
2. [Support of / maximum number of lists for] Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
3. [Support of / The maximum number of] PUCCH resource groups per BWP for simultaneous spatial relation update
4. FFS: details on whether/how to indicate band pairs which can share the same DL TCI state
5. FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info
 | Component 1: 2-1, 2-4Component 2: 2-59, 2-60Component 3: 2-53, 2-59, 4-24 |

• The maximum number of lists for simultaneous TCI state activation across multiple CC (PDSCH and PDCCH) can be the maximum number of CCs configurable to a UE. From a practical deployment perspective, a limited number of lists is sufficient, e.g. 2 or 4.• The same applies to maximum number of lists for simultaneous spatial relation update across CCs for AP-SRS and SP-SRS. • The maximum number of PUCCH resource groups per BWP for simultaneous spatial relation update should be decided based on the target deployment scenario. It is clear from past RAN1 discussion that the main usage for group-based PUCCH resource spatial relation update is multi-TRP scenario where each PUCCH group intends to be transmitted to a specific TRP. It was known in prior 3GPP studies that the number of TRP with sufficiently strong signal strength to a UE is quite limited (e.g. 2 or 3) in FR1. For FR2, the number is expected be smaller due to strong cell isolation than FR1. Hence a small number (e.g. 2) seems sufficient here. • For the two FFS points, CATT doesn’t see the need to introduce such UE capability signaling based on band. The general framework of cross-CC activation is sufficiently flexible where the configuration unit is CC. As for UE capability reporting, it should be made possible that cross-CC activation capability signal is also sufficiently flexible and not hardwired to RF bands (e.g. inter-CC activation capability may not cover a whole band). Therefore CATT prefers a more generic framework that is future proof and not based on band limitation. **16-1e:**

|  |  |  |  |
| --- | --- | --- | --- |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. The maximum number of configured pathloss reference RSs for PUSCH/SRS~~/PUCCH via MAC CE~~ by RRC for MAC-CE based pathloss reference RS update ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
2. FFS: The maximum number of activated pathloss reference RS update for PUSCH/SRS/PUCCH [across CCs / within a slot across all CCs / per CC] ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
3. FFS: Number of measurement samples N to apply newly activated pathloss reference RS
 | 8-2, 8-3 |

• The maximum number of configured pathloss reference RS for PUSCH/SRS by RRC for MAC-CE based pathloss reference RS update is up to 64 in Rel.16. As UE complexity is decided by the number of activated pathloss RS (not the number of configured RS), the need for introducing UE capability on the maximum number of RRC configured pathloss RS is unclear according to CATT. • The maximum number of activated pathloss reference RS for PUSCH/SRS is up to 4 per RAN1 agreement. CATT doesn’t think it is necessary to further introduce a UE capability here. • The maximum number of samples N to apply the newly activated measurement RS has been discussed and it is FFS whether a fixed value (e.g. N = 5) is sufficient or a UE capability should introduced. The motivation for introducing a UE capability is to allow faster application timing of the newly activated pathloss RS when UE can stabilize its pathloss measurement with a smaller sample size. Given that practical, quantitative analysis on the performance gain has not been thoroughly established during the RAN1 phase, CATT is OK to accept a fixed value (e.g. N = 5) without introducing yet another UE capability. **16-1f:**

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| --- | --- | --- | --- |
| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
2. FFS: Support of PUCCH-BFR ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
3. FFS: The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC] ~~(FFS to replace this component to 14)~~
4. FFS: ~~Densigy~~ Density of CSI-RS for new beam identification for SCell BFR
 | 2-31 |

• As for the maximum number of SCells for beam failure recovery, CATT’s view is that any SCell should be able to be configured for beam failure recovery and the maximum value should be 15. Other smaller candidate values can be introduced for practical need (e.g. 2, 4).• Support of PUCCH-BFR should not be a UE capability. CATT’s view is that if the UE supports SCell BFR, it needs to support PUCCH-BFR. • It was agreed that the maximum number of new beam identification RS should be 64. Smaller values (e.g. 16, 32) may be considered to reduce UE complexity. **16-1g:**

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| --- | --- | --- | --- |
| 16-1g | FFS: Resources for beam management, pathloss measurement, and BFR | 1. FFS: The maximum number of SSB/CSI-RS resources across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, and new beam identification.
2. FFS: The maximum number of SSB/CSI-RS resources across all CCs for pathloss measurement
3. FFS: The maximum number of SSB/CSI-RS resources across all CCs for BFD
4. FFS: The maximum number of SSB/CSI-RS resources across all CCs for new beam identification
 |  |

• CATT is OK to introduce this feature group.**16-2a:**

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| --- | --- | --- | --- |
| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config”
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config”
3. The value of R=[1,2] for BD/CCESupport of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
4. FFS: The maximum number of activated TCI states
5. FFS: the maximum number of CCs supporting multi-DCI based multi-TRP
6. Support of separate HARQ-ACK

Optional components:1. Whether the UE shall 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
2. FFS: Support of two PDSCH scrambling sequences per serving cell
3. Support of default QCL assumption per CORESETPoolIndex
4. Support of joint HARQ-ACK
5. Support of two TDMed long PUCCHs in a slot
6. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
7. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
8. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
 | TBD |

Regarding 16-2a, according to past agreement, CATT thinks item 4,5,6 should be optional for a UE supporting M-DCI based M-TRP.For the maximum number of MIMO layers of scheduled PDSCHs, as the maximum number of layers per PDSCH is a UE capability, CATT believes it’s not necessary to include the total number of layers in 16-2a. For multi-DCI based multi-TRP transmission, at least separate HARQ-ACK should be supported according to CATT. It should be listed as one of the basic components in 16-2a.**16-2b and 16-2b-1:**

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| 16-2b | Single-DCI based multi-TRP | Basic component(s):1. Support of MAC CE to activate multiple TCI states for a TCI codepoint
2. Number of CCs supporting single-DCI based multi-TRP operation
3. Support of DCI indication of of 2 TCI states by a codepoint and DMRS ports within two CDM groups
4. Support of DMRS entry {0, 2, 3}

Optional components:1. Support of default QCL assumption with two TCI states
2. Whether supporting two PTRS ports
 | TBD |
| ~~16-2b-1~~ | ~~Single-DCI based SDM scheme~~ | 1. ~~FFS: Support of DCI indication of of 2 TCI states by a codepoint and DMRS ports within two CDM groups~~
2. ~~Whether supporting two PTRS ports~~
3. ~~FFS Support of DMRS entry {0, 2, 3}~~
 | 16-2b, TBD |

Regarding 16-2b and 16-2b-1, as SDM is the same transmission scheme for both eMBB and URLLC, CATT thinks they should not be separate UE capabilities and suggest to keep 16-2b only. Furthermore, according to past agreements, whether supporting two PTRS ports is subject to UE capability for eMBB and URLLC, as CATT notes. This item should thus be one of the optional components for 16-2b in CATT’s view. In addition, in CATT’s opinion, the following items should all be basic component in 16-2b:1. Support of MAC CE to activate multiple TCI states for a TCI codepoint2. Number of CCs supporting single-DCI based multi-TRP operation3. Support of DCI indication of 2 TCI states by a codepoint and DMRS ports within two CDM groups4. Support of DMRS entry {0, 2, 3}**16-3a/b:**CATT proposes to support SD beam group restriction + per coefficient hard amplitude restriction as mandatory and soft with sum-power-ratio constraint as optional analogous to Rel.15 Type II codebook.CATT proposes to introduce UE capability on the support of cross codebook type, which includes the maximum number of resources across all CCs across all codebook types within a band simultaneously, the maximum number of Tx ports in a resource, and the total number of Tx ports across all CCs across all codebook types within a band simultaneously. In this way, Comb4/5/6 could be reported individually using the UE capability signalling.**16-5b:**Mode 1 introduces new codebook subsets which can support full power transmission. For each Tx, the new codebook subset is fixed and defined in the specification. CATT argues the FFS point is not needed. **16-5c:**CATT notes that it was agreed in RAN1 that the maximum number of different spatial relation info in a SRS set for usage set to “codebook” is 2. CATT doesn’t think it is necessary to introduce another capability here (e.g. value 1), and a fixed value of 2 is sufficient. |
| Samsung [9] | **Multi-TRP**Samsung makes the following proposals: Proposal 1: Support UE capability signaling of multi-DCI based multi-TRP per FSPC level.Proposal 2: Support to have all the out-of-HARQ operations {PDCCH-to-PDSCH, PDSCH-to-HARQ-ACK, PDCCH-to-PUSCH} (basic components #4-#6) as basic components for FG 16-2a.Proposal 3: Remove the basic component #8 from FG 16-2a.Proposal 4: Remove the basic component #9 from FG 16-2a.Proposal 5: Change optional component #7 in FG 16-2a as ‘Support of separate HARQ-ACK with intra-slot TDM’.Proposal 6: Remain FG 16-2b-1 to FG-2b-5 as separate FGs, all of which are optional.Proposal 7: Support to have component #1 in FG 16-2b-1.**MU-CSI**Samsung makes the following proposals:Proposal 8: Regarding UE capability for Rel. 16 eTypeII and eTypeII port selection codebooks,* The following is mandatory, hence doesn’t require additional capacity signalling.
	+ Rank restriction
	+ UCI omission
* The following (sub-)features requires additional capability signalling.
	+ R=2 and N3<=2
	+ L=6 for eTypeII codebook
	+ Rank 3-4
	+ Amplitude restriction – reuse Rel.15 parameter amplitudeSubsetRestriction
* The following and corresponding UE capability signalling is not supported.
	+ UE capability signalling for concurrent codebooks
	+ Maximum number of configured aperiodic CSI Report Settings

**Full-power UL Tx**Samsung makes the following proposals:Proposal 9: Regarding UE capability for full power UL transmission,* The following is mandatory, hence doesn’t require additional capacity signalling.
	+ new UL codebook set(s) when the UE reports mode1 as its capability
	+ TPMI group signalling when the UE reports mode2 as its capability
* The following (sub-)features requires additional capability signalling.
	+ Separate capability signalling for mode0, mode1, and mode2
* The following and corresponding UE capability signalling is not supported.
	+ Multiple modes, e.g., mode1AndMode2

**Low-PAPR RS**Samsung observes that in Rel-15, applicability of pi/2-BPSK for PUSCH or PUCCH was not mandated without capability signalling, i.e. a set of UE capability signalling on pi/2-BPSK has been supported from Rel-15. Given that efficiency of UL low PAPR sequences and/or modulation can be maximized when they are applied for both data and RS transmissions, Samsung does not see a strong motivation to make Rel-16 low-PAPR RS as mandatory scheme for Rel-16 UEs.  |
| LG Electronics [10] | **16-1a**

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| 16-1a | L1-SINR reporting | 1. Support of L1-SINR based beam measurement and reporting based on ZP IMR
2. Support of L1-SINR based beam measurement and reporting based on NZP IMR)
3. FFS: Support of group-based reporting for L1-SINR
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |

* Component1: The meaning/necessity of ‘the maximum number of L1-SINR based beam measurement and reporting’ is unclear, whether it is for the number of resources or for the number of report configurations. Prefer to define two separate UE features, which are ‘Support of L1-SINR based beam measurement and reporting based on ZP IMR’ and ‘Support of L1-SINR based beam measurement and reporting based on NZP IMR’.

**16-1b**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1b | TCI state activation and spatial relation update | 1. Support of Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH
2. Support of Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
3. Support of PUCCH resource groups per BWP for simultaneous spatial relation update
4. FFS: details on whether/how to indicate band pairs which can share the same DL TCI state
5. FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info
 | Component 1: 2-1, 2-4Component 2: 2-59, 2-60Component 3: 2-53, 2-59, 4-24 |  | N/A |  | TBD[Per BC or per band] | N | Y |  |  | TBD |

* Component1, 2 and 3: For these features, LGE thinks that whether to support these features would be sufficient given the fact that the CA related and PUCCH related capabilities already exist.

**16-1d**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1d | MAC CE spatial relation update for AP-SRS | Support of spatial relation update for AP-SRS via MAC CE  | 2-53, 2-59 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |

* Component1: Similarly as above, LGE thinks that whether to support this feature would be sufficient.

**16-1e**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. Support of MAC-CE based pathloss reference RS update via MAC-CE
2. The maximum number of configured pathloss reference RSs for PUSCH/SRS by RRC for MAC-CE based pathloss reference RS update
3. FFS: The maximum number of activated pathloss reference RS update for PUSCH/SRS/PUCCH [across CCs / within a slot across all CCs / per CC]
4. FFS: Number of measurement samples N to apply newly activated pathloss reference RS
 | ~~8-2,~~ 8-3 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |

* To be aligned with other sub-features, LGE thinks RAN1 needs to add one more component ‘Support of MAC-CE based pathloss reference RS update via MAC-CE’

**16-1f**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery
2. FFS: The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC]
3. FFS: Density of CSI-RS for new beam identification for SCell BFR
 | 2-31 |  | N/A |  | TBD | N |  |  |  | TBD |

* On the first FFS ‘Support of PUCCH-BFR’, sending SR for BFR over the configured PUCCH-BFR is the very initial step to support SCell BFR as agreed before. Although BFR MAC-CE transmission without sending PUCCH-BFR is also supported by the specification, it is only for the case when there is available UL-SCH for the UE. So, if a UE supports SCell BFR functionality, the UE should support sending BFRQ over PUCCH-BFR. Introducing this UE feature would create a new UE type who does not support PUCCH-BFR but can support sending BFR MAC-CE, which have not been considered for both RAN1 and RAN2 works. Note that TS38.321 already describes in a way that ‘SR for BFR’ is triggered if BF is detected on an SCell, and there is no description/function defined for such UE. Thus, LGE proposes to delete this feature.

**16-2a**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config”
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config”
3. The value of R=[1,2] for BD/CCESupport of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
4. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
5. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
6. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
7. FFS: The maximum number of activated TCI states
8. FFS: the maximum number of CCs supporting multi-DCI based multi-TRP

Optional components:1. Whether the UE shall 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
2. FFS: Support of two PDSCH scrambling sequences per serving cell
3. Support of default QCL assumption per CORESETPoolIndex
4. Support of separate HARQ-ACK
5. Support of joint HARQ-ACK
6. Support of two TDMed long PUCCHs in a slot
 | TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |

* Component8 among basic components: The necessity of this component is not clear. In RAN1 Ad-Hoc Meeting 1901, it was agreed that the total number of MIMO layers of scheduled PDSCHs is up to reported UE MIMO capability, if resource allocation of PDSCHs are overlapped. Since UE already reports maximal number of MIMO layers of a PDSCH as MIMO capability, this component is not needed.

**16-2b**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2b | Single-DCI based multi-TRP | Basic component(s):1. FFS: Support of MAC CE to activate two TCI states for a TCI codepoint
2. FFS: Number of CCs supporting single-DCI based multi-TRP operation

Optional components:Support of default QCL assumption with two TCI states | TBD |  | N/A |  |  | N | TBD |  |  | TBD |

* Component1 among basic components: Maximum two TCI states can be activated by MAC CE. So LGE prefers to change from ‘multiple’ to ‘two’.

**16-5b**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5b | UL full power transmission mode 1 | 1. Supported UL full power transmission mode 1
2. Number of Tx to support mode 1: {2Tx, 4Tx, 2Tx\_4Tx}
 | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N | N |  |  | TBD |

* Mode 1 is operated based on the new codebook subset (i.e., newly added TPMI from fully coherent subset). Thus, LGE thinks FFS is not needed.
 |
| Spreadtrum Communications [11] | **FG 16-1a:**Taking Rel-15 UE capability for L1-RSRP based BM as reference, Spreadtrum suggests component 2 should also be one independent FG, e.g., 16-1a-1, and “Support of non-group based reporting for L1-SINR” as one new FG should be added.Proposal 1: For FG 16-1a, - Suggest to separate component 2 as one independent FG, e.g., 16-1a-1- Suggest to add one new FG “Support of non-group based reporting for L1-SINR”**FG 16-1e:**For component 2, Spreadtrum suggests to remove it. They argue in RAN1#100e, there is one agreement to specify that UE is not required to tack the RSs which are not activated by MAC-CE. In RAN1#99, they note there is another agreement that UE only is required to track up to 4 pathloss RSs regardless of the number of pathloss RSs configured by RRC, i.e., same as the maximum number of tracked RS in Rel-15. Thus, Spreadtrum proposes to simplify set the maximum number of activated pathloss reference RS update for PUSCH/SRS/PUCCH as 4 and that a UE capability is not necessary.Proposal 2: For FG 16-1e, suggest to remove component 2**FG 16-1f:**For component 5, Spreadtrum suggests to remove it. They note in Rel-15 PScell BFR, there is no UE capability on whether to support CFRA for BFR. Following the same principle, they believe for Scell BFR, PUCCH-BFR should also be mandatory to be supported by UE, although NW has the right not to configure PUCCH-BFR.Proposal 3: For FG 16-1f, suggest to remove component 5**FG 16-2a:**Given that multiple feature components of FG 16-2a are uncorrelated, Spreadtrum suggests to split FG 16-2 into multiple feature groups.For component 3 of basic components, they prefer it should be separated into two components for the sake that there is no relation between “The value of R=[1,2] for BD/CCE” and “Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)”. Furthermore, they suggest that for the later component, PDSCHs overlapping types should also be detailed, e.g., full overlapping/partial overlapping/non-overlapping, which will bring different implementation complexity for UE.For component 4, 5 and 6 of basic components, in Spreadtrum’s view, they should not be basic components. In RAN1#99, out-of-order operations for multi-TRP case have been supported and also agreed to be optional for a UE as shown by the highlight in the following agreement.For component 8 of basic components, reusing FG 2-3 is enough, thus Spreadtrum suggests to remove it.For component 6 of optional components, although Rel-16 has introduced to support two TDMed long PUCCHs transmission in a slot, Spreadtrum notes there has already been one FG 4-22a to support it in TR38.822, where FG4-2 is for the case of two TDMed short PUCCHs transmission in a slot, and FG4-22 is for the case of one short PUCCH and one long PUCCH TDMed transmission in a slot. Thus, Spreadtrum prefers to remove it.Proposal 4: For FG 16-2a,* Suggest to split it into multiple FGs
* For component 3 of basic components, suggest to separate it into two components
	+ One component: The value of R=[1,2] for BD/CCE
	+ One component: Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
	+ The candidate values of overlapping types should be detailed, e.g, full overlapping, partial overlapping, not support
* Suggest all of component 4,5 and 6 of basic components as optional components
* Suggest to remove component 8 of basic components
* Suggest to remove component 6 of optional components

**FG 16-3a and 16-3b:**Spreadtrum prefers that basic components and optional components are in different FGs for both FG 16-3a and 16-3b. They suggest to remove UCI omission as UE capability, for the reason that like Rel-15, UCI omission should be mandatory to support.Proposal 5: For both FG 16-3a and 16-3b,- Suggest to split both FGs into multiple FGs, e.g., basic components as one FG, optional FGs as multiple separated FGs- Suggest to remove component 5 of basic components for both FGs**FG 16-5b:**For component 3, Spreadtrum suggests to remove it. UL full power transmission mode 1 is mandatory to support new codebook subset. There is no related to UE capability.Proposal 6: For FG 16-5b, suggest to remove component 3.**FG 16-5c:**For component 4, it is not clear to Spreadtrum. There is no related agreements and no necessity as UE capability.For Note, Spreadtrum doesn’t understand why it is specially listed here. All of UL full power transmission modes support full power transmission for 1 antenna port. Current specification has supported it.Proposal 7: For FG 16-5c, suggest to remove component 4 and Note. |
| Apple [12] | **FG 16-1a: L1-SINR reporting** To support L1-SINR based beam management, Apple argues the basic feature should be CMR based only, and UE should be able to indicated whether it supports ZP-IMR (CSI-IM) based, and, NZP-IMR (NZP-CSI-RS) based interference measurement separately. Therefore, Apple suggests to adopt similar approach as Rel-15 for L1-RSRP, i.e., FG 2-24, by adding components as the following 1. The max number of SSB/CSI-RS (1Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR to measure L1-SINR within a slot
2. The max number of CSI-RS resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR to measure L1-SINR
3. The max number of CSI-RS (2Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR to measure L1-SINR within a slot
4. Supported density of CSI-RS for CMR to measure L1-SINR
5. The max number of CSI-IM resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as ZP IMR to measure L1-SINR within a slot
6. The max number of CSI-IM resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as ZP IMR to measure L1-SINR
7. The max number of CSI-RS (1Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as NZP IMR to measure L1-SINR within a slot
8. The max number of CSI-RS (1Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as NZP IMR to measure L1-SINR

**FG 16-1g:** For the first component, “The maximum number of SSB/CSI-RS resources across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, and new beam identification”, it is agreed and captured in 38.213 that UE maintains at most 4 PL estimate per serving cell, and, at most 2 BFD resources for BFR per BWP. Therefore, Apple suggests to remove the PL and BFD related resources, i.e., “The maximum number of SSB/CSI-RS resources across all CCs for any of L1-RSRP measurement, L1-SINR measurement, ~~pathloss measurement, BFD,~~ and new beam identification” **FG 16-2a: Multi-DCI based multi-TRP**Apple suggests the following changes to the optional components:* Component 1: Apple thinks a top feature is needed which is whether UE supports CRS rate matching for Multi-DCI based Multi-TRP operation. Then it was agreed that supporting the union of CRS rate matching patterns from both TRPs is mandatory, but supporting individual CRS rate matching per TRP is optional. Therefore, Apple suggests the change
	+ Support of CRS rate matching for Multi-DCI based Multi-TRP operation. “Joint” is mandatory for UE that supports Multi-DCI based Multi-TRP CRS rate matching, but “Separate” is optional
		- Joint: UE rate match around the union of CRS from both TRPs
		- Separate: UE rate match around configured CRS patterns which is associated with CORESETPoolIndex (if not configured, CORESETPoolIndex=0) and are applied to the PDSCH scheduled with a DCI detected on a CORESET with the same value of CORESETPoolIndex
* Component 3: Some format issue here, “Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)” should be a separate component
* Component 6, Apple suggests to split into the following 3 cases
	+ Two TDMed long PUCCHs within a slot
	+ TDMed short PUCCH and long PUCCH within a slot
	+ TDMed short PUCCH and short PUCCH within a slot
* Apple proposes to add one component to report whether UE can support a single closed-loop power control process for PUCCH/PUSCH associated with different CORESETPoolIndex, i.e. “Support of common closed-loop power control process for PUCCH/PUSCH associated with different CORESETPoolIndex”
	+ Apple thinks one possible implementation for multi-DCI based operation is to use CA-like architecture. So, the simple approach is to configure separate closed-loop power control processes to PUCCH/PUSCH associated with different CORESETPoolIndex.

**FG 16-3a: Regular eType-II**Apple suggests the following changes to the basic components* Apple proposes to add another component “Support of rank 1,2”
* Component 5, “UCI omission”, Apple prefer this to be moved to “Optional components”

Apple suggests the following changes to the optional components* Component 3, “CBSR”. There are 2 mode of CBSR, one is just on and off, i.e. only 2 amplitude restrictions, the other is choice from 4 amplitude restrictions. The second mode is agreed to be optional even for UE supports CBSR. Therefore, Apple suggests the change "(1) Whether UE supports CBSR (2) If UE supports CBSR, whether UE supports 4 values of restriction, i.e. amplitudeSubsetRestriction as in 38.214"

**FG 16-3b: Port selection eType-II**Apple suggests the following changes to the basic components* Apple suggests to add another component “Support of rank 1,2”
* Component 5, “UCI omission”, Apple prefers this to be moved to “Optional components”

**FG 16-5a: UL full power transmission mode 0**Apple prefers this to be at least per band per BC**FG 16-5b: UL full power transmission mode 1**Apple argues 2-bit bitmap is more flexible {2Tx, 4Tx}. For UE capable of 4 ports UL, UE can indicate whether UE supports mode 1 when UE is configured with 2 port SRS or 4 port SRS for codebook based PUSCH operation, independently. Apple prefers this to be at least per band per BC **FG 16-5c: UL full power transmission mode 2**Apple argues component 2: similar comment, 2-bit bitmap is more flexible {2Tx, 4Tx} and prefers this to be at least per band per BC |
| Nokia, Nokia Shanghai Bell [13] | Nokia, NSB assumes all FFS points will be discussed as part of RAN1#100-bis-e, and hence they focus on selected points only. Nokia, NSB makes the following comments:* 16-1a, component 2: confirm “Support of group-based reporting for L1-SINR”
* 16-1b, components 4 and 5: details to be finalized by corresponding eMIMO maintenance work
* 16-1e, component 3: this is a RAN4 issue, not related to UE features
* 16-1f:
	+ component 5: this is an essential component for SCell BFR
	+ component 7: this is a design issue that should be discussed under eMIMO maintenance first
* 16-2a:
	+ Component 7 and 8: clarify if they are per CORESETPoolIndex or per UE.
	+ Optional component 2: Should be part of basic component list. Otherwise, basic component 3 does not work and requires specifying a new UE behaviour when this is not supported.
* 16-2b: component 1 is part of basic operation, no need for FFS.
* 16-2b-1: component 1 is part of basic operation of SDM scheme, no need FFS.
* 16-3a:
	+ Component 1: reuse same numbers as in R15.
	+ Component 2: Only the first 6 combinations are mandatory. The last 2 are optional and can be moved to the optional components with 1-bit capability (L=6).
	+ Component 3: add the following FFS: and, for , with value R=2
	+ Optional component 2: Support of PMI sub-bands with R=2 [FFS: and ]
	+ Optional component 3: distinction is needed between support of “amplitude subset restriction” and “no amplitude subset restriction”
* 16-3b:
	+ Component 1: reuse same numbers as in R15.
	+ Component 3: add the following FFS: and, for , with value R=2
	+ Optional component 1: Support of PMI sub-bands with R=2 [FFS: and ]
* 16-5a: not a new feature, to be removed.
* 16-5c: Add that UE indicating support to this feature needs to support 16-5b as well, otherwise it becomes very difficult to utilize the feature in the network in practice.
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| Ericsson [14] | **Enhancements to multi-beam operation**

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| 16-1a | L1-SINR reporting | 1. The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)
2. ~~FFS: Support of group-based reporting for L1-SINR~~
 | TBD  |  | N/A |  | ~~TBD~~~~[~~Per band~~]~~ | N/A | N/A |  |  | TBD |
| 16-1a1 | Group-based reporting of L1-SINR | Support of group-based reporting for L1-SINR | 16-1a |  | N/A |  | Per band |  |  |  |  |  |
| ~~16-1b~~ | ~~TCI state activation and spatial relation update~~ | 1. ~~[Support of / maximum number of lists for] Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH~~
2. ~~[Support of / maximum number of lists for] Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS~~
3. ~~[Support of / The maximum number of] PUCCH resource groups per BWP for simultaneous spatial relation update~~
4. ~~FFS: details on whether/how to indicate band pairs which can share the same DL TCI state~~
5. ~~FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info~~
 | ~~Component 1: 2-1, 2-4~~~~Component 2: 2-59, 2-60~~~~Component 3: 2-53, 2-59, 4-24~~ |  | ~~N/A~~ |  | ~~TBD~~~~[Per BC or per band]~~ | ~~N/A~~ | ~~N/A~~ |  |  | ~~TBD~~ |
| 16-1b1 | Cross-CC TCI state activation | Support of simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH  | 2-1, 2-4 |  | N/A |  | Per band | N/A | N/A |  |  | TBD |
| 16-1b2 | Cross-CC spatial relation update | Support of simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS | 2-59, 2-60 |  | N/A |  | Per band | N/A | N/A |  |  | TBD |
| 16-1b3 | PUCCH resource groups  | Support of PUCCH resource groups per BWP for simultaneous spatial relation update | 2-53, 2-59, 4-24 |  | N/A |  | Per band | N/A | N/A |  |  | TBD |
| 16-1c | Default spatial relation | Support of default spatial relation and pathloss reference RS for dedicated-PUCCH/SRS and PUSCH scheduled by DCI format 0\_0 | 2-53, 2-59 |  | N/A |  | ~~TBD~~~~[~~Per band~~]~~ | N/A | N/A |  |  | TBD |
| 16-1d | MAC CE spatial relation update for AP-SRS | [Support of / ~~The maximum number of~~] spatial relation update for AP-SRS via MAC CE | 2-53, 2-59 |  | N/A |  | ~~TBD~~[Per UE] | No | No |  |  | TBD |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. ~~The maximum number of configured pathloss reference RSs for PUSCH/SRS by RRC~~ Support for MAC-CE based pathloss reference RS update for PUSCH/SRS
2. ~~FFS: The maximum number of activated pathloss reference RS update for PUSCH/SRS/PUCCH [across CCs / within a slot across all CCs / per CC]~~
3. ~~FFS: Number of measurement samples N to apply newly activated pathloss reference RS~~
 | ~~8-2,~~ 8-3 |  | N/A |  | ~~TBD~~[Per UE] | No | No |  |  | TBD |
| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery
2. ~~FFS: Support of PUCCH-BFR~~
3. ~~FFS: The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC]~~
4. ~~FFS: Density of CSI-RS for new beam identification for SCell BFR~~
 | 2-31 |  | N/A |  | ~~TBD~~Per UE | N |  |  |  | TBD |
| ~~16-1g~~ | ~~FFS: Resources for beam management, pathloss measurement, and BFR~~ | 1. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, and new beam identification.~~
2. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for pathloss measurement~~
3. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for BFD~~
4. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for new beam identification~~
 |  |  | ~~N/A~~ |  | ~~TBD~~ | ~~N~~ |  |  |  | ~~TBD~~ |

Ericsson further proposes to make as many feature groups per UE. For cases where this is not deemed possible, or when there is a Rel-15 decision on a similar feature group, Ericsson proposes per band**L1-SINR reporting:** The basic capability is to support L1-SINR reporting. Ericsson thinks there is no need to distinguish between ZP IMR and NZP IMR – in fact due to recent agreements there is no difference in the UE measurements for the two configuration options. Ericsson proposes to include a separate component for the group-based reporting, similar to the group-based RSRP reporting.**TCI state activation and spatial relation update:** Ericsson thinks it is sufficient if the UE indicates that it supports these features. They argue the signalling only allows a small number of groups, and experience from R15 shows that restrictions in the number of configurable quantities should be avoided. Ericsson does not understand the proposed component 4 and 5, the functionality does not allow sharing of TCI states or spatial relations, only that the signalling applies to several CCs. Ericsson suggests the components have to be separate feature groups.**MAC CE spatial relation update for AP-SRS:** Ericsson believes it is sufficient that the UE indicates that it supports this feature. For the corresponding update of the spatial relation of semi-persistent SRS, Ericsson continues there is no restriction on the number of spatial relation update. **Pathloss reference RS activation via MAC CE:** Ericsson believes it is sufficient that the UE indicates that it supports this feature. They continue there is no significant complexity impact on the number of configured RSs, the complexity impact is on the number of RSs that are actually used. They think experience from R15 shows that restrictions in the number of configurable quantities should be avoided. They suggest component 2 and 3 have no impact on the network, so there is no need for a capability. **SCell beam failure recovery:** Ericsson thinks PUCCH-BFR should be mandatory for a UE that supports SCell BFR. They note there is already a capabilities for the maximum number of RSs for new beam identification: maxNumberCSI-RS-SSB-CBD that can be reused. **Resources for beam management, pathloss measurement, and BFR:** Ericsson notes 16-1g-3 and 16-1g-4 already exists in R15 and there is no need for 16-1g1 or 16-1g2.**Enhancements to multi-TRP/panel transmission**

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| 16-2a | Multi-DCI based multi-TRP Basic components | ~~Basic components:~~1. The maximum number of CORESETs configured per “PDCCH-Config”
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config”
3. The value of R=[1,2] for BD/CCE
4. Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
5. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
6. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
7. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
8. Support of separate HARQ-ACK
9. FFS: The maximum number of activated TCI states
10. FFS: The maximum number of MIMO layers of scheduled PDSCHs
11. FFS: the maximum number of CCs supporting multi-DCI based multi-TRP

~~Optional components:~~1. ~~Whether the UE shall 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~~
2. ~~FFS: Support of two PDSCH scrambling sequences per serving cell~~
3. ~~Support of default QCL assumption per CORESETPoolIndex~~
4. ~~Support of separate HARQ-ACK~~
5. ~~Support of joint HARQ-ACK~~
6. ~~Support of two TDMed long PUCCHs in a slot~~
 | TBD |  | N/A |  | TBD [per band / per FSPC] | N/A | N/A |  |  | TBD |
| 16-2ab | Rate matching PDSCH around CRS patterns associated with CORESET pool index | 1. Whether the UE shall 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
 | 16-2a |  | NA |  | TBD | N/A | N/A |  |  | TBD |
| 16-2ac | Two PDSCH scrambling sequences per serving cell | 1. FFS: Support of two PDSCH scrambling sequences per serving cell
 | 16-2a |  | NA |  | TBD | N/A | N/A |  |  | TBD |
| 16-2ad | default QCL assumption per CORESETPoolIndex | 1. Support of default QCL assumption per CORESETPoolIndex
 | 16-2a |  | NA |  | TBD | N/A | N/A |  |  | TBD |
| 16-2ae | Joint HARQ-ACK feedback for multi-DCI based multi-TRP | 1. Support of joint HARQ-ACK
 | 16-2a |  | NA |  | TBD | N/A | N/A |  |  | TBD |
| 16-2af | Two TDMed long PUCCHs in a slot for multi-DCI based multi-TRP | 1. Support of two TDMed long PUCCHs in a slot
 | 16-2a |  | NA |  | TBD | N/A | N/A |  |  | TBD |
| 16-2b | Single-DCI based multi-TRP basic components | ~~Basic component(s):~~1. FFS: Support of MAC CE to activate multiple TCI states for a TCI codepoint
2. FFS: Number of CCs supporting single-DCI based multi-TRP operation

~~Optional components:~~~~Support of default QCL assumption with two TCI states~~ | TBD |  | N/A |  | TBD | N | TBD |  |  | TBD |
| 16-2bb | Single-DCI based multi-TRP optional components | Support of default QCL assumption with two TCI states | TBD |  | N/A |  | TBD | N | TBD |  |  | TBD |
| 16-2b-1 | Single-DCI based SDM scheme | 1. FFS: Support of DCI indication of of 2 TCI states by a codepoint and DMRS ports within two CDM groups
2. ~~Whether supporting~~ Support of two PTRS ports
3. FFS Support of DMRS entry {0, 2, 3}
 | ~~16-2b,~~ TBD |  | N/A |  | TBD | N | TBD |  |  | TBD |
| 16-2b-2 | Single-DCI based FDMSchemeA | Support of FDMSchemeA | ~~16-2b,~~ TBD |  | N/A |  | TBD | N | TBD |  |  | TBD |
| 16-2b-3 | Single-DCI based FDMSchemeB | 1. Support of FDMSchemeB
2. For FDMSchemeB, whether the UE can support CW soft combining
 | ~~16-2b,~~ TBD |  | N/A |  | TBD [per FSPC] | N | TBD |  |  | TBD |
| 16-2b-4 | Single-DCI based TDMSchemeA | 1. Support of TDMSchemeA
2. Supported maximum TBS size for TDMSchemeA
 | ~~16-2b,~~ TBD |  | N/A |  | TBD | N | TBD |  |  | TBD |
| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation

FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping) | ~~16-2b,~~ TBD |  | N/A |  | TBD | N | TBD |  |  | TBD |

**16-2a:*** Ericsson suggests to split Basic components and optional components of multi-DCI based multi-TRP into separate feature groups. From Multi-DCI based multi-TRP, the UE does not need to support all the optional components in Ericsson’s view. Hence, the Multi-DCI based multi-TRP optional components are further split into different feature groups 16-2ab, 16-2ac, 16-2ad, 16-2ae, and 16-2af.
* Component 3 of 16-2a should be split into 2 components according to Ericsson. They propose to separate ‘The value of R=[1,2] for BD/CCE’ and ‘Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)’ into different components.
* Ericsson suggests one of the feedback modes should be part of the Basic components. They propose to move ‘Support of separate HARQ-ACK’ to Multi-DCI basic components

**16-2b:** * Both components under ‘basic components’ are FFS. Ericsson wonders what happens to the structure if these two ‘basic’ components are not agreed? The basic component feature group is lost in this case according to Ericsson. One concern that Ericsson has is that it may not be a good idea to indicate that the feature groups 16-2b-1, 16-2b-2, 16-2b-3, 16-2b-4, and 16-2b-5 depend on feature group 16-2b which is not agreed yet. Hence, for now Ericsson suggests to remove 16-2b from the Prerequisite feature groups column of feature groups 16-2b-1, 16-2b-2, 16-2b-3, 16-2b-4, and 16-2b-5.
* Ericsson proposes to split basic component and optional component into different feature groups. Ericsson proposes to split the Single-DCI based multi-TRP optional components into feature group 16-2bb.
* Ericsson notes there were comments by one company on RAN1 reflector suggesting to merge 16-2b with 16-2b-1 (i.e., to make SDM scheme as part of the Basic components). They don’t share the same understanding. A UE does not need to support the SDM scheme in order to support one of the other schemes 16-2b-2, 16-2b-3, 16-2b-4, or 16-2b-5. So they prefer to keep all 5 schemes as separate feature groups.

**16-2b-1:** * On component 2 of 16-2b-1, Ericsson believes it is a bit odd to pose this component as a question by including ‘whether’. They suggest to revise this component as ‘support of two PTRS ports’

**CSI Enhancements for MU-MIMO support**

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| 16-3a | Regular eType-II | ~~Basic components:~~1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 8 parameter combinations (FFS: Value of L per the number of antenna ports)
3. Support of PMI sub-bands with value R=1
4. Rank restriction
5. UCI omission

~~Optional components~~1. ~~Support of PMI sub-bands with R=2~~
2. ~~Support of rank 3,4~~
3. ~~CBSR~~
4. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
5. ~~FFS: Support of mixed codebook types~~
 | TBD |  | N/A |  | ~~FFS:~~ Per band ~~or Per band per BC~~ | N/A | N/A |  |  | Optional |
| 16-3a-1 | PMI sub-bands with R=2 | Support for PMI sub-bands with R=2 for regular eType-II | 16-3a |  | N/A |  | Per band |  |  |  |  |  |
| 16-3a-2 | Rank 3,4 | Support for rank 3,4 for regular eType-II | 16-3a |  | N/A |  | Per band |  |  |  |  |  |
| 16-3a-3 | CBSR | Support for CBSR for regular eType-II | 16-3a |  | N/A |  | Per band |  |  |  |  |  |
| 16-3b | Port selection eType-II | ~~Basic components:~~1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 6 parameter combinations (combos with L=6 don’t apply) (FFS: Value of L per the number of antenna ports)
3. Support of PMI sub-bands with value R=1
4. Rank restriction
5. UCI omission

~~Optional components:~~1. ~~Support of PMI sub-bands with R=2~~
2. ~~Support of rank 3,4~~
3. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
4. ~~FFS: Support of mixed codebook types~~
 | TBD |  | N/A |  | ~~FFS:~~ Per band ~~or Per band per BC~~ | N/A | N/A |  |  | Optional |
| 16-3b-1 | PMI sub-bands with R=2 | Support for PMI sub-bands with R=2 for port selection eType-II | 16-3b |  | N/A |  | Per band |  |  |  |  |  |
| 16-3b-2 | Rank 3,4 | Support for rank 3,4 for port selection eType-II | 16-3b |  | N/A |  | Per band |  |  |  |  |  |

In accordance with the RAN2 guidance, Ericsson proposes not to make any features per band per BC. Ericsson reminds that the optional features must be separate feature groups. There is no need for any additional restrictions on the number of configured aperiodic CSI Report settings, or on mixing codebooks.**Low PAPR RS**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-4 | Low PAPR DMRS for DL | Low PAPR DMRS for PDSCH | TBD  |  | N/A |  | Per UE | No | No |  |  | ~~[Optional]~~ TBD |
| 16-6a | Low PAPR DMRS for PUSCH | 1. For PUSCH without transform precoding
2. For PUSCH with transform precoding and with pi/2 BPSK modulation
 | TBD |  | N/A |  | ~~FFS:~~ Per band | N/A | N/A |  |  |  FFS: Optional with capability signalling |
| 16-6b | Low PAPR DMRS for PUCCH | 1. For PUCCH format 3 and/or PUCCH format 4 with transform precoding and with pi/2 BPSK modulation
 | TBD |  | N/A |  | ~~FFS:~~ Per band | N/A | N/A |  |  |  FFS: Optional with capability signalling |

**Full TX Power UL transmission**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5a | UL full power transmission mode 0 | 1. Supported UL full power transmission ~~[~~mode 0~~]~~

Number of Tx to support mode 0: {2Tx, ~~4Tx,~~ 2Tx\_4Tx} | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N/A | N/A |  |  | TBD |
| 16-5b | UL full power transmission mode 1 | 1. Supported UL full power transmission mode 1
2. Number of Tx to support mode 1: {2Tx~~, 4Tx,~~ 2Tx\_4Tx}

~~FFS: New UL codebook set(s) per supported Tx~~ | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N/A | N/A |  |  | TBD |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of Tx to support mode 2: {2Tx, ~~4Tx,~~ 2Tx\_4Tx}
3. The maximum number of SRS resources in a set with ~~different number of ports [for~~ usage set to ‘codebook’~~]~~. ~~FFS on details for supported number of Tx.~~
4. ~~FFS: Number of ports per SRS resource~~
5. ~~FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set~~
6. TPMI group which delivers full power:
* For 2 Tx: {not supported, or either or both of TPMI=0 and TPMI=1 are supported}, or
* For 4 Tx non-coherent: {not supported or one of Group 0 – Group 3}, or
* For 4 Tx partial coherent: {not supported or one of Group 0 – Group 6}

~~FFS on details for supported number of Tx.~~Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14 |  | N/A |  | FFS: Per FS or Per band or Per band per BC | N/A | N/A |  |  | TBD |

**Overall:** * Ericsson supports 16-5a/b/c being separately defined as proposed above
* UEs should be able to indicate independent support of the 3 different full power ‘modes’, since then UEs can support full power in a network that does not support one of Mode 0, 1, or 2.
* Ericsson thinks per band capability seems sufficient for 16-5/a/b/c
* It is not clear to Ericsson why per band capability is insufficient, and given the RAN2 guidance on limiting per band combination capabilities and the greater scheduler complexity that comes with per band combination constraints, only per band combination capability should be defined for 16-5a/b/c.
* Ericsson thinks the need to define ‘4Tx-only’ full power capability is unclear
* 2Tx should be a subset of 4Tx full power operation, and so 2Tx and 2Tx\_4Tx are sufficient
	+ If a UE can virtualize 4 tx chains to one layer non-coherently, it can do so for 2 pairs of Tx chains to 2 ports.
	+ In the partially coherent case, it is unclear why a partially coherent UE would not always be able to virtualize to one layer by combining 2 port pairs coherently and the combined port pairs non-coherently. Unless there is some reason why this is not possible, then there is no need to define 4 Tx only capability for the partially coherent case either.

**16-5b:*** Ericsson thinks there is no need for additional Mode 1 codebook subsets.
* As has been discussed at length in Rel-16, Mode 1 and Mode 2 functionality overlap should be minimized, and TPMI groups have been defined for Mode 2. The FFS can be removed.

**16-5c:*** Component 3.: According to Ericsson, values should be 2 or 4 as agreed; square brackets should be removed; clarify ‘resources with different number of ports’; no need for FFS on number of Tx.
* The maximum number of SRS resources for Mode 2 can be 2 or 4 resources for both 2 Tx and 4 Tx as agreed in RAN1#98. When there are e.g. 4 resources used, then the maximum number of resources with different numbers of ports is actually 3, which is confusing. We’d suggest to identify the number of resources that can be configured for mode 2 rather than the number of resources that can have different numbers of ports. Then 3 should be:

3. The maximum number of SRS resources in a set with different number of ports [for usage set to ‘codebook’]* Full power mode 2 operation is only defined for codebook based operation according to agreements, so the square brackets should be removed.
* Ericsson sees no reason why a partially coherent UE can’t virtualize to one layer by combining 2 port pairs coherently and the combined port pairs non-coherently. So unless there is some other rationale for this FFS, it should be removed.
* Component 4.: Ericsson suggests to remove; unclear how UE implementation needs to restrict ports per resource
* The number of ports per SRS resource should generally be different in order to support mode 2 operation. However, unless there is some strong reason from a UE implementation perspective to restrict the number of ports per resource, Ericsson thinks this can be left to gNB configuration. Therefore, they suggest to not include component #4.
* Component 5.: Should be removed based on agreements in Ericsson’s view
* When the agreement for the maximum number of SRS resources for Mode 2 was reached in RAN1#98, it was also agreed that up to 2 different spatial relation info can be configured for all SRS resources in an SRS resource set with usage set to ‘codebook’. This is already specified in 38.214, and Ericsson doesn’t see why a UE feature component is required to reflect this. Therefore, they suggest to not include component #5.
* Component 6.: In Ericsson’s view, baseline value ranges should be defined as below; FFS on number of Tx should be removed.
* Supported values for currently defined TPMI groups which delivers full power should be as follows. While defining additional TPMI groups can be discussed, the performance gains of these new TPMI groups over what is already defined for UL full power should be evaluated. Therefore, the default should be what is already agreed, and the following can be used as baseline value ranges.
	+ 2 Tx: {not supported, or either or both of TPMI=0 and TPMI=1 are supported}, or
	+ 4 Tx non-coherent: {not supported or one of Group 0 – Group 3}, or
	+ 4 Tx partial coherent: {not supported or one of Group 0 – Group 6}
* As discussed above, Ericsson sees no reason why a partially coherent UE can’t virtualize to one layer by combining 2 port pairs coherently and the combined port pairs non-coherently. So unless there is some other rationale for this FFS, it should be removed.
 |
| CMCC [15] | **UL full power transmission**

|  |  |  |  |
| --- | --- | --- | --- |
| 16-5a | UL full power transmission mode 0 | 1. Supported UL full power transmission ~~[~~mode 0~~]~~
2. Number of antenna ports to support mode 0: {2, 4, 2&4} ~~Number of Tx to support mode 0: {2Tx, 4Tx, 2Tx\_4Tx}~~
 | 2-13, 2-14 |
| 16-5b | UL full power transmission mode 1 | 1. Supported UL full power transmission mode 1
2. Number of antenna ports to support mode 1: {2, 4, 2&4} ~~Number of Tx to support mode 1: {2Tx, 4Tx, 2Tx\_4Tx}~~
3. FFS: New UL codebook set(s) ~~per supported mode~~ per supported Tx
 | 2-13, 2-14 |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of antenna ports to support mode 2: {2, 4, 2&4} ~~Number of Tx to support mode 2: {2Tx, 4Tx, 2Tx\_4Tx}~~
3. The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.
4. ~~FFS: Number of ports per SRS resource~~
5. ~~FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set~~
6. TPMI group which delivers full power. FFS on details for supported number of Tx.
	* 2-port TPMIs in codebookSubset = *nonCoherent* if UE reports ‘non-coherent’ or ‘partial/non-coherent’ capability in 2-13
	* 4-port TPMIs in codebookSubset = *nonCoherent* if UE reports ‘non-coherent’ or ‘partial/non-coherent’ capability in 2-13
	* 4-port TPMIs in codebookSubset = *partialandNonCoherent* if UE reports ‘partial/non-coherent’ capability in 2-13

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14 |

1. CMCC observes these three UE feature groups all mention that the number of Tx to support for each mode is {2Tx, 4Tx, 2Tx\_4Tx}. However, from RAN1 spec perspective, CMCC argues the number of Tx is invisible, and the number of antenna ports is used instead, e.g., the precoding information field in DCI is determined per number of antenna ports for different modes according to table 7.3.1.1.2-2~5 in TS38.212. Therefore, CMCC proposes to update the second bullet in each of these three feature groups as “Number of antenna ports to support mode 0/1/2: {2, 4, 2&4}”.
2. In 16-5c, CMCC thinks that the 4th bullet is not needed. CMCC continues that the UE should support 1 or 2 ports per SRS resource if UE reports 2 antenna ports in the second bullet, and UE should support 1 or 4 ports per SRS resource if UE reports 4 antenna ports in the second bullet, and UE should support 1, 2 or 4 ports per SRS resource if UE reports 2&4 antenna ports in the second bullet.
3. For the 5th bullet in 16-5c, CMCC thinks it could be removed or keep the candidate value as {1, 2} based on past agreements in RAN1#98 meeting
4. CMCC notes there is also a FFS point in 6th bullet. In their understanding, for 2Tx UE reporting ‘non-coherent’ capability in 2-13, UE can report 2-port TPMI(s) in codebookSubset = nonCoherent that can support full power transmission. They continue that for 4Tx UE reporting ‘non-coherent’ capability in 2-13, UE can report 2-port and/or 4-port TPMI(s) in codebookSubset = nonCoherent that can support full power transmission. Lastly, in CMCC’s view, for 4Tx UE reporting ‘partial/non-coherent’ capability in 2-13, UE can report 2-port TPMI(s) in codebookSubset = nonCoherent and/or 4-port TPMI(s) in codebookSubset = nonCoherent and/or 4-port TPMI(s) in codebookSubset = partialandNonCoherent that can support full power transmission.
 |
| Qualcomm Incorporated [16] | **16-3a and 16-3b:**Qualcomm inputs the necessary signaling for 16-3a and 16-3b analoguous to Rel-15 FG2-36/40/41/43. Other comments are as follows.* + - 1. Regarding the triplets of supported CSI-RS resources {max # ports per resource, max # resources, max # total ports}, it should be signaled independently for eType II and eType II port-selection. UE is allowed to signal 7 triplets (for # ports per resource being 2, 4, 8, 12, 16, 24, 32) per-band per-codebook. As eType II and eType II port selection are more complicated than other codebooks, these triplets cannot be inferred from other codebooks, and they are essential for commercial success of eType II and eType II port-selection.
			2. Regarding parameter combinations,

For 16-3a, *there was previous agreement in RAN1#99* that parameter combinations 7-8 are optional with extra capability signalling. The intention is to signal whether UE support L=6 spatial beams for linear combination L={2,4} or L={2,4,6}. So, Qualcomm proposes signal {‘support L=6’, ‘not support L=6’}.For 16-3b, since *there was agreement in RAN1#99* that only combination 1-6 are supported, there is no need of extra signalling for it.* + - 1. Regarding number of PMI subbands for both 16-3a and 16-3b, there was debating in RAN1 #98b that whether the signal should be N3 > 19 or R=2. For better UE differentiation, Qualcomm’s preference is supporting R=2 as it increases the total number of PMI subbands, and also introduces more than one PMIs in one CQI subbands. Qualcomm also think whether support R=2 should be jointly signalled with the triplet of CSI-RS capabilities. Detailed discussion is under section 2.2.
			2. Regarding supporting rank of 1-4 for both 16-3a and 16-3b. *There was previous agreement in RAN1 #99* that supporting RI={1,2} is mandatory and supporting RI={3,4} are optional. So the capability signalling should be {1-2, 1-4}.
			3. Regarding CBSR,

For 16-3a, *there was agreement in RAN1 #99* that supporting “soft” amplitude restriction as an optional feature. In other words, the codepoint “01” and “10” in table 5.2.2.2.5-6are optional, analogous to Type II in Rel-15. So, Qualcomm proposes to reuse the capability signaling *amplitudeSubsetRestriction* in Type II. UE will signal “supported” or “not supported”.For 16-3b, there is no need amplitude restriction applied to RAN1#99* + - 1. Regarding rank-restriction and UCI omission, they should be supported by default if UE support 16-3a and 16-3b, so there is no need of signalling.
			2. Regarding concurrent codebooks with mixed types, it should be supported to solve under-reporting issue. However, it shall not be a sub-feature of either eType II or eType II port-selection, it is general to all codebook types. Qualcomm’s proposal is as follows and detailed explanation is given in section 2.3

Signaled in a form as {codebook A, codebook B, max # ports per resource, max # resource, max # total ports}, where Codebook A is one of {Type I SP, Type I MP}, codebook B is one of {Type II, Type II port-selection, eType II, eType II port-selection}Signal max 4 list of {codebook A, codebook B, max # ports per resource, max # resource, max # total ports}.For other codebook A + codebook B which are not signaled,1. Any combination of codebook A = {Type II, Type II port-selection, eType II, eType II port-selection} and codebook B = {Type II, Type II port-selection, eType II, eType II port-selection} is not allowed.
2. Else, the combined capability should be within the capability of each codebook. E.g., (8,2) Type I + (16,1) e Type II is valid if (max{8,16}, 2+1, 8\*2+16\*1)=(16,3,32) is within the reported capability of Type I and Rel-16 Type II.

**Number of PMI subbands:**Qualcomm argues the fundamental feature of eType II CSI is specifying frequency compression so as to achieve overhead reduction compared to Rel-15 Type II CSI. In Qualcomm’s view the motivation of R=2 is to achieve further performance enhancement under comparable overhead of R=1, so it shall be considered as an additional feature. Qualcomm continues, R=2 involves new operations compared with R=1 on both UE side as well as gNB side. For this reason, Qualcomm believes it is good to separate basic core features from more advanced features. Moreover, it is also not clear to Qualcomm whether all gNB vendors will have R=2 in the initial roll out of etype II to allow proper interoperability testing. In their view, in the event where gNB only have R=1 supported and without capability bit to signal R=2 is not tested, this would imply a release 16 UE will have to either deferring basic eType II feature with R=1 or supporting eType II with R=2 wihout proper interoperability testing. Neither option is attractive for release 16 type II feature adoption in Qualcomm’s opinion. Furthermore, Qualcomm argues that from complexity perspective, supporting (R=2, N3<=19) as mandatory increases the complexity for UEs supporting small bandwidth. Hence, based on the discussion, Qualcomm proposes support R=2 as optional for Rel-16 Type II CSI.In Rel-15, UE reports{max # ports per resource, max # resources, max # total ports}. These reflect UE’s capacity to store intermediate results of CSI measurements. When R=2 is configured in Rel-16, there would be two different PMIs in one CQI. In other words, the number PMI calculations would be doubled for a single CSI-RS resource. Thus, compared to R=1, the memory cost and the CSI calculation cost is doubled. Hence, Qualcomm proposes for R=2 that support one of the following for CSI-RS resource and ports occupation* Alt A: When R=2, the number of active resources and the number of active ports within the resources should be counted twice in both CSI-RS account and codebook capability accounting;
* Alt B: In UE capability signalling, include whether supporting R=2 in each SupportedCSI-RS-Resource, i.e., SupportedCSI-RS-Resource contains {max number of ports per resource, max number of resources, max number of total ports, max number of PMIs per subband CQI}.

**Concurrent codebooks with mixed types:**Based on the discussion in their paper, Qualcomm observes * UE may have to underreport its per codebook capability FG 2-36/2-40/2-41/2-43 to accommodate concurrently triggered codebooks with mixed types.
* Current UE capability FG2-33 does not solve the per codebook capability underreporting problem as it only captures the envelop of all codebook types and does not manage to exclude particular codebook combinations cases effectively.
* Current signalling of CSI processing capability may lead to a regression of Rel-15 Type II capability for Rel-16 UE compared to Rel-15 UE.

To address the underreporting problem, Qualcomm thinks the UE need to be allowed to make more reasonable assumption on mixed codebook concurrency. For a specific codebook combination, network can outright ban this combination; explicitly collect a separate CSI capability from UE; or implicitly deduce capability from per codebook capability.The most straightforward solution for Qualcomm is to avoid UE side concurrent processing of codebooks with mixed types. Qualcomm notes the network can still configure different codebook type in report config, just they should not be simultaneously active. This might be reasonable for some codebook combinations (Rel15 type II + Rel16 Type II, for example), however, for other combinations, this solution can be overly restrictive due to the following reasons according to Qualcomm’s paper. Based on further discussion in their paper, Qualcomm observes and proposes* Implicit scheme lose some flexibilities in triggering current CSI reports with mixed codebook types, explicit scheme may cause large RRC overhead, thus a combination of the two schemes may achieve good balance.
* In Rel-16, support explicit scheme, or implicit scheme or combination of them to specify UE capability of processing concurrent codebooks with mixed types.
* In Rel-16, for UE capability of supporting concurrent codebooks with mixed types, support the following solution:
* Report {codebook1, codebook2, max number of ports per resource, max number of resources, max number of ports} for concurrent codebook with mixed types
	+ Codebook1 is restricted to Type I (SP/MP), and codebook2 is restricted to Type II (any type, Rel-15/16, regular/port-selection)
	+ Limit the total number of current capabilities to 4
* For other concurrent codebooks types, the combined capability of the concurrent codebooks shall be within the capability of each codebook;
	+ Combination of 3 codebooks is not allowed.
	+ Any combination of type II codebooks is not allowed.
	+ Else, for concurrent codebook 1 with and codebook 2 with , where and denote the number of ports per resource and the number of resources for codebook triggered by the gNB, the UE expects is within the capability report of both codebook 1 and codebook 2.

**16-2a:**

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| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config” (other than CORESET 0)
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config” (other than CORESET 0)
3. The value of R=[1,2] for BD/CCESupport of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
4. PDSCH processing capability for a CC configured with multi-DCI
5. Maximum number of unicast PDSCHs per CORESETPoolIndex per slot
 | TBD |  | N/A |  | per FSPC | N | TBD |  | Component 1 candidate values: {2, 3, 4}Component 2 candidate values: {1, 2}Component 3 candidate values: {1, 2}Component 4 candidate values: {Capability 1, Capability 2 with scheduling limitation, Capability 2}Component 5 candidate values: {1, 2, 4, 7} | TBD |
| 16-2a-1 | Out-of-order for multi-DCI based multi-TRP | 1. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
2. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
3. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
 | 16-2a |  |  |  | Per UE |  |  |  |  |  |
| 16-2a-2 | Maximum number of active TCI states for multi-DCI based multi-TRP | 1. Maximum number of active TCI states per BWP per CC per value of CORESETPoolIndex (including both data and control)
2. Support 16 active TCI states per BWP per CC, including control and data
 | 16-2a |  |  |  | Per band |  |  |  | Component 1 candidate values: {1, 2, 4, 8} |  |
| 16-2a-3 | CRS rate matching for multi-DCI based multi-TRP | Support of rate match around configured CRS patterns which is associated with CORESETPoolIndex and are applied to the PDSCH scheduled with a DCI detected on a CORESET with the same value of CORESETPoolIndex | 16-2a |  |  |  | Per UE |  |  |  |  |  |
| 16-2a-4 | Multi-beam for multi-DCI based multi-TRP | Indicates whether UE supports receiving time-overlapping PDSCHs/PDCCHs with different beams | 16-2a |  |  |  | Per band | TDD only | FR2 only |  |  |  |
| 16-2a-5 | Two default beams for multi-DCI based multi-TRP | Support of default QCL assumption per CORESETPoolIndex | 16-2a, 16-2a-5 |  |  |  | Per band | TDD only | FR2 only |  |  |  |
| 16-2a-6 | Feedback for multi-DCI based multi-TRP | 1. Support of separate HARQ-ACK
2. Support of joint HARQ-ACK
3. Support of two TDMed long PUCCHs in a slot
 | 16-2a |  |  |  | Per UE |  |  |  |  |  |
| 16-2a-7 | PDSCH scrambling for multi-DCI based multi-TRP | FFS: Support of two PDSCH scrambling sequence per serving cell | 16-2a |  |  |  | Per UE |  |  |  |  |  |

Detailed explanation given by Qualcomm:* Different component should be different rows. There is no reason to include all components in the same feature group as one type/granularity (per FSPC/per band/etc) may not be suitable for all these components.
	+ Components 1-3 should be one row.
		- Since support of multi-DCI requires more complexity, the UE should be able to indicate the support of this feature per-CC of per-band and per-band-combination. Hence, per-band is not acceptable for achieving that trade-off, and per FSPC is proposed.
		- For components 1 and 2, CORESET 0 should be excluded. This is similar to FG 3-3 (*multipleCORESET*) in Rel. 15.
		- The support of Cap1 vs Cap2 as well as 1TB vs multi-TB per slot (and per CORESET pool index) should be taken into account. This is because the UE should be able to indicate the support of multi-DCI feature per-CC of per-band and per-band-combination in the presence/absence of other features that impact the complexity (such as processing capability, or number of TBs per slot). Hence Qualcomm propose to add two components to the basic multi-DCI support.
	+ Components 4-6 (out-of-order) can be a new row.
	+ “The maximum number of activated TCI states” should be a new row. Note that number of activated TCI states is already a UE capability in Rel. 15 in FG 2-1 (for up to 8 active TCI states). Instead, the following should be added as a separate row.
		- Maximum number of activated TCI states per CORESETPoolIndex value
		- Maximum total number of activated TCI states only for the case of more than 8 active TCI states.
	+ “Number of CCs supporting multi-DCI based multi-TRP operation” is not needed if the basic feature group for multi-DCI is per FSPC since UE can indicate the support of multi-DCI per CC of a band in a band combination.
	+ Optional components can also be grouped into multiple UE feature groups, but Qualcomm thinks they should not be all grouped together as in the current version, and only those that are closely related to each other should be grouped.
		- Optional components related to PUCCH (separate / joint HARQ-Ack, two long PUCCHs in the case of separate HARQ-Ack) should be one separate row.
	+ A row for “whether UE supports receiving time-overlapping PDSCHs/PDCCHs with different beams” should be added. This capability is only applicable to FR2 (and the type can be “per band”) and is a prerequisite for “Support of default QCL assumption per CORESETPoolIndex”. It is noted that UE can be capable of supporting multi-DCI in both FR1 and FR2, but in FR2 UE can be only capable of receiving one beam at a given time, which means that the two PDCCHs / PDSCHs with different beams should be TDMed.

**16-2b and 16-2b-1:**

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| 16-2b-1 | Single-DCI based SDM scheme | 1. Support of DCI indication of 2 TCI states by a codepoint and DMRS ports within two CDM groups
2. Whether supporting two PTRS ports
3. Support of DMRS entry {0, 2, 3}
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  |  | TBD |
| 16-2b-2 | Single-DCI based FDMSchemeA | Support of FDMSchemeA | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  |  | TBD |
| 16-2b-3 | Single-DCI based FDMSchemeB | 1. Support of FDMSchemeB
2. For FDMSchemeB, whether the UE can support CW soft combining
 | 16-2b, TBD |  | N/A |  | per FSPC | N | TBD |  |  | TBD |
| 16-2b-4 | Single-DCI based TDMSchemeA | 1. Support of TDMSchemeA
2. Supported maximum TBS size for TDMSchemeA
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  | Component 2 candidate values {10 CBs, TBD} | TBD |
| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation
3. FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  | Component 1 candidate values: {8,16}Component 2 candidate values {10 CBs, TBD} | TBD |
| 16-2b-6 | Two default beams for single-DCI based multi-TRP | Support of two default QCL assumptions for single-DCI based multi-TRP | 16-2b |  |  |  | Per band | TDD only | FR2 only |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

Detailed explanation given by Qualcomm:* Support of MAC-CE does not need to be a UE capability since a prerequisite for this is support of at least one of the single-DCI based schemes. UE has to support the new MAC-CE if it indicates support of at least one of 16-2b-1, 16-2b-2, …, 16-2b-5.
* “Number of CCs supporting single-DCI based multi-TRP operation” is not clear. Indicating a number of CCs irrespective of which single-DCI scheme may not achieve the goal intended by adding this component. For features that requires complexity trade-off between # of CCs with and w/o support of that feature, a typical way is to indicate the support per FSPC / per FS. This should be discussed for each single-DCI scheme separately.
* “Support of default QCL assumption with two TCI states” should be a separate row as it is only relevant for FR2.
* A “basic” feature group is not needed for the single-DCI case, as different schemes have their own characteristics and requirements.
* 16-2b-1: FFS should be removed from components 1 and 3. There is no reason to mandate a particular scheme (e.g. SDM scheme). In addition, without the support of new port entry {0,2,3}, SDM scheme can still be supported. This new port entry is added for rank combination 1+2, which can be scheduled by existing port entry {0,1,2} by using a different TCI codepoint with a reverse order of TCI state pairs.

**16-1a:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. ~~The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)~~
2. L1-SINR based on CMR without dedicated IMR
3. L1-SINR based on CSI-RS as CMR and dedicated ZP IMR
4. L1-SINR based on CSI-RS as CMR and dedicated NZP IMR
5. L1-SINR based on SSB as CMR and dedicated ZP IMR
6. L1-SINR based on SSB as CMR and dedicated NZP IMR
7. ~~FFS:~~ Support of group-based reporting for L1-SINR for each supported component
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |

Qualcomm prefers to distinguish scenarios for SSB vs. CSI-RS as CMR, since SSB as CMR + CSI-RS as IMR may need additional coordination to compute L1-SINR. Specifically, Qualcomm preferd the following 5 sub-components. In addition, they prefer to remove “FFS” on separate capability of L1-SINR based group reportOn 16-1a, support the following 5 sub-components for L1-SINR, and support remove “FFS” on group-based report.* L1-SINR based on CMR without dedicated IMR
* L1-SINR based on CSI-RS as CMR and dedicated ZP IMR
* L1-SINR based on CSI-RS as CMR and dedicated NZP IMR
* L1-SINR based on SSB as CMR and dedicated ZP IMR
* L1-SINR based on SSB as CMR and dedicated NZP IMR

**16-1b:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1b | TCI state activation and spatial relation update | 1. ~~[Support of /~~ maximum number of lists for~~]~~ Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH ~~(FFS whether to be a separate UE feature, e.g. 16-1b)~~
2. ~~[Support of /~~ maximum number of lists for~~]~~ Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
3. ~~[Support of /~~ The maximum number of~~]~~ PUCCH resource groups per BWP for simultaneous spatial relation update
4. ~~FFS: details on whether/how to indicate~~ band pairs which can share the same DL TCI state
5. ~~FFS: details on whether/how to indicate~~ band pairs which can share the same UL spatial relation info
 | Component 1: 2-1, 2-4Component 2: 2-59, 2-60Component 3: 2-53, 2-59, 4-24 |  | N/A |  | TBD[Per BC or per band] | N | ~~Y~~ FR2 only for component 1, 2, 4, 5 |  |  | TBD |

Qualcomm thinks that for component 4 & 5, to make the feature work for simultaneous beam update across multiple CCs, additional capability on which bands/BCs sharing same DL/UL QCL is needed, based on which gNB can activate same set of TCI state IDs or spatial relation infos for CCs within those bands/BCs. Otherwise, gNB has no clue how to create the applicable CC list. This is also reflected by the corresponding agreement. In addition, Qualcomm would like to restrict the group CC based beam update to FR2, since this feature is motivated by the fact that multiple CCs may share same analog beamformer on FR2. On 16-1b, component 3, they believe this capability should be on max # of configured PUCCH resource groups, which is up to 4 in RRC configuration. The corresponding candidate value could be 0,1,2,3,4, where 0 indicates UE does not support this feature in Qualcomm’s view. On 16-1b, component 1 & 2, the capability can be indicated via the supported max # of CC lists, which is up to 2 in RRC configuration according to Qualcomm. The corresponding candidate value could be 0,1,2, where 0 indicates UE does not support this feature. In summary, Qualcomm support the following proposals* On component 4 & 5, remove “FFS”, i.e. support UE to report band pairs/groups sharing same DL/UL QCL
* On component 3, support UE to report max number of PUCCH resource groups for simultanoues spatial relation update with candidate value of 0 indicating no support of this feature
* On component 1 & 2, support UE to report max number of CC lists with candidate value of 0 indicating no support of corresponding feature
* Component 1, 2, 4, 5 should be restricted to FR2 only

**16-1e:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. The maximum number of configured pathloss reference RSs for PUSCH/SRS/PUCCH~~/PUCCH via MAC CE~~ by RRC for MAC-CE based pathloss reference RS update ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
2. FFS: The maximum number of activated pathloss reference RS update for PUSCH/SRS/PUCCH [across CCs / within a slot across all CCs / per CC] ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
3. ~~FFS:~~ Number of measurement samples N to apply newly activated pathloss reference RS
 | ~~8-2,~~ 8-3 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |

On 16-1e, component 1, the max # of configured PL RS should include PUCCH as well in Qualcomm’s view. Qualcomm notes it was agreed that the total configured PL RS # can be up to 64 for PUSCH/SRS/PUCCH. If component 1 does not include PUCCH, the configured PUCCH PL RS can be large according to Qualcomm. They prefer to have limit on it as well. On 16-1e, component 3, Qualcomm supports UE capability on required sample # for application time of new PL RS. They prefer not to have the fixed 5 samples for all UEs, since the corresponding application latency can be as large as 100 ms if SSB is used as PL RS. Qualcomm supports the following proposals* On component 1, support max # of configured PL RS includes PUCCH, in addition to PUSCH/SRS
* On component 3, support UE capability on required sample # for application time of new PL RS, i.e. remove “FFS”

**16-1f:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery per band ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
2. ~~FFS:~~ Support of PUCCH-BFR ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
3. ~~FFS:~~ The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR ~~[across all CCs /~~ within a slot across all CCs ~~/ per CC]~~ ~~(FFS to replace this component to 14)~~
4. FFS: ~~Densigy~~ Density of CSI-RS for new beam identification for SCell BFR
 | 2-31 |  | N/A |  | TBD | N |  |  |  | TBD |

Qualcomm prefers capability on max # of SCells for BFR per band, since UE can be configured with only one SCell for BFR per band to reduce monitoring complexity for BFD. In addition, they support separate capability of PUCCH-BFR, which requires additional prioritization rule when collided with normal SR. On 16-1f, component 3, the max # of RS for new beam identifications should be limited across CCs in a slot, since the time density is most critical to UE complexity in Qualcomm’s view. They support the following proposals* On component 1, support max # of SCells for BFR per band
* On component 2, support UE capability on PUCCH-BFR, i.e. remove “FFS”
* On component 3, support max # of RS for new beam identification in a slot across all CCs

**16-1g:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1g | FFS: Resources for beam management, pathloss measurement, and BFR | 1. ~~FFS:~~ The maximum number of SSB/CSI-RS resources across all CCs in a slot for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, and new beam identification.
2. FFS: The maximum number of SSB/CSI-RS resources across all CCs for pathloss measurement
3. FFS: The maximum number of SSB/CSI-RS resources across all CCs for BFD
4. FFS: The maximum number of SSB/CSI-RS resources across all CCs for new beam identification
 |  |  | N/A |  | TBD | N |  |  |  | TBD |  |  |  |  |  |  |  |  |  |  |  |  |  |

Qualcomm supports to define a general limit on the total time density of at least NZP CSI-RS for various use cases, including BFD, RLM, PL RS, L1-RSRP, L1-SINR. Because the total time density is the fundamental limitation. In addition, compared with specifying max # per use case, they propose gNB can configure more on some use cases while less on other use cases, as long as the sum is below the total limit. Their detailed proposal is to support to at least limit max # of NZP CSI-RS across all CCs in a slot for various use cases, including BFD, RLM, PL RS, L1-RSRP, L1-SINR**Low PAPR RS UE features**For 16-4 “Low PAPR DMRS for DL”, “Need of FR1/FR2 differentiation” Qualcomm proposes to be set to “YES” because a UE can support this feature in FR1 may not able to support this in FR2. For 16-6a “Low PAPR DMRS for PUSCH” and 16-6b “Low PAPR DMRS for PUCCH”, Qualcomm proposes for these two features to be “per band”, as a UE may be able support Pi/2 BPSK in one band but not in another band. Furthermore, these two feature should be optional features with capability signaling, as there is strong motivation to force all UEs to support them as mandatory features.**UL full power transmission**For 16-5a “UL full power transmission mode 0”, 16-5b “UL full power transmission mode 1”, and 16-5c “UL full power transmission mode 2”, these three features need to be “per FC”, i.e. per band per band combination in Qualcomm’s viewFurthermore, on 16-5c “UL full power transmission mode 2”, Qualcomm proposes that the UE capability for component 3 on SRS resource configuration and component 6 on TPMI group reporting need to be separately signalled from the capability signalling of mode 2. A UE support mode 2 does not necessarily have to support SRS resource configuration with different number of SRS ports or TPMI group reporting on full power. Qualcomm further propose to decouple 16-5c into three separate features, 16-5c “UL full power transmission mode 2”, 16-5d “Multiple SRS resources in set with different number of ports for full power Tx”, and 16-5e “Indication of TPMIs with full power capability”, as listed in the table below. 16-5c is the prerequisite for 16-5d and 16-5e. |
| Huawei, HiSilicon [17] | **16-1: Multi-Beam Operation**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. Supported type of interference measurement resource
2. Supported type of dedicated IMR
3. Max number of SSB/CSI-RS resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR for L1-SINR
4. Max number of NZP CSI-RS and CSI-IM resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as IMR for L1-SINR
5. Maximum number of L1-SINR report setting per BWP
6. FFS: Support of group-based reporting for L1-SINR
 | TBD  | TBD[Per band] | N | N | TBD |
| 16-1b | TCI state activation and spatial relation update | 1. [Support of / maximum number of lists for] Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH ~~(FFS whether to be a separate UE feature, e.g. 16-1b)~~
2. [Support of / maximum number of lists for] Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
3. [Support of / The maximum number of] PUCCH resource groups per BWP for simultaneous spatial relation update
4. Maximum number of PUCCH resources within each PUCCH resource group
5. FFS: details on whether/how to indicate band pairs which can share the same DL TCI state
6. FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info
 | Component 1: 2-1, 2-4Component 2: 2-59, 2-60Component 3: 2-53, 2-59, 4-24 | TBD[Per BC or per band] | N | Y | TBD |
| 16-1c | Default spatial relation | Support of default spatial relation and pathloss reference RS for dedicated-PUCCH/SRS and PUSCH scheduled by DCI format 0\_0 | 2-53, 2-59 | TBD[Per band] | N | Y | TBD |
| 16-1d | MAC CE spatial relation update for AP-SRS | [Support of / The maximum number of] spatial relation update for AP-SRS via MAC CE ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~ | 2-53, 2-59 | TBD[Per UE] | N | Y | TBD |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. The maximum number of configured pathloss reference RSs for PUSCH/SRS~~/PUCCH via MAC CE~~ by RRC for MAC-CE based pathloss reference RS update ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
2. FFS: The maximum number of activated pathloss reference RS update for PUSCH/SRS/PUCCH [across CCs / within a slot across all CCs / per CC] ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
3. FFS: Number of measurement samples N to apply newly activated pathloss reference RS
 | ~~8-2,~~ 8-3 | TBD[Per UE] | N | N | TBD |
| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
2. FFS: Support of PUCCH-BFR ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
3. FFS: The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC] ~~(FFS to replace this component to 14)~~
4. FFS: ~~Densigy~~ Density of CSI-RS for new beam identification for SCell BFR
 | 2-31 | TBD | N |  | TBD |
| 16-1g | FFS: Resources for beam management, pathloss measurement, and BFR | 1. FFS: The maximum number of SSB/CSI-RS resources within a slot across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, and new beam identification.
2. FFS: The maximum number of SSB/CSI-RS resources within a slot across all CCs for pathloss measurement
3. FFS: The maximum number of SSB/CSI-RS resources within a slot across all CCs for BFD
4. FFS: The maximum number of SSB/CSI-RS resources across all CCs for new beam identification
 | 2-24/2-31 | TBD | N |  | TBD |

Regarding the UE features on multi-beam operation, Huawei and HiSilicon have the following comments:* FG 16-1a: The current version of component 1 is overly general and hence unfriendly to UE implementation. Huawei and HiSilicon suggest splitting into components of
	+ Components 1a) Supported type of interference measurement resource, with candidate values of {“Dedicated”, “Non-dedicated”, “Both”}
	+ Components 1b) Supported type of dedicated IMR, with candidate values of {“NZP CSI-RS only”, “CSI-IM only”, “NZP CSI-RS only and CSI-IM only”, “NZP CSI-RS only and CSI-IM only and Mixed NZP CSI-RS + CSI-IM”}
	+ Components 1c) Max number of SSB/CSI-RS resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR for L1-SINR
	+ Components 1d) Max number of NZP CSI-RS and CSI-IM resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as IMR for L1-SINR
	+ Components 1g) Maximum number of L1-SINR report setting per BWP
* FG 16-1b: Additional component on maximum number of PUCCH resources within each PUCCH resource group is needed, as mentioned in Question 5 of RAN2 LS in R2-2001683.
* FG 16-1d: FR1/FR2 differentiation is needed, as spatial relation is currently not supported in FR1.
* FG 16-1g: As the target of component 8/9/10/11 is to restrict peak simultaneous processing across multiple functionalities, it is critical to add the restriction of ‘within a slot’, similar to FG 2-24 in Rel-15. It is intended to restrict total maximal number of measurement RSs (i.e., L1/L3-RSRP RSs, L1/L3-SINR RSs) used for different functionalities across all CCs within a slot. In practice, the hardware of processing BM-RS/BFD-RS/CBD-RS/PL-RS can be shared by UE, because the computational complexity are similar under the condition of using 1/2-port BM-RS/BFD-RS/CBD-RS/PL-RS for L1/L3-RSRP/SINR calculation. If the UE capability on BM-RS/BFD-RS/CBD-RS/PL-RS are separately reported in Rel-16, then UE tends to report more conservative values assuming that above three types of RS may be activated within the same slot. In contrast, when the UE capability of processing BM-RS/BFD-RS/CBD-RS/PL-RS within a slot is reported as a whole (i.e., shared across different functionalities), the gNB only needs to ensure that the total number of activated BM-RS, BFD-RS, CBD-RS and PL-RS within a slot do not exceed the reported total UE capability. In this way, a better balance between UE implementation complexity and gNB scheduling flexibility can be achieved. In addition, as this FG involves both L1-RSRP reporting and beam failure recovery, it is necessary to add the relevant Rel-15 FGs, i.e., 2-24/2-31, as prerequisite feature groups.

Regarding the UE features on multi-beam operation, Huawei and HiSilicon have the following comments:* FG 16-1a: Split into components of ‘Supported type of interference measurement resource’, ‘Supported type of dedicated IMR’, ‘Max number of SSB/CSI-RS resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR for L1-SINR’, ‘Max number of NZP CSI-RS and CSI-IM resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as IMR for L1-SINR’, ‘Maximum number of L1-SINR report setting per BWP’
* FG 16-1b: Add additional component on maximum number of PUCCH resources within each PUCCH resource group
* FG 16-1d: Update ‘Need of FR1/FR2 differentiation’ as ‘Y’
* FG 16-1g: Add ‘within a slot’ to components 8/9/10 and add ‘2-24/2-31’ to ‘Prerequisite feature groups’

**16-2: Multi-TRP operation**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config”
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config”
3. The value of R=[1,2] for BD/CCE
4. Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
5. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
6. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
7. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
8. FFS: The maximum number of activated TCI states
9. A list of pairs per band with {the maximal number of CCs supporting different values of CORESETPoolIndex, the maximal of CCs supporting the same values of CORESETPoolIndex}
10. Support of intra-slot separate, and/or, joint HARQ-ACK codebook.

Optional components:1. Whether the UE shall 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
2. FFS: Support of two PDSCH scrambling sequences per serving cell
3. Support of default QCL assumption per CORESETPoolIndex
4. Support of two TDMed long PUCCHs in a slot
 | TBD | TBD [per band / per FSPC] | N | TBD | TBD |
| 16-2b | Single-DCI based multi-TRP | Basic component(s):1. FFS: Support of MAC CE to activate multiple TCI states for a TCI codepoint
2. FFS: Number of CCs supporting single-DCI based multi-TRP operation

Optional components:1. Support of default QCL assumption with two TCI states
 | TBD |  | N | TBD | TBD |
| 16-2b-1 | Single-DCI based SDM scheme | 1. FFS: Support of DCI indication of of 2 TCI states by a codepoint and DMRS ports within two CDM groups
2. Whether supporting two PTRS ports
3. FFS Support of DMRS entry {0, 2, 3}
 | 16-2b, TBD |  | N | TBD | TBD |
| 16-2b-2 | Single-DCI based FDMSchemeA | Support of FDMSchemeA | 16-2b, TBD |  | N | TBD | TBD |
| 16-2b-3 | Single-DCI based FDMSchemeB | 1. Support of FDMSchemeB
2. For FDMSchemeB, whether the UE can support CW soft combining
 | 16-2b, TBD | TBD [per FSPC] | N | TBD | TBD |
| 16-2b-4 | Single-DCI based TDMSchemeA | 1. Support of TDMSchemeA
2. Supported maximum TBS size for TDMSchemeA
 | 16-2b, TBD |  | N | TBD | TBD |
| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation
3. FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)
 | 16-2b, TBD |  | N | TBD | TBD |

With regard to 16-2a Component 9, “FFS: the maximum number of CCs supporting multi-DCI based multi-TRP”, Huawei and HiSilicon prefer to change it as “A list of pairs per band with {the maximal number of CCs supporting different values of *CORESETPoolIndex*, the maximal of CCs supporting the same values of *CORESETPoolIndex*}”* The motivation is that, if the UE can report to support 2 CORESET sets for 2 CCs in a band, the NW can choose to use CA with 2CC as usual, or the NW can choose to use either CC1 or CC2 (without CA) to be configured with the first and second CORESETs with Multi-DCI based operation depending on NW’s preferences and also avoiding over-capability of UE. Therefore, with potential CA capability trade-off, in addition to the number of CCs supporting M-DCI, information about the number of CCs for normal operations without M-DCI could be reported as well. Moreover, if Component 9 is reported per band (or per band combination), flexible sharing among CCs can be per band (or per band combination).

Huawei and HiSilicon propose that the component of “FFS: the maximum number of CCs supporting multi-DCI based multi-TRP” should be extended to “A list of pairs per band with {the maximal number of CCs supporting different values of CORESETPoolIndex, the maximal of CCs supporting the same values of CORESETPoolIndex}”.For multi-DCI based multi-TRP transmission, Huawei and HiSilicon argue joint feedback design is close to HARQ-ACK codebook design for CA in R15, therefore related design is relatively friendlier to UE implementation. Although the NW implementation with non-ideal backhaul is difficult to consider dynamic codebook across TRPs due to tight scheduling coordination in Huawei and HiSilicon’s view, the support of joint HARQ-ACK codebook could be used for single TRP scenario or TRPs connected with ideal backhaul at least, whereas two PDCCHs are transmitted from the same TRP with different beams or different TRPs and two codewords are scheduled for two PDSCHs respectively to allow better performance for middle/center UEs with higher rank and edge UE with improved robustness. Huawei and HiSilicon continue that on the other hand, intra-slot separate feedback can provide a prompt feedback of HARQ-ACK information, which may be more beneficial under non-ideal backhaul due to less stringent coordination requirement between TRPs. As a trade-off, Huawei and HiSilicon suggest if a UE can support multi-DCI based multi-TRP transmission, at least the UE can support joint feedback and whether supporting intra-slot separate HARQ feedback can be signaled to the NW, e.g. if the NW with non-ideal backhaul is desired to be supported more efficiently. Therefore intra-slot HARQ-ACK feedback modes shall be one of the basic components according to Huawei and HiSilicon. They propose that the component of supporting intra-slot separate, and/or, joint HARQ-ACK feedback should be basic components.With regard to 16-2a basic component 4, “Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain”, Huawei and HiSilicon prefer to add/clarify candidate values for this component, including “No support, Fully overlapped PDSCHs, Full and partially overlapped PDSCHs”, which represent different level complexity of receiver design to support this feature. Huawei and HiSilicon suggests to clarify or 16-2a component 4 candidate values as “No support, Fully overlapped PDSCHs, Full and partially overlapped PDSCHs”.Similar to Samsung and Qualcomm’s comments, Huawei and HiSilicon believes Rel-15 capability of total MIMO layers will apply to overlapping PDSCHs from multi-TRPs as well and suggest to remove component 8.**16-3: eType-II codebook**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3a | Regular eType-II | Basic components:1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 8 parameter combinations (FFS: Value of L per the number of antenna ports)
3. Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with value R=1
4. Rank restriction
5. FFS: UCI omission

Optional components1. Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with R=2
2. Rank 1 to 4 Support of rank 3,4
3. CBSR
4. FFS: The maximum number of configured aperiodic CSI Report Settings
5. FFS: Support of mixed codebook types
 | TBD | **FFS: Per band or Per band per BC** | N | N |  |
| 16-3b | Port selection eType-II | Basic components:* FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
* 6 parameter combinations (combos with L=6 don’t apply) (FFS: Value of L per the number of antenna ports)
* Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with value R=1
* Rank restriction
* FFS: UCI omission

Optional components:1. Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with R=2
2. Rank 1 to 4 Support of rank 3,4
3. FFS: The maximum number of configured aperiodic CSI Report Settings
4. FFS: Support of mixed codebook types
 | TBD | **FFS: Per band or Per band per BC** | N | N |  |

 highly prefer to combine optional component 1 (Support of PMI sub-bands with R=2) and basic component 1 as a quadruplet, i.e., {R, max # of Tx ports in one resource, Max # of resources and total # of Tx ports} per band and also per band combination, assuming that the length of quadruplet list remains same as or less than the maximal number of Rel-15 triplets. In their view, all four parameters are highly correlated to CSI processing complexity for eType II codebook. They note that the UE still has full freedom to report R=1 in all quadruplets, if R=2 is not referred by the UE. Therefore in their view, basic component 3 of “Support of PMI sub-bands with value R=1” is not needed. Huawei and HiSilicon propose for both 16-3a and 16-3b, to combine optional component 1 and basic component 1 as the new component 1, i.e., {R, max # of Tx ports in one resource, Max # of resources and total # of Tx ports} per band and also per band combination.Huawei and HiSilicon note that in Rel-15, the capabilities on CSI-RS are per codebook. If one UE supports multiple codebook types, this UE may report conservative values assuming that multiple CSI reports associated with different codebook types are triggered simultaneously. Huawei and HiSilicon believes this issue becomes more serious in Rel-16, because two more codebook types are introduced. To avoid above issue, Huawei and HiSilicon proposes the UE shall report the capabilities of CSI-RS per codebook per codebook-combination additionally. The capability signalling can be a list of supported combination for one codebook in one codebook combination in their view. Huawei and HiSilicon propose the UE shall report the capabilities of supported codebook per codebook-combination additionally. For 16-3a and 16-3b, Huawei and HiSilicon suggest to remove “UCI omission” from now unless RAN1 spec can clarify further UE behavior. Moreover “Rank restriction” seems to be rephrased as “Support of rank 1, 2” to align with optional component 2, if that is the intention of Basic components in Huawei and HiSilicon’s view.**16-5: Power-efficient UL transmission**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5 | UL full power transmission | 1. Supported UL full power transmission
 | 2-13, 2-14 | **FFS: Per FS or Per band or Per band per BC** | N | N | TBD |
| 16-5a | UL full power transmission mode 1 | 1. Supported UL full power transmission mode 1
2. Number of Tx to support mode 1: {2Tx, 4Tx, 2Tx\_4Tx}
3. FFS: New UL codebook set(s) per supported mode per supported Tx
 | 2-13, 2-14, 16-5 | **FFS: Per FS or Per band or Per band per BC** | N | N | TBD |
| 16-5b | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of Tx to support mode 2: {2Tx, 4Tx, 2Tx\_4Tx}
3. The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.
4. FFS: Maximum number of ports per SRS resource
5. FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set
6. TPMI group which delivers full power. FFS on details for supported number of Tx.

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14, 16-5 | **FFS: Per FS or Per band or Per band per BC** | N | N | TBD |

Huawei and HiSilicon believe that for 16-5a in current version, at first, it is not necessary to split the UE features as 3 independent features, since the agreed two transmission modes are sub-features for full power transmission. In their view, it is clear that current signalling is two levels: ULFPTx for enable full power transmission, and *ULFPTxModes* for selecting one of transmission modes. Furthermore, they argue there is no “UL full power transmission mode 0” defined in RAN1 (no agreement as well). So in their view it is better to design the feature reporting as two levels, i.e., the first level is enable the whole feature of full power, and second level is enable one of the transmission modes. Accordingly, 16-5a should be revised as 16-5 and remove the “mode 0” (i.e., first level feature reporting). They propose FG 16-5a be renamed as “16-5 UL full power transmission” as a basic feature for transmission mode to match with RAN1 agreements and specification.For 16-5b in current version, Huawei and HiSilicon believe candidate values, e.g. 2Tx\_4Tx for component-2, need to be clarified. Since in transmission Mode-1, it is assumed with no virtualization so that 2Tx\_4Tx has no use in their eyes. Moreover, for the FFS part “*New UL codebook set(s) per supported mode per supported Tx*”, they argue introducing new codebook subset is useless as well since there is only one codebook subset for Mode-1. Hence, they propose for FG 16-5b “UL full power transmission mode 1”, * Candidate values for component “Number of Tx to support mode 1” should be clarified.
* Component-3 should be removed.

For 16-5c in current version, Huawei and HiSilicon believe component-2 is not clear, whether it means 2Tx = 2 ports, 2Tx\_4Tx = 2 and 4 ports? The component should be clarified in their view. Furthermore, they argue the relationship between component-4 and component-2 is also unclear till now. They note that multiple SRS resources with different number can be configured for different virtualization, so UE may report both a 2-port TPMI Group and a 4-port TPMI group. For FG 16-5c “UL full power transmission mode 2”, Huawei and HiSilicon propose * Component-2 and the relationship between component-2 and 4 should be clarified.
* For component-6, the detailed reporting should be:
	+ 2 ports (bitmap): {None, [1,0], [0,1], or Both [1,0] and [0,1]}; and/or
	+ 4 ports: None coherent: {None, G0, G1, G2, or G3}, or Partial coherent: {None, G0, G1, G2, G3, G4, G5, G6};
 |
| Fraunhofer IIS, Fraunhofer HHI [18] | Fraunhofer argues the achieved performance gains using R=2 are not that significant compared to R=1. Also, they continue, for R=2, the computational complexity of the UE is high. Thus, in their view, mandatorily supporting R=2 may not be beneficial in view of the marginal performance gain and high complexity issues. Therefore, they propose R=2 shall only be optionally supported.  |

# Proposals for discussion and priority order

The LTE/NR UE feature discussions are a top priority to complete ASN.1 by June. To this end, the following guidelines apply in determining the priority of a proposal:

1. First priority will be given to issues that impact the feature list structure such as whether a certain FG is necessary or not

2. Second priority will be the discussion and resolution of issues impacting the capability signalling including type, component candidate values, and xDD/FRx differentiation

3. Lowest priority is for clarifications on components, whether a feature is mandatory/optional, what the prerequisites are, etc. These may, in fact, be postponed in order to better manage email load during RAN1 #100bis-e

RAN1 is thus encouraged to focus on priorities #1 and #2. Specifically, any merging and splitting of features is crucial to be concluded as are proposals for fields in columns towards the second half of the feature list table that are empty, have TBD or FFS, or list many options.

The proposed alternatives and revisions in this Section try to merge individual companies’ inputs as much as possible. Whenever necessary, various alternatives for a (set of) row(s) are listed. While not always possible, in general it is desirable to limit discussion on clarification of components and to focus on a final structure of feature groups and the signalling aspects related to them (candidate values, type, xDD/FRx differentiation …) instead.

Proposals are given with tables or alternatives between a plurality of tables. The prioritization of issues within a proposal of such kind is as follows:

* High priority:
	+ Any change to the number of rows, i.e., deletion of rows, merging of rows, splitting of rows …
* Medium priority:
	+ Any change to a component that impacts signalling design, e.g., because the component requires candidate values to be signalled incl. {enabled, disabled}
	+ Any change to the type
	+ Any change to xDD/FRx differentiation
	+ Any change to whether the gNB needs to know if the feature is supported
	+ Any change to whether capability exchange between UEs (V2X only) is applicable
	+ Any change to a note that impacts signalling design, e.g., because a component requires candidate values to be signalled incl. {enabled, disabled}
* Low priority:
	+ Any change to a component that does not impact signalling design
	+ Any change to a note that does not impact signalling design
	+ Any change to whether a feature group is mandatory or optional
	+ Any change to consequences if a feature is not supported by a UE
	+ Any change to prerequisite feature groups for a feature

The following eight tables summarize all proposals for FG 16-1a from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the ninth table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)
2. ~~FFS: Support of group-based reporting for L1-SINR~~
 | TBD  |  | N/A |  | ~~TBD~~~~[~~Per band~~]~~ | N | N |  |  | TBD |
| 16-1h | Group-based reporting for L1-SINR | Support of group-based reporting for L1-SINR | 16-1a |  | N/A |  | Per band |  |  |  |  |  |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. ~~The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)~~
2. ~~FFS:~~ Support of group-based reporting for L1-SINR
3. Supported RS for CMR/IMR configurations for L1-SINR
4. 2. Max. number of reference signal configurations for CMR and IMR for L1-SINR across all CCs
5. 3. Max. number of reference signal configurations for CMR and IMR for L-SINR within a slot
6. 4. Max. number of reference signal configurations for CMR for L1-SINR and L1-RSRP
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR ~~and/or~~
2. Support of L1-SINR based beam measurement and reporting based on NZP IMR ~~(FFS details on the sub-components, e.g., FG 2-24)~~
3. ~~FFS:~~ Support of group-based reporting for L1-SINR
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |

**Alt. 4:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. Support of ~~The maximum number of~~ L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)
2. FFS: Support of group-based reporting for L1-SINR
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |

**Alt. 5:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)
2. ~~FFS: Support of group-based reporting for L1-SINR~~
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |
| 16-1h | Group-based reporting for L1-SINR | Support of group-based reporting for L1-SINR | 16-1a |  |  |  |  |  |  |  |  |  |
| 16-1i | Non-group-based reporting for L1-SINR | Support of non-group based reporting for L1-SINR | 16-1a |  |  |  |  |  |  |  |  |  |

**Alt. 6:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. The max number of SSB/CSI-RS (1Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR to measure L1-SINR within a slot
2. The max number of CSI-RS resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR to measure L1-SINR
3. The max number of CSI-RS (2Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR to measure L1-SINR within a slot
4. Supported density of CSI-RS for CMR to measure L1-SINR
5. The max number of CSI-IM resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as ZP IMR to measure L1-SINR within a slot
6. The max number of CSI-IM resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as ZP IMR to measure L1-SINR
7. The max number of CSI-RS (1Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as NZP IMR to measure L1-SINR within a slot
8. The max number of CSI-RS (1Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as NZP IMR to measure L1-SINR
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |

**Alt. 7:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. ~~The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)~~ Supported type of interference measurement resource
2. Supported type of dedicated IMR
3. Max number of SSB/CSI-RS resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as CMR for L1-SINR
4. Max number of NZP CSI-RS and CSI-IM resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured as IMR for L1-SINR
5. Maximum number of L1-SINR report setting per BWP
6. FFS: Support of group-based reporting for L1-SINR
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |

**Alt. 8:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1a | L1-SINR reporting | 1. ~~The maximum number of L1-SINR based beam measurement and reporting based on ZP IMR and/or NZP IMR (FFS details on the sub-components, e.g., FG 2-24)~~
2. L1-SINR based on CMR without dedicated IMR
3. L1-SINR based on CSI-RS as CMR and dedicated ZP IMR
4. L1-SINR based on CSI-RS as CMR and dedicated NZP IMR
5. L1-SINR based on SSB as CMR and dedicated ZP IMR
6. L1-SINR based on SSB as CMR and dedicated NZP IMR
7. ~~FFS:~~ Support of group-based reporting for L1-SINR for each supported component
 | TBD  |  | N/A |  | TBD[Per band] | N | N |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We prefer Alt. 6 with the following modification* Similar as FG2-24, it is “per band”

Add “Support of group-based reporting for L1-SINR”The prerequisite is FG2-24 |
| Ericsson | In many of the alternatives, several components have been added. In our understanding, the components are only used to describe the feature group. The signaling is performed on the FG as a whole. Since the L1-SINR reuses the L1-RSRP measurement, there is no need to introduce additional detailed capabilities on CMRs: not on the number, or the type. The corresponding FG for L1-RSRP reporting could be pre-requisite. The interference measurement based on dedicated ZP and NZP is the same, so there is no need to distinguish those.Non-group based reporting is part of the basic capability. Group-based should be an optional feature, or included in the basic capability. |
| ZTE | Alt1 is supported, but we can also live with Alt 3 and Alt 5.We should minimize components about the numbers of NZP-IMR and/or ZP-IMR, in order to improve the universal quality of this L1-SINR reporting. |
| LG | Prefer Alt.4 with a modification that the first component is spitted into two as below. 1. Support of L1-SINR based beam measurement and reporting based on ZP IMR
2. Support of L1-SINR based beam measurement and reporting based on NZP IMR
 |
| MediaTek | We support the principle of Alt.1. However, we think Alt. 1 is not clear enough. For example, it does not say the maximum number is for “the number of configured RS” or “the number of resources to perform measurement within a slot”. Our suggestion is keeping 16-1h as it is and modify 16-1a as follows-              The max number (sum of periodic/semi-persistent/aperiodic) of SSB/NZP-CSI-RS/CSI-IM resources configured for L1-RSRP/L1-SINR across all CCs-              The max number (sum of periodic/semi-persistent/aperiodic) of SSB/NZP-CSI-RS resources to perform measurement on CMR for L1-RSRP/L1-SINR across all CCs within a slot |
| Nokia, Nokia Shanghai Bell | Alt.3 is preferred as reference for discussion.  |

The following two tables summarize all proposals for FG 16-1b from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the third table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1b | TCI state activation and spatial relation update | 1. [Support of / maximum number of lists for] Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH ~~(FFS whether to be a separate UE feature, e.g. 16-1b)~~
2. [Support of / maximum number of lists for] Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
3. [Support of / The maximum number of] PUCCH resource groups per BWP for simultaneous spatial relation update
4. Maximum number of PUCCH resources within each PUCCH resource group
5. FFS: details on whether/how to indicate band pairs which can share the same DL TCI state
6. FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info
 | Component 1: 2-1, 2-4Component 2: 2-59, 2-60Component 3: 2-53, 2-59, 4-24 |  | N/A |  | TBD[Per BC or per band] | N | ~~Y~~FR2 only for component 1, 2, 4, 5 |  |  | TBD |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1b | TCI state activation and spatial relation update | 1. ~~[~~Support of ~~/ maximum number of lists for]~~ Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH ~~(FFS whether to be a separate UE feature, e.g. 16-1b)~~
2. ~~[Support of / maximum number of lists for] Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS~~
3. ~~[Support of / The maximum number of] PUCCH resource groups per BWP for simultaneous spatial relation update~~
4. FFS: details on whether/how to indicate band pairs which can share the same DL TCI state
5. ~~FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info~~
 | Component 1: 2-1, 2-4~~Component 2: 2-59, 2-60~~~~Component 3: 2-53, 2-59, 4-24~~ |  | N/A |  | TBD[Per BC or per band] | N | Y |  |  | TBD |
| 16-1b-2 | Spatial relation update across multiple CCs | 1. Support of Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS
2. FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info
 | Component 1: 2-59, 2-60 |  | N/A |  | TBD[Per BC or per band] | N | Y |  |  | TBD |
| 16-1b-3 | Spatial relation update for PUCCH group | Support of PUCCH resource groups per BWP for simultaneous spatial relation update | 2-53, 2-59, 4-24 |  | N/A |  | TBD[Per BC or per band] | N | Y |  |  | TBD |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ~~16-1b~~ | ~~TCI state activation and spatial relation update~~ | 1. ~~[Support of / maximum number of lists for] Simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH (FFS whether to be a separate UE feature, e.g. 16-1b)~~
2. ~~[Support of / maximum number of lists for] Simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS~~
3. ~~[Support of / The maximum number of] PUCCH resource groups per BWP for simultaneous spatial relation update~~
4. ~~FFS: details on whether/how to indicate band pairs which can share the same DL TCI state~~
5. ~~FFS: details on whether/how to indicate band pairs which can share the same UL spatial relation info~~
 | ~~Component 1: 2-1, 2-4~~~~Component 2: 2-59, 2-60~~~~Component 3: 2-53, 2-59, 4-24~~ |  | ~~N/A~~ |  | ~~TBD~~~~[Per BC or per band]~~ | ~~N~~ | ~~Y~~ |  |  | ~~TBD~~ |
| 16-1b1 | Cross-CC TCI state activation | Support of simultaneous TCI state activation across multiple CCs: PDCCH, PDSCH  | 2-1, 2-4 |  | N/A |  | Per band | N/A | N/A |  |  | TBD |
| 16-1b2 | Cross-CC spatial relation update | Support of simultaneous spatial relation update across multiple CCs: AP-SRS, SP-SRS | 2-59, 2-60 |  | N/A |  | Per band | N/A | N/A |  |  | TBD |
| 16-1b3 | PUCCH resource groups  | Support of PUCCH resource groups per BWP for simultaneous spatial relation update | 2-53, 2-59, 4-24 |  | N/A |  | Per band | N/A | N/A |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We prefer Alt.2, and we prefer to remove “FFS”Furthermore, we prefer to clarify the component 4 in 16-1b in Alt. 2: “the same DL TCI state” is changed to “the same QCL-TypeD” |
| Ericsson | We prefer alt 3 or 2, which are very similar.Note that this feature is only about a signaling optimization: no new configuration possibilities of TCI states is introduced. The same possibilities to share DL TCI states exists in R16 as in R15.We should avoid limitations on sizes of configuration – no FG for PUCCH group size. |
| ZTE | Alt. 3 is supported. Considering the flexibility of TCI/spatial relation configuration and backward compatibility for Rel-15 UE, we suggest to have the support of components directly rather than the maximum value, and the maximum value is based on the existing agreements or Rel-15 UE capability reporting for active TCI/spatial relation in a single CC.* The maximum number of simultaneous TCI state activation across multiple CCs is determined according to Component 2-4: TCI states for PDSCH.
* The maximum number of simultaneous spatial relation update across multiple CCs is determined according to Component 2-59: Configured spatial relations.
* The maximum number of PUCCH resource groups is 4 according to agreements.
 |
| LG | Support Alt2 or Alt3, which are very similar. From wording perspective, it may be clearer if we can change the names as below16-1b1: Simultaneous TCI state update across multiple CCs for PDCCH/PDSCH16-1b2: Simultaneous spatial relation update across multiple CCs for AP/SP SRS16-1b3: PUCCH resource group based spatial relation update |
| MediaTek | Support Alt. 2 because DL beam reporting and UL beam reporting should be divided. Type should be Per BC because inter band is not precluded. The maximum number of lists should be added for both 16-1b and 16-1b2. |
| Nokia, Nokia Shanghai Bell | Alt. 1 as starting point for technical discussion.  |

The following table summarizes all proposals for FG 16-1c from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1c | Default spatial relation | Support of default spatial relation and pathloss reference RS for dedicated-PUCCH/SRS and PUSCH scheduled by DCI format 0\_0 | 2-53, 2-59 |  | N/A |  | ~~TBD~~~~[~~Per band~~]~~ | N | Y |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | Okay for us |
| Ericsson | Support |
| ZTE | Support the above candidate. |
| LG | Support  |
| MediaTek | Support |
| Nokia, Nokia Shanghai Bell | OK |

The following table summarizes all proposals for FG 16-1d from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1d | MAC CE spatial relation update for AP-SRS | ~~[~~Support of ~~/ The maximum number of]~~ spatial relation update for AP-SRS via MAC CE ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~ | 2-53, 2-59 |  | N/A |  | ~~TBD~~~~[~~Per band~~]~~ | N | ~~N~~Y |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | Okay for us |
| Ericsson | Support |
| ZTE | Support the above candidate. |
| LG | Support  |
| MediaTek | Support |
| Nokia, Nokia Shanghai Bell | OK |

The following four tables summarize all proposals for FG 16-1e from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the fifth table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. Support of MAC-CE based pathloss reference RS update via MAC-CE
2. The maximum number of configured pathloss reference RSs for PUSCH/SRS/PUCCH~~/PUCCH via MAC CE~~ by RRC for MAC-CE based pathloss reference RS update ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
3. FFS: The maximum number of activated pathloss reference RSs ~~update~~ for PUSCH/SRS~~/PUCCH~~ and configured pathloss reference RSs for PUCCH [across CCs / within a slot across all CCs / per CC] ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
4. FFS: Number of measurement samples N to apply newly activated pathloss reference RS
 | ~~8-2,~~ 8-3 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. ~~The maximum number of configured pathloss reference RSs for PUSCH/SRS/PUCCH via MAC CE by RRC for MAC-CE based pathloss reference RS update (FFS whether to be a separate UE feature, e.g. 16-1c)~~
2. FFS: The maximum number of activated pathloss reference RSs ~~update~~ for PUSCH/SRS~~/PUCCH~~ and configured pathloss reference RSs for PUCCH [across CCs / within a slot across all CCs / per CC] ~~(FFS whether to be a separate UE feature, e.g. 16-1c)~~
3. FFS: Number of measurement samples N to apply newly activated pathloss reference RS
 | ~~8-2,~~ 8-3 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1e | Pathloss reference RS activation via MAC CE | ~~The maximum number of configured pathloss reference RSs for PUSCH/SRS/PUCCH via MAC CE by RRC~~ Support for MAC-CE based pathloss reference RS update for PUSCH/SRS | ~~8-2,~~ 8-3 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |

**Alt. 4: Replace FG 16-1e with**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1e | Pathloss reference RS activation via MAC CE | The support of pathloss reference RS activation for PUSCH/SRS/PUCCH via MAC CE | ~~8-2,~~ 8-3 |  | N/A |  | TBD[Per UE] | N | N |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We prefer Alt 1.  |
| Ericsson | We prefer Alt3, but would be OK to add a FG for the maximum number of configured pathloss reference RSs for PUSCH/SRS/PUCCH, as long as the value is high enough. |
| ZTE | Alt.4 is supported. We prefer to have a fixed value for maximum number of activated pathloss reference RS(s) rather than according to UE capability. As a baseline, up to 4 activated pathloss reference RS(s) can be supported mandatory without capability signaling, which is the same as in Rel-15. |
| LG | Prefer Alt3  |
| MediaTek | Support Alt. 1, Regarding the maximum number of pathloss reference RSs being tracked, we suggest to add 3 “The maximum number of activated pathloss reference RSs ~~update~~ for PUSCH/SRS~~/PUCCH~~ and configured pathloss reference RSs for PUCCH within a slot across all CCs in Alt. 1. Also, we support to add “number of measurement samples N”. |
| Nokia, Nokia Shanghai Bell | We prefer Alt 1 as starting point for technical discussions. |

The following table summarizes all proposals for FG 16-1f from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1f | SCell beam failure recovery | 1. The maximum number of SCells for SCell beam failure recovery ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
2. FFS: Support of PUCCH-BFR ~~(FFS whether to be a separate UE feature, e.g. 16-1d)~~
3. FFS: The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC] ~~(FFS to replace this component to 14)~~
4. FFS: ~~Densigy~~ Density of CSI-RS for new beam identification for SCell BFR
 | 2-31 |  | N/A |  | ~~TBD~~ Per UE | N |  |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | Similar as FG2-31, it should be per band. We also prefer to further discuss whether we need the similar structure as FG2-31 or FG2-31already covers all the cells including SCells and SpCells.  |
| Ericsson  | The maximum number of SCells for SCell BFR needs to be signaled. Component 2 is included in basic capability – so not a separate FG. There is a separate FG for PCell BFR that corresponds to component 3. All densities are supported for component 4. |
| ZTE | The support of PUCCH-BFR shall be mandatory with capability signaling for FR2 and optional for FR1 (as we did for PCell-BFR), in order to guarantee the effectiveness/low-latency of SCell-BFR. Hence, this component 5 in 16-1f should be removed, and the UE supporting the basic feature group FG 16-1f should support both SR based and PUCCH based-BFR. For frequency density of CSI-RS for SCell BFR, we prefer to align it with PCell-BFR, i.e., there is no further restriction nor capability for frequency density of CSI-RS for SCell BFR. |
| LG | Remove Component 2,3,4. Especially, inclusion of component 2 will create many CR issues for RAN2 and RAN1 as all specs are written in a way that if BFD happens LLR (or SR for BFR) is triggered, and the LLR is associated to dedicatedly configured PUCCH resources for BFR. |
| MediaTek | We don’t need capability component for “Support of PUCCH-BFR” because it is just the same as normal SR transmission. Capability component for “Density of CSI-RS for new beam identification for SCell BFR” is unnecessary. FG 16-1g can include capability component for “The maximum number of CSI-RS and/or SSB resources for new beam identification of SCell BFR [across all CCs / within a slot across all CCs / per CC]”.  |
| Nokia, Nokia Shanghai Bell | We agree that separate features are not needed for the components listed above. In addition component 4 is a design issue, and it should not be discussed within UE features AI yet. |

The following three tables summarize all proposals for FG 16-1g from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the fourth table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1: Delete FG 16-16**

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1g | ~~FFS:~~ Resources for beam management, pathloss measurement, BFD, and BFR | 1. FFS: The maximum number of SSB/CSI-RS resources within a slot across all CCs for any of L1-RSRP measurement, L1-SINR measurement, ~~pathloss measurement, BFD~~, and new beam identification.
2. FFS: The maximum number of SSB/CSI-RS resources within a slot across all CCs for pathloss measurement
3. FFS: The maximum number of SSB/CSI-RS resources within a slot across all CCs for BFD
4. FFS: The maximum number of SSB/CSI-RS resources across all CCs for new beam identification
 |  |  | N/A |  | TBD | N |  |  |  | TBD |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1g | ~~FFS:~~ Resources for beam management, pathloss measurement, BFD, and BFR | 1. The total number (sum of periodic/semi-persistent/aperiodic) of
	* SSB/NZP-CSI-RS/CSI-IM resources configured for L1-RSRP/L1-SINR, and
	* BFR resources configured for new beam identification, and
	* BFD resources configured for beam failure detection, and
	* Pathloss RS resources configured for pathloss measurement

across all CCs shall not exceed M\_11. The total number of aperiodic NZP-CSI-RS/CSI-IM resources configured for L1-RSRP/L1-SINR across all CCs shall not exceed M\_2
2. The total number (sum of periodic/semi-persistent/aperiodic) of
	* SSB/NZP-CSI-RS resources to perform measurement on CMR for L1-RSRP/L1-SINR, and
	* BFR resources to perform measurement for new beam identification, and
	* BFD resources to perform measurement for beam failure detection, and
	* Pathloss RS resources to perform measurement for pathloss

across all CCs within a slot shall not exceed M\_31. The total number (sum of periodic/semi-persistent/aperiodic) of NZP-CSI-RS/CSI-IM resources to perform measurement on IMR for L1-SINR across all CCs within a slot shall not exceed M\_4
2. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, and new beam identification.~~
3. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for pathloss measurement~~
4. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for BFD~~
5. ~~FFS: The maximum number of SSB/CSI-RS resources across all CCs for new beam identification~~
 | 2.24 |  | N/A |  | TBD | N |  |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | In principle, we are fine with either Alt. 2 or Alt. 3 with further discussion to clarify the detailed components or merge them  |
| Ericsson | Delete FG 16-1g. The components are present in other FGs. |
| ZTE | Alt1 is supported |
| LG | Prefer Alt1 by assuming that Alt1 is to delete FG 16-1g, not 16-16 |
| MediaTek | Support Alt. 3. In principle, the UE capability in the amounts of reference signal resources for various functions in NR-eMIMO can be considered altogether. It is not needed to have individual component for each, unless some of them have quite different characteristics from others and can be addressed separately in that case. The capability for the number of *configured resources* and for the number of *resources to perform measurement in a slot* should be separately captured. The former corresponds to the capability of the memory size, while the latter is concerned with the capability of computation complexity. The computation complexity at IMR for L1-SINR measurement and that at other resources such as those for CMR of L1-RSRP/L1-SINR, pathloss measurement, new beam identification, and beam failure detection are quite different. For the former, only measurement on the total received power is sufficient, while for the latter, separate estimation for signal and noise is required. Therefore, the corresponding capability should be separately captured for the IMR of L1-SINR and for other purposes. Further, it is also noted the aperiodic CSI-RS resource is separated in a different component in FG 2-24. Thus, it is proposed that the same rule is applied to FG 16-1g. |
| Nokia, Nokia Shanghai Bell | We are OK with Alt 1. |

The following four tables summarize all proposals for FG 16-2a from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the fifth table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config” (other than CORESET 0)
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config” (other than CORESET 0)
3. The value of R=[1,2] for BD/CCE
4. Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
5. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
6. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
7. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
8. FFS: The maximum number of activated TCI states
9. FFS: The maximum number of MIMO layers of scheduled PDSCHs
10. FFS: the maximum number of CCs supporting multi-DCI based multi-TRP

~~Optional components:~~1. ~~Whether the UE shall 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~~
2. ~~FFS: Support of two PDSCH scrambling sequences per serving cell~~
3. ~~Support of default QCL assumption per CORESETPoolIndex~~
4. ~~Support of separate HARQ-ACK~~
5. ~~Support of joint HARQ-ACK~~
6. ~~Support of two TDMed long PUCCHs in a slot~~
 | TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-2 | Different PDSCH scrambling per TRP | FFS: Support of two PDSCH scrambling sequences per serving cell | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-3 | Default QCL enhancement fr multi-DCI based multi-TRP | Support of default QCL assumption per CORESETPoolIndex | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-4 | HARQ-ACK for multi-DCI based multi-TRP | 1. Support of separate HARQ-ACK
2. Support of joint HARQ-ACK
3. Support of two TDMed long PUCCHs in a slot (two TDMed long PUCCHs within a slot, TDMed short PUCCH and long PUCCH within a slot, TDMed short PUCCH and short PUCCH within a slot)
 | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config” (other than CORESET 0)
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config” (other than CORESET 0)
3. The value of R=[1,2] for BD/CCE
4. Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
5. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
6. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
7. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
8. FFS: The maximum number of activated TCI states
9. FFS: The maximum number of MIMO layers of scheduled PDSCHs
10. FFS: the maximum number of CCs supporting multi-DCI based multi-TRP
11. Support of two PDSCH scrambling sequences per serving cell
12. Support of separate HARQ-ACK

~~Optional components:~~1. ~~Whether the UE shall 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~~
2. ~~FFS: Support of two PDSCH scrambling sequences per serving cell~~
3. ~~Support of default QCL assumption per CORESETPoolIndex~~
4. ~~Support of separate HARQ-ACK~~
5. ~~Support of joint HARQ-ACK~~
6. ~~Support of two TDMed long PUCCHs in a slot~~
 | TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-3 | Default QCL enhancement fr multi-DCI based multi-TRP | Support of default QCL assumption per CORESETPoolIndex | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-4 | Joint HARQ-ACK for multi-DCI based multi-TRP | Support of joint HARQ-ACK | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-5 | Two TDMed long PUCCHs in a slot | Support of two TDMed long PUCCHs in a slot (two TDMed long PUCCHs within a slot, TDMed short PUCCH and long PUCCH within a slot, TDMed short PUCCH and short PUCCH within a slot) | 16-2a |  |  |  |  |  |  |  |  |  |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config” (other than CORESET 0)
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config” (other than CORESET 0)
3. The value of R=[1,2] for BD/CCE
4. Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
5. ~~Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)~~
6. ~~Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)~~
7. ~~Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)~~
8. FFS: The maximum number of activated TCI states
9. FFS: The maximum number of MIMO layers of scheduled PDSCHs
10. FFS: the maximum number of CCs supporting multi-DCI based multi-TRP
11. Indication of supporting type(s) of separate/joint HARQ-ACK (candidate values {separate, joint, both})
12. Support of default QCL assumption per CORESETPoolIndex
13. PDSCH processing capability for a CC configured with multi-DCI
14. Maximum number of unicast PDSCHs per CORESETPoolIndex per slot

~~Optional components:~~1. ~~Whether the UE shall 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~~
2. ~~FFS: Support of two PDSCH scrambling sequences per serving cell~~
3. ~~Support of default QCL assumption per CORESETPoolIndex~~
4. ~~Support of separate HARQ-ACK~~
5. ~~Support of joint HARQ-ACK~~
6. ~~Support of two TDMed long PUCCHs in a slot~~
 | TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  | Component 1 candidate values: {2, 3, 4}Component 2 candidate values: {1, 2}Component 3 candidate values: {1, 2}Component 13 candidate values: {Capability 1, Capability 2 with scheduling limitation, Capability 2}Component 14 candidate values: {1, 2, 4, 7} | TBD |
| 16-2a-2 | Different PDSCH scrambling per TRP | FFS: Support of two PDSCH scrambling sequences per serving cell | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-3 | Out-of-order operation for PDCCH to PDSCH | Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component) | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-4 | Out-of-order operation for PDSCH to HARQ-ACK | Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component) | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-5 | Out-of-order operation for PDCCH to PUSCH | Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component) | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-6 | Simultaneous reception for PDCCH/PDSCH | Support of simultaneous reception for PDCCH/PDSCH associated with two QCL-Type-D RSs | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |
| 16-2a-7 | PDSCHs overlapping types | Indication of supported “PDSCHs overlapping types”, with bitmap signalling for {fully, partial, non-overlapped TDM, non-overlapped FDM}.” | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |

**Alt. 4:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2a | Multi-DCI based multi-TRP | Basic components:1. The maximum number of CORESETs configured per “PDCCH-Config” (other than CORESET 0)
2. The maximum number of CORESETs configured per CORESETPoolIndex ( if CORESETPoolIndex is not configured, it is assumed CORESETPoolIndex = 0) per “PDCCH-Config” (other than CORESET 0)
3. The value of R=[1,2] for BD/CCE
4. Support of fully/partially time/frequency overlapped PDSCH reception (PDSCHs overlapping types in time and frequency domain)
5. PDSCH processing capability for a CC configured with multi-DCI
6. Maximum number of unicast PDSCHs per CORESETPoolIndex per slot
7. ~~Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)~~
8. ~~Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)~~
9. ~~Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)~~
10. ~~FFS: The maximum number of activated TCI states~~
11. ~~FFS: The maximum number of MIMO layers of scheduled PDSCHs~~
12. ~~FFS: the maximum number of CCs supporting multi-DCI based multi-TRP~~

~~Optional components:~~1. ~~Whether the UE shall 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~~
2. ~~FFS: Support of two PDSCH scrambling sequences per serving cell~~
3. ~~Support of default QCL assumption per CORESETPoolIndex~~
4. ~~Support of separate HARQ-ACK~~
5. ~~Support of joint HARQ-ACK~~

~~Support of two TDMed long PUCCHs in a slot~~ | TBD |  | N/A |  | per FSPC | N | TBD |  | Component 1 candidate values: {2, 3, 4}Component 2 candidate values: {1, 2}Component 3 candidate values: {1, 2}Component 4 candidate values: {Capability 1, Capability 2 with scheduling limitation, Capability 2}Component 5 candidate values: {1, 2, 4, 7} | TBD |
| 16-2a-1 | Out-of-order for multi-DCI based multi-TRP | 1. Support of out-of-order operation for PDCCH to PDSCH (FFS whether to be a basic component)
2. Support of out-of-order operation for PDSCH to HARQ-ACK (FFS whether to be a basic component)
3. Support of out-of-order operation for PDCCH to PUSCH (FFS whether to be a basic component)
 | 16-2a |  |  |  | Per UE |  |  |  |  |  |
| 16-2a-2 | Maximum number of active TCI states for multi-DCI based multi-TRP | 1. Maximum number of active TCI states per BWP per CC per value of CORESETPoolIndex (including both data and control)
2. Support 16 active TCI states per BWP per CC, including control and data
 | 16-2a |  |  |  | Per band |  |  |  | Component 1 candidate values: {1, 2, 4, 8} |  |
| 16-2a-3 | CRS rate matching for multi-DCI based multi-TRP | Support of rate match around configured CRS patterns which is associated with CORESETPoolIndex and are applied to the PDSCH scheduled with a DCI detected on a CORESET with the same value of CORESETPoolIndex | 16-2a |  |  |  | Per UE |  |  |  |  |  |
| 16-2a-4 | Multi-beam for multi-DCI based multi-TRP | Indicates whether UE supports receiving time-overlapping PDSCHs/PDCCHs with different beams | 16-2a |  |  |  | Per band | TDD only | FR2 only |  |  |  |
| 16-2a-5 | Two default beams for multi-DCI based multi-TRP | Support of default QCL assumption per CORESETPoolIndex | 16-2a, 16-2a-5 |  |  |  | Per band | TDD only | FR2 only |  |  |  |
| 16-2a-6 | Feedback for multi-DCI based multi-TRP | 1. Support of separate HARQ-ACK
2. Support of joint HARQ-ACK
3. Support of two TDMed long PUCCHs in a slot
 | 16-2a |  |  |  | Per UE |  |  |  |  |  |
| 16-2a-7 | PDSCH scrambling for multi-DCI based multi-TRP | FFS: Support of two PDSCH scrambling sequence per serving cell | 16-2a |  |  |  | Per UE |  |  |  |  |  |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We prefer Alt. 3 with the following modification* Component 8 We would also like to discuss the limit on UL, i.e. the maximum number of spatial relation info or the “Max number of downlink RS resources used for QCL type-D in the active TCI states and active spatial relation info” as in FG2-62
* Component 10 We prefer to remove “FFS”, but the maximum number of CCs with Multi-DCI MTRP operation is a function of the number of CCs with single TRP operation configured simultaneously. Need further discussion
* Component 11 in the basic components, “Indication of supporting type(s) of separate/joint HARQ-ACK”, For UE that supports separate HARQ-ACK, we also prefer to separate the following 3 cases
	+ Two TDMed long PUCCHs within a slot
	+ TDMed short PUCCH and long PUCCH within a slot
	+ TDMed short PUCCH and short PUCCH within a slot

For UE indicates that it supports separate HARQ-ACK feedback, the above 3 cases should be covered by optional component(s)* Component 12 in the basic components, “Support of default QCL assumption per CORESETPoolIndex” should be optional component, like captured as 16-2a-5 in Alt 4

We propose to add one component to report whether UE can support a single closed-loop power control process for PUCCH/PUSCH associated with different CORESETPoolIndex, i.e. “Support of common closed-loop power control process for PUCCH/PUSCH associated with different CORESETPoolIndex”  |
| Ericsson | Our preference is Alt2. On the Basics components in Alt 2, the following components are fundamental to multi-DCI based multi-TRP operation. So we prefer to remove the FFSs on these components.1. Support of out-of-order operation for PDCCH to PDSCH ~~(FFS whether to be a basic component)~~
2. Support of out-of-order operation for PDSCH to HARQ-ACK ~~(FFS whether to be a basic component)~~
3. Support of out-of-order operation for PDCCH to PUSCH ~~(FFS whether to be a basic component)~~
 |
| ZTE | Support Alt.2 as a starting point. Generally, we think out of order process should be basic for UE supporting M-DCI. Otherwise, it is impossible to implement M-DCI based MTRP since scheduling between two TRPs are usually independent in this case. Further, we think two scrambling IDs and separate HARQ-ACK should also be the basic components since they are the typical functionalities for M-DCI based MTRP.In addition, it is better to remove ‘(other than CORESET 0)’ in 16-2a. Since CORESET 0 may not be configured in Scell, the UE capability report should indicate all supported CORESETs including CORESET0. Then, gNB can have a full picture for the number of potential CORESETs.  |
| LG | We prefer Alt. 1 with removing basic component 9 “FFS: The maximum number of MIMO layers of scheduled PDSCHs” |
| MediaTek | We support Alt 3 or Alt 4. Out-of-order operation in components 5, 6, 7 are agreed to be optional and hence cannot put them in the basic component. |
| Nokia, Nokia Shanghai Bell | We prefer Alt 2 as starting point for technical discussions. |

The following four tables summarize all proposals for FG 16-2a-1 from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the fifth table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2a-1 | Separate CRS rate matching  | Whether the UE shall 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 | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2a-1 | Separate CRS rate matching  | Support of CRS rate matching for Multi-DCI based Multi-TRP operation. “Joint” is mandatory for UE that supports Multi-DCI based Multi-TRP CRS rate matching, but “Separate” is optional * Joint: UE rate match around the union of CRS from both TRPs
* Separate: UE rate match around configured CRS patterns which is associated with CORESETPoolIndex (if not configured, CORESETPoolIndex=0) and are applied to the PDSCH scheduled with a DCI detected on a CORESET with the same value of CORESETPoolIndex
 | 16-2a, TBD |  | N/A |  | TBD [per band / per FSPC] | N | TBD |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We prefer Alt. 2 |
| Ericsson | We prefer Alt 1. In our view, this capability is about whether UE supports separate rate matching. If the UE doesn’t support this, then the UE will do joint rate matching (this is already captured in 38.214). So, the descriptions in Alt. 2 are not necessary. |
| ZTE | Slightly prefer Alt.1. The description in Alt.1 is more natural to us since joint rate matching is the basic UE feature even in Rel-15, we don’t need to mention it again.  |
| LG | We prefer Alt. 2  |
| MediaTek | Support Alt 2, which is the agreement we have in the past meeting. |

The following four tables summarize all proposals for FG 16-2b from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the fifth table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2b | Single-DCI based multi-TRP | Basic component(s):1. FFS: Support of MAC CE to activate ~~multiple~~ two TCI states for a TCI codepoint
2. FFS: Number of CCs supporting single-DCI based multi-TRP operation

~~Optional components:~~1. ~~Support of default QCL assumption with two TCI states~~
 | TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| 16-2b-0 | Two default beams for single-DCI based multi-TRP | Support of default QCL assumption with two TCI states | 16-2b |  | N/A |  | Per band | TDD only | FR2 only |  |  | TBD |
| 16-2b-1 | Single-DCI based SDM scheme | 1. FFS: Support of DCI indication of ~~of~~ 2 TCI states by a codepoint and DMRS ports within two CDM groups
2. ~~Whether supporting~~ Support of two PTRS ports
3. FFS Support of DMRS entry {0, 2, 3}
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  |  | TBD |
| 16-2b-2 | Single-DCI based FDMSchemeA | Support of FDMSchemeA | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  |  | TBD |
| 16-2b-3 | Single-DCI based FDMSchemeB | 1. Support of FDMSchemeB
2. For FDMSchemeB, whether the UE can support CW soft combining
 | 16-2b, TBD |  | N/A |  | TBD [per FSPC] | N | TBD |  |  | TBD |
| 16-2b-4 | Single-DCI based TDMSchemeA | 1. Support of TDMSchemeA
2. Supported maximum TBS size for TDMSchemeA
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  | Component 2 candidate values {10 CBs, TBD} | TBD |
| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation
3. FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  | Component 1 candidate values: {8,16}Component 2 candidate values {10 CBs, TBD} | TBD |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2b | Single-DCI based multi-TRP | Basic component(s):1. ~~FFS:~~ Support of MAC CE to activate ~~multiple~~ two TCI states for a TCI codepoint
2. Support of DCI indication of of 2 TCI states by a codepoint and DMRS ports within two CDM groups
3. Support of DMRS entry {0, 2, 3}
4. ~~FFS: Number of CCs supporting single-DCI based multi-TRP operation~~

~~Optional components:~~1. ~~Support of default QCL assumption with two TCI states~~
 | TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| 16-2b-0 | Single-DCI based multi-TRP optional components | Support of default QCL assumption with two TCI states | TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| 16-2b-1 | Two PTRS ports for single-DCI based multi-TRP~~Single-DCI based SDM scheme~~ | 1. ~~FFS: Support of DCI indication of of 2 TCI states by a codepoint and DMRS ports within two CDM groups~~
2. ~~Whether supporting~~ Support of two PTRS ports
3. ~~FFS Support of DMRS entry {0, 2, 3}~~
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  |  | TBD |
| 16-2b-2 | Single-DCI based FDMSchemeA | Support of FDMSchemeA | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  |  | TBD |
| 16-2b-3 | Single-DCI based FDMSchemeB | 1. Support of FDMSchemeB
2. For FDMSchemeB, whether the UE can support CW soft combining
 | 16-2b, TBD |  | N/A |  | TBD [per FSPC] | N | TBD |  |  | TBD |
| 16-2b-4 | Single-DCI based TDMSchemeA | 1. Support of TDMSchemeA
2. Supported maximum TBS size for TDMSchemeA
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  | Component 2 candidate values {10 CBs, TBD} | TBD |
| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation
3. FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  | Component 1 candidate values: {8,16}Component 2 candidate values {10 CBs, TBD} | TBD |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2b | Single-DCI based multi-TRP | Basic component(s):1. FFS: Support of MAC CE to activate ~~multiple~~ two TCI states for a TCI codepoint
2. FFS: Number of CCs supporting single-DCI based multi-TRP operation

~~Optional components:~~1. ~~Support of default QCL assumption with two TCI states~~
 | TBD |  | N/A |  |  | N | TBD |  |  | TBD |
| 16-2b-1 | Single-DCI based SDM scheme | 1. FFS: Support of DCI indication of ~~of~~ 2 TCI states by a codepoint and DMRS ports within two CDM groups
2. ~~Whether supporting~~ Support of two PTRS ports
3. FFS Support of DMRS entry {0, 2, 3}
4. Support of default QCL assumption with two TCI states
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  |  | TBD |
| 16-2b-2 | Single-DCI based FDMSchemeA | Support of FDMSchemeA | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  |  | TBD |
| 16-2b-3 | Single-DCI based FDMSchemeB | 1. Support of FDMSchemeB
2. For FDMSchemeB, whether the UE can support CW soft combining
 | 16-2b, TBD |  | N/A |  | TBD [per FSPC] | N | TBD |  |  | TBD |
| 16-2b-4 | Single-DCI based TDMSchemeA | 1. Support of TDMSchemeA
2. Supported maximum TBS size for TDMSchemeA
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  | Component 2 candidate values {10 CBs, TBD} | TBD |
| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation
3. FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)
 | 16-2b, TBD |  | N/A |  | Per band | N | TBD |  | Component 1 candidate values: {8,16}Component 2 candidate values {10 CBs, TBD} | TBD |

**Alt. 4:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2b | Single-DCI based multi-TRP | ~~Basic component(s):~~1. ~~FFS: Support of MAC CE to activate multiple TCI states for a TCI codepoint~~
2. FFS: Number of CCs supporting single-DCI based multi-TRP operation

~~Optional components:~~1. Support of default QCL assumption with two TCI states
 | TBD |  | N/A |  |  | N | Y |  |  | Optional |
| 16-2b-1 | Single-DCI based SDM scheme | 1. ~~FFS:~~ Support of DCI indication of ~~of~~ 2 TCI states by a codepoint and DMRS ports within two CDM groups
2. ~~Whether supporting~~ Support of two PTRS ports
3. ~~FFS~~ Support of DMRS entry {0, 2, 3}
4. Maximum number of QCL Type D RSs indicated in a codepoint of a DCI
 | ~~16-2b,~~ TBD |  | N/A |  | Per Band | N | Y |  |  | Optional |
| 16-2b-2 | Single-DCI based FDMSchemeA | 1. Support of FDMSchemeA
2. Maximum number of QCL Type D RSs indicated in a codepoint of a DCI
 | ~~16-2b,~~ TBD |  | N/A |  | Per Band | N | Y |  |  | Optional |
| 16-2b-3 | Single-DCI based FDMSchemeB | 1. Support of FDMSchemeB
2. For FDMSchemeB, whether the UE can support CW soft combining
3. Maximum number of QCL Type D RSs indicated in a codepoint of a DCI
 | ~~16-2b,~~ TBD |  | N/A |  | Per Band] | N | Y |  |  | Optional |
| 16-2b-4 | Single-DCI based TDMSchemeA | 1. Support of TDMSchemeA
2. Supported maximum TBS size for TDMSchemeA
 | ~~16-2b,~~ TBD |  | N/A |  | Per band | N | N |  | Component 2 candidate values {10 CBs, TBD} | Optional |
| 16-2b-5 | Single-DCI based inter-slot TDM | 1. Support of RepNumR16 in PDSCH-TimeDomainResourceAllocation and the maximum value of RepNumR16
2. Supported maximum TBS size according to RepNumR16 in PDSCH-TimeDomainResourceAllocation
3. FFS: TCI state mapping to PDSCH transmission occasions (Cyclical mapping or Sequential mapping)
 | ~~16-2b,~~ TBD |  | N/A |  | Per band | N | N |  | Component 1 candidate values: {8,16}Component 2 candidate values {10 CBs, TBD} | Optional |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We prefer Alt.1. We can further consider to add “Maximum number of QCL Type D RSs indicated in a codepoint of a DCI” as proposed in Alt. 4  |
| Ericsson | Our preference is Alt 1. We don’t think ‘Maximum number of QCL Type D RSs indicated in a codepoint of a DCI’ is needed. The intention of the proponent is to indicate ‘if a UE only supports one Rx beam at a time, it can report a value of one for this component’. But if a UE only supports one RX beam at a time, then this UE should report support for one of the TDM schemes (i.e., either TDMSchemeA or inter-slot TDM). So, ‘Maximum number of QCL Type D RSs indicated in a codepoint of a DCI’ is not needed.  |
| ZTE | Support Alt.2Generally, we think a basic FG is needed for single-DCI based MTRP, where the basic components can include SDM scheme, two TCI states, and DMRS entry {0, 2, 3}. These are typical functionalities. |
| LG | We prefer Alt. 1 |
| MediaTek | We prefer Alt.4. For Alt.4, it is also agreeable to have separate FGs for Components 2 and 3 in 16-2b. The SDM scheme should be an independent scheme, rather than a basic component. Also, support of default QCL assumption with two TCI states should be applicable to all schemes. |

The following four tables summarize all proposals for FG 16-3a from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the fifth table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3a | Regular eType-II | Basic components:1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 8 parameter combinations (FFS: Value of L per the number of antenna ports)
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with value R=1
4. Rank restriction
5. ~~FFS:~~ UCI omission

~~Optional components~~1. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with R=2~~
2. ~~Rank 1 to 4 Support of rank 3,4~~
3. ~~CBSR~~
4. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
5. ~~FFS: Support of mixed codebook types~~
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-1 | Frequency unit size for eType-II | For regular eType-II: Support of PMI sub-bands with N3>19; [Support of PMI sub-bands with R=2 and N3 <=19]  | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-2 | Rank for eType-II | Support of rank 3,4 for regular eType-II | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-3 | CBSR for eType-II | Support for CBSR for regular eType-II | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-4 | FFS: AP-CSI reports for eType-II | FFS: The maximum number of configured aperiodic CSI Report Settings | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-5 | FFS: Mixed codebook type for eType-II | FFS: Support of mixed codebook types | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3a | Regular eType-II | Basic components:1. ~~FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II~~
2. ~~8~~ Support of parameter combinations ~~(FFS: Value of L per the number of antenna ports)~~ 1-6
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with value ~~R=1~~ N3<=19
4. Rank ~~restriction~~ 1 and 2
5. ~~FFS:~~ UCI omission

~~Optional components~~1. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with R=2~~
2. ~~Rank 1 to 4 Support of rank 3,4~~
3. ~~CBSR~~
4. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
5. ~~FFS: Support of mixed codebook types~~
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-1 | CSI-RS and number of PMI subbands for eType-II | For regular eType-II: A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources across all CCs simultaneously, total # of Tx ports across all CCs simultaneously, Max # of PMI subbands N3}, where N3>=19 | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-2 | Rank for eType-II | Support of rank 3,4 for regular eType-II | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-3 | CBSR for eType-II | Support of CBSR for regular eType II | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-4 | Codebook parameter combination 7-8 for eType II | Support of codebook parameter combinations 7-8 | 16-3a, TBD |  |  |  |  |  |  |  |  |  |
| 16-3a-5 | FFS: Mixed codebook type for eType-II | FFS: Support of mixed codebook types | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3a | Regular eType-II | Basic components:1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 8 parameter combinations (FFS: Value of L per the number of antenna ports)
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with value R=1
4. Rank restriction
5. ~~FFS: UCI omission~~
6. Support of rank 1,2

~~Optional components~~1. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with R=2~~
2. ~~Rank 1 to 4 Support of rank 3,4~~
3. ~~CBSR~~
4. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
5. ~~FFS: Support of mixed codebook types~~
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-1 | Frequency unit size for eType-II | For regular eType-II: Support of PMI sub-bands with N3>19; [Support of PMI sub-bands with R=2 and N3 <=19]  | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-2 | Rank for eType-II | Support of rank 3,4 for regular eType-II | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-3 | CBSR for eType-II | (1) Whether UE supports CBSR (2) If UE supports CBSR, whether UE supports 4 values of restriction, i.e. amplitudeSubsetRestriction as in 38.214 | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-4 | FFS: AP-CSI reports for eType-II | FFS: The maximum number of configured aperiodic CSI Report Settings | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-5 | FFS: Mixed codebook type for eType-II | FFS: Support of mixed codebook types | 16-3a, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3a-6 | UCI omission | Support of UCI omission | 16-3a, TBD |  |  |  |  |  |  |  |  |  |

**Alt. 4: Replace existing FG 16-3a with the following FG:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3a | Regular eType-II | CSI-RS capability: A list of supported combinations, each combination is of {Max # of Tx ports in one resource, max # of resources and total # of Tx ports} to support regular eType IISupport of parameter combinations {support L=6, not support L=6}Number of PMI subbands {R=1, R=1-2}Jointly reported with component 1, i.e., a list of supported combinations, each combination is of { Max # of Tx ports in one resource, max # of resources and total # of Tx ports, R=1 or R=1-2}Supported rank: {1-2, 1-4}Support amplitude subset restriction level {no amplitude subset restriction, support amplitude subset restriction} | TBD | YES | N/A | Regular eType-II codebook is not supported. | FFS: Per band or Per band per BC or per band | N/A |  N/A |  | Component 1 (same to FG2-36/40/41/43): Maximum size of the list is 16. the candidate values for the max # of Tx port in one resource is {4, 8, 12, 16, 24, 32}The candidate value set of the max # of resources is:{from 1 to 64}The candidate value set of total # of ports (including both channel and NZP-CSI-RS based interference measurement) is:{from 2 to 256}Component 2 (already agreed in RAN1#99): candidate values {‘support L=6’, ‘not support L=6’}Component 3: candidate values {‘R=1’, ‘R=1-2’}Component 4 (already agreed in RAN1#99): candidate values {‘RI={1,2}’, ‘RI={1,2,3,4}’}Component 5 (already agreed in RAN1 #98b): candidate values { ‘no amplitude subset restriction’, ‘support amplitude subset restriction’}  | Optional with capability signaling |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple  | We prefer Alt. 3 |
| ZTE | We support Alt 2. In general, we think it’s better to split the whole eType II feature group as one basic feature and several optional sub-features, as given in Alt 1/2/3. As a next level of details, for 16-3a-1 in Alt 2, although we think it’s better to signal whether maximum N3 equals to 19 or larger than 19 in the joint report of CSI-RS and the number of PMI subbands capabilities, we can also live with reporting the maximum number of PMI subbands per CQI subband in this joint report, with candidate value 1 or 2. In this sense, the basic feature would be support of PMI subbands with R=1 in 16-3a. The first two rows in Alt 2 can be revised as16-3a:Basic components:1. Support of parameter combinations 1-6
2. Support of PMI sub-bands with value R =1
3. Rank 1 and 2
4. UCI omission

16-3a-1:A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources across all CCs simultaneously, total # of Tx ports across all CCs simultaneously, Max # of PMI subbands per CQI subband} |
| LG | We prefer Alt. 2 |
| Nokia, Nokia Shanghai Bell | We prefer Alt 1 as starting point for technical discussions. |
| vivo | Support alternative 1 with following revision:16-3a-1:Support of PMI sub-bands with R =2 and N3>19.16-3a-3:(1) Whether UE supports CBSR (2) If UE supports CBSR, whether UE supports 4 values of restriction, i.e. amplitudeSubsetRestriction as in 38.21416-3a-4:Remove sub-feature 16-3a-4 |

The following four tables summarize all proposals for FG 16-3b from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the fifth table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3b | Port selection eType-II | Basic components:1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 6 parameter combinations (combos with L=6 don’t apply) (FFS: Value of L per the number of antenna ports)
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with value R=1
4. Rank restriction
5. ~~FFS:~~ UCI omission

~~Optional components:~~1. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with R=2~~
2. ~~Rank 1 to 4 Support of rank 3,4~~
3. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
4. ~~FFS: Support of mixed codebook types~~
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-1 | Frequency unit size for port selection eType-II | For port selection eType-II: Support of PMI sub-bands with N3>19; [Support of PMI sub-bands with R=2 and N3 <=19] | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-2 | Rank for port selection eType-II | Support of rank 3,4 for port selection eType-II | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-3 | FFS: AP-CSI reports for port selection eType-II | FFS: The maximum number of configured aperiodic CSI Report Settings | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-4 | FFS: Mixed codebook type for port selection eType-II | FFS: Support of mixed codebook types | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3b | Port selection eType-II | Basic components:1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 6 parameter combinations (combos with L=6 don’t apply) (FFS: Value of L per the number of antenna ports)
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with value ~~R=1~~ N3<=19
4. Rank restriction
5. ~~FFS:~~ UCI omission

~~Optional components:~~1. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with R=2~~
2. ~~Rank 1 to 4 Support of rank 3,4~~
3. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
4. ~~FFS: Support of mixed codebook types~~
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-1 | CSI-RS and number of PMI subbands for port selection eType-II | For port selection eType-II: A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources across all CCs simultaneously, total # of Tx ports across all CCs simultaneously, Max # of PMI subbands N3}, where N3>=19 | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-2 | Rank for port selection eType-II | Support of rank 3,4 for port selection eType-II | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-4 | FFS: Mixed codebook type for port selection eType-II | FFS: Support of mixed codebook types | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3c | Number of AP-CSI report settings per BWP | Support up to 8 configured aperiodic CSI report setting per BWP | TBD |  |  |  |  |  |  |  |  |  |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3b | Port selection eType-II | Basic components:1. FFS: {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} to support regular eType-II
2. 6 parameter combinations (combos with L=6 don’t apply) (FFS: Value of L per the number of antenna ports)
3. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional)~~ Support of PMI sub-bands with value R=1
4. Rank restriction
5. ~~FFS: UCI omission~~
6. Support of rank 1,2

~~Optional components:~~1. ~~Number of PMI sub-bands (R=1 is mandatory, FFS: R=2 is mandatory or optional) Support of PMI sub-bands with R=2~~
2. ~~Rank 1 to 4 Support of rank 3,4~~
3. ~~FFS: The maximum number of configured aperiodic CSI Report Settings~~
4. ~~FFS: Support of mixed codebook types~~
 | TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-1 | Frequency unit size for port selection eType-II | For port selection eType-II: Support of PMI sub-bands with N3>19; [Support of PMI sub-bands with R=2 and N3 <=19] | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-2 | Rank for port selection eType-II | Support of rank 3,4 for port selection eType-II | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-3 | FFS: AP-CSI reports for port selection eType-II | FFS: The maximum number of configured aperiodic CSI Report Settings | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-4 | FFS: Mixed codebook type for port selection eType-II | FFS: Support of mixed codebook types | 16-3b, TBD |  | N/A |  | FFS: Per band or Per band per BC | N | N |  |  | Optional |
| 16-3b-5 | UCI omission | Support of UCI omission | 16-3b, TBD |  |  |  |  |  |  |  |  |  |

**Alt. 4: Replace existing FG 16-3a with the following FG:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3b | Port selection eType-II | CSI-RS capability: A list of supported combinations, each combination is of {Max # of Tx ports in one resource, max # of resources and total # of Tx ports} to support eType II port-selectionNumber of PMI subbands {R=1, R=1-2}Jointly reported with component 1, i.e., a list of supported combinations, each combination is of { Max # of Tx ports in one resource, max # of resources and total # of Tx ports, R=1 or R=1-2}Supported rank: {1-2, 1-4} | TBD | YES | N/A | eType-II port-selection codebook is not supported. | FFS: Per band or Per band per BC or per band | N/A | N/A |  | Component 1 (same to FG2-36/40/41/43): Maximum size of the list is 16. the candidate values for the max # of Tx port in one resource is {4, 8, 12, 16, 24, 32}The candidate value set of the max # of resources is:{from 1 to 64}The candidate value set of total # of ports (including both channel and NZP-CSI-RS based interference measurement) is:{from 2 to 256}Component 2: candidate values {‘R=1’, ‘R=1-2’}Component 3 (already agreed in RAN1#99): candidate values {‘RI={1,2}’, ‘RI={1,2,3,4}’} | Optional with capability signaling |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple  | We prefer Alt. 3 |
| ZTE | We support Alt 2. In general, we think it’s better to split the whole eType II feature group as one basic feature and several optional sub-features, as given in Alt 1/2/3. As a next level of details, for 16-3a-1 in Alt 2, although we think it’s better to signal whether maximum N3 equals to 19 or larger than 19 in the joint report of CSI-RS and the number of PMI subbands capabilities, we can also live with reporting the maximum number of PMI subbands per CQI subband in this joint report, with candidate value 1 or 2. In this sense, the basic feature would be R=1 in 16-3a. The first two rows in Alt 2 can be revised as16-3a:Basic components:1. Support of parameter combinations 1-6 (combos with L=6 don’t apply)
2. Support of PMI sub-bands with R=1
3. Rank 1 and 2
4. UCI omission

16-3a-1:A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources across all CCs simultaneously, total # of Tx ports across all CCs simultaneously, Max # of PMI subbands per CQI subband}Further, it’s necessary to note that the last row in Alt 2 16-3c is not a sub-feature of eType II CSI. It is independent with eType II codebook or eType II port selection codebook. |
| LG | We prefer Alt. 2 |
| Nokia, Nokia Shanghai Bell | We prefer Alt 1 as starting point for technical discussions. |
| vivo | Support alternative 1 with following revision:16-3b-1:Support of PMI sub-bands with R =2 and N3>19.16-3b-3:Remove sub-feature 16-3b-3 |

The following table summarizes all proposals for FG 16-4 from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-4 | Low PAPR DMRS for DL | Low PAPR DMRS for PDSCH | ~~TBD~~  | Y | N/A |  | Per UE | N | ~~N~~ Y |  |  | [Optional] |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We are open to discuss whether to change “N” to “Y”, but it is okay to us as of now. |
| ZTE | Agree with the update. |

The following table summarizes all proposals for FG 16-5a from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1: Delete FG 16-5a**

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5a | UL full power transmission mode 0 | 1. Supported UL full power transmission [mode 0]
2. Number of ~~Tx~~ SRS antenna ports to support mode 1: {2~~Tx~~, 4~~Tx, 2Tx\_4Tx~~ }
 | 2-13, 2-14 | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5a | UL full power transmission ~~mode 0~~ | 1. Supported UL full power transmission ~~[mode 0]~~
2. ~~Number of Tx SRS antenna ports to support mode 1: {2Tx, 4Tx, 2Tx\_4Tx }~~
 | 2-13, 2-14 | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We slightly prefer Alt 2. |
| Ericsson | We prefer Alt 1. This is in line with the RRC signaling, whereas Alts 1 & 3 are not.  |
| LG | We prefer Alt. 3. If the second bullet in Alt2 is removed, we are also ok with that.  |
| MediaTek | Support Alt.2, in which * There is no “Mode0” defined in specification, it is better to clarify this is when ULFPTx is configured but ULFPTxModes is not configured.
* component 2: “mode 1” should be “mode 0”
* component 2: 2&4 option should be added back
 |
| Nokia, Nokia Shanghai Bell | We prefer Alt 1. |
| vivo | Support Alt 3. It is Per Band |

The following table summarizes all proposals for FG 16-5b from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5b | UL full power transmission mode 1 | 1. Supported UL full power transmission mode 1
2. Number of ~~Tx~~ SRS antenna ports to support mode 1: {2~~Tx~~, 4~~Tx, 2Tx\_4Tx~~}
3. FFS: New UL codebook set(s) per supported mode per supported Tx
 | 2-13, 2-14 | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | Okay for us  |
| Ericsson | Proposal is OK, except that FFS can be removed. We see no need for additional codebook sets in Mode 1. |
| LG | Same view with Ericsson. The FFS bullet is not needed.  |
| MediaTek | • Component 2: add back 2&4 option • Component 3 is no needed as when UE report it supports mode 1, which codebook subset(s) are supported is clear. |
| vivo | Remove component 3, component 2 implicitly implies the new codebook for 2 Tx or 4Tx. It is Per Band |

The following six tables summarize all proposals for FG 16-5c from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the seventh table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of ~~Tx~~ SRS antenna ports to support mode 1: {2~~Tx~~, 4~~Tx, 2Tx\_4Tx~~ }
3. The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.
4. FFS: Maximum number of ports per SRS resource
5. FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set
6. TPMI group which delivers full power. FFS on details for supported number of Tx.

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14, 16-5b | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5c | UL full power transmission mode 2--SRS resource based | 1. Supported UL full power transmission mode 2
2. ~~Number of Tx to support mode 2: {2Tx, 4Tx, 2Tx\_4Tx}~~
3. The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.
4. FFS: Number of ports per SRS resource
5. FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set
6. ~~TPMI group which delivers full power. FFS on details for supported number of Tx.~~

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14, 16-5b | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |
| 16-5c-1 | UL full power transmission mode 2-- TPMI/TPMI group | 1. Supported UL full power transmission mode 2
2. ~~Number of Tx to support mode 2: {2Tx, 4Tx, 2Tx\_4Tx}~~
3. ~~The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.~~
4. FFS: Number of ports per SRS resource
5. FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set
6. TPMI group which delivers full power. FFS on details for supported number of Tx.

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14, 16-5b | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |

**Alt. 3:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. ~~Number of Tx to support mode 2: {2Tx, 4Tx, 2Tx\_4Tx}~~
3. ~~The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.~~
4. ~~FFS: Number of ports per SRS resource~~
5. ~~FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set~~
6. TPMI group which delivers full power. FFS on details for supported number of Tx.
7. . Number of SRS resources and Number of ports combination supported for mode 2 operation :
* 4Tx UE
	+ NSRS=2, Nports combination: {[2port, 4port]}
* FFS for other candidate values

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port Nports combination [1,2] shall be supported by 2Tx UE and [1,4] shall be supported by 4Tx UE. | 2-13, 2-14, 16-5b | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |

**Alt. 4:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of ~~Tx~~ SRS antenna ports to support mode 1: {2~~Tx~~, 4~~Tx, 2Tx\_4Tx~~ }
3. The maximum number of SRS resources in a set ~~with different number of ports [for~~ usage set to ‘codebook’~~]. FFS on details for supported number of Tx.~~
4. ~~FFS: Number of ports per SRS resource~~
5. ~~FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set~~
6. TPMI group which delivers full power. ~~FFS on details for supported number of Tx.~~
	1. For 2 Tx: {not supported, or either or both of TPMI=0 and TPMI=1 are supported}, or
	2. For 4 Tx non-coherent: {not supported or one of Group 0 – Group 3}, or
	3. For 4 Tx partial coherent: {not supported or one of Group 0 – Group 6}

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14, 16-5b | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |

**Alt. 5:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of ~~Tx~~ SRS antenna ports to support mode 1: {2~~Tx~~, 4~~Tx, 2Tx\_4Tx~~ }
3. The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.
4. ~~FFS: Number of ports per SRS resource~~
5. ~~FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set~~
6. TPMI group which delivers full power. FFS on details for supported number of Tx.
	1. 2-port TPMIs in codebookSubset = *nonCoherent* if UE reports ‘non-coherent’ or ‘partial/non-coherent’ capability in 2-13
	2. 4-port TPMIs in codebookSubset = *nonCoherent* if UE reports ‘non-coherent’ or ‘partial/non-coherent’ capability in 2-13
	3. 4-port TPMIs in codebookSubset = *partialandNonCoherent* if UE reports ‘partial/non-coherent’ capability in 2-13

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14, 16-5b | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |

**Alt. 6:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5c | UL full power transmission mode 2 | 1. Supported UL full power transmission mode 2
2. Number of ~~Tx~~ SRS antenna ports to support mode 1: {2~~Tx~~, 4~~Tx, 2Tx\_4Tx~~ }
3. ~~The maximum number of SRS resources in set with different number of ports [for usage set to ‘codebook’]. FFS on details for supported number of Tx.~~
4. ~~FFS: Maximum number of ports per SRS resource~~
5. ~~FFS: Maximum number of different spatial relation info for all SRS resources for usage set to ‘codebook’ in a resource set~~
6. ~~TPMI group which delivers full power. FFS on details for supported number of Tx.~~

Note: UE indicating mode 2 shall support full power transmission for 1 antenna port | 2-13, 2-14, 16-5b | Y | N/A | Y | FFS: Per FS or Per band or Per band per BC | ~~N~~ N/A | ~~N~~ N/A |  |  | TBD |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We prefer Alt.1 with the following correction* For component 2, “mode 1” -> “mode 2”

Component 4: remove “maximum”. If UE indicates UE supports 4 layer CB MIMO, UE should support 4 port. But for mode 2, we don’t want gNB randomly configures SRS resources with different number ports, meaning whether gNB should configured 1 port SRS and/or 2 port SRS together with 4 port SRS.  |
| Ericsson | The list of alternatives is fine for now. We can discuss details next week. |
| LG | We slightly prefer Alt4, and open for further discussion next week.  |
| MediaTek | Support combination of Alt.2, Alt.3, Alt.4. In particular, * Alt.3’s component 7 can merge into Alt.2 16-5c
* Alt.4’s component 6 can merge into Alt.2 16-5c-1
* Alt.2 16-5c-1’s component 4&5 are no need
 |
| Nokia, Nokia Shanghai Bell | We have a slight preference for Alt 1 as starting point for technical discussions. |
| vivo | Support Alt2. It is Per BandIn Alt1, Alt4, Alt5, Alt6 remove component 2. Alt4 is incomplete (suggest to remove), doesn’t include multiple SRS configured with different number of SRS ports. First bullet under component 6, is should be “either of TPMI=0 and TPMI=1”, not support “both…”Alt5 component 6 is not clear, what is the intention of sub-component A, B, C. for example, 4 Tx UE has to report nonCoherent or partialandNonCoherent, with this information it is clear which full power TPMI groups UE is supposed to report in Mode 2.Alt6 is incomplete (suggest to remove) |

The following two tables summarize all proposals for FG 16-6a from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the third table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

**Alt. 1:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-6a | Low PAPR DMRS for PUSCH  | 1. For PUSCH without transform precoding
2. For PUSCH with transform precoding and with pi/2 BPSK modulation
 | ~~TBD~~ | Y | N/A | Y | FFS: Per band | ~~N~~ N/A | ~~N~~ N/A |  | Component-1 candidate value set: {‘supported’, ‘not supported’}Component-2 candidate value set: {‘supported’, ‘not supported’} |  FFS: Optional with capability signalling |

**Alt. 2:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-6a | Low PAPR DMRS for PUSCH without transform precoding | 1. For PUSCH without transform precoding
2. ~~For PUSCH with transform precoding and with pi/2 BPSK modulation~~
 | ~~TBD~~ | Y | N/A | Y | FFS: Per band | ~~N~~ N/A | ~~N~~ N/A |  |  |  FFS: Optional with capability signalling |
| 16-6c | Low PAPR DMRS for PUSCH with transform precoding and with pi/2 BPSK | For PUSCH with transform precoding and with pi/2 BPSK modulation | TBD | Y | N/A | Y | FFS: Per band | ~~N~~ N/A | ~~N~~ N/A |  |  |  FFS: Optional with capability signalling |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We prefer Alt.1, but Alt. 2 is the same for us. |
| Ericsson | We are fine to introduce 16-6c. Support per band, i.e. remove FFS |
| ZTE | Support Alt.2Since the design on Low PAPR DMRS for CP-OFDM and for DFT-S-OFDM are completely different, we think FG 16-6a should be split into two FGs. For CP-OFDM, the enhanced low PAPR DMRS is still inserted in frequency domain, like DL low PAPR DMRS, the only change compared with Rel-15 is just on sequence initialization. However, for DFT-S-OFDM, DFT process is needed to transform DMRS from the time domain to the frequency domain. Hardware implementation change at both gNB side and UE side may be needed for this feature group.  |
| MediaTek | Support Alt. 1 |
| vivo | Suggest changing the second bullet ‘For PUSCH with transform precoding and with pi/2 BPSK modulation’ to ‘For PUSCH without transform precoding and for PUSCH with transform precoding and with pi/2 BPSK modulation’ in Alt.1, since low PAPR DMRS for PUSCH without transform precoding is easier to implementation. |

The following table summarizes all proposals for FG 16-6b from Section 2 as revisions on top of the reference in [1]. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-6b | Low PAPR DMRS for PUCCH | For PUCCH format 3 and~~/or~~ PUCCH format 4, if capable, with transform precoding and with pi/2 BPSK modulation | ~~TBD~~ | Y | N/A | Y | FFS: Per band | ~~N~~ N/A | ~~N~~ N/A |  |  |  FFS: Optional with capability signalling |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | Okay for us |
| Ericsson | Support the change in description. Support per band, i.e. remove FFS |
| ZTE | We are OK for the above update. |

The following new feature group was proposed. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-2a-x | PDSCHs overlapping types | Support of common closed-loop power control process for PUCCH/PUSCH associated with different CORESETPoolIndex | 16-2a, TBD |  |  |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We support this proposal  |
| ZTE | We are generally fine with the proposal. But we have to clarify what the UE behavior is if such UE capability is not supported. For instance, UE should assume independent closed-loop power control for PUCCH/PUSCH associated with different CORESETPoolIndex if this capability is not supported. |

The following new feature group was proposed. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-3c | CSI-RS capabilities for concurrent codebooks with mixed types | A list of supported combinations, each combination is of {Codebook A, Codebook B, Max # of Tx ports in one resource, max # of resources and total # of Tx ports} to support codebook combinations of codebook A and codebook B. | TBD |  |  |  | FFS: Per band or Per band per BC or per band |  |  |  | The candidate values for Codebook A is {Type I single-panel, Type I multi-panel}The candidate values for Codebook B is {Type II, Type II port-selection, eType II, eType II port-selection}the candidate values for the max # of Tx port in one resource is {4, 8, 12, 16, 24, 32}The candidate value set of the max # of resources is:{from 1 to 64}The candidate value set of total # of ports (including both channel and NZP-CSI-RS based interference measurement) is:{from 2 to 256} | Optional with capability signaling |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | We need further discussion |

The following new feature group was proposed. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5d | Multiple SRS resources in set with different number of ports for full power Tx  | Support multiple SRS resources in SRS resource set with different number of ports for 2TxMaximum number of SRS resources in an SRS resource set for 2TxSupport multiple SRS resources in set with different number of ports for 4TxMaximum number of SRS resources in an SRS resource set for 4Tx | 16-5c | Yes | N/A | Yes | FS | N/A | N/A |  | Component-1 candidate value set: {‘supported’, ‘not supported’}Component-2 candidate value set: {2, 3, 4}Component-3 candidate value set: {‘supported’, ‘not supported’}Component-4 candidate value set: {2, 3, 4} | Optional with capability signalling |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | Okay for usWe propose to add the following component Component 5: Support of 2 port SRS resource configured together with 4 port SRS resource in the same resource set for 4Tx We assume that UE has to support full power transmission when UE is downgraded to 1 port SRS, but we are open for further discussion  |
| Ericsson | We don’t yet see the need for 16-5d. Why can’t it be addressed with value ranges in 16-5c?  |
| MediaTek | This can be merged to FG 16-5c (see our previous comments)We also think for mode2, number of SRS resource and number of port need to consider together (i.e., candidate value specifies the possible combination) |
| vivo | Is this a parallel sub-feature with respective to 16-5a, 16-5b, 16-5c? this should be a component not a separate sub-feature |

The following new feature group was proposed. Companies provide their inputs in the second table below in order to allow the moderator to make a recommendation on which of the proposed changes should be discussed during RAN1 #100bis-e.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-5e | Indication of TPMIs with full power capability | TPMI group which delivers full powerTPMIs for 2TxTPMIs for 4Tx non-coherentTPMIs for 4Tx partially coherent | 16-5c | Yes | N/A | Yes | FS | N/A | N/A |  | Component-1: 2-bit bitmap, b0, b1Component-2: 2-bit: {G0, G1, …, G3}Component-3: 4-bit: {G0, G1, …, G6} | Optional with capability signalling |

|  |  |
| --- | --- |
| Company | Comments/Questions/Suggestions |
| Apple | Okay for us  |
| Ericsson | We don’t yet see the need for 16-5e. Why can’t it be addressed with value ranges in 16-5c?  |
| MediaTek | This can be merged to FG 16-5c (see our previous comments) |
| Nokia, Nokia Shanghai Bell | The need for this FG is not clear. |
| vivo | Is this a parallel sub-feature with respective to 16-5a, 16-5b, 16-5c? this should be a component not a separate sub-feature |

# Conclusion

[To be completed towards the end of the preparation phase]

# References

1. R1-2001484, RAN1 UE features list for Rel-16 NR after RAN1#100-E, AT&T & NTT DOCOMO
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3. R1-2001722, Discussion on Rel-16 eMIMO UE features, vivo
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6. R1-2001829, Views on Rel-16 UE features for NR eMIMO, MediaTek Inc.
7. R1-2002020, UE features for NR eMIMO, Intel Corporation
8. R1-2002071, Discussion of UE features for NR MIMO, CATT
9. R1-2002155, UE features for eMIMO, Samsung
10. R1-2002161, Discussion on RAN1 UE feature for NR eMIMO, LG Electronics
11. R1-2002274, Discussions on UE features for eMIMO, Spreadtrum Communications
12. R1-2002353, Views on Rel-16 eMIMO UE feature list, Apple
13. R1-2002476, On UE features for eMIMO, Nokia & Nokia Shanghai Bell
14. R1-2002494, eMIMO UE features, Ericsson
15. R1-2002499, Discussion on UE features for eMIMO, CMCC
16. R1-2002567, Discussion on eMIMO UE features, Qualcomm Incorporated
17. R1-2002592, Rel-16 UE features for MIMO. Huawei & HiSilicon
18. R1-2002628, Discussion on UE capability issues , Fraunhofer IIS &Fraunhofer HHI