**3GPP TSG RAN WG1 #117 R1-24xxxxx**

**Fukuoka City, Fukuoka, Japan, May 20th – 24th, 2024**

**Agenda item:** 8.2.1

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

**Title:** Summary of discussion on UE features for TEIs

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 8.2.1 regarding UE features for TEIs.

According to the updated UE features list agreed in RAN1#116bis [1], there are following feature groups for TEI18.

* FGs for additional periodicity of the scheduling request
	+ 55-1 additionalSR-Periodicities-r18
* FGs for 1-symbol PRS
	+ 55-2a 1-symbol PRS for MG-based measurement in RRC\_CONNECTED state
	+ 55-2b 1-symbol PRS for outside MG in RRC\_CONNECTED state
	+ 55-2c 1-symbol PRS in RRC\_INACTIVE state
	+ 55-2d 1-symbol PRS for PDC
* FGs for multi-PUSCH scheduling with single DCI
	+ 55-3 Multiple PUSCHs scheduling by single DCI for non-consecutive slots in FR1
* FGs for HARQ multiplexing for PDSCH scheduling after UL grant on PUSCH
	+ 55-4a Multiplexing Type-1 HARQ-ACK codebook in a PUSCH for PDSCH scheduled after UL grant
	+ 55-4b Multiplexing Type-2 HARQ-ACK codebook in a PUSCH for PDSCH scheduled after UL grant
	+ 55-4c Multiplexing Type-3 HARQ-ACK codebook in a PUSCH for PDSCH scheduled after UL grant
	+ 55-4d Determining a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant
	+ 55-4e Determining different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant
* FGs for pathloss RS updates for Type 1 CG-PUSCH
	+ 55-5 Enable MAC CE based pathloss RS updates for Type 1 CG-PUSCH
* FGs for span-based PDCCH monitoring with additional restrictions
	+ 55-6 (2, 2) span-based PDCCH monitoring with additional restriction(s)
	+ 55-6a Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells
	+ 55-6b Mix of Rel-16 PDCCH monitoring capability and Rel. 15 PDCCH monitoring capability on different carriers
	+ 55-6c Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers
	+ 55-6d Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span for MCG and for SCG when configured for NR-DC operation with Rel-16 PDCCH monitoring on all the serving cells
	+ 55-6e Number of carriers for CCE/BD scaling for MCG and for SCG when configured for NR-DC operation with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers
	+ 55-6f Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells with restriction for non-aligned span case
	+ 55-6g Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers with restriction for non-aligned span case
	+ 55-6h PDCCH repetition for Rel-16 PDCCH monitoring
* FGs for multi-DCI based multi-TRP
	+ 55-7 Two QCL TypeD for CORESET monitoring in multi-DCI based multi-TRP

# **FG 55-6h**

In [1], FG 55-6h is captured as below.

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 55. TEI18 | 55-6h | PDCCH repetition for Rel-16 PDCCH monitoring | 1. Support of PDCCH repetition with Rel-16 PDCCH monitoring capability as defined in FG 11-2 family.2. Supported mode of PDCCH repetition3. X per CC4. X across all CCs | FG23-2-1, and;FG11-2 for (7, 3) or (4, 4) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | Component 3: {4, 8, 16, 32, 44, 64, no limit}Component 4: {4, 8, 16, 32, 44, 64, 128, 256, 512, no limit}NOTE:* Components 3 and 4 are reported only if UE supports inter-span PDCCH repetition.
* The limit X is associated with the total number of linked candidates of which the first candidate is received and the second one has not been received at any given span, where "received" and "not been received" is w.r.t. the end of the corresponding span of PDCCH candidate.
* The limit X is indicated as a total count assuming count 1 for AL=1; 2 for AL=2; 4 for AL=4 or 8 or 16.
* Candidate value "no limit" does not imply BD limit can be exceeded

When a UE reports both FG 23-2-1e and this FG, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG 55-6This capability is signalled for SCS 15 kHz and 30 kHz. | Optional with capability signalling |

Following inputs are provided in contributions for the RAN1#116bis meeting.

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| [2] | Samsung | From Topic 3 in R1-2401679, RAN2 asked the following things to RAN1. In this contribution, we would like to provide our view on RAN2’s questions for Rel-17/18 TEI related UE feature groups (e.g., FG 55-6h and *mTRP-PDCCH-legacyMonitoring-r17*) which contain component(s) with description “across all CCs”. Regarding Rel-17/18 MIMO related UE feature groups (e.g., FG 40-x families and Rel-17 capabilities in below, except *mTRP-PDCCH-legacyMonitoring-r17*), our view is provided in our companion contribution [5].

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| * **Topic 3: UE capabilities with "across all CCs”**

In R1-2312705, some features (i.e. FG 40-1-1/2/2a/7/9, FG 40-2-8, FG, 40-3-1-1/1a/3/5/5a/7/8, FG 40-3-2-1/1a/2/5/6, FG 40-3-3-1/5, FG 40-6-5, FG 40-7-2a, FG 42-1/1a/1b/2/2a/2b, FG 55-6h) indicating capability “across all CCs” have different granularity, i.e. either per band, per BC or per FS. RAN2 thinks the definition of “across all CCs” for a feature group with “per BC” granularity is clear, but further clarification of “across all CCs” is needed if the feature group’s granularity is per band or per FS.Therefore, RAN2 would like to ask RAN1 to further clarify the granularity of “across all CCs” for the above listed feature groups if their granularity are per band/per FS in Rel-18 RAN1 NR UE features list. Additionally, RAN2 also would like to ask RAN1 to clarify the granularity of “across all CCs” for the below Rel-17 capabilities for correction:* *mTRP-CSI-EnhancementPerBand-r17*
* *mTRP-CSI-EnhancementPerBC-r17*
* *mTRP-GroupBasedL1-RSRP-r17*
* *unifiedJointTCI-mTRP-InterCell-BM-r17*
* *mTRP-PDCCH-Case2-1SpanGap-r17*
* *mTRP-PDCCH-legacyMonitoring-r17*
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The following table is for FG 55-6h which is per FS including “across all CCs” in component 4.

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| 55-6h | PDCCH repetition for Rel-16 PDCCH monitoring | 1. Support of PDCCH repetition with Rel-16 PDCCH monitoring capability as defined in FG 11-2 family.2. Supported mode of PDCCH repetition3. X per CC4. X across all CCs | FG23-2-1, and;FG11-2 for (7, 3) or (4, 4) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | Component 3: {4, 8, 16, 32, 44, 64, no limit}Component 4: {4, 8, 16, 32, 44, 64, 128, 256, 512, no limit}NOTE:* Components 3 and 4 are reported only if UE supports inter-span PDCCH repetition.
* The limit X is associated with the total number of linked candidates of which the first candidate is received and the second one has not been received at any given span, where "received" and "not been received" is w.r.t. the end of the corresponding span of PDCCH candidate.
* The limit X is indicated as a total count assuming count 1 for AL=1; 2 for AL=2; 4 for AL=4 or 8 or 16.
* Candidate value "no limit" does not imply BD limit can be exceeded

When a UE reports both FG 23-2-1e and this FG, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG 55-6This capability is signalled for SCS 15 kHz and 30 kHz. | Optional with capability signalling |

Also, the following table is for FG 23-2-1e (*mTRP-PDCCH-legacyMonitoring-r17*) which is per FS including “across all CCs” in component 4.

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| 23-2-1e | PDCCH repetition for Rel-16 PDCCH monitoring | 1. Support of PDCCH repetition with Rel-16 PDCCH monitoring capability as defined in FG 11-2 family.2. Supported mode of PDCCH repetition3. X per CC4. X across all CCs | 11-2, 23-2-1 | Yes |  | PDCCH repetition for Rel-16 PDCCH monitoring is not supported | Per FS | n/a | n/a | n/a | This capability is signalled for SCS 15 kHz and 30 kHz.Component2: {intra-span, inter-span, both}Component3: {4, 8, 16, 32, 44, 64, no limit} Component 4: {4, 8, 16, 32, 44, 64, 128, 256, 512, no limit}Note: * Components 3 and 4 are reported only if UE supports inter-span PDCCH repetition.
* The limit X is associated with the total number of linked candidates of which the first candidate is received and the second one has not been received at any given span, where “received” and “not been received” is wrt the end of the corresponding span of PDCCH candidate.
* The limit X is indicated as a total count assuming count 1 for AL=1; 2 for AL=2; 4 for AL=4 or 8 or 16.
* Candidate value “no limit” does not imply BD limit can be exceeded
 | Optional with capability signalling |

As discussed in Clause 2.4.4 in [5], from the perspective of UE’s implementation, since what eventually matters would be the total complexity in each BC. This is similar with per FS reporting, hence we would like to consider two options below, either “in a band” or “in a BC” for the meaning of “across all CCs”.**Proposal 5:** For per FS capability reporting, consider between two things.* 1) Component including “across all CCs” in per FS reporting can mean that “across all CCs in a band”.
* 2) Component including “across all CCs” in per FS reporting can mean that “across all CCs in a BC”.
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| [3] | Ericsson | In [3], RAN2 brings up an issue related to the wide-spread use of the term “across all CCs”. This statement is somewhat ambiguous, but in our understanding, this statement “across all CCs” refer to all CCs of the signaled granularity. For a “per band” or a “per FS” feature, “across all CCs” mean “across all CCs in the band”, and for a “per BC” feature, “across all CCs” mean “across all CCs in the band combination”. FG 55-6h is reported per FS, and we propose to clarify:1. Clarify that “across all CCs” means “across all CCs in the band” for FG 55-6h.

The proposed changes are captured in Annex A.

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| 55. TEI18 | 55-6h | PDCCH repetition for Rel-16 PDCCH monitoring | 1. Support of PDCCH repetition with Rel-16 PDCCH monitoring capability as defined in FG 11-2 family.2. Supported mode of PDCCH repetition3. X per CC4. X across all CCs in the band | FG23-2-1, and;FG11-2 for (7, 3) or (4, 4) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | Component 3: {4, 8, 16, 32, 44, 64, no limit}Component 4: {4, 8, 16, 32, 44, 64, 128, 256, 512, no limit}NOTE:* Components 3 and 4 are reported only if UE supports inter-span PDCCH repetition.
* The limit X is associated with the total number of linked candidates of which the first candidate is received and the second one has not been received at any given span, where "received" and "not been received" is w.r.t. the end of the corresponding span of PDCCH candidate.
* The limit X is indicated as a total count assuming count 1 for AL=1; 2 for AL=2; 4 for AL=4 or 8 or 16.
* Candidate value "no limit" does not imply BD limit can be exceeded

When a UE reports both FG 23-2-1e and this FG, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG 55-6This capability is signalled for SCS 15 kHz and 30 kHz. | Optional with capability signalling |

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| [4] | DCM | At the RAN1#116bis meeting, UE features for TEIs were discussed, and one remaining issue is following question from RAN2 [4, 5].

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| * **Topic 3: UE capabilities with "across all CCs”**

In R1-2312705, some features (i.e. FG 40-1-1/2/2a/7/9, FG 40-2-8, FG, 40-3-1-1/1a/3/5/5a/7/8, FG 40-3-2-1/1a/2/5/6, FG 40-3-3-1/5, FG 40-6-5, FG 40-7-2a, FG 42-1/1a/1b/2/2a/2b, FG 55-6h) indicating capability “across all CCs” have different granularity, i.e. either per band, per BC or per FS. RAN2 thinks the definition of “across all CCs” for a feature group with “per BC” granularity is clear, but further clarification of “across all CCs” is needed if the feature group’s granularity is per band or per FS.Therefore, RAN2 would like to ask RAN1 to further clarify the granularity of “across all CCs” for the above listed feature groups if their granularity are per band/per FS in Rel-18 RAN1 NR UE features list.  |

As indicated by RAN2, the definition of “across all CCs” for a per-BC capability is rather clear; we believe it just means “across all CCs in all bands in the band combination”. Also, given that there may be more than a CC even in a single band (e.g., intra-band CA), it is clear for a per-band capability as well – “across all CCs” indicated in a per-band capability means “across all CCs in the band”. For per-FS (i.e., per band per band combination) capability such as FG55-6h, however, it may not be so clear as the above. Assuming a UE supporting a band combination {band#A, band#B}, a per-FS capability can be reported to any of band#A and #B independently, between which a component in the per-FS capability may report different values. This situation can be depicted as follows: Fig.1: Per-FS capability reporting with “across all CCs” value reportIn the above case, we identify there may be two different interpretations; 1) the “across all CCs” implies “across all CCs in a band” or 2) “across all CCs in a band combination”. Taking a per-FS capability reported to band#A and band#B, both in a band combination {band#A, band#B}, in Fig.1 as an example, * If interpretation#1 (the “across all CCs” implies “across all CCs in a band in a band combination”) is taken, N1 and N2 would imply component#1 value across all CCs in Band#A and Band#B, respectively, assuming the band combination{band#A, band#B} (thus N1 and N2 can be different).
* If interpretation#2 (the “across all CCs” implies “across all CCs in a band combination”) is taken, both N1 and N2 would imply component#1 value across all CCs in band combination {Band#A, Band#B} (thus N1 and N2 must be the same).

Our understanding is aligned with interpretation#1, i.e., any component in a per-FS report indicates the value applicable to the FS (i.e., the band in the band combination) since the defined Type applies to all the components in the FG unless stated otherwise. Meanwhile, we understand that there may be the ones who rather follows the other interpretation, i.e., interpretation#2, given that per-FS capability, by definition, takes a band combination into consideration. We strongly hope to see no ambiguity for interpretation of any UE capability information for the sake of work efficiency at our commercial side, and thus suggest discussing the issue at least for per-FS capability. In addition, once the interpretation for “across all CCs” component for FG55-6h is clarified, same clarification/interpretation could be applied to corresponding Rel-17 capabilities mentioned in RAN2 LS (mTRP-PDCCH-Case2-1SpanGap-r17 and mTRP-PDCCH-legacyMonitoring-r17).**Proposal 14: For the meaning of “across all CCs” component for FG55-6h, mTRP-PDCCH-Case2-1SpanGap-r17 and mTRP-PDCCH-legacyMonitoring-r17 that are per-FS (i.e. per band per band combination) capabilities, discuss which of the following interpretations is correct:** * **Interpretation#1: “across all CCs” implies “across all CCs in a band in a band combination”.**
* **Interpretation#2: “across all CCs” implies “across all CCs in a band combination”.**
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## **Discussion**

### **Proposal 4-1:**

* **For the meaning of “across all CCs” component for FG55-6h which is per-FS (i.e. per band per band combination) capability, discuss which of the following interpretations is correct:**
	+ **Interpretation#1: “across all CCs” implies “across all CCs in a band in a band combination”.**
	+ **Interpretation#2: “across all CCs” implies “across all CCs in a band combination”.**

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| Company | Comment |
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### **Proposal 4-2:**

* + **For the meaning of “across all CCs” component for mTRP-PDCCH-Case2-1SpanGap-r17 and mTRP-PDCCH-legacyMonitoring-r17, same interpretation as for FG55-6h is applied**

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# **Conclusions**

To be updated

# **References**

[1] R1-2403703 Updated RAN1 UE features list for Rel-18 NR after RAN1#116bis Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2404101 UE features for other Rel-18 work items (Topics A) Samsung

[3] R1-2404523 Rel-18 UE features topics set A Ericsson

[4] R1-2405028 Discussion on UE features for other Rel-18 work items (Topics A) NTT DOCOMO, INC.

[5] R1-2401679 LS on questions and recommendations to Rel-18 RAN1 UE features list RAN2, Intel