**3GPP TSG RAN WG1 #121 R1-2504374**

**St Julian’s, Malta, May 19th – 23th, 2025**

**Agenda Item: 9.15.14**

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

**Title: Summary of UE features for Rel-19 TEI and other relevant issues**

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

# Introduction

This document presents the summary of email discussion [121-R19-UE\_features] during RAN1 #121. According to the Chair’s Notes:

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| [121-R19-UE\_features] Email discussion on Rel-19 UE features – Ralf (AT&T), Naoya (DOCOMO), Ralf (AT&T)   * To be used for sharing updates on online/offline schedule, details on what is to be discussed in online/offline sessions, tdoc number of the moderator summary for online session, etc |

The following was discussed during RAN1 #121 within the scope of [121-R19-UE\_features]. All proposals are based on the latest RAN1 UE features list for Rel. 19 in [1].

# Summary of Contributions Submitted to RAN1 #121

The following is the moderator’s summary of contributions submitted to RAN1 #121 in this agenda item. All proposals are based on the latest RAN1 UE features list for Rel. 19 in [1].

## Enhanced handling of simultaneous SRS carrier switching and uplink Tx switching [SRSCS\_ULTxSwitch]

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| Company | Summary |
| Samsung [2] |  |
| MediaTek Inc., Nokia, Apple, Ericsson, NTT DOCOMO, Orange [3] |  |
| Apple [4] | In RAN1#120, a Rel-19 TEI proposal was endorsed to support concurrent configuration of SRS carrier-based switching and uplink Tx switching, as follows  Agreement  To resolve ambiguities with concurrent configuration of SRS-CS and ulTxswitch in a case where a UE configured with SRS CS on target CC and its “switch-from” CC on CC2 and configured with UL Tx switching operation for UL CC2 and at least one UL CC1   * + Confirm that the prioritization rules in 38.214 Sec. 6.2.1.3 are applied between target and CC1, regardless of SRS-AS antenna port configuration on target CC, if UE indicates based on srs-SwitchingAffectedBandsListNR-r17 that SRS-CS on target impacts CC1, where CC1 is one of the CC(s) which may share Tx chains with source CC. No spec change is needed.     - Note: if UE does not indicate srs-SwitchingAffectedBandsListNR-r17, UE can only perform simultaneous transmission when the total number of involved Tx chains for simultaneous transmission on all the bands/carriers is not greater than number of Tx chains supported by the UE for simultaneous UL transmission. No spec change is needed.   + If the UE is under the operation state in which all Tx chains are available at the source CC, the required switching time before the beginning of SRS-CS transmission on target CC is SRS-SwitchingTimeNR. Otherwise, the required switching time before the beginning of SRS-CS transmission on target CC is indicated by a UE capability. Details about UE capability will be discussed in UE feature session.   + The existing scheduling restriction of maximum one switching per reference slot for UL Tx switching is also taking into account the triggered SRS CS   + After SRS transmissions within an SRS resource set is done, if UE is indicated to transmit on CC1, the required switching time between the end of SRS-CS transmission on target CC and start of UL transmission on CC1 is indicated by the UE capability defined above. Otherwise, it is assumed for the determination of any future switching time that all Tx chains are returned to the source CC, and the RF tuning time to switch from target to source will be SRS-SwitchingTimeNR   In RAN1#120, a UE capability corresponding to that feature was agreed in UE FG 67-5, as follows.  **Agreement:** Introduce the following Rel. 19 UE FGs (yellow highlighting, if any, shows text that’s not yet agreed)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 67. TEI19 | 67-5 | Enhanced handling of simultaneous SRS carrier switching and uplink Tx switching [SRSCS\_ULTxSwitch] | 1. The switching time between carriers other than the SRS CS source carrier and the SRS CS target carrier is indicated by this capability.  2. After SRS CS, the Ul Tx Switching state is determined according to TS 38.214 Section 6.1.6   1. 3. Prioritization rules between uplink carriers are determined according to TS 38.214 Section6.2.1.3 | FG 2-56, 7-1 | Yes | n/a | Ambiguity in simultaneous operation of uplink Tx switching and SRS carrier switching. | Per BC | n/a | n/a | n/a | For a UE supporting this feature, the UE reports one of {“max”,”sum”}, where “max” indicates that the switching time is the maximum between the uplink Tx switching time (refer to ULTxSwitchingBandPair) and SRS carrier switching times (refer to SRS-SwitchingTimeNR), and “sum” indicates that the switching time is the sum of the uplink Tx switching time and the SRS carrier switching time. | Optional with capability signalling |   Afterward, we received some offline clarification questions from (RAN2 TS 38.306 rapporteur) on the WGs associated with the prerequisite feature groups, and the applicability of the Note to the Component 1. To address those, we propose the following:  **Proposal**: UE FG 67-5 is modified for Prerequisite and Note columns, as below with modification in red:   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 67. TEI19 | 67-5 | Enhanced handling of simultaneous SRS carrier switching and uplink Tx switching [SRSCS\_ULTxSwitch] | 1. The switching time between carriers other than the SRS CS source carrier and the SRS CS target carrier is indicated by this capability.  2. After SRS CS, the Ul Tx Switching state is determined according to TS 38.214 Section 6.1.6   1. 3. Prioritization rules between uplink carriers are determined according to TS 38.214 Section6.2.1.3 | RAN1 FG 2-56, RAN4 7-1 | Yes | n/a | Ambiguity in simultaneous operation of uplink Tx switching and SRS carrier switching. | Per BC | n/a | n/a | n/a | For a UE supporting this feature, the UE reports one of {“max”,”sum”} as candidate values for Component 1, where “max” indicates that the switching time is the maximum between the uplink Tx switching time (refer to ULTxSwitchingBandPair) and SRS carrier switching times (refer to SRS-SwitchingTimeNR), and “sum” indicates that the switching time is the sum of the uplink Tx switching time and the SRS carrier switching time. | Optional with capability signalling | |
| NTT DOCOMO, INC. [5] | At the last RAN1 meeting, the following FG has been agreed for one of the agreed TEI19 features, which is related to simultaneous operation of SRS carrier switching and UL Tx switching.   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 67. TEI19 [SRSCS\_ULTxSwitch] | 67-5 | Enhanced handling of simultaneous SRS carrier switching and uplink Tx switching [SRSCS\_ULTxSwitch] | 1. The switching time between carriers other than the SRS CS source carrier and the SRS CS target carrier is indicated by this capability.  2. After SRS CS, the Ul Tx Switching state is determined according to TS 38.214 Section 6.1.6  3. Prioritization rules between uplink carriers are determined according to TS 38.214 Section6.2.1.3 | FG 2-56, 7-1 | Yes | n/a | Ambiguity in simultaneous operation of uplink Tx switching and SRS carrier switching. | Per BC | n/a | n/a | n/a | For a UE supporting this feature, the UE reports one of {“max”,”sum”}, where “max” indicates that the switching time is the maximum between the uplink Tx switching time (refer to ULTxSwitchingBandPair) and SRS carrier switching times (refer to SRS-SwitchingTimeNR), and “sum” indicates that the switching time is the sum of the uplink Tx switching time and the SRS carrier switching time. | Optional with capability signalling |   Although the above is quite clear already, after some offline discussions with companies from RAN1 and RAN2 point of views, we have identified the following for further clarity:   * First, for prerequisite FGs, FG 2-56 is a RAN1 feature, while FG 7-1 is defined by RAN4, not by RAN1. To avoid any misunderstanding, this point should be clarified, e.g., modifying the corresponding column to be “RAN1 FG 2-56, RAN4 FG 7-1” * For component 1 and corresponding description in Note column, our understanding is that the intention is to define candidate values as {“max”, “sum”} from signalling perspective, and exact values for each will be calculated by NW implementation based on UE reporting of the prerequisite FGs. It could be further clarified by adding a bit of clarifications in Note column, such as “For a UE supporting this feature, the UE reports one of {“max”,”sum”}, as candidate values for Component 1, where “max” indicates that the switching time is the maximum between the uplink Tx switching time (refer to ULTxSwitchingBandPair) and SRS carrier switching times (refer to SRS-SwitchingTimeNR), and “sum” indicates that the switching time is the sum of the uplink Tx switching time and the SRS carrier switching time.”   In summary, we propose the following refinements for FG 67-5.  **Proposal 1:**   * **Adopt the following refinements for FG 67-5**  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 67. TEI19 [SRSCS\_ULTxSwitch] | 67-5 | Enhanced handling of simultaneous SRS carrier switching and uplink Tx switching [SRSCS\_ULTxSwitch] | 1. The switching time between carriers other than the SRS CS source carrier and the SRS CS target carrier is indicated by this capability.  2. After SRS CS, the Ul Tx Switching state is determined according to TS 38.214 Section 6.1.6  3. Prioritization rules between uplink carriers are determined according to TS 38.214 Section6.2.1.3 | RAN1 FG 2-56, RAN4 FG 7-1 | Yes | n/a | Ambiguity in simultaneous operation of uplink Tx switching and SRS carrier switching. | Per BC | n/a | n/a | n/a | For a UE supporting this feature, the UE reports one of {“max”,”sum”}, as candidate values for Component 1, where “max” indicates that the switching time is the maximum between the uplink Tx switching time (refer to ULTxSwitchingBandPair) and SRS carrier switching times (refer to SRS-SwitchingTimeNR), and “sum” indicates that the switching time is the sum of the uplink Tx switching time and the SRS carrier switching time. | Optional with capability signalling | |
| EBU [6] |  |
| Huawei/HiSilicon [7] |  |

## Simultaneous NZP-CSI-RS resource counting

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| Company | Summary |
| Samsung [2] | In RAN1#120bis, the following agreement was made in Rel-19 TEI session.   |  | | --- | | Agreement in RAN1#120bis  For simultaneous CSI-RS reception in UE features 2-33, 2-36, 2-40, 2-41, 2-43, 16-3a and 16-3b, define 1 new UE capability:   * UE capability 1: To allow the UE to indicate that CSI-RS ports within one periodic/semi-persistent CSI-RS resource, as well as the periodic/semi-persistent CSI-RS resource, are counted as one resource, even if the periodic/semi-persistent CSI-RS resource is referred by N Report Settings. |   Hence, we would like to suggest the following FG supporting the relevant functionality.   * Component: component 1 is basic description on the feature. Considering such new UE behavior, it is good for UE to report new values for maximum resource/port counting per CC and across CC via component 2, 3, 4, and 5. * Pre-requisite: as agreed, it could be at least one of {2-33, 2-36, 2-40, 2-41, 2-43, 16-3a, and 16-3b}. * Type: It could be per Band considering FG 2-33 and component 4 and 5. Component 6 and 7 can be reported per band combination.   **Proposal 1**. Support the following FG supporting relevant functionality of the above agreement.   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | X-1 | Enhanced active resource counting for periodic/semi-persistent CSI-RS resource | 1. Support to count as one CSI-RS resource for periodic/semi-persistent CSI-RS resource/port, even if the periodic/semi-persistent CSI-RS resource is referred by N CSI reporting settings.  2. Supported max # simultaneous NZP-CSI-RS resources per CC  3. Supported max total # of CSI-RS ports in simultaneous NZP-CSI-RS resources per CC  4. Supported max # simultaneous NZP-CSI-RS resources in active BWPs across all CCs  5. Supported max total # of CSI-RS ports in simultaneous NZP-CSI-RS resources in active BWPs across all CCs | At least one of {2-33, 2-36, 2-40, 2-41, 2-43, 16-3a, and 16-3b} | FFS | FFS | Active resource/port counting for periodic/semi-persistent CSI-RS is done by N times when the periodic/semi-persistent CSI-RS resource is referred by N CSI report Settings | Per band | FFS | FFS | FFS | Component-4: candidate values {5, 6, 7, 8, 9, 10, 12, 14, 16, …, 62, 64} (includes all even numbers between 16 and 64)  Component-5: candidate values {1, 2, 3 … 32}  Component-6: candidate values {8, 16, 24, …, 248, 256}  Component-7: candidate values {8, 16, 24, … 128 }  Note: Component 6 and 7 are reported per band combination. | Optional with capability signalling | |
| MediaTek Inc., Nokia, Apple, Ericsson, NTT DOCOMO, Orange [3] | At RAN1#120bis, the following agreement was made:  *Agreement*   * *For simultaneous CSI-RS reception in UE features 2-33, 2-36, 2-40, 2-41, 2-43, 16-3a and 16-3b, define 1 new UE capability:*   + *UE capability 1: To allow the UE to indicate that CSI-RS ports within one periodic/semi-persistent CSI-RS resource, as well as the periodic/semi-persistent CSI-RS resource, are counted as one resource, even if the periodic/semi-persistent CSI-RS resource is referred by N Report Settings.*   **Proposal: Agree on the following UE capability description**   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | TEI19  [SimCSI\_count] | XX-1-1 | Simultaneous NZP-CSI-RS resource counting | For simultaneous CSI-RS reception in UE features 2-33, 2-36, 2-40, 2-41, 2-43, 16-3a and 16-3b, CSI-RS ports within one periodic/semi-persistent CSI-RS resource, as well as the periodic/semi-persistent CSI-RS resource, are counted one time by the UE, even if the periodic/semi-persistent CSI-RS resource is referred N times by one or more CSI Reporting Settings not configured with higher layer parameter *csi-ReportSubConfigToAddModList*. | 2-33 and {2-36 or 2-40 or 2-41 or 2-43 or 16-3a or 16-3b} | yes | n/a | gNB would not assume that UE supports this capability | Per UE | No | Yes | n/a |  | Optional with capability signalling | |
| Apple [4] |  |
| NTT DOCOMO, INC. [5] |  |
| EBU [6] |  |
| Huawei/HiSilicon [7] | In last meeting, a new UE capability regarding CSI-RS active resource counting was agreed, as copied below.   |  | | --- | | Agreement  For simultaneous CSI-RS reception in UE features 2-33, 2-36, 2-40, 2-41, 2-43, 16-3a and 16-3b, define 1 new UE capability:   * UE capability 1: To allow the UE to indicate that CSI-RS ports within one periodic/semi-persistent CSI-RS resource, as well as the periodic/semi-persistent CSI-RS resource, are counted as one resource, even if the periodic/semi-persistent CSI-RS resource is referred by N Report Settings. |   For UE features 2-33, 2-36, 2-40, 2-41, 2-43, 16-3a and 16-3b, there are UE features on supported maximum number of simultaneous CSI-RS resources and maximum number of CSI-RS ports in simultaneous CSI-RS resources, as an example in UE feature 2-33 below.   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 2-33 | CSI-RS and CSI-IM reception for CSI feedback | 1) Supported max # of configured NZP-CSI-RS resources per CC,  2) Supported max # of ports across all configured NZP-CSI-RS resources per CC  3) Supported max # of configured CSI-IM resources per CC  4) Supported max # simultaneous NZP-CSI-RS resources in active BWPs across all CCs  5) Supported max # simultaneous NZP-CSI-RS resources per CC  6) Supported max total # of CSI-RS ports in simultaneous NZP-CSI-RS resources in active BWPs across all CCs  7) Supported max total # of CSI-RS ports in simultaneous NZP-CSI-RS resources per CC | 2-32 | *csi-RS-IM-ReceptionForFeedback* {  1. *maxConfigNumberNZP-CSI-RS-PerCC*  2. *maxConfigNumberPortsAcrossNZP-CSI-RS-PerCC*  3. *maxConfigNumberCSI-IM-PerCC*  5. *maxNumberSimultaneousNZP-CSI-RS-PerCC*  7. *totalNumberPortsSimultaneousNZP-CSI-RS-PerCC*  } | *MIMO-ParametersPerBand*  *Phy-ParametersFRX-Diff* (for FR1 + FR2 band combination) | n/a | n/a | All the candidate values are the range of capability signalling which doesn't determine whether UE is mandatory to support all the signalling values. | Mandatory with capability signalling  Component-1 candidate values: {from 1 to 32}  Component-2 candidate values: {2, 4, 8, 12, 16, 24, 32, 40, 48 … ,256}  Component-3: candidate values: {1,2,4,8,16,32}  Component-4: candidate values {5, 6, 7, 8, 9, 10, 12, 14, 16, …, 62, 64} (includes all even numbers between 16 and 64)  Component-5: candidate values {1, 2, 3 … 32}  Component-6: candidate values {8, 16, 24, …, 248, 256}  Component-7: candidate values {8, 16, 24, … 128 } |   With the introduction of the new UE capability, when counting the above highlighted capabilities, the counting of active CSI-RS resources and corresponding ports are counted as one resource if they are referred by N reporting settings. For this new UE capability, the following FG is proposed:  ***Proposal 1: Introduce the following FG:***   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 67. TEI19 [CSI-RS Counting] | 67-6 | Support of active CSI-RS resource and port counting as one resource. | CSI-RS ports within one periodic/semi-persistent CSI-RS resource, as well as the periodic/semi-persistent CSI-RS resource, are counted as one resource, even if the periodic/semi-persistent CSI-RS resource is referred by N Report Settings. | 2-33, 2-36, 2-40, 2-41, 2-43, 16-3a or 16-3b | Yes |  | CSI-RS resource and ports are counted N times when referred to by N report settings | Per band |  |  |  |  | Optional with capability signalling | |

## CAS Muting

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| Company | Summary |
| Samsung [2] |  |
| MediaTek Inc., Nokia, Apple, Ericsson, NTT DOCOMO, Orange [3] |  |
| Apple [4] |  |
| NTT DOCOMO, INC. [5] |  |
| EBU [6] | The current RAN1#121 meeting will kickstart discussions on the UE features for the Rel-19 TEI agreed during last RAN1#120bis meeting. In particular, it concerns so-called "CAS muting," which is intended to enable time-division multiplexing (TDM) between different broadcast technologies.  We provide our views on UE features for Rel-19 TEI CAS Muting.   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 3. 5GBC\_CAS Muting | 3-1 | 5GBC\_CAS Muting | Muting of always-on signals in 5G broadcast |  |  |  | CAS Muting cannot be used | FFS |  |  | For a MBMS-dedicated cell, there is no RAN4 impact from the above TEI proposal. | Optional with capability signalling | |
| Huawei/HiSilicon [7] |  |

# Discussion Items during RAN1 #121

After review of contributions submitted to RAN1 #121 in this agenda item, the following topics were identified by the moderator for discussion during RAN1 #121.

**General comments**

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| Company | Comments/Questions/Suggestions |
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## Enhanced handling of simultaneous SRS carrier switching and uplink Tx switching [SRSCS\_ULTxSwitch]

After review of contributions submitted to RAN1 #121 in this agenda item, the following is proposed by the moderator. Companies submitted the following views on the moderator’s proposals.

**Proposal: Adopt the following changes highlighted in chromatic fonts, while keeping the yellow highlighting, if any, as shown**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 67. TEI19 | 67-5 | Enhanced handling of simultaneous SRS carrier switching and uplink Tx switching [SRSCS\_ULTxSwitch] | 1. The switching time between carriers other than the SRS CS source carrier and the SRS CS target carrier is indicated by this capability.  2. After SRS CS, the Ul Tx Switching state is determined according to TS 38.214 Section 6.1.6  3. Prioritization rules between uplink carriers are determined according to TS 38.214 Section6.2.1.3 | RAN1 FG 2-56, RAN4 FG 7-1 | Yes | n/a | Ambiguity in simultaneous operation of uplink Tx switching and SRS carrier switching. | Per BC | n/a | n/a | n/a | For a UE supporting this feature, the UE reports one of {“max”,”sum”} as candidate values for Component 1, where “max” indicates that the switching time is the maximum between the uplink Tx switching time (refer to ULTxSwitchingBandPair) and SRS carrier switching times (refer to SRS-SwitchingTimeNR), and “sum” indicates that the switching time is the sum of the uplink Tx switching time and the SRS carrier switching time. | Optional with capability signalling |

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| Company | Comments/Questions/Suggestions |
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## Simultaneous NZP-CSI-RS resource counting

After review of contributions submitted to RAN1 #121 in this agenda item, the following is proposed by the moderator. Companies submitted the following views on the moderator’s proposals.

**Proposal: Introduce the following Rel. 19 UE FGs (yellow highlighting, if any, shows text that’s not yet agreed)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 67. TEI19 [SimCSI\_count] | 67-6 | Simultaneous NZP-CSI-RS resource counting | For simultaneous CSI-RS reception in UE features 2-33, 2-36, 2-40, 2-41, 2-43, 16-3a and 16-3b, CSI-RS ports within one periodic/semi-persistent CSI-RS resource, as well as the periodic/semi-persistent CSI-RS resource, are counted one time by the UE, even if the periodic/semi-persistent CSI-RS resource is referred N times by one or more CSI Reporting Settings not configured with higher layer parameter *csi-ReportSubConfigToAddModList*. | 2-33 and {2-36 or 2-40 or 2-41 or 2-43 or 16-3a or 16-3b} | yes | n/a | gNB would not assume that UE supports this capability | Per UE | No | Yes | n/a |  | Optional with capability signalling |

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| Company | Comments/Questions/Suggestions |
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## CAS Muting

After review of contributions submitted to RAN1 #121 in this agenda item, the following is proposed by the moderator. Companies submitted the following views on the moderator’s proposals.

**Proposal: Introduce the following Rel. 19 UE FGs (yellow highlighting, if any, shows text that’s not yet agreed)**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 67. TEI19 [5GBC\_CasMuting] | 67-7 | 5GBC\_CAS Muting | Muting of always-on signals in 5G broadcast |  |  |  | CAS Muting cannot be used | FFS | FFS | FFS | FFS | For a MBMS-dedicated cell, there is no RAN4 impact from the above TEI proposal. | Optional with capability signalling |

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| Company | Comments/Questions/Suggestions |
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# Conclusion

Agreements reached during RAN1 #121 as part of this agenda item are summarized in [ ].

# References

1. R1-2502977, Updated RAN1 UE features list for Rel-19 NR after RAN1 #120bis, Moderators (AT&T, NTT DOCOMO, INC.)
2. R1-2503604, UE features for Rel-19 TEI, Samsung
3. R1-2504278, TEI19 UE features, MediaTek Inc./Nokia/Apple/Ericsson/NTT DOCOMO/Orange
4. R1-2504362, Clarification on UE feature for Rel-19 TEI SRSCS\_ULTxSwitch, Apple
5. R1-2504534, Discussion on UE features for Rel-19 TEI, NTT DOCOMO, INC.
6. R1-2504578, UE features for Rel-19 TEI, EBU
7. R1-2504647, UE features for CSI-RS active resource counting, Huawei/HiSilicon