**3GPP TSG RAN WG1 #103e R1-200xxxx**

**e-Meeting, October 26th–November 13th, 2020**

**Source: Moderator (ZTE)**

**Title: Summary of Email Discussion [103-e-NR-7.1CRs-01]**

**Agenda item: 7.1**

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

# Introduction

In RAN1#103e meeting, the following email discussion is assigned by Chairman to discuss the ambiguity issue for Rel-15 UE features in case of cross-carrier operation.

[103-e-NR-7.1CRs-01] Ambiguity Issues for UE Features with Cross-Carrier Operation (Rel-15) – Xingguang (ZTE)

* Discussion and decision by 10/29, TPs by 11/5

This document is used for collecting companies’ input and summarizing the email discussion.

# Background

For some per-band or per-FS UE features, if these UE features are related to more than one carrier/band, it is not clear for companies how to interpret these UE features in case of cross-carrier operation. Take the Rel-15 UE capability *aperiodicTRS* as an example. UE capability *aperiodicTRS* is a “per Band” signaling, which is to indicate the network whether the UE supports DCI triggering aperiodic TRS associated with periodic TRS. If UE indicates support of *aperiodicTRS* for Band A and NOT support of *aperiodicTRS* for Band B, without clarification, it is not clear whether UE supports triggering TRS for Band B from Band A. Based on the clarification made in RAN1#102e [1], support of *aperiodicTRS* in case of cross-carrier operation is only determined by the triggered cell (i.e., the cell transmitting the TRS). Thus, in this example, UE doesn’t support triggering TRS for Band B from Band A.

During RAN1#102e meeting, companies discussed the ambiguity issue for some of the Rel-15 UE features and reached the following conclusion [1] together with an LS to RAN2 to clarify this issue [2]. However, there are still several Rel-15 UE features that companies didn’t reach consensus on how to interpret them in case of cross-carrier operation, e.g., *ue-SpecificUL-DL-Assignment* and *bwp-DiffNumerology / bwp-SameNumerology* [3].

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| **Conclusion*** Regarding the interpretation of UE capabilities in case of cross-carrier operation, RAN1 clarifies that support of the following UE capability is based on the support of this capability for the band of the scheduled/triggered/indicated cell only.
	+ *aperiodicTRS*
	+ *beamSwitchTiming*
* Regarding the interpretation of UE capabilities in case of cross-carrier operation, RAN1 clarifies that support of the following UE capability is based on both the support of this capability for the band of the scheduled/triggered/indicated cell and the support of this capability for the band of the scheduling/triggering/indicating cell.
	+ crossCarrierScheduling-SameSCS
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# Discussion

As also summarized in the moderator’s summary [3], basically, there are three different interpretations as shown below to interpret the UE capabilities with such ambiguity issue. In the following discussion in this document, we use the Interpretation1, Interpretation2 and Interpretation3 to clarify this ambiguity issue.

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| **Interpretation1**: Support of this UE capability is based on the support of this capability for the band of the scheduled/triggered/indicated cell only.**Interpretation2**: Support of this UE capability is based on the support of this capability for the band of the scheduling/triggering/indicating cell only.**Interpretation3**: Support of this UE capability is based on the support of this capability for both the band of the scheduled/triggered/indicated cell and the band of the scheduling/triggering/indicating cell. |

During RAN1#103e, four contributions are submitted under AI.1 to discuss this ambiguity issue, i.e., [4, ZTE], [5, Apple], [6, vivo] and [7, Huawei/HiSilicon]. The proposals of these four contributions are summarized in Appendix. Among them, four UE features are discussed, i.e., *ue-SpecificUL-DL-Assignment*, *bwp-DiffNumerology/bwp-SameNumerology* and *pdcch-MonitoringAnyOccasionsWithSpanGap*. In this Section, we discuss these UE features raised by companies.

## FG: ue-SpecificUL-DL-Assignment

The description of *ue-SpecificUL-DL-Assignment* from TS38.306 is as below.

| ***ue-SpecificUL-DL-Assignment***Indicates whether the UE supports dynamic determination of UL and DL link direction and slot format based on Layer 1 scheduling DCI and higher layer configured parameter UL-DL-configuration-dedicated as specified in TS 38.213 [11]. | FS | No | N/A | N/A |
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As clarified in [4, ZTE] and [6, vivo], UE feature *ue-SpecificUL-DL-Assignment* is not the FG for SFI. The UE feature for SFI should be *dynamicSFI*. *ue-SpecificUL-DL-Assignment* contains the following two parts.

1. Determination of UL and DL link direction and slot format based on Layer 1 scheduling DCI. From moderator’s perspective, the corresponding spec for this part is in Section 11.1 of TS 38.213 (copied below for your convenience).

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| **Spec from Section 11.1 of TS38.213**If a UE is not configured to monitor PDCCH for DCI format 2\_0, for a set of symbols of a slot that are indicated as flexible by *tdd-UL-DL-ConfigurationCommon* and *tdd*-*UL-DL-ConfigurationDedicated* if provided, or when *tdd-UL-DL-ConfigurationCommon* and *tdd*-*UL-DL-ConfigurationDedicated* are not provided to the UE- the UE receives PDSCH or CSI-RS in the set of symbols of the slot if the UE receives a corresponding indication by a DCI format 1\_0, DCI format 1\_1, or DCI format 0\_1 - the UE transmits PUSCH, PUCCH, PRACH, or SRS in the set of symbols of the slot if the UE receives a corresponding indication by a DCI format 0\_0, DCI format 0\_1, DCI format 1\_0, DCI format 1\_1, DCI format 2\_3, or a RAR UL grant  |

1. Determination of UL and DL link direction and slot format based on higher layer configured parameter *UL-DL-configuration-dedicated*. Note: There is a typo in 38.306. *UL-DL-configuration-dedicated* should be *TDD-UL-DL-ConfigDedicated* instead.

Based on the previous email discussion, it seems companies have different understanding on whether UE is allowed to report *ue-SpecificUL-DL-Assignment* for FDD band. This may potentially affect the understanding of which Interpretation should be adopted for *ue-SpecificUL-DL-Assignment*. For example, as discussed in [4, ZTE], if UE is not allowed to report for *ue-SpecificUL-DL-Assignment* FDD band, Interpretation3 will preclude the use case of FDD cross-carrier scheduling TDD for this UE capability. However, if we go with Interpretation1 for *ue-SpecificUL-DL-Assignment*, this kind of scenario can be supported.

Based on the above introduction, companies are encouraged to answer the following questions and provide the corresponding technical justification.

### Question 1:

Is UE allowed to report *ue-SpecificUL-DL-Assignment* for FDD band?

Which interpretation should be adopted for *ue-SpecificUL-DL-Assignment*?

Please provide your answers with corresponding technical justification. Comparison between different interpretations are encouraged.

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| Company | Answers and Comments |
| ZTE | Our understanding is **Interpretation1**.From our perspective, *ue-SpecificUL-DL-Assignment* is not applicable to FDD band because it is used to indicate whether UE supports UE-specific DL/UL configuration via *TDD-UL-DL-ConfigDedicated* and *TDD-UL-DL-ConfigDedicated* is only allowed to be configured for TDD band based on TS38.331.

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| ServingCellConfig ::= SEQUENCE { tdd-UL-DL-ConfigurationDedicated TDD-UL-DL-ConfigDedicated OPTIONAL, -- Cond TDD |

As *ue-SpecificUL-DL-Assignment* is not applicable to FDD band, Interpretation3 will preclude the use case of FDD band cross-carrier scheduling/triggering/indicating TDD band because Interpretation3 requires UE to indicate support of this capability for both the scheduling/triggering/indicating cell and scheduled/triggered/indicated cell.If companies believe that *ue-SpecificUL-DL-Assignment* is applicable to FDD band, then some further RAN1/RAN2 CRs are needed to clarify what the corresponding UE behaviors for FDD are.Another part of UE behavior of *ue-SpecificUL-DL-Assignment* is that, UE supports determination of UL and DL link direction and slot format based on Layer 1 scheduling DCI. The Layer 1 scheduling DCI refers to DCI format 0\_0, DCI format 0\_1, DCI format 1\_0, DCI format 1\_1 and etc., all the Layer 1 scheduling DCIs are regular scheduling DCI, it doesn’t impose any implementation burden on UE. Thus, from this perspective, Interpretation1 is more appropriate as the implementation of this UE feature is more about how to realize the slot formation determination for the scheduled/triggered/indicated cell instead of the DCI receiving for the scheduling/triggering/indicating cell. |
| Intel | We share same view as ZTE and support Interpretation #1.  |
| vivo  | Our understanding is **Interpretation1**.Regarding the reporting, our understanding is that according to the RRC spec, *TDD-UL-DL-ConfigDedicated* can only be configured for a TDD cell (shown below), which means that the *ue-SpecificUL-DL-Assignment* capability can be reported for TDD cell only. This also implies that **Interpretation1** is reasonable, because either **Interpretation2** or **Interpretation3** requires the *ue-SpecificUL-DL-Assignment* capability to be reported for the scheduling cell, which precludes the scenario of FDD cell being the scheduling cell.

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| *TDD* | This field is optionally present, Need R, for TDD cells. It is absent otherwise. |

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| Nokia | 1. Not applicable for an FDD band
2. Interpretation #1
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| Qualcomm | Our understanding is the support is based on Interpretation 3, i.e., on both bands of the cross-carrier operation.This feature has a requirement on both control channel processing on the scheduling band and the data channel or reference signal processing. It is hard to isolate one from the other. For example, this requires UE to be able to support the relatively tight timeline due to dynamic determination of L1 transmission or reception. In case a support of FDD/TDD scheduling relationship needs to be specified, it is understood that his feature should be reported for both bands. |
| Apple | Our understanding is interpretation 3According to 38.306, *ue-SpecificUL-DL-Assignment* “*Indicates whether the UE supports dynamic determination of UL and DL link direction and slot format based on Layer 1 scheduling DCI and higher layer configured parameter UL-DL-configuration-dedicated as specified in TS 38.213 [11]. Indicates whether the UE supports dynamic determination of UL and DL link direction and slot format based on Layer 1 scheduling DCI and higher layer configured parameter UL-DL-configuration-dedicated as specified in TS 38.213 [11].* “This capability contains two parts (1) The L1 scheduling DCI (2) The *UL-DL-configuration-dedicated.* We do agree that tdd-UL-DL-ConfigurationDedicated (which we may need to update 38.306 to align the RRC IE) can only be configured in TDD band. But we need to discuss the L1 scheduling DCI part which we believe interpretation 3 may be beneficial for UE capability reporting. |
| OPPO | We share the same view as QC/Apple, i.e., interpretation 3. Cross-carrier scheduling involves both the scheduling carrier and the scheduled carrier. Thus, we should consider the capabilities of both carriers. |

## FG: bwp-DiffNumerology / bwp-SameNumerology

The description of *bwp-DiffNumerology / bwp-SameNumerology* from TS38.306 is as below.

| ***Bwp-DiffNumerology***Indicates whether the UE supports BWP adaptation up to 4 BWPs with the different numerologies, via DCI and timer. For the UE capable of this feature, the bandwidth of a UE-specific RRC configured DL BWP includes the bandwidth of the CORESET#0 (if CORESET#0 is present) and SSB for Pcell and PSCell (if configured). For Scell(s), the bandwidth of the UE-specific RRC configured DL BWP includes SSB, if there is SSB on Scell(s). | Band | No | N/A | N/A |
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| ***bwp-SameNumerology***Defines type A/B BWP adaptation (up to 2/4 BWPs) with the same numerology, via DCI and timer. For the UE capable of this feature, the bandwidth of a UE-specific RRC configured DL BWP includes the bandwidth of the CORESET#0 (if CORESET#0 is present) and SSB for Pcell and PSCell (if configured). For Scell(s), the bandwidth of the UE-specific RRC configured DL BWP includes SSB, if there is SSB on Scell(s). | Band | No | N/A | N/A |
| --- | --- | --- | --- | --- |

These two capabilities are used to indicate whether the UE supports BWP adaptation up to 2/4 BWPs with different/same numerologies, via DCI and timer. The cell with DCI triggering this BWP switch and the target cell can be in different bands.

These two UE capabilities contain two parts (1) support of up to 2/4 BWPs (2) DCI-based or timer-based BWP switch. As discussed in [4, ZTE] and [6, vivo], if we take Interpretation 3 for this UE capability, in order to support cross-carrier BWP switching, it requires UE to support up to 2/4 BWPs in both scheduling cell and scheduled cell. This may not be reasonable. With Interpretation 1, a carrier with 1 BWP can still be used to cross-carrier switch the BWP of a carrier with up to 2/4 BWPs as long as cross-carrier scheduling is supported. [7, Huawei/HiSilicon] also proposes to adopt Interpretation1 for these two UE capabilities.

Based on the above introduction, companies are encouraged to answer the following question and provide the corresponding justification.

### Question 2:

Which interpretation should be adopted for *bwp-DiffNumerology / bwp-SameNumerology*?

Please provide your answer with corresponding technical justification. Comparison between different interpretations are encouraged.

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| Company | Answers and Comments |
| ZTE | Our understanding is **Interpretation1**.As pointed out by our contribution, Interpretation3 requires both the scheduling cell and the scheduled cell to support up to 2/4 BWPs and Interpretation1 precludes the use case of a carrier with 1 BWP cross-carrier scheduling another carrier with up to 2/4 BWPs. Interpretation1 can remove the above mentioned restrictions.Furthermore, these two UE capabilities *bwp-DiffNumerology / bwp-SameNumerology* are about supporting up to 2/4 BWPs in the scheduled cell. The DCIs received in the scheduling cell are regular scheduling DCIs, which doesn’t put any additional implementation burden on top of the regular cross-carrier scheduling if UE has already indicated support of cross-carrier scheduling. Thus, Interpretation1 is more appropriate from this perspective.  |
| Intel | We share same view as ZTE and support Interpretation #1.  |
| Vivo | Our understanding is **Interpretation1**.Given that these two capabilities are RF-related capabilities, i.e., they are dependent on the target band being BWP adaptation, **Interpretation2** is not applicable. On the other hand, if **Interpretation3** is accepted, both the scheduling and scheduled cells should support up to 2 or 4 BWPs, which is not desirable from UE implementation perspective.  |
| Nokia | Interpretation #1, this is in our view clearly a property of the scheduled/triggered/indicated cell. |
| Qualcomm | Interpretation 3 is our understanding.Similar reason as to question 1. Interpretation 3 allows UE to have a better control of the support for the cross-carrier operation. With interpretation 1 and 2, if UE supports the feature on one band, it is forced to support the feature in all cross-carrier operation with the band where UE supports the feature involved. This is even more undesirable for UE implementation. |
| Apple | Our understanding is interpretation 3Dynamic BWP switch involves cross carrier scheduling, which in general, impact UE implementation and the related UE capability is not adequate.  |
| OPPO | Our understanding is interpretation 3. Similar reasons as Question 1. |

## FG: pdcch-MonitoringAnyOccasionsWithSpanGap

The description of *pdcch-MonitoringAnyOccasionsWithSpanGap* from TS38.306 is as below.

| ***pdcch-MonitoringAnyOccasionsWithSpanGap***Indicates whether the UE supports PDCCH search space monitoring occasions in any symbol of the slot with minimum time separation between two consecutive transmissions of PDCCH with span up to two OFDM symbols for two OFDM symbols or span up to three OFDM symbols for four and seven OFDM symbols. Value set1 indicates the supported value set (X,Y) is (7,3), value set2 indicates the supported value set (X,Y) is (4,3) and (7,3) and value set 3 indicates the supported value set (X,Y) is (2,2), (4,3) and (7,3). | FS | No | N/A | N/A |
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The corresponding UE feature description is as below.

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| 3-5b |  All PDCCH monitoring occasion can be any OFDM symbol(s) of a slot for Case 2 with a span gap | PDCCH monitoring occasions of FG-3-1, plus additional PDCCH monitoring occasion(s) can be any OFDM symbol(s) of a slot for Case 2, and for any two PDCCH monitoring occasions belonging to different spans, where at least one of them is not the monitoring occasions of FG-3-1, in same or different search spaces, there is a minimum time separation of X OFDM symbols (including the cross-slot boundary case) between the start of two spans, where each span is of length up to Y consecutive OFDM symbols of a slot. Spans do not overlap. Every span is contained in a single slot. The same span pattern repeats in every slot. The separation between consecutive spans within and across slots may be unequal but the same (X, Y) limit must be satisfied by all spans. Every monitoring occasion is fully contained in one span. In order to determine a suitable span pattern, first a bitmap b(l), 0<=l<=13 is generated, where b(l)=1 if symbol l of any slot is part of a monitoring occasion, b(l)=0 otherwise. The first span in the span pattern begins at the smallest l for which b(l)=1. The next span in the span pattern begins at the smallest l not included in the previous span(s) for which b(l)=1. The span duration is max{maximum value of all CORESET durations, minimum value of Y in the UE reported candidate value} except possibly the last span in a slot which can be of shorter duration. A particular PDCCH monitoring configuration meets the UE capability limitation if the span arrangement satisfies the gap separation for at least one (X, Y) in the UE reported candidate value set in every slot, including cross slot boundary.For the set of monitoring occasions which are within the same span:* Processing one unicast DCI scheduling DL and one unicast DCI scheduling UL per scheduled CC across this set of monitoring occasions for FDD
* Processing one unicast DCI scheduling DL and two unicast DCI scheduling UL per scheduled CC across this set of monitoring occasions for TDD
* Processing two unicast DCI scheduling DL and one unicast DCI scheduling UL per scheduled CC across this set of monitoring occasions for TDD

The number of different start symbol indices of spans for all PDCCH monitoring occasions per slot, including PDCCH monitoring occasions of FG-3-1, is no more than floor(14/X) (X is minimum among values reported by UE).The number of different start symbol indices of PDCCH monitoring occasions per slot including PDCCH monitoring occasions of FG-3-1, is no more than 7.The number of different start symbol indices of PDCCH monitoring occasions per half-slot including PDCCH monitoring occasions of FG-3-1 is no more than 4 in SCell. |

Apple raises the following example in [5, Apple].

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| Using a 3 band, FR1 + FR2, deployment with 3 SCS as an example, namely* Sub-1GHz FR1 NR FDD band with 15kHz SCS
* ~3GHz FR1 NR TDD band with 30KHz SCS
* FR2 NR TDD band with 120KHz SCS

One of the reasonable UE implementation is that UE supports CCS with different SCS, i.e., “Scheduling cell of lower SCS and scheduled cell of higher SC” in the corresponding BC, but* UE only supports FG3-5b for FR1 scheduling FR1
* UE does not support FG3-5b for FR1 scheduling FR2

As of now, it is unclear whether this capability is allowed by the specification or not, depending on the interpretation of per FS FG3-5b, under the context of CCS. To resolve this issue, we propose to interpret FG3-5b based on the support of this feature for both scheduling/triggering/indicating cell and scheduled/triggered/indicated cell. |

From moderator’s perspective, UE feature *pdcch-MonitoringAnyOccasionsWithSpanGap* is only related to PDCCH search space monitoring occasions and is not related to the scheduled/triggered/indicated cell. Thus, Interpretation3 may not be a reasonable interpretation from this perspective.

Based on the above analysis, companies are encouraged to answer the following question and provide the corresponding justification.

### Question 3:

Which interpretation should be adopted for *pdcch-MonitoringAnyOccasionsWithSpanGap*?

Please provide your answer with corresponding technical justification. Comparison between different interpretations are encouraged.

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| Company | Answers and Comments |
| ZTE | Our understanding is **Interpretation2**.Our understanding is that UE capability is not ambiguous because all the related UE behaviors are only about PDCCH monitoring and PDCCH reception and it seems to have nothing related to the scheduled/triggered/indicated cell. Thus, technically speaking, Interpretation2 is the appropriate interpretation for *pdcch-MonitoringAnyOccasionsWithSpanGap*. |
| Intel | We support Interpretation 2. As commented by Xinguang, this feature focuses on the PDCCH transmission/reception. We think it can be independent to the target cell where the UL/DL data/control transmission happens.  |
| vivo | Our understanding is **Interpretation2**.There is no PDCCH monitoring occasion in any cross-carrier scheduled cell, which means that this FG is only relevant to the scheduling cell.Regarding the example considered by Apple, the feature of X-CC scheduling with mix SCSs is not supported in Rel-15, thus is not relevant to this email thread (which is for Rel-15 maintenance). |
| Nokia |  Support interpretation #2, this is a property of the scheduling cell. |
| Qualcomm | We support Interpretation 3.Similar reason as question 1 and 2. This feature has an impact on both control channel and data channel for the mini slot-based scheduling and data transmission and reception. These two aspects cannot be isolated from each other. |
| Apple | Our understanding is interpretation 3FG3-5b involves both the scheduling cell and scheduled cell. In terms of the UE implementation, it is different to support 15kHz cell to schedule 30kHz cell, compared to support 15kHz cell to schedule 120kHz cell. The UE capability needs to address and differentiate different levels of UE implementation complexity, which not only depends on the scheduled cell, but also depends on the scheduling cell.  |
| OPPO | Our understanding is interpretation 3. Similar reasons as Question 1/2. |

## Any other issue

If you figure out any other issue or any other UE capabilities with the same ambiguity issue that may need further clarification, please input your comments below.

### Question 4:

Any other issue?

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| Company | Answers and Comments |
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# Conclusion

TBD

# Reference

1. RAN1#102e chairman note.
2. R1-2007334, LS on Interpretation of UE Features in Case of Cross-Carrier Operation, RAN1#102e.
3. R1-2007333, Email Discussion Summary of [102-e-NR-7.1CRs-07], Moderator (ZTE), RAN1#102e.
4. R1-2007722, Discussion on Ambiguity Issues for UE Features with Cross-Carrier Operation, ZTE, RAN1#103e.
5. R1-2008423, Clarification of FG3-5b with Cross Carrier Operation, Apple, RAN1#103e.
6. R1-2008653, Discussion on UE FG in case of cross-carrier operation, vivo, RAN1#103e.
7. R1-2008787, Clarifications on UE features in case of cross-carrier operation, Huawei, HiSilicon, RAN1#103e.

# Appendix: Proposal Summary

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| Contribution | Proposals |
| R1-2007722ZTE | ***Observation 1****: If ue-SpecificUL-DL-Assignment can NOT be reported for FDD band, Interpretation3 will preclude the use of this UE capability in case of FDD-TDD cross-carrier operation, i.e., UE is not expected to be scheduled/triggered PDSCH, CSI-RS, PUSCH, PUCCH, PRACH or SRS in the flexible symbols in TDD band from a FDD band based on the current specification in Section 11.1 of TS 38.213.* ***Observation 2****: If UE is allowed to report ue-SpecificUL-DL-Assignment for FDD band, RAN1 and/or RAN2 spec changes are needed to specify the corresponding UE behaviors on interpreting ue-SpecificUL-DL-Assignment reported for FDD bands.****Observation 3****: The market drive and implementation concern on supporting Interpretation3 instead of Interpretation1 for ue-SpecificUL-DL-Assignment is not clear.****Observation 4****: With Interpretation3 for bwp-DiffNumerology / bwp-SameNumerology, in order to support cross-carrier BWP switching, it requires UE to support up to 2/4 BWPs in both scheduling cell/band and scheduled cell/band.****Proposal 1****: Regarding the interpretation of UE capabilities in case of cross-carrier operation, the support of the following UE capability is based on the support of this capability for the band of the scheduled/triggered/indicated cell only.** + *ue-SpecificUL-DL-Assignment*
	+ *bwp-DiffNumerology / bwp-SameNumerology*
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| R1-2008423Apple | ***Proposal 1: Clarify that the support of the following feature is based on the support of this feature for both scheduling/triggering/indicating cell and scheduled/triggered/indicated cell.**** ***FG3-5b, i.e., pdcch-MonitoringAnyOccasionsWithSpanGap***
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| R1-2008653vivo | ***Proposal 1:* *In case of cross-carrier operation, the support of UE capability ue-SpecificUL-DL-Assignment is reported for the band of the scheduled/triggered/indicated cell only (i.e., Interpretation1).******Proposal 2:* *In case of cross-carrier operation*, *the support of UE capability bwp-DiffNumerology / bwp-SameNumerology is reported for the band of the scheduled/triggered/indicated cell only (i.e., Interpretation1).*** |
| R1-2008787Huawei, HiSilicon | ***Proposal:*** *In case of cross-carrier operation, the support of the following UE capabilities is based on the support of a capability for the band of the scheduled/triggered/indicated cell only.** *ue-SpecificUL-DL-Assignment*
* *bwp-DiffNumerology/bwp-SameNumerology*
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