**3GPP TSG RAN WG1 #106-e R1-21xxxxx**

**E-meeting, August 16th – 27th, 2021**

**Agenda Item: 7.1**

**Source: Moderator (Huawei, HiSilicon)**

**Title: Summary of [106-e-NR-7.1CRs-02] Issue#2: Correction on prioritization rules of SRS carrier switching**

**Document for: Discussion and Decision**

# Introduction

The document provides a summary for the following email discussion:

[106-e-NR-7.1CRs-02] Issue#2: Correction on prioritization rules of SRS carrier switching by August 20 – Keyvan (Huawei)

As the deadline for the email discussion is August 20, please provide your initial views by **UTC 23:59 pm, August 17.**

# Discussion

Possible corrections/clarifications on prioritization rules of SRS carrier switching have been discussed during the last two RAN1 meetings in [104b-e-NR-7.1CRs-02] (summary available in [1]) and [105-e-NR-7.1CRs-12] (summary available in [2]) which led to the following agreements in RAN1 105-e:

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| **Agreement (1)**The prioritization rules of SRS carrier switching apply to at least the source CC.* FFS : Whether the specification needs to be updated or not

**Agreement (2)**Down select one from the following two options in RAN1#106-e meeting to determine which UL CCs other than the source CC should be used for SRS carrier switching priority rules:* Option 1: The UL CCs  in the same band as the source CC
* Option 2: The UL CCs can be any carriers which result in uplink transmissions beyond the UE ’s indicated uplink carrier aggregation capability.
	+ Companies should indicate how “UE’s indicated uplink CA capability” is derived based on current ASN.1 signaling.
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References [3]-[9] have further studied prioritization rules of SRS carrier switching and related timelines in this meeting.

## Current prioritization rules specified in 38.214

Most sources [3], [4], [5], [6], [9], seem to maintain the understanding that the current prioritization rules in four paragraphs of Section 6.2.1.3 of 38.214 (marked in grey and brought in Appendix A) specify the prioritization of carrier switching SRS on the target carrier c1 when conflicting with UL transmission only on the source carrier c2 where the source carrier c2 is indicated to the UE using *SwitchFromServCellIndex* and *srs-SwitchFromCarrier*: In case of collision between SRS transmission on c1 and UL transmission on c2, depending on their relative priority, either SRS on c1 or UL transmission on c2 is dropped. Source [7] does not seem to directly address this issue and Source [8] seems to advocate that the current text in Section 6.2.1.3 of 38.214 can be used to specify UE behavior when there is a collision between carrier switching SRS on a target carrier c1 and any other carrier on any band in a supported band combination if further UE capability signaling are properly introduced.

In moderator’s view, making following conclusion can help providing a framework for further possible agreements:

**Conclusion 1: Section 6.2.1.3 of 38.214 V16.6.0 specifies the prioritization of carrier switching SRS on the target carrier c1 when conflicting with UL transmission on only the source carrier c2 where the source carrier c2 is indicated to the UE using *SwitchFromServCellIndex* and *srs-SwitchFromCarrier*.**

Moderator would like to ask sources’ comments about above conclusion. If Conclusion 1 is not agreeable “as is”, please, if possible, provide modification/suggestions, e.g., by adding a Note.

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## SRS Prioritization when conflicting with carriers in the same band as the source carrier

Most proponents of both Option 1 and Option 2 in Agreement (2) above seem to share a common understanding that the same prioritization rules that apply to the UL transmission of source c2 (indicated to the UE using *SwitchFromServCellIndex* and *srs-SwitchFromCarrier*)and specified in Section 6.2.1.3 of 38.214 also apply to at least any other carrier c3 in intra-band CA with the source carrier c2 as c2 and c3 share the same Tx chain. Sources [3] and [5] have provided CRs on Section 6.2.1.3 of 38.214 based on such understanding. Note that proponents of Option 2 have additional views on how to handle the case that there is a conflict between the carrier switching SRS in c1 and carriers in inter-band CA with the source carrier c2 [3], [8]. This will be further discussed in next subsections. Moderator would like to know companies’ views about the following proposal emphasizing that the following proposal does not aim to down-select between Option 1 and Option 2.

***Proposal 1: The same prioritization rules that apply to the UL transmission of source carrier as specified in Section 6.2.1.3 of 38.214 also apply to at least other carriers in intra-band CA with the source carrier.***

* ***Note 1: How to handle the case that there is a conflict between SRS on the target carrier and UL transmissions on carriers in inter-band CA with the source carrier is separately discussed.***

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## Views regarding “UE’s indicated uplink carrier aggregation capability”

Regarding Option 1 vs. Option 2 in Agreement (2) above, two sources [4], [6] are explicitly supportive of Option 1 and two sources [3], [7] are explicitly supportive of Option 2 and two other sources [8], [9], in view of their discussions on “UE’s indicated uplink carrier aggregation capability”, seem to be supportive of Option 2. Moderator’s understanding is that Option 2 can be selected if sources can reach a consensus on how “UE’s uplink CA capability” indicates the priority of carrier switching SRS when conflicting with an UL transmission on a carrier which may be intra-band or inter-band with the source carrier.

Sources that are proponent of Option 2 or discussed this option in their t-docs have quite diverse views on how “UE’s indicated uplink CA capability” is/should be defined. Once defined, this would also clarify UE behavior when there is a conflict between carrier switching SRS on target carrier and other carriers in inter-band CA with the source carrier.

According to [8], given current specifications, UE behavior for collision between carrier switching SRS on the target carrier c1 and an UL transmission on a carrier c3 should not be discussed based on whether or not c3 and the source c2 are in an intra-band CA or inter-band CA: If such categorization is used, while UE behavior is well-defined in the case of intra-band CA, UE behavior may be left undefined/ambiguous in inter-band CA case due to the lack of cancellation timeline or the lack of precise UE capability signaling to indicate which bands within the band combination will be impacted.

Source [6] has also discussed option 2 and also concluded that, currently, there is no UE capability that addresses capability of simultaneous SRS transmission on the target band and a third band (other than source and target).

In turn, according to [3], [7], [9], current UE capability signaling indicate uplink carrier aggregation capability by means of which the priority rules of SRS carrier switching when conflicting with any supported UL carrier in a band combination can be specified. The following table shows the UE capabilities that, according to the proponents, may be used to indicate UL CA capacity and specify the SRS carrier switching priority rules in any supported band combination.

**Table 1: Suggested UE capabilities to derive SRS carrier switching priority rules in Option 2 of RAN1 105-e agreement**

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| **Item** | **UE capabilities**  |
| 1 | *uplinkTxSwitching-r16 [3]* |
| 2 | *CA-ParametersNR, ca-BandwidthClassUL-NR [7]* |
| 3 | *supportedBandwidthCombinationSet,* *SRS-SwitchingTimeNR, ca-BandwidthClassUL-NR [9]* |

Moderator would like to ask companies to provide their views on the following discussion point:

**Discussion point 1:**

**Regarding Agreement in RAN1 105-e to determine which UL CCs other than the source CC should be used for SRS carrier switching priority rules, provide your views on the following alternatives**

**Alt 1) UL CCs  in the same band as the source CC are used for priority rules (Option 1 in RAN1 105-e)**

**Alt 2) UL CCs can be any carriers which result in uplink transmissions beyond the UE ’s indicated uplink carrier aggregation capability (Option 2 in RAN1 105-e).**

* **Alt 2-1) Such uplink carrier aggregation capability is not currently supported and should be introduced.**
* **Alt 2-2) Such uplink carrier aggregation capability is currently supported and provided in Item X (=1, 2, 3) in Table 1 (please specify which item and exactly how)**
* **Alt 2-3) Such uplink carrier aggregation capability is currently supported but not provided in Table 1 (please specify)**

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## Extending timelines for multiple UL CCs

 Clause 6.2.1.3 of 38.214 specifies the required timeline for the transmission prioritization between the target carrier switching SRS and an UL transmission on the switched-from source CC. Source [8] has provided their view on how such a timeline should be extended to the case that the carrier switching SRS on the target CC is in conflict with multiple UL CCs. Similar discussion was provided by the same source in RAN1 105-e where majority of companies expressed their preference to delay such discussion to after finalizing the discussion of priority rules between the target carrier and other UL CCs. In view of the fact that some intermediate agreements were achieved in RAN1 105-e on such priority rules (cf. Agreement (2)), moderator would like to know if sources are ready to discuss extending timelines in Clause 6.2.1.3 of 38.214 to multiple UL CCs.

**Discussion point 2:**

**Regarding extending the required timeline for the transmission prioritization between the target SRS and the UL transmission of the source CC to multiple UL CCs, please provide your views on the following two proposals from [8] including whether or not they should be discussed in this meeting.**

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| **Proposal 2**: For the case that aperiodic SRS transmission on the target cell has higher priority than overlapping UL transmissions on other carriers, and the simultaneous transmission is beyond UE’s capability:* UE does not expect that the gap between the last symbol of DCI indicating A-SRS on target CC and the first symbol of the earliest low priority UL transmission, among a group of overlapping UL transmissions with a priority lower than A-SRS, to be less than $T\_{proc}^{max}$, with $T\_{proc}^{max}=max\{T\_{proc}^{1}, …,T\_{proc}^{i}, …\}$

where $T\_{proc}^{i}$ is based on *N2*, which itself is determined based on the UE processing capability on the i-th low priority carrier, and the minimum of (*µDL*, *µith-UL*), where the *µDL* corresponds to the SCS of the PDCCH scheduling A-SRS, and *µith-UL* corresponds to the SCS of the uplink channel on the i-th low priority carrier.**Proposal 3**: For the case that UE is scheduled by a DCI, or a set of DCIs, to transmit a high priority UL transmission on a serving cell overlapping with a low priority SRS transmission on a carrier without configured PUSCH/PUCCH, and simultaneous transmission is beyond UE’s capability:* UE does not expect the gap between the first symbol of the earliest low priority SRS transmission on the target cell and a last symbol of the last DCI among all DCIs indicating high priority transmissions on another carriers, to be less than $T\_{proc}^{max}$, with $T\_{proc}^{max}=max\{T\_{proc}^{1}, …,T\_{proc}^{i}, …\}$

where $T\_{proc}^{i}$ is based on SRS-SwitchingTime + *N2*, and *N2* is determined based on the UE processing capability on the target carrier, and the minimum of (*µith-DL*, *µUL*), where the *µith-DL* corresponds to the SCS of the PDCCH scheduling a high priority UL transmission on the i-th high priority carrier, and *µUL* corresponds to the SCS of the SRS on the target cell. SRS-SwitchingTime represents the UL or DL RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR,*  |

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## Switching for multiple SRS resource set triggered by a single DCI

It has been discussed in [7] that, for antenna switching purposes, more than one carrier switching SRS resources may be triggered by a single DCI. In such a case, it seems unclear in the current specifications if the UE should switch back to the source CC during the time period between aperiodic SRS resource sets. In particular, UE behavior may be different depending the time length between aperiodic SRS resource sets relative to the RF tuning time. As such, Moderator would like to ask sources to provide their views regarding the following proposal from [7]:

***Proposal 2:***

***RAN1 to clarify when multiple SRS resource sets are triggered by single DCI, whether the UE should stay in the target CC or not during the period between the triggered SRS resource sets.***

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On a related issue, [7] observes that when the UE performs collision handling for SRS carrier switching, there is a deadline whether to consider the DCI triggering the SRS or other uplink signals. However, it is currently unclear when a single DCI triggers more than one carrier switching SRS resource sets, whether the same timeline applies to all triggered resources sets or an individual timeline would apply to each resource set. Moderator would like to ask sources to provide their views regarding the following proposal from [7]:

***Proposal 3:***

***In the case that multiple SRS resource sets are triggered by the same DCI, RAN1 to clarify whether individual timeline operation is applied to each triggered SRS resource set, or the same timeline is applied to all the triggered SRS resource sets.***

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# References

1. [R1-2104067](file:///C%3A%5CUsers%5CK00903651%5CAppData%5CLocal%5CTemp%5CDocs%5CR1-2104067.zip) Summary of [104b-e-NR-7.1CRs-02] Correction on prioritization rules of SRS carrier switching Moderator (Huawei)
2. [R1-2106100](file:///D%3A%5CRAN1%20106-e%5CAgreements%20and%20SR%20and%20LS%20prior%20to%20106-e%5CDocs%5CR1-2106100.zip), Summary of [105-e-NR-7.1CRs-12] Issue#26 SRS carrier switching, Moderator (ZTE)
3. R1-2106516, Correction on prioritization rules of SRS carrier switching, Huawei, HiSilicon
4. R1-2106533, Discussion on SRS carrier switching, ZTE
5. R1-2106534, Draft CR on SRS carrier switching, ZTE
6. R1-2107311, Discussion on SRS carrier switching, Qualcomm Incorporated
7. R1-2107567, Discussion on SRS carrier switching, Intel Corporation
8. R1-2107710, Timeline Considerations for SRS Carrier Switching and Dropping Procedure in Rel-16, Apple
9. R1-2107975, Discussion on SRS carrier switching, vivo

# Appendix A: Section 6.2.13 of 38.214

A UE can be configured with SRS resource(s) on a carrier *c1* with slot formats comprised of DL and UL symbols and not configured for PUSCH/PUCCH transmission. For carrier *c1*, the UE is configured with higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier* the switching from carrier *c2* which is configured for PUSCH/PUCCH transmission. During SRS transmission on carrier *c1* (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR*), the UE temporarily suspends the uplink transmission on carrier *c2*.

For an SRS transmission starting in symbol $N\_{c\_{1}}$ of carrier $c\_{1}$ and a conflicting transmission in carrier $c\_{2}$ starting in symbol$ N\_{c\_{2}}$, the UE shall apply the prioritization / dropping rules in the remainder of this clause taking into account:

- DCI(s) for which the time interval between the last symbol of PDCCH and $N\_{c\_{1}}$ is at least$ N\_{2} $symbols and an additional time duration $T\_{SRS\_{CS}}$, and the time interval between the last symbol of PDCCH and $N\_{c\_{2}}$ is at least $ N\_{2}$ symbols*;* and

- semi-persistent CSI reports or SRS considered active at least $N\_{2}$ symbols and an additional time duration $T\_{SRS\_{CS}}$ before $N\_{c\_{1}}$, and considered active at least $N\_{2}$ symbols before $N\_{c\_{2}}$.

where $T\_{SRS\_{CS}}=max⁡\{switchingTimeUL,switchingTimeDL\}$, and the time interval unit of OFDM symbol is counted based on the smaller subcarrier spacing across $c\_{1}, c\_{2}$ and their corresponding scheduling cells.

For a carrier of a serving cell with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, the UE shall not transmit SRS whenever SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell and PUSCH/PUCCH transmission carrying HARQ-ACK/positive SR/RI/CRI/SSBRI and/or PRACH happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].

For a carrier of a serving cell with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, the UE shall not transmit a periodic/semi-persistent SRS whenever periodic/semi-persistent SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell and PUSCH transmission carrying aperiodic CSI happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].

For a carrier of a serving cell with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, the UE shall drop PUCCH/PUSCH transmission carrying periodic/semi-persistent CSI comprising only CQI/PMI/L1-RSRP/L1-SINR, and/or SRS transmission on another serving cell configured for PUSCH/PUCCH transmission whenever the transmission and SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the serving cell happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].

For a carrier of a serving cell with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, the UE shall drop PUSCH transmission carrying aperiodic CSI comprising only CQI/PMI/L1-RSRP/L1-SINR whenever the transmission and aperiodic SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133]) as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].

[…]