3GPP TSG RAN WG1 Meeting #102-e R1-200xxxx

**eMeeting, 17th – 28th Aug., 2020**

**Source: Moderator (ZTE)**

Title: FL summary #3 on SRS enhancements

Agenda Item: 8.1.3

Document for: Discussion and Decision

# Introduction

In RAN#86, the Rel-17 WID of further enhancements on MIMO for NR is approved [1]. In the approved WID, a particular point is about SRS enhancements in terms of flexibility, coverage and capacity, targeting both FR1 and FR2. The detailed scope of the SRS enhancement is given as follows.

*3. Enhancement on SRS, targeting both FR1 and FR2:*

* 1. *Identify and specify enhancements on aperiodic SRS triggering to facilitate more flexible triggering and/or DCI overhead/usage reduction*
	2. *Specify SRS switching for up to 8 antennas (e.g., xTyR, x = {1, 2, 4} and y = {6, 8})*
	3. *Evaluate and, if needed, specify the following mechanism(s) to enhance SRS capacity and/or coverage: SRS time bundling, increased SRS repetition, partial sounding across frequency*

In this contribution, we discuss high and medium priority topics selected from the first-round email discussion, in order to consolidate proposals to agreements.

# Void

This section is intended to be void.

# Flexibility enhancements

## Void

This section is intended to be void.

## Flexible DCI

***FL Proposal 3-2:*** *Study the following two alternatives in the scope to enhance at least one DCI format for aperiodic SRS triggering*

* + *Alt 1: Use UE-specific DCI, e.g., extending DCI 0\_1 without uplink data and without CSI*
	+ *Alt 2: Use group-common DCI, e.g., extending DCI 2\_3 for cases other than carrier switching*
	+ *Further consideration aspects may include simultaneous or CC-specific SRS triggering for multiple CCs, dynamic indication of SRS frequency resources, etc..*

Companies’ further views are collected as follows.

|  |  |  |
| --- | --- | --- |
| **Companies** | **Agree with the current proposal or not** | **If no, what specific change to make** |
| CEWiT | yes |  |
| Futurewei | Yes |  |
| MediaTek | Yes |  |
| Huawei, HiSilicon | Yes |  |
| OPPO |  | {1T6R,1T8R} at least should in the same level as Flexible DCI. The reason is that {1T6R,1T8R} get more proponents and less opponents than this feature. However, there are put in brackets. If {1T6R,1T8R} are in the brackets, this proposal should be modified for studying instead of supporting something |
| LGE | Yes |  |
| NTT DOCOMO | Yes |  |
| Lenovo/MotM | Yes  |  |
| QC | Yes |  |
| Samsung | Yes |  |
| Ericsson | No | We would be more comfortable with a study of these until next meeting. Hence, “*Support at least one DCI format to enhance aperiodic SRS triggering, by at least one of the following two alternatives” can be changed to “Study at least these DCI formats with scope to enhance aperiodic SRS triggering”* |
| Spreadtrum | Yes |  |
| vivo | Yes/No | We are fine with studying further until next meeting. |
| ZTE | Yes | To OPPO, we are not sure about the relation of this feature and whether to support {1T6R, 1T8R}. If you can elaborate more, it would be better to understand your technical logic.From technical perspective, it is quite clear that one clear use case for NW operation is missing in current specification, i.e., the flexibility for NW to acquire CSI dynamically before data arrives. Hence we think this enhancement is necessary. |
| Intel | Partially Yes | We are also fine to change ‘support’ to ‘study’.Since the last sub-bullet is for further consideration, we suggest to include one more aspect for further consideration. The change is shown as below:*Further consideration aspects may include simultaneous SRS triggering among multiple CCs, dynamic indication of SRS frequency resources, CC-specific SRS triggering, etc.* |
| CMCC | Yes |  |

## Flexible antenna switching

***FL Proposal 3-3:*** *For flexibility enhancement of SRS antenna switching, study the aspect of triggering/updating a subset of the configured Tx/Rx antennas, considering use cases like overhead/power saving, NW performance, etc..*

Companies’ further views are collected as follows.

|  |  |  |
| --- | --- | --- |
| **Companies** | **Agree with the current proposal or not** | **If no, what specific change to make** |
| CEWiT | yes |  |
| Futurewei | Yes  | Ok to study if time allows, but not sure if this is strictly within the scope |
| MediaTek | No | We don’t see this can have significant saving. It still takes same amount of sounding for gNB to get full set of channel coefficients (say 8Rx). Furthermore, current framework is able to control the density of sounding by periodicity.  |
| Huawei, HiSilicon | No | Not sure if such dynamic change is necessary and whether it’s in the scope.  |
| OPPO | No | Fail to see the benefits and doubt whether it is in the scope. |
| LGE | No | We think the antenna switching across subset of UE Rx antennas is already supported as specified in Rel-16 TEI, and we don’t see the benefit of dynamic indication/update of it. Also, it is not sure whether this is within the scope or not. |
| NTT DOCOMO | No | The benefits are not clear. DL signaling overhead will increase if dynamic subset selection has to be done while the achievable DL throughput will be lower (e.g. 8Rx -> 4Rx) |
| Lenovo/MotM | Yes |  |
| QC | Yes |  |
| Samsung | Yes | Positive but have question about benefits and use cases. |
| Ericsson | Yes | Fine to study the details of these |
| Spreadtrum | No | Not clear about the use case, and the benefit. |
| vivo | No | It seems like title of section 3 itself is incorrect. The scope is way too enlarged. |
| ZTE | Yes | We think it is in the scope of this WID, as it is related with flexibility of triggering SRS. Regarding benefits, it is for sure what we need to study.  |
| Intel | Yes | We support the proposal. |

## Usage/overhead reduction

***FL Proposal 3-4:*** *For SRS overhead reduction, study reusing same resources among multiple usages, at least for “codebook” and “antenna switching”.*

* + *Study aspects include*
		- *Whether implementation approach based on legacy SRS configuration is sufficient*
			* *If not, and if there are benefits other than RRC overhead reduction, study further on the case that antenna switching and PUSCH have different number of Tx antennas, whether UL BWP for different SRS usages is the same or different, whether and how to ensure UE to use same virtualization, the set of applicable usages, UE implementation complexity and overhead, etc..*

Companies’ further views are collected as follows.

|  |  |  |
| --- | --- | --- |
| **Companies** | **Agree with the current proposal or not** | **If no, what specific change to make** |
| CEWiT | Partially yes | We propose to have the full set of usages to be captured like interference management, positioning etc.  |
| Futurewei | Yes |  |
| MediaTek | Yes |  |
| Huawei, HiSilicon | Partially | Fine to study it, but we think implementation approach based on legacy SRS configuration is sufficient |
| OPPO | Fine to study this although we think current mechanism is sufficient. |  |
| LGE | Partially but same view with Huawei, OPPO. |  |
| NTT DOCOMO | Yes |  |
| Lenovo/MotM | Partially | Fine to discuss it, however, we also this this feature can be achieved by implementation on Rel-15/16 SRS configuration. |
| QC | Partially | We are okay to study. However, it should be lower priority and may be discussed if time allows. In our views, the benefits of the proposals are not clear neither motivating to justify the increased constraints and the extra complexity/overhead on UE implementation. Also, some mechanics of SRS resource sharing is already supported in Rel-15 and up to UE implementation.  |
| Ericsson | Yes | It needs to be clarified how “implementation approach” can be used. It is not clear to us, as whether a UE use same virtualization or not is not known to the gNB. So for gNB it is very risky to use “codebook SRS” measurements for reciprocity based operation. More details would be helpful if Huawei, Lenovo and Qualcomm can provide this.  |
| Spreadtrum | Yes |  |
| vivo | Yes | The sub-bullet looks bit unclear, main study point should be reuse of SRS resource(s) and ensuring the UE behavior between SRS used for ‘codebook’ and PUSCH transmission. SRS resource sharing can also be between SRS with different time domain behavior. |
| ZTE | Yes |  |
| Intel | Yes |  |
| CMCC | Yes |  |

# Antenna switching up to 8Rx

## Supported configurations

***FL Proposal 4-1:*** *For SRS antenna switching up to 8Rx, study the configuration of {1T6R, 1T8R, 2T6R, 2T8R, 4T6R, 4T8R}.*

* + *Study points may include CSI latency, performance considering aspects like insertion loss, use cases, antenna structure, UE power saving, SRS resource configuration, etc..*

Companies’ further views are collected as follows.

|  |  |  |
| --- | --- | --- |
| **Companies** | **Agree with the current proposal or not** | **If no, what specific change to make** |
| Futurewei | Yes |  |
| MediaTek | Yes |  |
| Huawei, HiSilicon | No for the updated proposal | For 1T6R and 1T8R, we do not see the use case with 1Tx to transmit and 6 or 8 antennas for receiving. How much insertion loss for the switcher? Then, for 4T6R, we do not know whether there is such antenna structures, and how to switching in the mind of the supporting companies?For Rel-17, we should priority the higher possibility cases, such as 2T6R, 2T8R and 4T8R. |
| OPPO | Yes and some modification is needed | Refer to our comments for 3.2*For SRS antenna switching up to 8Rx, support the configuration of {~~[~~1T6R~~]~~, ~~[~~1T8R,~~]~~ 2T6R, 2T8R, [4T6R], ~~[~~4T8R~~]~~}* |
| LGE | Yes |  |
| NTT DOCOMO | Yes |  |
| Lenovo/MotM | Yes. | We agree with OPPO that we also think all possible antenna configurations should be supported. |
| QC | Yes, with removing the square brackets. | We share similar views with OPPO and Lenovo/MotM that all listed antenna configurations should be supported. There are enough motivations from performance gain, power savings and product needs for all the configurations of SRS antenna switching. 5G is not only about cellular phones and eMBB, there are other wide variety of devices (CPE, laptops, connected cars) that have different form factors and antenna configurations.  |
| Samsung | Partially Yes | We suggest focusing on up to two unless some companies have a plan to implement UEs with 4 TX antennas in the near future. |
| Ericsson | Yes |  |
| Spreadtrum | Yes |  |
| vivo | Partially yes |  |
| ZTE | Partially yes | We don’t object to include 1T6R and 1T8R if the benefit can be justified. Right now we think it introduces large latency and switching. Further, we think at least 4T8R should be supported. 4T8R is clearly beneficial for NW performance when maximum 8 layers can be supported, as it requires the least latency and switching. |
| Intel | Partially Yes. The antenna architecture should be identified. Please see our comment. | We support to include all the xTyR combinations.But one thing should be clarified is the antenna architecture for xTyR. Different implementation will lead to different solutions to support antenna switching with up to 8Rx.As shown in the figure below, for (a), some Tx path may not be capable of antenna switching, while for (b), each Tx path can perform antenna switching.We think (b) is the typical implementation, especially for 2T6R, 2T8R and 4T8R. But for 4T6R, we may need to further identify the antenna architecture.Therefore, we suggest to add the following note text to the proposal.***FL Proposal 4-1:*** *For SRS antenna switching up to 8Rx, support the configuration of {1T6R, 1T8R, 2T6R, 2T8R, 4T6R, 4T8R}.**Note: For {2T6R, 2T8R, 4T8R}, each Tx antenna can be connected to the same number of Rx antennas. For {4T6R}, FFS the antenna architecture for antenna switching.* |

## Antenna switching using multiple UE panels

***FL Proposal 4-2:*** *Identify the potential aspects that need to be studied for SRS antenna switching over multiple UE panels, taking UE’s fast panel switching into account.*

Companies’ further views are collected as follows.

|  |  |  |
| --- | --- | --- |
| **Companies** | **Agree with the current proposal or not** | **If no, what specific change to make** |
| Futurewei | Partially | The relation between antenna switching and panel switching is still not very clear. Maybe the first step is to identify more clearly what needs to be addressed.Suggested update:*FFS: Identify the potential aspects that need to be studied for SRS antenna switching over multiple UE panels, taking UE’s fast panel switching into account.* |
| MediaTek | No | UE panel not yet clearly defined. As unified TCI framework for UL fast panel selection will be studied in agenda item 8.1.1, this topic can be discussed after concrete conclusions are made in 8.1.1. |
| Huawei, HiSilicon | No | Similar concern with Futurewei and MediaTek, UL and DL panel will be discussed in beam management and MTRP cases. We can discuss them after the two parts. |
| OPPO | No | Fast panel selection is in the scope of 8.1.1 |
| LGE | Yes | We don’t see any harm if we study antenna switching using multiple UE panels, while 6R/8R in the configuration of xT6R/xT8R can include UE multiple Rx panels as Samsung refers also in their contribution. We can agree regarding time for the discussion (e.g., after the concrete conclusions in the other AI). |
| Lenovo/MotM | No | Multi-panel issue should be treated in AI 8.1.1 |
| QC | Partially | From our views, this is another low priority item that we should defer its discussion until fast panel switching in 8.1.1 is concluded.  |
| Samsung | Yes | Considering UE panel implementation at least for FR2, we think that the antenna switching has some relationship with the panel switching and understand concern from other companies. Support FL’s revised proposal. |
| Ericsson | Yes |  |
| Spreadtrum | No | It should be discussed in AI 8.1.1. |
| vivo | Partially yes | Similar view as QC |
| ZTE | Yes | The revision from Furturewei is okay for us.As antenna switching is related, we think it is okay to study it here as it is clearly related to SRS antenna switching and CSI acquisition. Regarding potential issues, it should be further studied whether the following restriction in current spec for SRS for antenna switching is still valid while initializing DL CSI acquisition for the case of DL multi-beam simultaneous transmission:* + “same spatial relation for AP-SRS resources in a set for antenna switching”
 |
| Intel | Yes | We support to study the SRS antenna switching across multiple UE panels. It should be discussed in AI 8.1.3 since it’s for SRS antenna switching. |
| CMCC |  | Similar concern in the last round discussion.The relation between antenna switching and panel switching needs clarification.It seems this feature is used for DL CSI acquisition for FR2 under the multi-panel assumption  |

# Coverage and capacity enhancements

The Rel-17 FeMIMO WID gives three categories to be evaluated for SRS coverage and capacity enhancements, including time bundling, increase repetition and partial frequency sounding. In order to proceed with evaluating these candidates, it is needed to have clear definition and categorization on them.

## Scheme categorization

***FL Proposal 5-1:*** *For SRS coverage/capacity enhancements, evaluate and, if needed, specify one or more from three categories based on the following definition.*

* + *Class 1 (Time bundling): Utilize relationship among two or more occasions of one or more SRS resources in one or more slots to enable joint processing within time domain.*
		- *Study aspects include the issue of phase discontinuity, interruption of SRS transmission by other UL signals, etc..*
	+ *Class 2 (Increase repetition): Change the legacy SRS pattern in one resource and one occasion from time domain by increasing SRS symbols for repetition.*
		- *Study aspects include to use TD-OCC to compensate the negative impact on SRS capacity, inter-cell interference randomization, whether these SRS symbols are in one slot or consecutive slots, etc..*
	+ *Class 3 (Partial frequency sounding): Support more flexibility on SRS frequency resources to allow SRS transmission on partial frequency resources within the legacy SRS frequency resources.*
		- *Study aspects include the partial frequency resources are with RB level or subcarrier level (e.g., larger comb, partial bandwidth), PAPR issue, etc..*

|  |  |  |
| --- | --- | --- |
| **Companies** | **Agree with the current proposal or not** | **If no, what specific change to make** |
| CEWiT | yes |  |
| Futurewei | Yes |  |
| MediaTek | Yes |  |
| Huawei, HiSilicon | Yes |  |
| OPPO | Yes |  |
| LGE | Yes |  |
| NTT DOCOMO | Yes |  |
| Lenovo/MotM | Yes |  |
| QC | Yes |  |
| Samsung | Yes |  |
| Ericsson | Yes |  |
| Spreadtrum | Yes |  |
| vivo | Yes | Some clarification on “*legacy SRS pattern*” might be good.  |
| ZTE | Yes |  |
| Intel | Yes |  |
| CMCC | Yes |  |

# Conclusion

***FL Proposal 5-1:*** *For SRS coverage/capacity enhancements, evaluate and, if needed, specify one or more from three categories based on the following definition.*

* + *Class 1 (Time bundling): Utilize relationship among two or more occasions of one or more SRS resources in one or more slots to enable joint processing within time domain.*
		- *Study aspects include the issue of phase discontinuity, interruption of SRS transmission by other UL signals, etc..*
	+ *Class 2 (Increase repetition): Change the legacy SRS pattern in one resource and one occasion from time domain by increasing SRS symbols for repetition.*
		- *Study aspects include to use TD-OCC to compensate the negative impact on SRS capacity, inter-cell interference randomization, whether these SRS symbols are in one slot or consecutive slots, etc..*
	+ *Class 3 (Partial frequency sounding): Support more flexibility on SRS frequency resources to allow SRS transmission on partial frequency resources within the legacy SRS frequency resources.*
		- *Study aspects include the partial frequency resources are with RB level or subcarrier level (e.g., larger comb, partial bandwidth), PAPR issue, etc..*

***FL Proposal 3-2:*** *Study the following two alternatives in the scope to enhance at least one DCI format for aperiodic SRS triggering*

* + *Alt 1: Use UE-specific DCI, e.g., extending DCI 0\_1 without uplink data and without CSI*
	+ *Alt 2: Use group-common DCI, e.g., extending DCI 2\_3 for cases other than carrier switching*
	+ *Further consideration aspects may include simultaneous or CC-specific SRS triggering for multiple CCs, dynamic indication of SRS frequency resources, etc..*

***FL Proposal 3-4:*** *For SRS overhead reduction, study reusing same resources among multiple usages, at least for “codebook” and “antenna switching”.*

* + *Study aspects include*
		- *Whether implementation approach based on legacy SRS configuration is sufficient*
			* *If not, and if there are benefits other than RRC overhead reduction, study further on the case that antenna switching and PUSCH have different number of Tx antennas, whether UL BWP for different SRS usages is the same or different, whether and how to ensure UE to use same virtualization, the set of applicable usages, UE implementation complexity and overhead, etc..*

***FL Proposal 4-1:*** *For SRS antenna switching up to 8Rx, study the configuration of {1T6R, 1T8R, 2T6R, 2T8R, 4T6R, 4T8R}.*

* + *Study points may include CSI latency, performance considering aspects like insertion loss, use cases, antenna structure, UE power saving, SRS resource configuration, etc..*

# Appendix

## Previous agreements

|  |
| --- |
| **Agreement**Enhance the determination of aperiodic SRS triggering offset, with at least one of the following alternatives* + Alt 1: Delay the SRS transmission to an available slot later than the triggering offset defined in current specification, including possible re-definition of the triggering offset
	+ Alt 2: Indicate triggering offset in DCI explicitly or implicitly
	+ Alt 3: Update triggering offset in MAC CE
	+ Further consideration aspects may include the cost v.s. the total combinations PDCCH and SRS locations for gNB to choose, DCI overhead, multi-UE SRS multiplexing, CA aspect, whether to have multiple opportunities to transmit SRS, etc.
 |

## Companies’ input in first round

Section 3.1:

|  |  |
| --- | --- |
| **Company** | **View** |
| Apple | Okay |
| NTT Docomo | We are fine with FL proposal. Regarding dynamic signaling, as an operator, we prefer not to increase DCI overhead further. Hence, MAC CE based solution is more preferable  |
| Futurewei | Support the proposal.For sufficient triggering offset flexibility, we suggest considering PUSCH/PDSCH TDRA or the like to indicate the SRS transmission in time domain.In addition, time-domain flexibility and frequency-domain flexibility are tightly related. It would be more useful to enlarge the scope of the proposal to include time/frequency-domain triggering flexibility. The benefit of providing time/frequency-domain triggering flexibility, which includes significant spectrum efficiency gain of more than 50% for TDD, is discussed in details in our contribution to 8.1.5 R1-2005291. |
| Samsung | We are support FL proposal at the first stage of discussion and both approaches are available options. |
| NEC | We are OK with the proposal.And we think it’s better to use dynamic signaling in DCI for the triggering offset (Alt 1 preferred). And tradeoff between signaling overhead and flexibility can be further discussed. For example, it seems there is no need to dynamically indicate all candidate values (0-32) for SRS triggering offset.  |
| OPPO | Support the proposal. |
| Huawei, HiSilicon | Fine for the proposal. |
| Spreadtrum | Support the proposal |
| QC | In our views, these are two different approaches (SRS delaying/postponing and dynamic DCI/MAC-CE signaling). The first category of SRS delaying or redefining the slot offset can be described under one umbrella of ‘one or more opportunities of SRS transmission’. For the DCI based indication (Alt 2 above), there are can solutions with implicit indication of the slot offset without the need of increasing the DCI overhead. Hence, suggest the following edits:***FL Proposal 3-1:*** *Enhance the determination of aperiodic SRS triggering offset with at least one of the following alternatives** + *Alt-1 Delay the SRS transmission to an available slot later than the triggering offset defined in current specification, including possible re-definition of the triggering offset and multiple opportunities of SRS transmission.*
	+ *Alt -2 Use more dynamic signaling with at least one of the following alternatives*
		- *Alt 2-1: Indicate triggering offset in DCI explicitly or implicitly*
		- *Alt 2-2: Update triggering offset in MAC CE*
 |
| Lenovo/MotM | Support the proposal. |
| ZTE | We support this proposal. Compared with using DCI and redefining SRS triggering offset, we think the latter one is more efficient with fewer cost. For example, if we add one more bit in DCI to select from triggering offset 0 and 1, we can have the first three cases in FL’s figure for gNB to choose. However, if we redefine the triggering offset, we can have the following 5 combinations for gNB to choose for triggering offset 0.Hence we think redefining SRS triggering offset provides better flexibility with fewer cost. |
| Intel | 1. The flexibility of SRS triggering offset should include same CC and cross-CC SRS triggering.We suggest adding a note that both same-CC and cross-CC SRS triggering are considered for enhancement.2. One thing to clarify is for Alt 1, whether the offset is purely based on DCI or it could be DCI+RRC? |
| Sharp | Support the proposal |
| LGE | We are generally fine with the FL’s proposal.But we think multi-UE SRS multiplexing aspect should be considered here. Regarding delaying/postponing SRS(first sub-bullet), delayed/postponed SRS can be somewhat overloaded on the first UL slot. This should be investigated to avoid multi-UE SRS collision issue. |
| CMCC | We support the FL’ s proposal for the 1st phase to collect the approaches. |
| CEWiT | We support the proposal to increase flexibility in SRS triggering offsets. |
| InterDigital | Support Qualcomm revised version |
| vivo | Support the proposal. |
| Nokia/NSB | Support FL’s proposal |
| CATT | Support the proposal. |
| Ericsson | Support |

Section 3.2:

|  |  |
| --- | --- |
| **Company** | **View** |
| Apple | We are okay to discuss, but we are not sure if it is truly high priority. 0\_1, 0\_2, 1\_1, 1\_2 and 2\_3 can all be used for AP-SRS triggering  |
| NTT DOCOMO | We are fine with further discussing this |
| Futurewei | Support the proposal.Please note that in our contribution we proposed to support Alt 2. So we added our position above.We also feel Alt. 1 is useful and would like to support Alt. 1 as well. |
| Samsung | We are also support FL proposal. However, considering the main motivation of dynamic SRS triggering, we think group-common DCI can solve the problems of DCI overhead reduction, triggering without data, and dynamic triggering. |
| NEC | Support the proposal. |
| OPPO | Suggest the following changes for the main bullet*~~Support at least one~~ Study DCI format to trigger SRS without data and without CSI, by at least one of the following two alternatives, where the triggered SRS is able to be used for cases other than carrier switching*The motivation is not clear so far. CSI reporting can be only triggered by UL grant. Thus in some case (e.g., DL-dominated UDP data stream), there will be less chances to trigger CSI reporting. However, SRS can be triggered by DL and UL grant. If there is no much chance for both DL/UL, there will be no (or almost no) UL / DL data. In this case, why do we need to trigger SRS?  |
| Huawei, HiSilicon | We are fine with Alt 1. For Alt 2, whether and how to extending DCI 2\_3 need further study. |
| Spreadtrum | Support the proposal |
| QC | Support the FL proposal 3-2 with added minor note on the enhanced GC DCI 2\_3. ***FL Proposal 3-2:*** *Support at least one DCI format to trigger SRS without data and without CSI, by at least one of the following two alternatives, where the triggered SRS is able to be used for cases other than carrier switching, e.g., simultaneous SRS triggering across multiple component carrier.** + *Alt 1: Use UE-specific DCI, e.g., extending DCI 0\_1*
	+ *Alt 2: Use group-common DCI, e.g., extending DCI 2\_3*

 |
| Lenovo/MotM | We are supportive to discuss this issue with medium or low priority.  |
| ZTE | We support this proposal and we think it should have high priority. Clearly some important use cases are restricted by the current specification. The use cases include the network wants to trigger SRS for CSI acquisition, interference probing, preparation for frequency-selective scheduling before scheduling DL or UL data. |
| Intel | We are fine to discuss this |
| Sharp | Support the proposal |
| LGE | Support the proposal, and we slightly prefer alt 1. |
| CMCC | Support the proposal for providing more opportunities of SRS triggering and transmission. For the specific detailed mechanisms, such as through UE specific or group-common DCI, needs more discussion and analysis. |
| CEWiT | We support the FL proposal. This will be useful especially in cases where SRS is required to be transmitted for interference emulation or cross-link interference measurement in various scenarios. |
| InterDigital | Support OPPO’s revision. We would like to have further discussion before committing to support. |
| vivo | Support the proposal. |
| Nokia/NSB | Support FL’s proposal |
| CATT | Support FL’s proposal. |
| Futurewei | Support the proposal, but we think the proposal would read better if we put the two conditions side by side with the corresponding alternatives to avoid confusion. Suggested updated proposal is:***FL Proposal 3-2:*** *Support at least one DCI format to trigger SRS by at least one of the following two alternatives** + *Alt 1: Use UE-specific DCI, e.g., extending DCI 0\_1 without uplink data and without CSI triggered*
	+ *Alt 2: Use group-common DCI, e.g., extending DCI 2\_3 where the triggered SRS is able to be used for cases other than carrier switching*
	+ *Further consideration aspects may include simultaneous SRS triggering among multiple CCs, dynamic indication of SRS frequency resources, etc.*
 |
| Ericsson | Support the modification by OPPO  |

Section 3.3:

|  |  |
| --- | --- |
| **Company** | **View** |
| Apple | Okay |
| NTT DOCOMO | Even though we do not think this is of much importance, we are open to discuss it |
| Futurewei | The WID has* 1. *Identify and specify enhancements on aperiodic SRS triggering to facilitate more flexible triggering and/or DCI overhead/usage reduction*
	2. *Specify SRS switching for up to 8 antennas (e.g., xTyR, x = {1, 2, 4} and y = {6, 8})*

We’d like to understand whether this fits into the scope of “flexible triggering” or “antenna switching” of the WID. Objective A does not include flexible antenna switching. Objective B will specify antenna switching but does not explicitly mention flexible switching. We might consider this as an optimization for Objective B and work on it after Objective B is done (if time allows). |
| Samsung | Depending on implementation of antenna switching, flexible antenna switching might be used but doubt the necessity of dynamic change. |
| NEC | Support the proposal. |
| OPPO | The motivation needed to be justifiedMoreover, it is unclear whether this enhancement is within scope of the WID.  |
| Huawei, HiSilicon | Similar concern with Samsung, and also doubt the discussion is in the scope. |
| Spreadtrum | Share the same view with Samsung. That which antenna would be switched depends on UE implementation. |
| QC | Support the FL proposal 3-3 |
| Lenovo/MotM | Support the proposal. |
| ZTE | We support FL’s proposal. We think it is part of the WID as it is able to enhance SRS triggering flexibility clearly. |
| Intel | We think this is in the WID scope since it is related with the flexible triggering.We are ok to discuss it and support the FL proposal. |
| Sharp | Support the proposal |
| LGE | We share the view with Samsung and Huawei. |
| CMCC | We are open to this topic |
| CEWiT | Flexibility in antenna switching will help in scenarios on multi-TRP. Hence, we support the FL proposal. |
| InterDigital | Support FL proposal |
| vivo | This may be out of scope, but we are open for discussion |
| Nokia/NSB | We do not support this proposal. We share similar view with Samsung, Huawei, and Sharp |
| CATT | Support FL proposal. |
| Ericsson | Support the proposal to study and discuss this aspect further |

Section 3.4:

|  |  |
| --- | --- |
| **Company** | **View** |
| Apple | We think it should be high priority.  |
| NTT DOCOMO | We are fine with discussing it |
| Futurewei | Support the proposal. |
| NEC | Support the proposal. |
| OPPO | We are fine to study this though we think current mechanism is sufficient. |
| Huawei, HiSilicon | The reusing SRS resources for different usage is allowed from Rel-15, through the same SRS resource are configured in different resource set. If with the following clarification, it will be more clear: *The UE is not expected to be configured to transmit an SRS resource shared by antenna switching and codebook SRS resource sets with a different Tx power and slotoffset(for AP-SRS).* |
| Spreadtrum | Support the proposal |
| QC | Rel-15 already supports same SRS resource shared by two SRS resource sets (e.g. antenna switching and codebook). We are concerned on having more constraints on UE by having same SRS resource or SRS resource set with different usages. Also, we are wondering what the key benefit of merging SRS usages is. In our views, RRC configuration reduction doesn’t justify putting more constraints on UE implementation. |
| Lenovo/MotM | Fine with the proposal. |
| ZTE | We support the proposal. We think it should be a medium-priority issue as implementation approach based on Rel-15 specification can already achieve reusing same resource for multiple usages. Clearly more study is needed. |
| Intel | We are fine to discuss SRS with different usages and different BWP configurations.We propose the following changes:*The study aspects include whether UL BWP for different SRS usages is the same or different, whether implementation approach based on legacy SRS configuration is sufficient, the case that antenna switching and PUSCH have different number of Tx antennas, etc.* |
| Sharp | Support the proposal |
| LGE | We have similar view with QC. |
| CMCC | We are fine with this proposal. Reusing same resources among multiple usages could reduce the overhead and make the system more efficient. |
| CEWiT | We support the proposal of reusing same SRS resources which will be useful in scenarios like CSI/interference measurement for non-serving cell in multi-TRP scenario as proposed in our contribution.  |
| InterDigital | Support FL proposal |
| vivo | Support the proposal, should be higher priority. |
| Nokia/NSB | We are O.K. to study. |
| CATT | Support the FL proposal to study. |
| Ericsson | Support the proposal and agree with Apple it should be high priority. Note that from the UE perspective, an implementation approach can be used where same virtualization is used for both codebook and antenna switching (e.g. in the 2T=2R case). However, the issue here is that the gNB does not know whether it can rely on that the UE use same virtualization, hence gNB cannot trust that the measurements on codebook SRS can be used also for reciprocity operation. From our perspective, this is the core of the problem to be resolved.  |

Section 4.1:

|  |  |
| --- | --- |
| **Company** | **View** |
| Apple | Okay |
| NTT DOCOMO | In addition to what is captured in the table (2T6R, 4T6R, and 4T8R), we also support 1T6R, 2T8R  |
| Futurewei | Support the proposal. |
| Samsung | We also support 1T6R and 1T8R |
| NEC | Support the proposal. And we think all the configurations can be supported. |
| OPPO | We suggest to modify the proposal as below*For SRS antenna switching up to 8Rx, support at least the configuration of {2T6R, 2T8R, 1T6R, 1T8R}.**FFS: whether to support one or more from {~~1T6R, 1T8R~~, 4T6R, 4T8R}*The main reason is that some CPE products in the market are equipped with 8 or 6 Rx antennas and 1 Tx antenna. We don’t have any reason to preclude enhancement for the antenna architectures already in the market.We also think 4T8R should be supported. Considering there are no product with 8 Rx antennas and 4 Tx antennas, we are ok to keep it in the FFS part  |
| Huawei, HiSilicon | OK for the proposal |
| Spreadtrum | Support |
| QC | We do not support the proposal as it is. It is not justified that some SRS antenna configuration are FFS based only on some concerns. For example, in our contribution, we show performance gain for supporting 1T6R/1T8R which are also essential from UE power savings aspects. For other wireless devices, such CPE and laptop, they can be equipped with 6 or 8 antenna and can support more transmit chains. Therefore, 4T8R and 4T6R are necessary SRS antenna switching configurations.  |
| Lenovo/MotM | We think all possible configurations should be support from the specification point of view. |
| ZTE | We support the proposal. The terminal type should be clarified for this enhancement. We think an imbalanced capability between Tx and Rx antennas is not typical for a UE supporting more than 4Rx. Hence we have concern on 1T6R and 1T8R. |
| Intel | We are supportive to include {1T6R, 1T8R, 4T6R, 4T8R}. If we discuss {2T6R, 2T8R}, we think at least the UE can downgrade to {1T6R, 1T8R}. |
| Sharp | Support the proposal |
| LGE | Support the proposal. |
| CMCC | Support the proposal. It seems that different markets have different requirements and preference for the UE type. We stay open to this kind of UE diversity. And more efficient operations are encouraged for the study.  |
| InterDigital | Support the proposal |
| MediaTek | Agree with QC. We think none of 6 configurations should be excluded in order to support difference use cases considering different purposes. |
| vivo | Support the proposal. |
| Nokia/NSB | O.K. with the proposal. But we think the supported configuration of antenna switching should be considered together whether it is targeting MPUE with panel switching. |
| CATT | Share QC’s views that the configuration listed as FFS should be given same priority as 2T6R and 2T8R. |
| Ericsson | **OK to study all listed configurations, but would like somehow to focus on the most beneficial and realistic ones.** SRS switching provides extra CSI that enhances downlink throughput. While we as network vendors appreciate UEs taking on the burden in their RF circuitry of implementing switching, we would hope that the effort RAN1 expend on specifying, and we will spend potentially going through IoT for a wide variety of switching configurations, actually pays off in enhanced downlink throughput in relevant scenarios. So we are OK to study all these different switching configurations, but would like to know what the gains are in order to spend our efforts judiciously. **Should we formalize the evalutions more to align among companies?** |

Section 4.2:

|  |  |
| --- | --- |
| **Company** | **View** |
| Apple | Support |
| NTT DOCOMO | We are fine with discussing it |
| Futurewei | Can the proponents clarify the relation between antenna switching and panel switching? For example, if antenna switching is supported, would panel switching be also supported or not? |
| Samsung | Considering FR2 panel implementation at the UE side, we support to discuss panel switching in the antenna switching discussion. |
| NEC | Support the proposal. |
| OPPO | We need to study whether current antenna switching mechanism can support antenna switching over panels firstly.Moreover, we prefer keep such kind of study in AI 8.1.1 since the study of fast panel switching is at there |
| Huawei, HiSilicon | The discussion is low priority, while the UL and DL panel will be discussed in beam management and MTRP cases. We can discuss them after the two parts. |
| Spreadtrum | Fine to discuss. But it should be low priority at the moment. Antenna switching up to 8Rx over one UE panel should be high priority. |
| QC | SRS antenna switching for UE with multi panels can be achieved with the proposed enhancement of SRS antenna switching configuration (xTyR, x=1,2,4; y=6,8). For example, UE with 3 panels each with 2 ports (x-pol) and one active Tx panel can be configured with 2T6R and the UE can sound the three panels over three symbols with enough guard time in between for panel switching. We would like to understand what needs to be treated differently other than guard time which is better discussed in RNA4. Agree with Huawei, HiSilicon that this discussion should be low priority.  |
| Lenovo/MotM | We prefer to discuss this issue in AI 8.1.1. |
| ZTE | We agree to perform more study on this. In our views, the AP-SRS triggering with a large triggering offset for panel activation, which is similar to AP-CSI-RS beam switching in Rel-15, e.g., 224 or 336 OFDM symbols, can be considered. In such case, the sounding procedure of antenna switching may be equivalent to that of fast panel switching. * + For instance, one example for inter-panel antenna switching is described as follows. In such case, there may be different spatial relations applied to the respective UE panels, and the restriction about “same spatial relation for AP-SRS resources in a set for antenna switching” in the current spec may become invalid herein.
	+ It can be observed that the working assumption on the architecture of UE panels is very essential for studying SRS antenna switching over multiple UE panels.

 |
| Intel | Support the FL proposal |
| Sharp | Support the proposal |
| Sony | Support the proposal |
| LGE | Support the proposal. |
| CMCC | The relation between antenna switching and panel switching needs clarification. Then we can move into the discussion of antenna switching using multiple UE panels.It is a little confused for us to combine the two features together. From our understanding, the UE panels are mainly used for FR2 for tx and rx beamforming. But the antenna switching is mainly used for FR1 for the downlink channel estimation. And the transmission of SRS under antenna switching is usually none beam formed. More clarifications are need for the using scenarios and how to combine those two features together. |
| InterDigital | We are ok discussing it, however needs further clarification |
| vivo | We are ok to further study with lower priority, panel switching can similar to antenna switching |
| Nokia/NSB | O.K. to discuss. But we prefer this issue to be included in SRS antenna switching configuration |
| CATT | Same view as OPPO - prefer to study this issue in 8.1.1 |

Section 5.1:

Class 1:

|  |  |
| --- | --- |
| **Company** | **View** |
| Apple | We have concern due to the phase continuity, which should be first addressed  |
| NTT DOCOMO | Agree with Apple. It is better to address phase discontinuity issue first |
| Futurewei | Agree with Apple. Can the proponents provide some reasoning that this is not a problem or suggest a potential solution? |
| Samsung | We think that the phase continuity is separate issue (we already have 4 alternatives for phase continuity models in EVM discussion) and at least for categorization, time bundling can be the one option for enhancement.  |
| NEC | Agree with Apple, DoCoMo and Futurewei. |
| OPPO | Share the same view as Apple, DCM, Futurewei and NEC |
| Huawei, HiSilicon | The restriction “*without changing legacy SRS pattern in one resource*” need to be removed.Time bundling between legacy whole band SRS transmission and SRS for partial sounding also can be considered to increase SRS capacity and/or SRS coverage. So we think the restriction “*without changing legacy SRS pattern in one resource*” need to be removed. |
| Spreadtrum | Fine to discuss. Share the same view with Samsung, EVM has considered the effect. Considering possible benefit of coverage improvement, at the moment, we should be open, and time bundling could be as one option for further evaluation. |
| QC | Agree with Apple, DCM, Futurewei, NEC and OPPO that phase coherency model is essential to evaluate the expected gains of time bundling schemes. Also, we think intra-slot and inter-slot time bundling can be applied between same or different SRS resources.Propose the following update:* + *Class 1 (Time bundling): Utilize relationship among two or more occasions of one or more SRS resources to enable joint processing within time domain, without changing legacy SRS pattern in one resource.*
 |
| Lenovo/MotM | Share the same view as Apple, DCM, Futurewei, NEC and OPPO. |
| ZTE | We agree with the proposed definition. Phase discontinuity will be taken into account in the evaluation.  |
| Intel | We support the time bundling. But the design should take into account the phase continuity including interruption of SRS transmission by other UL transmission signals with different power control.From this perspective, the contiguous time bundling should be prioritized for the study. |
| Sharp | Share the same view as companies mentioning phase discontinuity issue |
| LGE | Share the same view as Apple, DCM, Futurewei, NEC, OPPO and sharp. |
| CMCC | Support the time bundling. But the phase discontinuity issue should be clarified and addressed first.  |
| CEWiT | Share the same view on phase discontinuity as Apple, NTT DOCOMO. |
| InterDigital | Support the FL proposal. Phase discontinuity may indeed be an issue, however its impact will be reflected during the evaluation.  |
| vivo | We share the same view that phase discontinuity issue should be addressed first. |
| Nokia/NSB | We are O.K. for further discussion.  |
| CATT | We are OK to further study time bundling.  |
| Ericsson | It is not clear if bundling within a slot is included in the definition of time bundling. Can this be clarified?Agree we need a clearly defined phase discontinuity model. The current proposals need more elaboration, as we mentioned above. Presuming that only cross slot bundling is addressed here, increased repetition within a slot seems to be the more logical starting point, and cross slot bundling for SRS should use slot repetition as a baseline.  |

Class 2:

|  |  |
| --- | --- |
| **Company** | **View** |
| Apple | Okay |
| NTT DOCOMO | We are fine with discussing it |
| Futurewei | Support  |
| Samsung | We are fine with putting this class on the table. However, considering level and depth of classification, we suggest to remove the sub-bullet in class 2 of the FL proposal 5-1 |
| NEC  | Support the proposal. |
| OPPO | Fine to discuss it and further clarify the benefit of TD-OCC |
| Huawei, HiSilicon | For the first proposal is confusion. Is that increasing SRS symbol for repetition? Or just increasing symbols. Increasing repetitions of SRS transmission is not efficient way to improve channel estimation accuracy, since it will reduce SRS multiplexing capability. Reducing hopping bandwidth can also be used to increase coverage, which won’t cause SRS multiplexing capability reduction, as shown in our Tdoc.For SRS repetition transmission(as well as time bundling), inter-cell interference randomization should be supported to ensure channel estimation accuracy, such as cyclic shift hopping. |
| Spreadtrum | Support the proposal. But to use TD-OCC should be FFS, and the benefit should be further clarified. |
| QC | We have concerns with TD-OCC schemes because of the possible loss of orthogonality if SRS transmission of one UE is dropped.  |
| Lenovo/MotM | Support the proposal. |
| ZTE | We agree with this definition.  |
| Intel | We are ok with the proposal. |
| Sharp | Support the proposal |
| Sony | Support the proposal |
| LGE | We have similar view as OPPO, spreadtrum and QC. |
| CMCC | We are fine with the proposal. And further discussions are needed for the TD-OCC. Since the Rel-16 NR-U has extended the available symbols for SRS transmission in a slot, the benefit and the impact to the system of TD-OCC needs more discussion. |
| CEWiT | We support increase in repetition of SRS. However, along with repetition, we also propose to support a precoder to maintain time domain circularity over the repeated symbols.  |
| InterDigital | Support FL proposal |
| vivo | Support the proposal. |
| Nokia/NSB | Support to discuss |
| CATT | Support the proposal. |
| Ericsson | Can we clarify the definition, i.e. are the symbols within a slot, and if not are only consecutive slots included? |

Class 3:

|  |  |
| --- | --- |
| **Company** | **View** |
| Apple | This should have relatively lower importance in our view  |
| NTT DOCOMO | We are fine with discussing it |
| Futurewei | We support flexible partial frequency sounding but would like to clarify some aspects.* + To allow SRS on partial frequency resources within the legacy SRS bandwidth is already supported since SRS does not occupy all subcarriers of the bandwidth. Maybe a better wording is “to allow SRS transmission on partial frequency resources within the legacy SRS frequency resources”.
	+ The flexibility described here may not be limited to flexible configuration. We can down-select later but at this stage we should keep it open.

So we suggest the following update:*Supports more flexibility on SRS frequency resources to allow SRS transmission on partial frequency resources within the legacy SRS frequency resources.* |
| NEC  | Support the proposal. |
| OPPO | We think more evaluation is needed to justify the benefit of partial band sounding over larger comb. We are fine to further study it, but in proposal 5-1, we propose to add larger comb (which was proposed by multiple companies) as a candidate for capacity enhancement, as supported in positioning in rel-16. Thus we add Case 4 as below (highlighted by RED) |
| Huawei, HiSilicon | Fine to discuss it. |
| Spreadtrum | If we support partial sounding across frequency domain, actually it will be new configuration, new SRS resource.So we suggest the following update:*Supports more flexibility on SRS frequency resources to allow SRS transmission on partial frequency resources within the SRS frequency resources.* |
| QC | We support partial frequency sounding as in some scenarios UL BWP is smaller than DL BWP or a cell-edge UE can sound on partial of the configured SRS frequency resource to improve the SNR at gNB. Also we share similar views with OPPO as comb8 is added for positioning SRS in Rel-16, it can be adopted in Rel-17 SRS for capacity enhancement. The current description of class 3 is very narrow; hence we propose to make it broader.*Class 3 (Partial frequency sounding): Supports more flexible configuration on SRS frequency resources to allow partial frequency SRS transmission and frequency sparse SRS (e.g. comb8).*On the evaluation and specification language of proposal 5-1, we would like to add clarification note that the decision of the specification is based on UL/DL performance considerations (e.g. DL performance improvement). |
| Lenovo/MotM | We are fine to discuss and evaluate it.  |
| ZTE | We agree with the definition and the revision from Futurewei. On Comb 8, I think it is within the scope as given in the updated definition from Futurewei. The partial frequency resource can be RB level or subcarrier level. So there is no need to list it separately. On the revision from Qualcomm, could you please give an example that the updated definition from Futurewei cannot cover what you have in mind? In our view, Futurewei’s definition is clearer, and it is broad enough. |
| Intel | Fine with discussing it. |
| Sharp | We are fine to discuss this. |
| Sony | Fine to discuss it. |
| LGE | We are fine to discuss it. |
| InterDigital | Support the proposal. For partial sounding, depending on the design, we may need to check PAPR as part of evaluation. |
| vivo | We are fine to further study different options. |
| Nokia/NSB | Not support. We prefer to clarify the use case and potential benefits first. We also have concerns on PAPR issue.  |
| CATT | We are fine to introduce a clear definition, and further study its performance.  |
| Ericsson | The revised categorization seems OK. OK to study and evaluate the options. |

# References

[1] RP-193133, New WID: Further enhancements on MIMO for NR, Samsung

[2] Offline email discussion on FeMIMO evaluation methodology: Item 3

[3] R1-2005247, Enhancements on SRS for Rel-17, Huawei, HiSilicon

[4] R1-2005288, Enhancements on SRS flexibility, coverage and capacity, FUTUREWEI

[5] R1-2005368, Discussion on SRS enhancement, vivo

[6] R1-2006963, Enhancements on SRS flexibility, coverage and capacity, ZTE

[7] R1-2005487, Discussion on SRS Enhancements, InterDigital, Inc.

[8] R1-2005565, Considerations on SRS flexibility, coverage and capacity, Sony

[9] R1-2005622, Enhancements on SRS flexibility, coverage and capacity, MediaTek Inc.

[10] R1-2005688, Discussion on enhancements on SRS flexibility, coverage and capacity, CATT

[11] R1-2005754, Discussion on SRS enhancement, NEC

[12] R1-2005824, Enhancements on SRS, Lenovo, Motorola Mobility

[13] R1-2005863, Discussion on SRS enhancements, Intel Corporation

[14] R1-2005988, Enhancements on SRS flexibility, coverage and capacity, OPPO

[15] R1-2006133, Enhancements on SRS, Samsung

[16] R1-2006205, Enhancements on SRS flexibility, coverage and capacity, CMCC

[17] R1-2006255, Considerations on SRS enhancement, Spreadtrum Communications

[18] R1-2006364, Discussion on enhancement of SRS in Rel. 17 further enhanced MIMO, CEWiT

[19] R1-2006504, Views on Rel-17 SRS enhancement, Apple

[20] R1-2006568, Enhancement on SRS, Sharp

[21] R1-2006601, Enhancements on SRS flexibility, coverage and capacity, LG Electronics

[22] R1-2006610, SRS Performance and Potential Enhancements, Ericsson

[23] R1-2006723, Discussion on SRS enhancement, NTT DOCOMO, INC.

[24] R1-2006795, Enhancements on SRS flexibility, coverage and capacity, Qualcomm Incorporated

[25] R1-2006848, Enhancements on SRS in Rel-17, Nokia, Nokia Shanghai Bell