3GPP TSG RAN WG1 Meeting #106-e R1-2108512

**e-Meeting, Aug. 16th – 27th, 2021**

**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*

Previous RAN1 agreements on these SRS enhancements are given in Section 6.1.

In this contribution, we summarize companies’ views on the issues with wide interest after the two rounds of discussion in RAN1#106e.

# Flexibility enhancements

## SRS triggering offset

### 2.1.1. Collision handling

***FL Proposal 2-2:*** *Introduce dropping rule when collision happens among multiple aperiodic SRS resource sets in a same CC or different CCs.*

* *FFS the priority rule considering usage, order of triggering DCI, CC ID and set ID, whether the SRS is the Rel-17 flexible SRS, etc.*
* *FFS collision handling among Rel-17 flexible SRS and other UL channels/signals*
* *FFS whether to restrict this rule is only applicable to SRS resource sets triggered by a same DCI or different DCIs*
* *Note: strive for a unified rule for single-CC and multi-CC cases*

The above proposal has been discussed in the first round. Companies’ views are summarized as given below.

Support: Qualcomm, ZTE, Ericsson, Intel, vivo, Futurewei, Huawei/HiSilicon, Spreadtrum, CATT, China Telecom, Nokia/NSB, NEC, NTT DOCOMO, Xiaomi, InterDigital

Concern: OPPO, LGE

FL would like to check whether companies with concern can follow majority view to address the issue when multiple SRS resource sets collide in time domain.

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| InterDigital  | Support |
| Futurewei | Support |
| Huawei, HiSilicon | Support |
| QC | Support |
| Lenovo/MotM | We still cannot understand the collision scenario that different SRS resource sets are triggered by a same DCI.*FL’s response:* This can be further discussed based on the FFS bullet. At least we see companies’ interest on SRS resource sets triggered by one DCI. If an approach can be used to solve both cases, I see no issue but only benefit to address these collisions all together. |
| DOCOMO | Support. |
| Ericsson | Support. To Lenovo: if RAN1 cannot find a collision case, then RAN1 don’t need to do anything.  |
| OPPO | Not support. We would like to know the use case and the probability of the collision before we can make any decision. As a compromise, we can agree to further study the feature and hope to see detailed justification/motivation of this feature. |
| LGE | Not support. As commented by Lenovo/MotM and OPPO, we also think that the motivation of this proposal is unclear since there have been no such collision handling rule in Rel-15/16. We don’t typically define collision handling rule between aperiodic resources since they are totally under control of gNB. Why gNB cannot avoid this collision? |
| Xiaomi | Agree with E///, we are open for discussion on this issue.  |
| CATT | Since whether dropping rules would be defined for one or both of single-CC case or multi-CC case is FFS, the note in the proposal should be FFS. |
| Intel | Support FL proposal. |
| Nokia/NSB | Support. |
| Futurwei2 | Again we support the proposal. Since some companies commented that collisions among A-SRSs are avoidable by gNB implementations, we think we should enlarge the scope to also include “*collision handling among Rel-17 flexible SRS and other UL channels/signals*”. |
| vivo | Support FL proposal |

## Flexible DCI format

**Re-purpose**

Based on the agreement of using DCI 0\_1/0\_2 to trigger SRS without data and without CSI request, companies propose the following schemes to repurpose unused fields in these DCI fields to indicate SRS parameters dynamically.

Table 2-1

|  |
| --- |
| **Repurpose unused fields in DCI format 0\_1/0\_2 without data and without CSI** |
| Categories | Detailed alternatives | Companies |
| CAT-A (Time-domain parameters) * 10 supporting companies: ZTE, MediaTek, Ericsson, NTT DOCOMO, Xiaomi, Samsung, CATT, vivo, LGE, Futurewei
 | A-1: Indication of available slot position, i.e., the t values  | ZTE, MediaTek, Ericsson, NTT DOCOMO, Xiaomi, Samsung, CATT |
| A-2: Indication of slot offset  | vivo |
| A-3: Indication of SRS symbol-level offset  | LGE, Futurewei |
| A-4: Indication of time-domain behavior for SRS transmission over multiple OFDM symbols, e.g., repetition, hopping, and/or splitting  | Futurewei |
| CAT B (Frequency-domain parameters)* 7 supporting companies: Qualcomm, Futurewei, Xiaomi, Ericsson, LG, Intel, CMCC
* 1 company has concern
 | B-1: Indication of a group of CCs for SRS transmission | Qualcomm, Xiaomi |
| B-2: Indication of frequency domain resource in a BWP for SRS transmission | Ericsson, CMCC, LGE, Xiaomi, Futurewei |
| B-3: Indication of whether DL/UL BWP is applied for SRS transmission | Intel |
| Do not support this category | vivo |
| CAT C (Power control parameters)* 5 supporting companies: Qualcomm (for each CC), Futurewei, Intel, Xiaomi, Huawei/HiSilicon
* 2 companies have concern
 | C-1: Re-purpose ‘TPC command for PUSCH’ as ‘TPC command for SRS’ | Qualcomm (for each CC), Intel, Xiaomi, Futurewei |
| C-2: Indication of open loop power control parameter e.g., p0. | Huawei/HiSilicon |
| Do not support this category | CMCC, vivo |
| CAT D (Spatial-domain parameters, i.e., indication of SRS port and beamforming)* 1 supporting company: Futurewei
* 1 company has concern
 | Re-purpose CSI-RS/TPMI indication to indicate SRS spatial-domain parameters | Futurewei |
| Do not support this category | CMCC |
| CAT E (Extend the number of DCI codepoints for aperiodic SRS trigger states)* 4 supporting companies: Futurewei, Intel, Xiaomi, NTT DOCOMO
 | Extend the number of DCI codepoints for aperiodic SRS trigger states | Intel, NTT DOCOMO, Xiaomi, Futurewei |
| New functionalities | Re-purpose to indicate set usage | Spreadtrum |
| No or deprioritize | - | Apple, OPPO, Lenovo/MotM, InterDigital, NEC |

***FL Proposal 2-5:*** *Further discuss the issue of repurposing DCI field(s) for SRS parameter indication until RAN1#106bis-e, focused on CAT A – CAT E agreed in RAN1#104e. If no consensus can be achieved, conclude this issue as following.*

* *No repurpose of DCI field(s) is supported for SRS parameter indication in Rel-17.*

Support: Qualcomm, CATT, CMCC, Nokia/NSB, Lenovo/MotM, Samsung, OPPO, Apple, ZTE, Intel, Futurewei

This proposal is updated based on Futurewei’s comment in previous round. FL would like to thank Futurewei for the willingness to compromise. FL thinks it is a good compromise between the two alternative proposals in last round.

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| InterDigital  | We don’t see a strong motivation for this proposal at this time. |
| Futurewei | Support@InterDigital: We think the motivation is exactly the flexibility described by WID “*enhancements on aperiodic SRS triggering to facilitate more flexible triggering*”. We do not see any reason not to further discuss this and try to reach an agreement until the next meeting. |
| Huawei, HiSilicon | Support in principle, but has concerns on the second subbullet. For the subbullet “*Extend the number of DCI codepoints for aperiodic SRS trigger states*”, we may concern it, since 2 bits are agreed to be added for SP-SRS triggering for with/without data scheduling cases. Why use more code-point of AP-SRS triggering for non-data scheduling case?  |
| QC | Still think that we need to agree on the functionality first then decide whether to reuse/redesign bitfields, but also fine to continue the discussion. Suggest adding carrier indicator field.* *Reuse one or more existing DCI fields configured for data transmission for SRS parameter indication without changing the field bitwidths/parameters, e.g., TPC command field, bandwidth part indicator field, FDRA field, carrier indicator field.*

@Futurewei, we would like to clarify how the BWP field used for flexible A-SRS triggering? Would it trigger BWP switching and trigger A-SRS on the new BWP or something else?  |
| Lenovo/MotM | Share the similar concern on the second bullet to extend the number of SRS request codepoints. |
| DOCOMO | Support.@Huawei/Lenovo, total DCI size is unchanged irrespective of whether data/CSI exists. For example, if there is unused 1-bit field, when there is no data/CSI, 3-bit can be used for SRS request triggering (illustrated as below figure). Using large number of SRS request field size has more flexibility to indicate SRS resource set(s), when there is no data/CSI. We hope, this clarified. |
| *FL* | To companies who have concern on extending SRS trigger codepoints, this was one of the categories to be studied, i.e., CAT E. I see no issue to continue the study if we want to continue discussing this repurposing till next meeting. To address your concern, I further revise the two subbullets and make it more consistent with what we have agreed.  |
| Ericsson | Agree with Qualcomm that we should discuss a needed functionality first. As indicated, we have most interest in A-1 and B-2.  |
| OPPO | “*focused on CAT A – CAT E agreed in RAN1#104e*” seems unnecessary since it precludes nothing |
| LGE | OK with updated proposal. |
| Xiaomi | Fine with the proposal but it’s more focused on “no consensus” now. |
| CATT | Support. |
| Intel | Fine with FL proposal in principle. Agree with OPPO that “*focused on CAT A – CAT E agreed in RAN1#104e*” can be removed since it’s further discussion.In addition, we think it’s important to make sure that the feature of triggering SRS via DCI 0\_1/0\_2 without data can work properly even without re-purposing DCI field. We suggest RAN1 further discuss the following questions for SRS triggered by DCI 0\_1/0\_2 without data.1. How to determine the transmit power for the triggered SRS?2. What’s the UE behavior regarding the BWP indicator field? |
| Nokia/NSB | Support the FL proposal. We are fine to discuss this further in the upcoming meeting. |
| Futurewei2 | Fine with he updated FL proposal, though we prefer to have some focus. As now the scope is larger, we suggest to slightly relax the ‘no consensus’ part to ‘*If no high-level consensus can be achieved*’. Details can be worked out afterwards.We think the questions asked by Intel is important, which could be part of the repurposing design. @QC: Yes, that is our understanding, which is related to Intel’s discussions in the 1st round and their question in this round. We are open to other understandings from the group. |
| vivo | Fine with updated proposal |

## Flexible antenna switching

***FL proposal 2-6:*** *Support gNB indicating the used SRS resources from the configured SRS resources in SRS resource set(s) for antenna switching via MAC CE.*

* *Applicable to at least one of the following two cases*
	+ *Case 1: aperiodic SRS*
	+ *Case 2: periodic or semi-persistent SRS*
* *Support UE reporting of one preferred antenna switching configuration*
* *The gNB indicated or UE reported antenna switching configuration belongs to the supported antenna switching reported by UE capability signaling*
* *FFS whether DCI can be additional used to indicate the used antenna switching configuration*
* *Note: Any change on the configured number of Tx antennas in each SRS resource is precluded in either the gNB indication or UE reporting*

Support: Qualcomm, Ericsson, Xiaomi, Huawei/HiSilicon, ZTE, Lenovo/MotM, Futurewei, InterDigital, NTT DOCOMO, Nokia/NSB, OPPO

Concern: -

It seems companies begin to converge on the support of this functionality. If we only use MAC CE to do the indication and reporting, the rest of work in RAN1 is limited. FL would like to check whether the above proposal is acceptable to companies.

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| InterDigital  | Support |
| Futurewei | It seems the note we added on resolving the CSI issue is not included. We think it is a real issue but we can be flexible here. We’d like to confirm with the group that the CSI issue can be discussed and would not be viewed as “out of scope” in future. |
| Huawei, HiSilicon | Support the UE reporting and MAC-CE on Rx number switching. But, we need restrict on the switching only for Rx number switching. As we clarified many times, the Tx switching dynamically is very difficult, which need RF chains switching dynamically. So, we need to discuss the Tx switching in RAN4 first. Then, for the comment how to capture “Rx only”, it can be left to editor.So, please restrict “Rx only” in the main bullet and UE report.*FL’s response:* The current main bullet only talks about the update of SRS resources in a resource set. Following this way, there is no possibility to change the number of Tx as it requires to change the number of ports in a resource. Hence my understanding is the current version already restricts that there is only Rx number change. But anyway, a note is added to address your concern. |
| QC | Support and fine to restrict to ‘Rx only’. Also suggest to later discuss the UE reporting mechanism. * *Support UE reporting of one preferred antenna switching configuration ~~via MAC CE~~*
 |
| Lenovo/MotM | We also think it is too earlier to support UE capability reporting via MAC CE.* *Support UE reporting of one preferred antenna switching configuration ~~via MAC CE~~*
 |
| DOCOMO | Support. |
| Ericsson | Support FL proposal. Ok with the clarification by Huawei.  |
| OPPO | We are fine with the note suggested by Huawei.@QC, Lenovo: What kind of signaling is preferred in your mind? DCI or RRC? |
| Xiaomi | We agree with Futurewei that the FFS part on CSI issues should be added since dynamic adaptation of either Rx antennas or antenna switching configurations needs further study.According to the added note, it is too restricted in our view, UE can report the antenna switching configuration, and the scheduler may even take this into account for scheduling not only limited to Rx antenna switching, but also for a BWP switching scheduling or RRC reconfiguration… so the following is suggested, * *Note: Any change on the configured number of Tx antennas in each SRS resource is precluded in the gNB indication*

Or we can put it into FFS since other schemes like DCI schemes are still FFS, and try to have consensus in next meeting.* *FFS: Any change on the configured number of Tx antennas in each SRS resource is precluded in either the gNB indication or UE reporting*

Anyway, the UE reporting is only for reference to the gNB, more information should help both for the UE and the gNB.*FL’s response:* If the gNB indication can only change the number of Rx antennas, i.e., the number of SRS resources, what is the point for UE to report the number of Tx antennas? Hence it’s better to keep the note. Further, from FL perspective, it is useful to scope the potential discussion of further details, considering we only have two meetings left. Hope it is understandable.  |
| CATT | Support FL’s proposal. |
| Intel | Fine with FL proposal. |
| Nokia/NSB | Support the FL proposal.  |
| Futurewei2 | We support the note added by Huawei. We also suggest to add another note: * Note: Antenna switching leading to the configured number of Rx antennas less than the configured number of Tx antennas is precluded in either the gNB indication or UE reporting

We think this should obvious and there should not be any objection.Once again our preference is to have the CSI issue listed (this is also supported by Xiaomi). It seems that so far companies are fine with our understanding that the CSI issue can be discussed and is within the scope.  |
| vivo | One clarification, is MAC CE indication only for the UE reporting antenna switching combo in Rel-15/16? Or is it also supported the UE reporting only one antenna switching capability say {1t4r}? |
| *FL* | Clarify that both gNB indicated and UE reported configuration should belong to the ones that supported by UE capability, and promote this as a higher-level bullet. This can address the question from vivo. Meanwhile, it can also solve the concern from Futurewei on the possibility of having fewer Rx antennas than Tx antennas.@Futurewei, On the previous FFS point about CSI, several companies like CATT and OPPO cannot accept it. Let’s do not add it considering it is anyway an FFS point. To remove it doesn’t preclude companies to discuss it in future meetings. |

# Antenna switching up to 8Rx

## Extension for aperiodic SRS with <=4Rx

The following FL proposal has been discussed in the previous two rounds.

***FL Proposal 3-2:*** *For extension of antenna switching SRS configurations for <=4Rx, support N=4* *for 1T4R and N=2 for 1T2R/2T4R.*

Support: Ericsson, Xiaomi, Nokia/NSB, Huawei/HiSilicon, CATT, Intel, ZTE, NTT DOCOMO

Concern: OPPO, Lenovo/MotM, Apple, vivo

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| InterDigital  | We don’t see a strong motivation for this proposal at this time. |
| Huawei, HiSilicon | Support. In the cases, only two symbols in S slot for SRS transmission, it will be difficult to switching antennas in a slot. |
| Lenovo/MotM | We still think it’s out of R17 feMIMO WID scope and the benefit is not clear. Considering the scenario that only 2 UL symbols in a slot, at least 4 continuous slots are required for SRS AS transmission for DL channel acquisition. We are not sure the estimated channel matrix is still effective.  |
| DOCOMO | Support. |
| Ericsson | Support, as some operators are using X:Y:2 special slot pattern and cannot utilize the 2 UL symbols for SRS. To Lenovo, it is still useful, even if the SRS is spread out over 4 slots. The alternative is to leave these 2 symbols empty and use the UL slot, which reduces the UL capacity significantly, |
| OPPO | From the technical point of view, we have the following comments* we don’t think the 2 UL symbols in special slots will be wasted. They can still be used for SRS associated with PUSCH.
* With the penetration rate of 5G subscribers increases, only two symbols in special slots cannot provide sufficient SRS capacity. Thus, the network will have to allocate more symbols for SRS. In this sense, the current R15 configuration is future-proof.
* More sets for antenna switching will lead to long latency and the outdated channel state information will degrade the DL performance

On the other hand, we got more information during the offline discussion with Ericsson. And it will take us some time to double check the status with some operator. Thus, we hope to postpone the decision to the next meeting if possible.  |
| Xiaomi | support |
| CATT | Support. Allocating SRS resources in more slots is useful for the scenarios that UL resources are scarce.  |
| Intel | Support FL proposal. |
| Nokia/NSB | Support the FL proposal. Share the same view with Ericsson, this is useful enhancement to improve UL capacity. |

# Conclusion

**Repurposing**

***FL Proposal 2-5:*** *Further discuss the issue of repurposing DCI field(s) for SRS parameter indication until RAN1#106bis-e, focused on CAT A – CAT E agreed in RAN1#104e. If no consensus can be achieved, conclude this issue as following.*

* *No repurpose of DCI field(s) is supported for SRS parameter indication in Rel-17.*

**Flexible antenna switching**

***FL proposal 2-6:*** *Support gNB indicating the used SRS resources from the configured SRS resources in SRS resource set(s) for antenna switching via MAC CE.*

* *Applicable to at least one of the following two cases*
	+ *Case 1: aperiodic SRS*
	+ *Case 2: periodic or semi-persistent SRS*
* *Support UE reporting of one preferred antenna switching configuration*
* *The gNB indicated or UE reported antenna switching configuration belongs to the supported antenna switching reported by UE capability signaling*
* *FFS whether DCI can be additional used to indicate the used antenna switching configuration*
* *Note: Any change on the configured number of Tx antennas in each SRS resource is precluded in either the gNB indication or UE reporting*

# Appendix

## Previous agreements

Table 6-1

|  |
| --- |
| **RAN1#102e****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.

**Agreement**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..

**Agreement**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..

**Agreement**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..

**Agreement**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..

**RAN1#103e****Agreement**A given aperiodic SRS resource set is transmitted in the (t+1)-th available slot counting from a reference slot, where t is indicated from DCI, or RRC (if only one value of t is configured in RRC), and the candidate values of t at least include 0. Adopt at least one of the following options for the reference slot.* Opt. 1: Reference slot is the slot with the triggering DCI.
* Opt. 2: Reference slot is the slot indicated by the legacy triggering offset.
* FFS the detailed definition of “available slot” considering UE processing complexity and timeline to determine available slot, potential co-existence with collision handling, etc., e.g.,
	+ Based on only RRC configuration, “available slot” is the slot satisfying: there are UL or flexible symbol(s) for the time-domain location(s) for all the SRS resources in the resource set and it satisfies the minimum timing requirement between triggering PDCCH and all the SRS resources in the resource set
* FFS explicit or implicit indication of t
* FFS whether updating candidate triggering offsets in MAC CE may be beneficial

**Agreement**Support at least DCI 0\_1 and 0\_2 to trigger aperiodic SRS without data and without CSI.* FFS whether/how to re-purpose the unused fields, e.g., the triggering offset(s) and the frequency resources for triggering A-SRS on one or more component carriers, SFI-index, etc.
* FFS UL/DL DCI with data for aperiodic SRS
* FFS group common DCI

**Agreement**In Rel-17 SRS coverage and capacity enhancement, support at least one scheme from Class 2 and Class 3, and deprioritize Class 1.* Note: Extensions of Rel-15/16 frequency hopping are included in Classes 2 and 3, e.g. where UE hops once per symbol within a Rel-17 SRS resource.

**Agreement**Candidate schemes for Class 2:* Scheme 2-0: Increase the number of repetition symbols in one slot
* Scheme 2-1: Inter-slot repetition on consecutive symbols or non-consecutive symbols across slots
* Scheme 2-2: Repetition with TD-OCC
* Scheme 2-3: Repetition with CS hopping

Candidate schemes for Class 3:* Scheme 3-1: RB-level partial frequency sounding
* Scheme 3-2: Subcarrier-level partial frequency sounding
* Scheme 3-3: Subband-level partial frequency sounding
* Scheme 3-4: Partial-frequency sounding schemes assisted with CSI-RS, where SRS is transmitted in a subset of RBs of the original SRS frequency resource
* Scheme 3-5: Dynamic change of SRS bandwidth with RB-level subband size scaling
* Note: Consider issues like gNB receiver complexity, PAPR, etc., with above schemes
* Note: Joint operation between Class 2 and Class 3 schemes can be considered

**Agreement**For antenna switching up to 8Rx, support SRS resource configurations for {1T6R, 1T8R, 2T6R, 2T8R, [4T6R], 4T8R}.**RAN1#104e****Agreement**For Rel-17 SRS capacity and coverage enhancement, support the following* Increase the maximum number of repetition symbols in one slot and one SRS resource to S
	+ Support at least one S value from {8, 10, 12, 14}
		- FFS other candidate values
* Support to transmit SRS only in $\frac{1}{P\_{F}}m\_{SRS,B\_{SRS}}$ contiguous RBs in one OFDM symbol, where$m\_{SRS,B\_{SRS}}$  indicates the number of RBs configured by BSRS and CSRS
	+ Support at least one PF value from {2, [3], 4, 8}
		- FFS other candidate values, e.g., non-integer values for PF
	+ Note: SRS sequence shorter than the minimum length supported in the current specification is not pursued.
	+ No new sequence including length is introduced
	+ FFS it is applicable to frequency hopping and non-frequency hopping
	+ FFS detailed signaling mechanism to determine PF and the location of the $\frac{1}{P\_{F}}m\_{SRS,B\_{SRS}}$ RBs
* Support Comb 8
	+ Note: SRS sequence shorter than the minimum length supported in the current specification is not pursued.
* FFS whether and if needed, how to use harmonized approach to define the three supported schemes
* Note: other schemes for SRS capacity and coverage enhancements are not supported in Rel-17.

**Agreement*** For aperiodic antenna switching SRS, support to configure N <=N\_max resource sets, where totally K resources are distributed in the N resource sets flexibly based on RRC configuration.
	+ For 1T6R, K=6, N\_max = [4], and each resource has 1 port.
	+ For 1T8R, K=8, N\_max = [4], and each resource has 1 port.
	+ For 2T6R, K=3, N\_max = [3], and each resource has 2 ports.
	+ For 2T8R, K=4, N\_max = [4], and each resource has 2 ports.
	+ (Working Assumption) For 4T8R, K=2, N\_max = [2], and each resource has 4 ports.
	+ FFS the number of supported candidate values of N for each xTyR.
* FFS extension to increase N\_max for 1T4R, 2T4R, T=R and 1T2R cases for aperiodic, periodic and semi-persistent SRS resources
* FFS the number of resources and resource sets for semi-persistent and periodic antenna switching SRS
* Note: SRS could be transmitted over the last 6 OFDM symbols, or over any OFDM symbols within the slot subject to UE capability.

**Agreement**Further study whether and if needed, how to achieve further enhancements on aperiodic SRS triggering and resource management based on repurposing unused fields in DCI format 0\_1/0\_2 without data and without CSI. Consider the following examples* CAT A: Time-domain parameters
	+ A-1: Indication of available slot position, i.e., the t values
	+ A-2: Indication of slot offset
	+ A-3: Indication of SRS symbol-level offset
	+ A-4: Indication of time-domain behavior for SRS transmission over multiple OFDM symbols, e.g., repetition, hopping, and/or splitting
* CAT B: Frequency-domain parameters
	+ B-1: Indication of a group of CCs for SRS transmission
	+ B-2: Indication of frequency domain resource in a BWP for SRS transmission
	+ B-3: Indication of whether DL/UL BWP is applied for SRS transmission
* CAT C: Power control parameters
	+ C-1: Re-purpose ‘TPC command for PUSCH’ as ‘TPC command for SRS’
		- FFS impact on power control, impact from triggering a group of CCs for SRS
	+ C-2: Indication of open loop power control parameter e.g., p0.
* CAT D: Spatial-domain parameters, i.e., indication of SRS port and beamforming
* CAT E: Extend the number of DCI codepoints for aperiodic SRS trigger states
* Other examples are not precluded

**Agreement**A list of t values is configured in RRC for each SRS resource set. Adopt at least one of the following for DCI indication of t.* In DCI format 0\_1/0\_2 without data and without CSI request,
	+ Alt 1-1: Reuse the same scheme used for DCI format 0\_1/0\_2/1-1/1-2 that schedules a PDSCH or PUSCH
	+ Alt 1-2: Re-purpose unused DCI field to indicate t
	+ Alt 1-3: t is indicated by a configurable DCI field, where the DCI field may contain bits from unused fields and additional bits configured by gNB
		- FFS design details with other potential field(s)
	+ FFS: whether t can be slot offset
* In DCI format 0\_1/0\_2/1-1/1-2 that schedules a PDSCH or PUSCH
	+ Alt 2-1: t is indicated by adding a new configurable DCI field
	+ Alt 2-2: t is indicated without adding DCI payload
* Note: The size of DCI payload does not change dynamically
* Note: RAN1 should strive for unified solution for different DCI formats.
* FFS: The number of RRC configured t values per SRS resource set and DCI bit field size.

**Agreement**Confirm the following working assumption with modificationsAn “available slot” is a slot satisfying there are UL or flexible symbol(s) for the time-domain location(s) for all the SRS resources in the resource set and it satisfies UE capability on the minimum timing requirement between triggering PDCCH and all the SRS resources in the resource set.* From the first symbol carrying the SRS request DCI and the last symbol of the triggered SRS resource set, UE does not expect to receive SFI indication, UL cancellation indication or dynamic scheduling of DL channel/signal(s) on flexible symbol(s) that may change the determination of “available slot”.
* Note: Collision handling between the triggered SRS and any other UL channel/signal is performed after the determination of available slot.
* FFS: Rules to handle the case of multiple SRS resource sets with overlapping symbols and/or triggered by a same DCI

**RAN1#104bis-e****Agreement**For increased repetition in Rel-17, support the following N\_symbol (number of OFDM symbols in one SRS resource) and R (repetition factor) values* N\_symbol = 8, R = {1, 2, 4, 8}
* N\_symbol = 12, R = {1, 2, [3], 4, 6, 12}
* FFS the following configurations
	+ N\_symbol = 10, R = {1, 2, 5, 10}
	+ N\_symbol = 14, R = {1, 2, 7, 14}
* FFS options to reduce SRS BW for R>1

**Agreement**On aperiodic SRS configuration for antenna switching with > 4Rx, support the following N\_max values* 1T6R: N\_max = 3
* 1T8R: N\_max = 4
* 2T6R: N\_max = 3
* 2T8R: N\_max = 4
* [4T8R: N\_max = 2]
* The support of N\_max value does not imply the support of N value that is smaller than N\_max. This is FFS.
* FFS whether further enhancement for single-DCI or multi-DCI based MTRP is needed

**Agreement**For RB-level partial frequency sounding (RPFS) in Rel-17* The start RB index of the $\frac{1}{P\_{F}}m\_{SRS, B\_{SRS}}$ RBs in the $m\_{SRS, B\_{SRS}}$ RBs is $N\_{offset}=\frac{k\_{F}}{P\_{F}}m\_{SRS, B\_{SRS}}$, where kF = {0, …, PF-1}
	+ FFS support start RB location (Noffset) hopping in different SRS occasions, symbols or frequency hopping periods, and if supported, detailed hopping pattern
* Support to determine PF and Noffset at least via RRC configuration per SRS resource.
	+ FFS whether to introduce DCI and/or MAC CE in addition

**Working Assumption**For DCI indication of “t” in Rel-17 SRS triggering offset enhancement* For both DCI that schedules a PDSCH/PUSCH and DCI 0\_1/0\_2 without data and without CSI request
	+ t is indicated by adding a new configurable DCI field (up to 2 bits)
		- Applies only when there are multiple candidate values of t configured
	+ No further enhancement to indicate “t” for DCI 0\_1/0\_2 without data and without CSI request at least when the new DCI field is configured

**Agreement**On supported values of N for Rel-17 aperiodic SRS antenna switching with >4Rx, down-select at least one of the following alternatives in RAN1#105e* Alt 1: All the non-zero integer values <= N\_max are supported for N
* Alt 2: Support N=N\_max only
* Alt 3: Support specific N values <= N\_max
* FFS whether different alternatives may be selected for the same xTyR configuration subject to the UE capability on maximum number of symbols that can be used for SRS in a slot
* FFS: whether different alternatives may be selected for different xTyR configuration

**Agreement**Study the maximum number of cyclic shifts for Comb-8 in Rel-17, with the following alternatives as starting points* Alt 1: The maximum number of CSs for Comb-8 is 6
* Alt 2: The maximum number of CSs for Comb-8 is 12, and introduce a rule to restrict applicable CSs when SRS sequence is shorter than the maximum number of CSs

**Agreement*** Up to 4 “t” values can be configured per SRS resource set.

**Agreement*** For RPFS in Rel-17, support PF = {2, 4}.
* FFS 3, 8, 12, 16 or fractional numbers
* Support at least one of the following alternatives (to be decided in RAN1#105-e)
	+ Alt 1: $\frac{1}{P\_{F}}m\_{SRS, B\_{SRS}}$$\frac{1}{P\_{F}}m\_{SRS, B\_{SRS}}$ is an integer value
	+ Alt 2: $\frac{1}{P\_{F}}m\_{SRS, B\_{SRS}}$$\frac{1}{P\_{F}}m\_{SRS, B\_{SRS}}$ is an integer value with minimum value 4
	+ Alt 3: $\frac{1}{P\_{F}}m\_{SRS, B\_{SRS}}$ is a multiple of 4
	+ Alt 4: Round $\frac{1}{P\_{F}}m\_{SRS, B\_{SRS}}$$\frac{1}{P\_{F}}m\_{SRS, B\_{SRS}}$ to a multiple of 4 in case of Alt 1 or Alt 2

**Agreement**On aperiodic SRS configuration for antenna switching with 4T8R, support N\_max = 2**Agreement**For RPFS SRS in Rel-17, adopt one of the following alternatives for sequence generation, where no new sequence length other than the ones supported in the current spec is introduced (to be decided in RAN1#105-e)* Alt 1: Generate length- $\frac{12}{Comb⋅P\_{F}}m\_{SRS, B\_{SRS}}$$\frac{\frac{12}{P\_{F}}m\_{SRS, B\_{SRS}}}{Comb}$ ZC sequence
* Alt 2: Truncate from legacy length-$\frac{12}{Comb}m\_{SRS, B\_{SRS}}$$\frac{12⋅m\_{SRS, B\_{SRS}}}{Comb}$ sequence according to the location of RPFS SRS

**Agreement**For antenna switching, support one of the following * Alt 1: Support maximum one SRS resource set for periodic SRS and maximum one SRS resource set for semi-persistent SRS
* Alt 2: Support up to two semi-persistent SRS resource sets in addition to a periodic SRS resource set
	+ Note: the two SP-SRS resource sets are not activated at the same time.
* FFS whether further enhancement for single-DCI or multi-DCI based MTRP is needed
* FFS whether configurations on SRS repetitions have impact
* FFS relevant UE capability design

**RAN1#106-e****Agreement**Confirm the following WA.For DCI indication of “t” in Rel-17 SRS triggering offset enhancement* For both DCI that schedules a PDSCH/PUSCH and DCI 0\_1/0\_2 without data and without CSI request
	+ t is indicated by adding a new configurable DCI field (up to 2 bits)
		- Applies only when there are multiple candidate values of t configured
	+ No further enhancement to indicate “t” for DCI 0\_1/0\_2 without data and without CSI request at least when the new DCI field is configured

**Agreement**Support start RB location (*Noffset*) hopping in different SRS frequency hopping periods for RPFS and at least periodic/semi-persistent SRS, where *Noffset* is the start RB index of the $\frac{1}{P\_{F}}m\_{SRS, B\_{SRS}}$ RBs in the $m\_{SRS, B\_{SRS}}$ RBs.* For a given SRS transmission occasion, $N\_{offset}=\frac{\left(k\_{F}+k\_{hopping}\right) mod P\_{F}}{P\_{F}}m\_{SRS, B\_{SRS}}$ , where $k\_{hopping}$ is same for all SRS occasions within a legacy FH period but changes across legacy FH periods, kF and PF are at least configured by RRC signaling (kF = {0, 1, …, PF-1}).
	+ Support at least one pattern for $k\_{hopping}$ in time domain, FFS detailed pattern
	+ Note: the legacy FH period is the period to sound the full SRS hopping bandwidth across the different subbands of $m\_{SRS, B\_{SRS}}$ RBs each.
* This start RB location hopping is enabled or disabled by RRC signaling.
	+ FFS whether MAC CE or DCI can be additionally used
	+ When this start RB location hopping is disabled, $k\_{hopping}$ is fixed to be 0 for all SRS symbols
* This start RB location hopping is UE optional.
* FFS whether start RB location hopping is also applicable on SRS occasion(s) within one FH period (e.g., when R>1) and/or on aperiodic SRS, if so, how

**Agreement**For aperiodic xTyR antenna switching SRS, where xTyR is from {1T6R, 1T8R, 2T6R, 2T8R, 4T8R}, support all the non-zero integer values N<=N\_max except N=1 for 1T8R * For each xTyR configuration, UE does not expect multiple SRS resource sets are configured or triggered in one slot
* UE does not expect that the OFDM symbols contained in one SRS resource set exceed UE capability on which OFDM symbols can be used for SRS taking guard period into account

**Agreement**Support Opt. 2: Reference slot is the slot indicated by the legacy triggering offset.* If DCI is transmitted in slot n, and k is the legacy triggering offset, reference slot is slot n+k.
* Note: the legacy triggering offset can be 0, if slotOffset is absent.

**Conclusion**Do not support MAC CE for t value update in Rel-17. |