**3GPP TSG-RAN WG2 Meeting #123 R2-23xxxxx**

**Toulouse, France, August 21 – 25, 2023**

**Source: Samsung**

**Title: Report of [Post122][852][MIMOevo] 2TAs for multi-DCI multi-TRP**

**Agenda item:** **xxxx**

**Document for:** **Discussion and Decision**

# Introduction

This document records inputs and outcome for the following post-meeting discussion.

* [Post122][852][MIMOevo] RAN2 impacts of 2TAs for multi-DCI multi-TRP (Samsung)

 Scope: Long email discussions after the meeting, taking into account a) potential RAN1 reply to the previous R2 LS, and b) controversial/unclear aspects discussed during this RAN2 meeting.

 Intended outcome: Email discussion report with proposals, trying to align the understanding regarding the procedure of 2TAs and its impact from RAN2 point of view

 Intermediate Deadline for initial views: June 29th 1000 UTC

 Final Deadline for proposals: August 9th 1000 UTC

Contact information:

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# Discussion

On 2TA for multi-DCI multi-TRP, it has been agreed that 2 TAGs are configured for 2 TAs of a serving cell, with one TAT per TAG.

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| RAN2#122 Agreement [1]:* Configure one TAT per TAG to support two TAs for a serving cell, i.e., in this case 2 TAGs are configured for the serving cell.
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For discussion here, TAG1/TAT1 for TRP1 and TAG2/TAT2 for TRP2 are used to denote the two TAGs/TATs and two TRPs.

## TAG configuration

### Restriction on the association of cells/TRPs to TAGs

One issue is that whether there is any restriction on the association of serving cells/TRPs to TAGs. RAN2 has sent an LS R2-2304342 in RAN2#121bis-e and received the reply R1-2306249 in RAN2#122 [2] [3].

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| **Question 1 on TAG grouping**RAN2 discussed how the cells/TRPs configured for the UE, are to be grouped if UE is configured with two TA groups per serving cell. Currently, NR does not impose any requirements in configuring the association of serving cells and TAGs. **Q1a:** For the 2TA operation, are there any restrictions on the association of serving cells and/or TRPs to the TAGs?**Answer:**  *Apart from the agreements RAN1 has sent in LS R1-2302226 to RAN2 before, RAN1 has not agreed to any further restrictions on the association of serving cells and/or TRPs to the TAGs at this point. If RAN1 agrees to such restrictions, RAN1 will inform RAN2.* |

Based on RAN1 LS reply, the following RAN1 agreements are relevant.

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| RAN1#112 (2023-02) Agreement [4]:For associating TAGs to target UL channels/signals for multi-DCI based multi-TRP operation, support the following:Associate TAG to TCI-state* Associate TAG ID with UL/joint TCI state
* For UL transmission, the TAG ID associated with the UL/joint TCI state is utilized
* A baseline is UE expects that the [activated] UL/joint TCI states [of UL signals/channels] associated to one CORESET Pool Index correspond to one TAG
* Working Assumption: A UE may report that it supports that the [activated] UL/joint TCI states [of UL signals/channels] associated to one CORESETPoolIndex correspond to both TAGs

RAN1#113 (2023-05) Agreement [5]:For associating TAGs to target UL channels/signals for multi-DCI based multi-TRP operation, the baseline feature is revised as follows:* UE expects that the ~~[activated]~~ UL/joint TCI states ~~[~~of UL signals/channels~~]~~ associated to one CORESET Pool Index correspond to one TAG
* Association of TAG ID with UL/joint TCI state is via RRC configuration
	+ Above does not impact the association of the indicated TCI states and coresetPoolIndex values as agreed in previous meetings in 9.1.1.1.

Possible AgreementFor associating TAGs to target UL channels/signals for multi-DCI based multi-TRP operation, confirm or revert the following working assumption:A UE may report that it supports that the [activated] UL/joint TCI states [of UL signals/channels] associated to one CORESETPoolIndex correspond to both TAGs |

According to the above RAN1 agreements, on one aspect of TAG configuration, NW configures the association of TAG with UL/joint TCI state by RRC, that one TCI state is associated with either TAG-1 or TAG-2. This is also indicated in RAN1 RRC parameter list [6].



On another aspect, the unified TCI states indicated with a CORESET Pool Index (in TCI state activation/deactivation MAC CE for multi-DCI multi-TRP as agreed by RAN1/RAN2) correspond to one of the two TAGs for the baseline feature. This means PDCCH from one TRP schedules transmissions with beams only from/to the same TRP. For further enhancement, the RAN1 WA supports that the unified TCI states indicated with a CORESET Pool Index can correspond to both TAGs. This enhancement enables cross-TRP scheduling, i.e., PDCCH from one TRP can schedule transmissions with beams from/to TRP-1 and TRP-2.

Furthermore, from RAN1 point of view, there is no restrictions on grouping of serving cells/TRPs to TAGs. From RAN2 perspective, there is also no specification impacts identified on how to group serving cells/TRPs to TAGs. Based on the above analysis, the following question is asked.

**Q1) Do you agree that RAN2 confirms**

**a: each joint/UL TCI state is associated with either TAG1 or TAG2 via RRC configuration;**

**b: the joint/UL TCI states indicated with a CORESET Pool Index in MAC CE corresponds to one TAG for baseline feature, and if RAN1 agrees, can correspond to both TAGs;**

**c: no specification impacts on how to group serving cells/TRPs to TAGs.**

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| **Company** | **Yes to** | **Comments**  |
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### Maximum number of TAGs per cell group

Regarding the maximum number of TAGs per cell group, there is no consensus to increase the number in RAN1 as informed in the LS.

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| **Q1b:** NR currently supports up to 4 TAGs per cell group. Are the 4 TAGs enough or does RAN1 see a need to increase the number of TAGs per cell group?**Answer:**  *RAN1 has not reached consensus to increase the current number of TAGs per cell group.* |

Currently, each serving cell has one TA belonging to one TAG, and up to 4 TAGs can be configured per cell group. This implies in the worst scenario 4 serving cells can be supported if there are 4 different TAs per cell group. For intra-cell multi-DCI mulit-TRP, each serving cell can have 2 TAs. For inter-cell multi-DCI mulit-TRP, the additional cell with PCI other than the serving cell PCI can have a different TA than the serving cell TA. In the worst scenario, 4 TAGs can only support 2 serving cells with 4 different TAs for intra-/inter-cell operation. Thus, 4 TAGs seems not enough to support flexible NW implementation for multi-DCI multi-TRP. To maintain the application of 4 serving cells per cell group in the legacy case, the maximum number of TAGs may need to be doubled.

**Q2) Do you agree that the maximum number of TAGs per cell group should be increased?**

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**Q3) If Q2 is agreed, do you agree at least the following aspects need to be discussed?**

1. **To which value the maximum number of TAGs is increased;**
2. **Impacts on TAC MAC CE.**

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| **Company** | **Yes/No** | **Comments (e.g., other aspects)** |
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## UE behaviour when TAT expired

Regarding UE behaviour when TAT expired, RAN1 has replied as follows in the LS [3].

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| **Question 2 on operation****Q2:** When the time-alignment timer associated with one of the TRPs of a serving cell expires, are certain UL or DL operation only impacted towards that TRP while they are not impacted towards the another TRP? If so, which UL or DL operation?**Answer:** *RAN1 confirms that when the TA timer associated to one TRP expires for a TAG associated with a TCI state, UL or DL operation associated to the another TRP is not impacted. This further depends on PTAG/STAG definition, which is up to RAN2 to decide.**Which UL or DL operation is impacted have not been discussed in RAN1.* |

RAN1 confirms that when one TAT is expired, while the other TAT is running, UL and DL operation associated to the TRP whose TAT is running is not impacted.

Regarding the modeling of PTAG and STAG, the existing modeling may or may not be suitable for the new scenarios of multi-DCI multi-TRP with 2 TAs, which is up to RAN2 discussion. The discussion starting with TAG modeling would be difficult without a clear understanding of the operation. Instead, it would be beneficial to start with how UE behaves when TAT expired based on the functions of TRPs.

For multi-DCI multi-TRP operation with 2 TAs, UE behavior when TAT is expired can be discussed case by case based on the current list of actions. In TS 38.321 clause 5.2, the current procedure for TAT expiry is specified as follows.

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| 1> when a *timeAlignmentTimer* expires:2> if the *timeAlignmentTimer* is associated with the PTAG:3> flush all HARQ buffers for all Serving Cells;3> notify RRC to release PUCCH for all Serving Cells, if configured;3> notify RRC to release SRS for all Serving Cells, if configured;3> clear any configured downlink assignments and configured uplink grants;3> clear any PUSCH resource for semi-persistent CSI reporting;3> consider all running *timeAlignmentTimer*s as expired;3> maintain NTA (defined in TS 38.211 [8]) of all TAGs.2> else if the *timeAlignmentTimer* is associated with an STAG, then for all Serving Cells belonging to this TAG:3> flush all HARQ buffers;3> notify RRC to release PUCCH, if configured;3> notify RRC to release SRS, if configured;3> clear any configured downlink assignments and configured uplink grants;3> clear any PUSCH resource for semi-persistent CSI reporting;3> maintain NTA (defined in TS 38.211 [8]) of this TAG.When the MAC entity stops uplink transmissions for an SCell due to the fact that the maximum uplink transmission timing difference between TAGs of the MAC entity or the maximum uplink transmission timing difference between TAGs of any MAC entity of the UE is exceeded, the MAC entity considers the *timeAlignmentTimer* associated with the SCell as expired.The MAC entity shall not perform any uplink transmission on a Serving Cell except the Random Access Preamble and MSGA transmission when the *timeAlignmentTimer* associated with the TAG to which this Serving Cell belongs is not running, CG-SDT procedure is not ongoing and SRS transmission in RRC\_INACTIVE as in clause 5.26 is not on-going. Furthermore, when the *timeAlignmentTimer* associated with the PTAG is not running, CG-SDT procedure is not ongoing and SRS transmission in RRC\_INACTIVE as in clause 5.26 is not ongoing, the MAC entity shall not perform any uplink transmission on any Serving Cell except the Random Access Preamble and MSGA transmission on the SpCell. The MAC entity shall not perform any uplink transmission except the Random Access Preamble and MSGA transmission when the *cg-SDT-TimeAlignmentTimer* is not running during the ongoing CG-SDT procedure as triggered in clause 5.27 and the *inactivePosSRS-TimeAlignmentTimer* is not running. |

According to the above procedure, the list of actions are summarized as follows.

1. not perform any uplink transmission except the Random Access Preamble and MSGA transmission;
2. flush all HARQ buffers;
3. notify RRC to release PUCCH, if configured;
4. notify RRC to release SRS, if configured;
5. clear any configured downlink assignments and configured uplink grants;
6. clear any PUSCH resource for semi-persistent CSI reporting;
7. maintain NTA (defined in TS 38.211 [8]) of this TAG;
8. consider all running timeAlignmentTimers as expired.

The following cases for multi-DCI multi-TRP with 2 TAs need to be discussed.

1. For a SpCell/SCell, both TATs are expired.
2. For a SpCell/SCell, one TAT is expired and the other TAT is running.

**Q4) For the case both TATs for a SpCell/SCell are expired, please fill in table with the required actions (by numbers) and clarify the required actions are applied to which TRPs/serving cells.**

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| **Company** | **In case of SpCell** | **In case of SCell** | **Comment** |
| **actions** | **to which TRPs and/or serving cells** | **actions** | **to which TRPs and/or serving cells** |
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**Q5) For the case one TAT is expired and the other TAT is running, please fill in the table with the required actions (by numbers) and clarify the required actions are applied to which TRPs/serving cells.**

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| **Company** | **In case of SpCell** | **In case of SCell** | **Comment** |
| **actions** | **to which TRPs and/or serving cells** | **actions** | **to which TRPs and/or serving cells** |
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## Impacts on Random Access procedure

For multi-TRP operation with 2TAs, when 2 TAGs are configured, one issue is to determine which TAG is applied in Random Access procedure. RAN1 is mainly discussing PDCCH ordered RACH, for which the following agreement has been made.

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| RAN1#113 (2023-05) Agreement [5]:For intra-cell multi-DCI based Multi-TRP operation with two TA enhancement, down-select one of the following alternatives:* Alt 1: indicate TAG ID as part of TA command in RAR
* Alt 3: divide SSBs into two groups, one for each TRP. If a SSB associated to a RACH procedure belongs to the nth group (n=1,2), then the TA obtained via the RACH procedure corresponds to the nth TRP.
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For UE-initiated RACH, similar discussion is needed as UE has to decide which or RACH resouce is applied for PRACH. More specifically, in TS 38.211 Section 4.3, the following is specified regarding .

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| Uplink frame number  for transmission from the UE shall start before the start of the corresponding downlink frame at the UE where- and are given by clause 4.2 of [5, TS 38.213], except for msgA transmission on PUSCH where shall be used;- given by clause 4.2 of [5, TS 38.213] is derived from the higher-layer parameters *TACommon*, *TACommonDrift*, and *TACommonDriftVariation* if configured, otherwise ;- given by clause 4.2 of [5, TS 38.213] is computed by the UE based on UE position and serving-satellite-ephemeris-related higher-layers parameters if configured, otherwise .**Figure 4.3.1-1: Uplink-downlink timing relation.** |

For , a timing advance value shall be assumed for PRACH preamble [5.3.2 TS38.211], see appendix.

For , the second for the second TA/TAG is configured per cell, as indicated in RAN1 RRC parameter list [6].



And as indicated in RAN1 CR for TS 38.213 [7], the second is applied for the second TRP in intra-cell multi-TRP operation, and for the additional cell with different PCI than the serving cell in inter-cell scenario.

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| A UE can be provided a value of a timing advance offset for a serving cell by *n-TimingAdvanceOffset* for the serving cell. If for a serving cell the UE is provided two *coresetPoolIndex values 0 and 1 for first and second CORESETs, or is not provided coresetPoolIndex value for first CORESETs and is provided coresetPoolIndex value of 1 for second CORESETs, the UE can be provided first and second*  values by *n-TimingAdvanceOffset* and *n-TimingAdvanceOffset2* for transmissions with TCI states associated with the first and second CORESETs, respectively. A UE can be *provided a second*  value for transmissions with spatial domain filters corresponding to TCI states associated with *physCellId* different from *physCellId* for the serving cell in addition to a first value for transmissions with spatial domain filters corresponding to TCI states associated with *physCellId* for the serving cell. The *first and second*  values correspond to first and second TAGs [11, TS 38.321] having an association indicated by *tag-Id* with first and second joint TCI states provided by *dl-OrJointTCI-StateList* or first and second UL TCI states provided by *ul*-*TCI-State-List*.If the UE is not provided *n-TimingAdvanceOffset* for a serving cell, the UE determines a default value of the timing advance offset for the serving cell as described in [10, TS 38.133].  |

Upon initiation of random access (UE initiated or network initiated), UE has to know whether to apply TAG1 or TAG2 for the RA, in order to apply the corresponding NTA, offset for PRACH preamble transmission. This is for both intra-cell and inter-cell scenario. In the inter-cell scenario, RACH resource/configuration is different for the serving cell and the additional cell with different PCI. In order to apply appropriate RACH resource/configuration, UE also needs to know which TAG1/TAG2 (or TRP1/TRP2) is applied for PRACH preamble transmission.

**Q6) Do you agree that for both UE initiated RACH and PDCCH ordered RACH and for both intra-cell and inter-cell scenarios,** **UE has to know whether to apply TAG1 or TAG2 for PRACH transmission, in order to apply the appropriate** NTA, offset **and/or the RACH resource/configuration?**

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| **Company** | **Yes/No** | **Comments**  |
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As RAN1 is discussing the case for PDCCH ordered RACH. RAN2 can start discussing UE-initated RACH. Considering the options for PDCCH ordered RACH discussed in RAN1, the following options are listed for UE-initiated RACH.

**Option 1**: SSBs are partitioned, i.e., separate set of SSBs for each TRP

* UE selects SSB before preamble transmission as in legacy. So based on selected SSB index, UE can determine whether TAG1 or TAG2 is applied.

**Option 2**: Indication in RAR/absolute TAC MAC CE

* Note this approach does not work if Q6 is agreed.
* If this option is adopted, some rules are needed to determine whether TAG1 or TAG2 is applied for PRACH transmission

**Option 3**: Others

**Q7) Which option(s) do you agree for UE-initiated RACH? Please indicate other options if any.**

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## Other issues

**Q6) Please indicate other issues to be discussed.**

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# Conclusions and Proposals

**TBD**

# Appendix

TS 38.211

5.3.2 OFDM baseband signal generation for PRACH

The time-continuous signal  on antenna port for PRACH is defined by

where  and

-  is given by clause 6.3.3;

-  is the subcarrier spacing of the initial uplink bandwidth part during initial access. Otherwise,  is the subcarrier spacing of the active uplink bandwidth part;

- is the largest value among the subcarrier spacing configurations by the higher-layer parameter *scs-SpecificCarrierList*;

-  is the lowest numbered resource block of the initial uplink bandwidth part and is derived by the higher-layer parameter *initialUplinkBWP* during initial access. Otherwise,  is the lowest numbered resource block of the active uplink bandwidth part and is derived by the higher-layer parameter *BWP-Uplink*;

- is the frequency offset of the lowest PRACH transmission occasion in frequency domain with respect to physical resource block 0 of the active uplink bandwidth part. The quantity is given by the higher-layer parameter *msgA-RO-FrequencyStart* if configured and a type-2 random-access procedure is initiated as described in clause 8.1 of [5, TS 38.213], otherwise by *msg1-FrequencyStart* as described in clause 8.1 of [5 TS 38.213];

-  is the PRACH transmission occasion index in frequency domain for a given PRACH transmission occasion in one time instance as given by clause 6.3.3.2;

-  is the number of resource blocks occupied and is given by the parameter allocation expressed in number of RBs for PUSCH in Table 6.3.3.2-1.

- is the start CRB index of uplink RB set corresponding to the quantity . The UE assumes that the RB set is defined as when the UE is not provided *IntraCellGuardBandsPerSCS* for an UL carrier as described in Clause 7 of [6, TS 38.214]

- is the index of the RB set which contains the lowest PRACH transmission occasion in frequency domain indicated by . The UE may assume that is configured such that each PRACH transmission occasion is fully contained within an RB set.

-  and  are given by clause 6.3.3

- where

- for ,

- for kHz, is the number of times the interval overlaps with either time instance 0 or time instance  in a subframe

The starting position of the PRACH preamble in a subframe (for ) or in a 60 kHz slot (for kHz) is given by

 

where

- the subframe or 60 kHz slot is assumed to start at ;

- a timing advance value shall be assumed;

- and are given by clause 5.3.1;

-  shall be assumed for kHz, otherwise the value of corresponds to kHz and the symbol position  is given by

where

-  is given by the parameter "starting symbol" in Tables 6.3.3.2-2 to 6.3.3.2-4;

-  is the PRACH transmission occasion within the PRACH slot, numbered in increasing order from 0 to  within a RACH slot where  is given Tables 6.3.3.2-2 to 6.3.3.2-4 for and fixed to 1 for ;

-  is given by Tables 6.3.3.2-2 to 6.3.3.2-4;

-  is given by

- if kHz, then 

- if kHz and either of "Number of PRACH slots within a subframe" in Tables 6.3.3.2-2 to 6.3.3.2-3 or "Number of PRACH slots within a 60 kHz slot" in Table 6.3.3.2-4 is equal to 1, then , otherwise

- if kHz and

- the "Number of PRACH slots within a 60 kHz slot" in Table 6.3.3.2-4 is equal to 1, then for kHz and for kHz, or

- the "Number of PRACH slots within a 60 kHz slot" in Table 6.3.3.2-4 is equal to 2, then for kHz and for kHz.

If the preamble format given by Tables 6.3.3.2-2 to 6.3.3.2-4 is A1/B1, A2/B2 or A3/B3, then

- if , then the PRACH preamble with the corresponding PRACH preamble format from B1, B2 and B3 is transmitted in the PRACH transmission occasion;

- otherwise the PRACH preamble with the corresponding PRACH preamble format from A1, A2 and A3 is transmitted in the PRACH transmission occasion

# References

1. R2-2306552 Report from NR MIMO evolution session
2. R2-2304342 LS on 2TA for multi-DCI multi-TRP
3. R1-2306249 Reply on LS 2TA for multi-DCI multi-TRP
4. R2-2302455 LS to RAN2/4 on Agreements for Rel-18 MIMO
5. Draft Report of 3GPP TSG RAN WG1 #113 v0.1.0
6. R1-2306271 Consolidated higher layers parameter list for Rel-18
7. R1-2306292 Introduction of MIMO Evolution for Downlink and Uplink
8. R2-2304766 Discussion on multiple TAG OPPO discussion Rel-18 NR\_MIMO\_evo\_DL\_UL-Core
9. R2-2304938 Further issues for Multi-TRP with two TAs support SHARP Corporation discussion NR\_MIMO\_evo\_DL\_UL-Core
10. R2-2305318 Discussions on Two TAs for Multi-DCI Multi-TRP CATT discussion Rel-18 NR\_MIMO\_evo\_DL\_UL-Core
11. R2-2305588 Discussion on Two TAs for Multi-TRP NEC Corporation discussion NR\_MIMO\_evo\_DL\_UL-Core
12. R2-2305719 Discussion on the impacts of Two TAs for multi-DCI multi-TRP operation Lenovo discussion Rel-18
13. R2-2305720 Discussion on the UE-initiated RACH procedure in multi-TRP operation Lenovo discussion Rel-18
14. R2-2305752 RA procedure while SpCell is configured with 2 TAGs Nokia, Nokia Shanghai Bell discussion Rel-18 NR\_MIMO\_evo\_DL\_UL-Core
15. R2-2305799 Discussion on multi-DCI multi-TRP with two TAs Qualcomm Incorporated discussion NR\_MIMO\_evo\_DL\_UL-Core
16. R2-2305848 On 2TA operation Ericsson discussion Rel-18 NR\_MIMO\_evo\_DL\_UL-Core Withdrawn
17. R2-2305921 Two TAs for multi-DCI multi-TRP Huawei, HiSilicon discussion Rel-18 NR\_MIMO\_evo\_DL\_UL-Core
18. R2-2306036 On 2TA operation Ericsson discussion Rel-18
19. R2-2306140 Discussion on TA maintenance in two TAs for multi-TRP LG Electronics Inc. discussion Rel-18 NR\_MIMO\_evo\_DL\_UL-Core
20. R2-2306161 Support of Two TAs for multi-DCI multi-TRP Apple discussion Rel-18 NR\_MIMO\_evo\_DL\_UL-Core
21. R2-2306327 Discussion on two TAs for multi-DCI multi-TRP Samsung Research America discussion Rel-18 NR\_MIMO\_evo\_DL\_UL-Core
22. R2-2306421 Further Considerations On UE initiated RACH for acquiring TA ZTE Corporation,Sanechips discussion Rel-18 NR\_MIMO\_evo\_DL\_UL-Core
23. R2-2306433 Status of open issues on Two TAs for mDCI mTRP NTT DOCOMO INC. discussion Rel-19