



3GPP TSG RAN Meeting #110
Athens, GR, 26 Feb – 01 Mar, 2024

R4-2400489

Agenda item: 14
Source: Apple
Document for: Information

On RAN4 led RRM Enhancement in Rel-19

- Rel-19 RRM enhancement for NR and MR-DC is an umbrella WI for RRM enhancement, aiming to include:
 - FR2 Multi-Rx RRM Continuation
 - Enhancement for UE operating in multi-Rx simultaneous reception mode
 - RRM measurement delay reduction for both FR1 and FR2
 - A-TRS based RRM enhancements

FR2 Multi-Rx RRM Continuation

- **Enhancement for UE operating in multi-Rx simultaneous reception mode**
 - L3 measurement enhancements: intra/inter-freq. Measurement delay, scheduling restriction, support of simultaneous L1 and L3 measurements, and simultaneous L3 measurement and data/control
 - L3 fast beam sweeping capability based on UE implementation, similar to the L1 fast beam sweeping capability currently under discussion. Its applicability can be controlled by network for either L3 measurements in general or for L3 procedures such as handovers or PSCell addition/change.
 - UE can use indication of single-RX/multi-RX operation, as agreed in R18, to indicate to the network such a capability is enabled/disabled.
 - With such a capability, scheduling restriction can be relaxed if measurement/procedure delay is not reduced.
 - Dual TCI state switching based on R17/18 unified TCI framework
 - Note that in R18, dual TCI state switching is specified based on R15/16 legacy TCI framework.
 - RRM requirement for the case of MRTD > CP case
 - MRTD > CP can be considered in R19 given that operators may not always ensure MRTD < CP for mTRP scenarios
 - RTD for a beam pair can be reported together with the legacy group-based beam reporting (GBBR)
 - Or legacy GBBR should be enhanced to capture the RTD info
 - Network can use such RTD info to decide which is the best beam pair(s) for scheduling based on UE capability of supporting MRTD > CP.

- **Enhancement for UE operating in multi-Rx simultaneous reception mode**

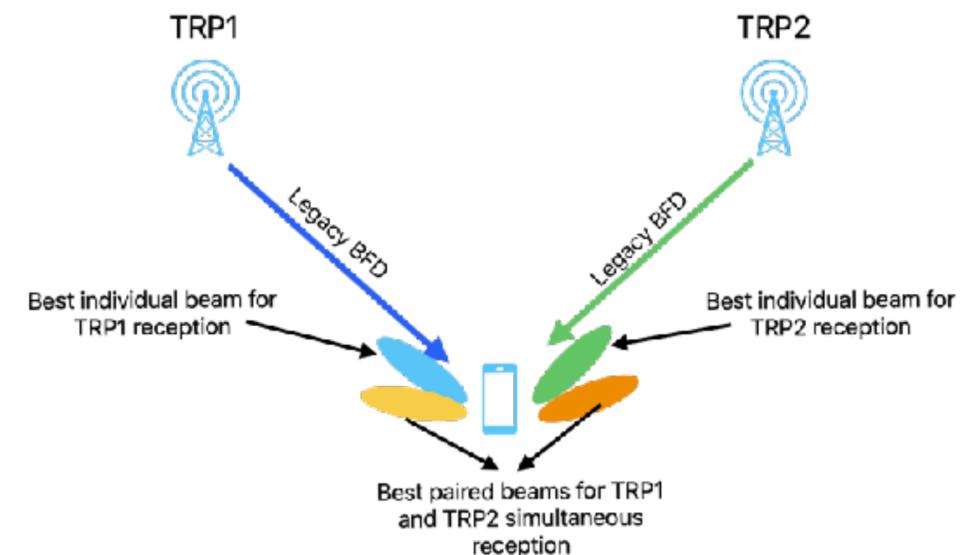
- Paired RLM or BFD for multi-Rx UE in multi-TRP scenario

- Motivation:

- The individual RLM or BFD cannot efficiently indicate the paired link quality (with paired Rx beam) since the legacy RLM and BFD can only indicate the individual reception condition.
- However, in mTRP mDCI case, the PDCCH/PDSCH can be simultaneously scheduled from TRP1 and TRP2, the legacy BFD and RLM cannot reflect the simultaneous reception quality from TRP1 and TRP2.
- The benefits of paired RLM or BFD is:
 - Reflect the actual paired link quality when multi-Rx beams are used by UE
 - Reduce the scheduling and measurement restriction for RLM/BFD

- Scope:

- Study and if feasible, specify RLM/BFD evaluation on a paired RSs (RS1 and RS2), and RS1 and RS2 are transmitted from different TRPs



RRM Measurement delay reduction

- Background:
 - CSSF enhancement:
 - With larger number of serving CCs in FR2, it would result into FR1 with huge long measurement/detection delay to degrade mobility performance based on CSSF factor without MG.

Table 9.2.5.2-1: Measurement period for intra-frequency measurements without gaps(FR1)

DRX cycle	$T_{SSB_measurement_period_intra}$
No DRX	$\max(200\text{ms}, \text{ceil}(5 \times K_p) \times \text{SMTC period})^{\text{Note 1}} \times \text{CSSF}_{intra}$
DRX cycle $\leq 320\text{ms}$	$\max(200\text{ms}, \text{ceil}(1.5 \times 5 \times K_p \times \max(\text{SMTC period}, \text{DRX cycle})) \times \text{CSSF}_{intra})$
DRX cycle $> 320\text{ms}$	$\text{ceil}(5 \times K_p) \times \text{DRX cycle} \times \text{CSSF}_{intra}$

NOTE 1: If different SMTC periodicities are configured for different cells, the SMTC period in the requirement is the one used by the cell being identified

2.1 Number of serving carriers for SA

Requirements for standalone NR with NR PCell are applicable for the UE configured with the following number of serving NR CCs:

up to 16 NR DL CCs in total, with 1 UL (or 2 UL if SUL is configured) in PCell and up to 8 UL (or 9 UL if SUL is configured) in total for SCells.

SUL may be configured together with one of the UL

For instance,

CSSF = 15 if 16 CCs are configured as CA (15 SCC share one searcher), and SCell measurement delay: $15 \times 5 = 75$ SMTC period (Kp=1 for simplicity)

- SMTC periodicity = 160ms, the total measurement delay can be up to 12000ms

- For FR2, the measurement delay is defined as $\max(600\text{ms}, \text{ceil}(M_{pss/sss_sync_w/o_gaps} \times K_{FR} \times K_p \times K_{layer1_measurement}) \times \text{SMTC period}) \times \text{CSSF}_{intra}$, without DRX. In the field, such delay can be easily exceeding 1000ms.

■ R19 enhancement:

- CSSF reduction in both FR1 and FR2, e.g., using certain carriers' measurements to represent other carriers and etc.



Rel-19 RRM enh-4 | RRM Measurement delay reduction (2/2)

- Background:

- Rx beam sweeping factor reduction:

- The beam sweeping factor reduction has been specified for certain features in previous release, e.g., R18 FR2 SCell activation enhancement.

<p><i>beamSweepingFactorReduction-r18</i> Indicates whether the UE supports beam sweeping factor reduction for FR2 unknown <u>SCell</u> activation. The capability comprises signalling of</p> <ul style="list-style-type: none"> - <i>reduceForCellDetection</i> indicates reducing beam sweeping factor for cell detection if UE has full set (N=8) of beam sweeping during AGC settling part during FR2-1 unknown <u>SCell</u> activation procedure. - <i>reduceForSSB-L1-RSRP-Meas</i> indicates reducing beam sweeping factor for SSB based L1-RSRP measurement if UE has full set (N=8) of beam sweeping during AGC settling part during FR2-1 unknown <u>SCell</u> activation procedure. <p>UE is required to meet the shortened <u>SCell</u> activation delay requirement in TS 38.133 [5] if the feature is supported.</p>	Band	No	TDD only	FR2-1 only
--	------	----	----------	------------

- For FR2, the delay requirement is scaled by a large number for Rx beam sweeping in both L3 and L1 measurement, e.g., N=8.

- However, there are some conditions can help UE to reduce the Rx beam sweeping factors, as proven in previous release.

- R19 enhancement:

- Rx beam sweeping factor reduction for L3 and L1 measurement.



A-TRS based RRM enhancement

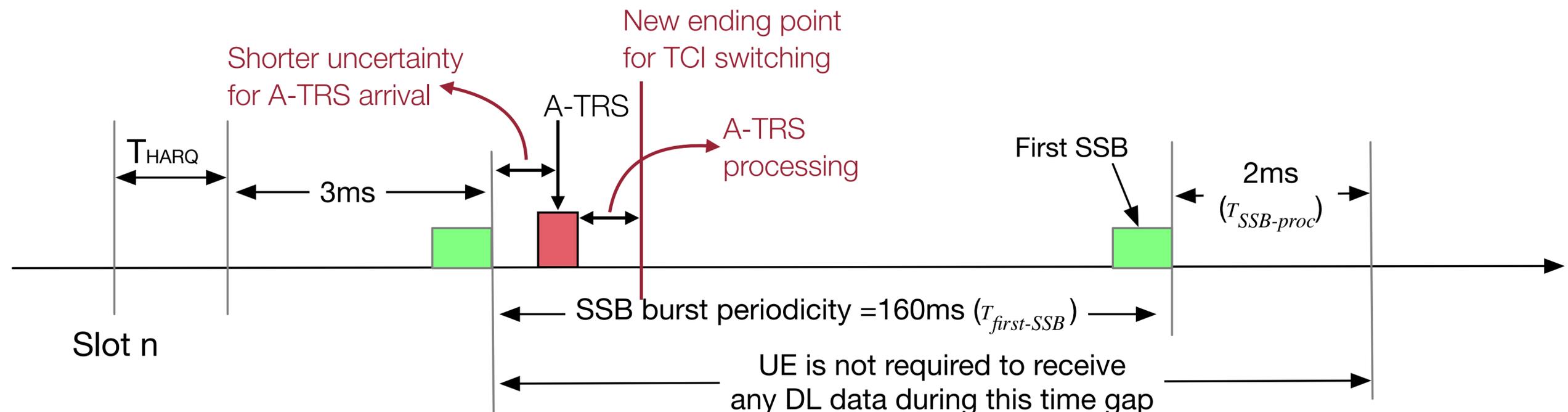
Rel-19 RRM enh-4 | A-TRS based RRM enhancement (1/2)

■ Background:

- In current spec, periodical RS (e.g., SSB) is mainly used for AGC and T/F tracking during RRM procedures, e.g., HO, TCI switching, SCell activation, and PSCell addition/change.

■ R19 enhancement:

- RAN4 can explore a general solution of utilizing A-TRS for the enhancement to the corresponding UE activities:
 - HO (incl. LTM),
 - TCI switching,
 - Example: In legacy TCI switching requirement, there was a time gap from “slot $n + T_{HARQ} + (3 \text{ ms}) / \text{NR slot length}$ ” to “slot $n + T_{HARQ} + (3 \text{ ms} + T_{OK} * (T_{\text{first-SSB}} + T_{SSB-proc})) / \text{NR slot length}$ ”. Since UE is not required to receive DL data during this time gap, it will probably impact the throughput performance in case the first SSB arrives 160ms later (analyzed in R4-2006616).
 - R19 enhancement: enhancement to use A-TRS for TCI T/F tracking to shorten the total switching delay.



■ R19 enhancement (cont.):

– RAN4 can explore a general solution of utilizing A-TRS for the enhancement to the corresponding UE activities:

- SCell activation,
- PSCell addition/change,
- SCG activation
- Others

8.9.2 PSCell Addition Delay Requirement

The requirements in this clause shall apply for the UE configured with only PCell in FR1.

Upon receiving PSCell addition in subframe n , the UE shall be capable to transmit PRACH preamble towards PSCell in FR1 or FR2 no later than in subframe $n + T_{\text{config_PSCell}}$. Upon receiving PSCell addition in subframe n , the UE shall be capable to transmit PRACH preamble towards PSCell in FR2 no later than in slot $n + \frac{T_{\text{config_PSCell}}}{NR \text{ slot length}}$.

where:

$$T_{\text{config_PSCell}} = T_{\text{RRC_delay}} + T_{\text{processing}} + T_{\text{search}} + T_{\Delta} + T_{\text{PSCell_DU}} + 2 \text{ ms}$$

$T_{\text{RRC_delay}}$ is the RRC procedure delay as specified in TS 38.331 [2].

$T_{\text{processing}}$ is the SW processing time needed by UE, including RF warm up period. $T_{\text{processing}} = 20\text{ms}$ when target cell is in FR1 and $T_{\text{processing}} = 40 \text{ ms}$ when target cell is in FR2.

T_{search} is the time for AGC settling and PSS/SSS detection. If the target cell is known, $T_{\text{search}} = 0 \text{ ms}$. If the target cell is unknown and the target cell $\hat{E}_s/I_{ot} \geq -2\text{dB}$, $T_{\text{search}} = 3 * N * T_{\text{Trs}} \text{ ms}$. $N = 1$ when target cell is in FR1, $N = 8$ when the target cell is in FR2-1, and $N = 12$ when the target cell is in FR2-2

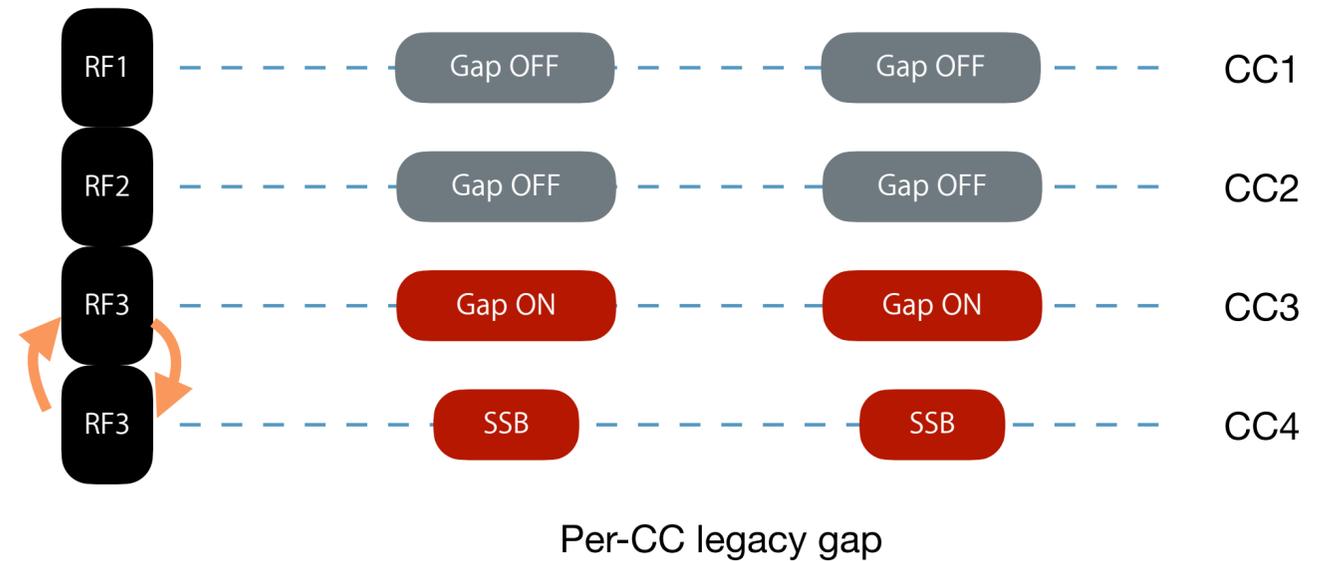
In PSCell addition the T_{Trs} based T/F tracking delay can be reduced by using A-TRS

T_{Δ} is time for fine time tracking and acquiring full timing information of the target cell. $T_{\Delta} = 1 * T_{\text{Trs}} \text{ ms}$ for a known or unknown PSCell.

Annex: other potential RRM enhancements

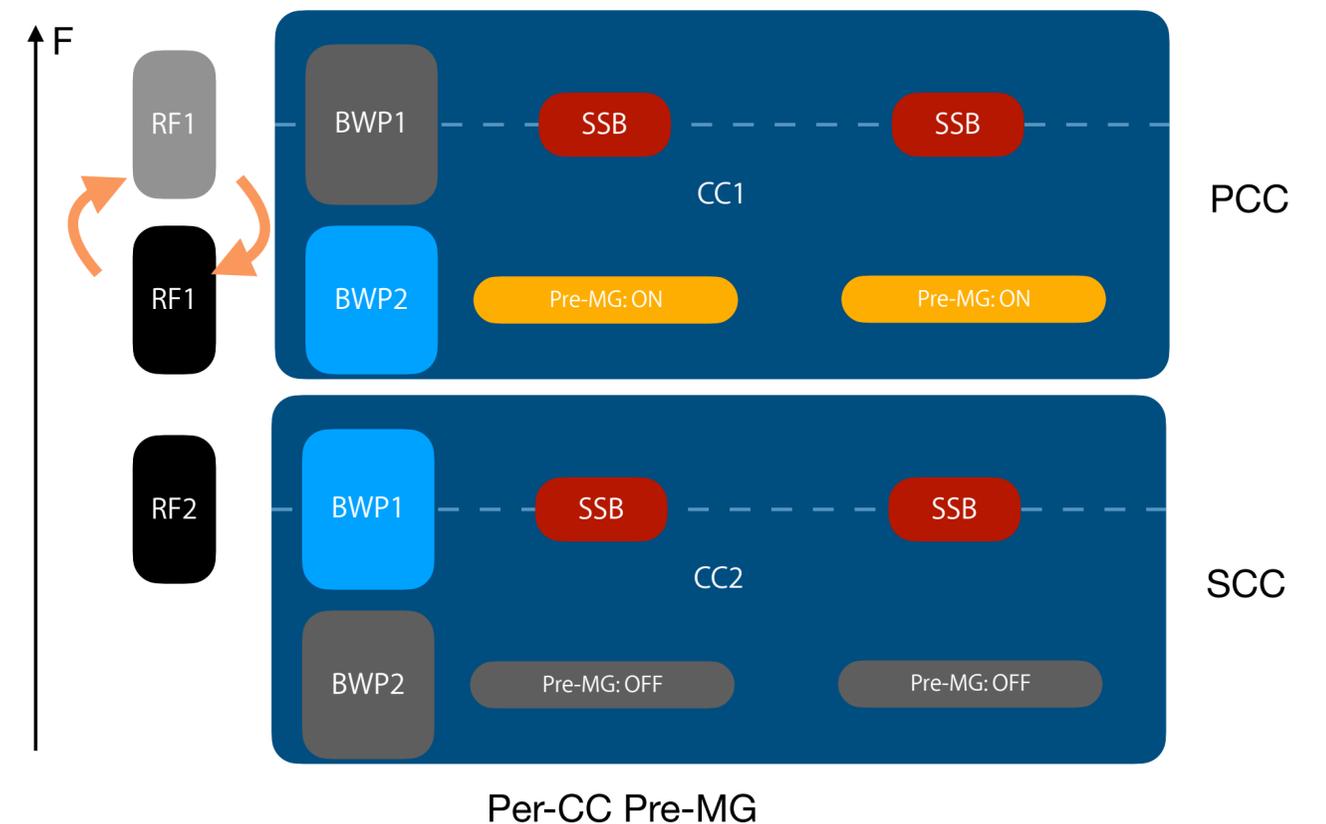
Background:

- Measurement gap is either per-UE or per-FR in legacy, including both type 1 and type 2 gaps. Note that during each gap occasion, UE only needs to measure one carrier. In other word, only one RF chain and BB searcher is needed during legacy gap. However, CA capable UE can have multiple chains and searchers, which can support data Rx/Tx and measurement simultaneously within gap.



R19 enhancement:

- RAN4 can consider per-CC or per-band measurement gap, including legacy gap, Pre-MG and NCSG.
 - per-CC legacy gap, gap is only enabled on the indicated CC(s).
 - pre-CC Pre-MG: Pre-MG is ON only on those serving cells whose active BWP cannot cover SSB (based on the MO on the same frequency carrier) to measure. Pre-MG is OFF on other serving cells, i.e. data scheduling is allowed during OFF Pre-MG occasions.
 - per-CC NCSG: add a band/CC list in NCSG feedback. Once NCSG is configured, VIL is only applicable to serving cells on the band/CC list.



■ **Background:**

- In R18 mobility enhancement, solution based on existing measurement (validity check) was introduced:
 - The measurements are considered valid if both of the following conditions are satisfied
 - A) the measurement are performed within the last [X] seconds before msg1 transmission for RRC resume/setup request
 - X value is network configured. If network doesn't provide configuration of the timer, UE is not required to perform validity check.
 - Candidate values for 'X': 5s, 10s, 20s, 50s, 100s
 - B) the reported measurement results satisfy measurement accuracy at the measurement instance
- However, it is unclear how to configure and implement X from both NW and UE sides.

■ **R19 enhancement:**

- RAN4 can consider additional criteria, e.g. linked with power saving:
 - Measurement results which are obtained during IDLE/INACTIVE mode are considered valid for stationary UE, e.g. when lowMobilityEvaluation and/or not-at-cell edge is configured and met.



■ **Background:**

- In R19 XR enhancement, one scope for RRM is:
 - Specify enhancements to enable transmission/reception in gaps/restrictions that are caused by RRM measurements (from inter-frequency RRM measurement gaps, or intra-frequency measurements, or other scheduling restrictions etc). [RAN1, RAN2, RAN4]
 - Specify the corresponding measurement gap and scheduling restriction to enable the identified enhancements with RRM performance impact taken into consideration, work being triggered by LS. [RAN4]

■ **R19 enhancement:**

- To accommodate new traffic type of XR to RRM spec, RAN4 may need to proactively discuss the potential impacts due to the prioritization between XR channel and MG or scheduling restriction,
 - For instance, instead of prioritizing all of the XR related channels, UE may differentiate XR related measurement from non-XR measurement, thus, UE behavior for prioritization may be changed to:
 - RACH related RS > XR related measurement > XR traffic related channels > MG or other non-XR measurement > other traffic related channels
 - The scheduling restriction caused by XR related measurement can still interrupt the XR traffic related channels

