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Overview of RAN4-led Rel-19 topics

Huawei, HiSilicon

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BS RF evolution and enhancements

- OTA test enhancement
- Study on more OTA requirements/options for BS type 1-H

OTA test enhancement

- Motivation
  - > Active Antenna System is widely deployed in NR. The OTA test is a must for type 1-O AAS BS. It has been found that the test time is prohibitive taking up to 3 times the time to perform the conformance testing compared to conducted conformance testing. Excessive OTA testing time has become a constraint for AAS product design, development and certification.
  - > In some cases it may be that the number of test cases could be reduced without impacting the coverage of the testing. OTA TRP testing is particularly time consuming. For example; the TX IMD texting comprises of up to 96 test cases, 6 interfere offsets are tested for each (12 for NC operation), these offsets date back to the UTRA requirements and have been carried through for each subsequent RAT however not they are generating such excessive test time so it is appropriate to see if they are all still necessary or can be reduced.

Test requirements	Type	Num of test cases	Num of TCs (TS 37.145-2)
OTA base station output power	TRP	1	ATCR7
OTA ACLR	TRP	3	ANTCR2, ANTCR8,ANTCR7
OTA out-of-band emission	TRP	4	ATCR7, ANTCR7, ATCR2a, ANTCR2
OTA transmitter spurious emission	TRP	1	ANTCR7
OTA transmitter intermodulation	TRP	36	ANTCR2, ANTCR8, ANTCR7
	TRP	48	ATCR7, ANTCR7, ATCR2a, ANTCR2
	TRP	12	ANTCR7

- Objective
  - > Study and specify the methods to reduce the testing time for OTA test without reducing the test coverage. For example,
    - Chose the worst case to reduce the number of test configurations
    - Chose the worst case to reduce the number of test points/offsets
    - The ACLR, OBUE, and spurious emission with the same configuration as TX intermodulation are not tested redundantly.
    - Other methods are not precluded

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Study on more OTA requirements/options for BS type 1-H

- Motivation
  - > Existing BS type 1-H (or Hybrid AAS BS) requirements contain 2 OTA requirements (i.e. EIRP and EIS) and many conducted requirements specified at the transceiver array boundary. Some conductive requirements may be over stringent without the verification the overall radiated performance. OTA directional requirements may yield some advantages in terms of design optimization so coherent effects can be optimized in the direction of transmission.

Requirement	**Requirement set**			
	BS type 1-H	BS type 1-O	OTA requirement type	1-H potential
Radiated transmit power	6.2	6.2	Directional requirement	N/A
OTA base station output power	NA	6.3	TRP	N
OTA output power dynamics		6.4	Directional Requirement	Y: +
OTA transmit ON/OFF power		6.5	Co-location requirement	N
OTA transmitted signal quality		6.6	Directional Requirement	Y：+++
OTA occupied bandwidth		6.7.2	Directional Requirement	Y: +
OTA ACLR		6.7.3	TRP	N
OTA out-of-band emission		6.7.4	TRP	N
OTA transmitter spurious emission		6.7.5	TRP	N
			Co-location requirement	Y：+++
OTA transmitter intermodulation		6.8	Co-location requirement	N
			Intra-system transmitter intermodulation	Y: +++ (no need if OTA EVM is done)

- Objective
  - > Evaluate possibilities for flexible selection of OTA TX and RX requirements for the new/evolved BS type 1-H.

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Further UL enhancement via UE RF evolution

- Improve PA transmission power to enhance uplink coverage
- MPR reduction by using two Tx on one CC

Improve PA Tx power to enhance uplink coverage

- Motivation
  - > Increase the UE output power is critical to enhance uplink performance
  - > Power boosting for QPSK DFT-s-OFDM is under discussion in Rel-18 coverage enhancement WI
  - > Further enhancement of transmission power or reduction of power back-off (MPR) can be supported by some technologies under some conditions, which could be applied to multiple waveforms and/or modulation orders
    - E.g. active constellation extension (ACE), uneven PSD transmission
    - Further power enhancement could be done with EVM requirements or ACLR requirements relaxation. But the performance can be guaranteed since the improved SNR at BS can be achieved.

- Objective
  - > Further enhance the transmission power or reduce the power back-off by allowing the relaxation of other RF requirements, e.g., EVM and/or ACLR
    - It is applicable to OFDM and DFT-s-OFDM waveform, QPSK and other modulation orders, and all the power classes
    - The uplink performance is expected to be improved.

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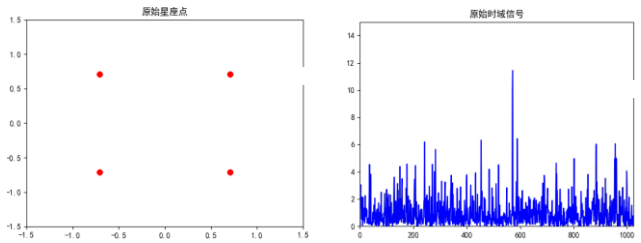
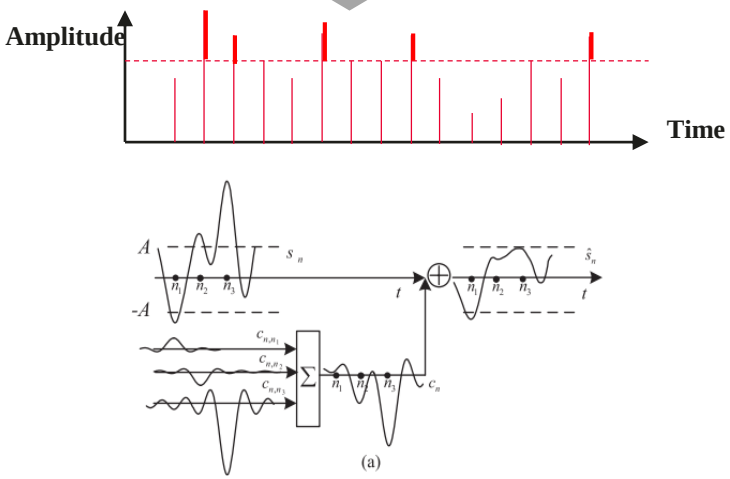
Improve PA Tx power to enhance uplink coverage

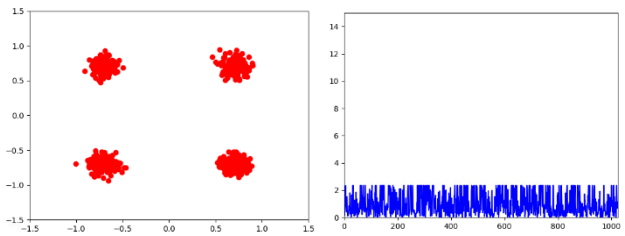
Active constellation extension (ACE)

- Conduct the power clipping with restriction that the distortion of modulation signal happens in the restricted region on modulation constellation
- Larger than 1dB SNR gain is expected



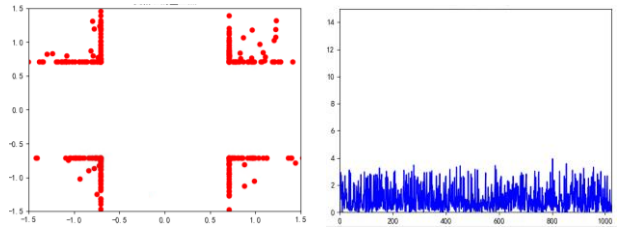


Traditional clipping



With demodulation performance degradation

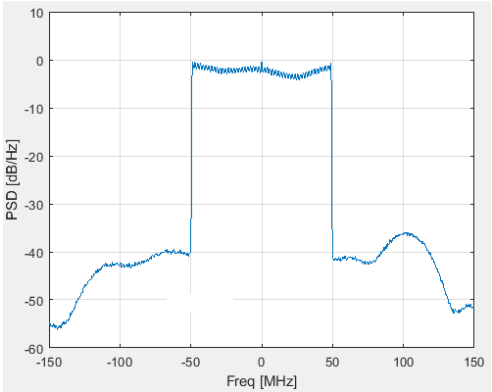
Active constellation extension (ACE)

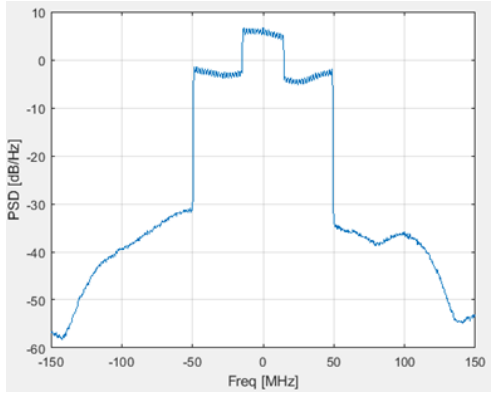


Without demodulation performance degradation

UL transmission with uneven PSD

- Transmit the center PRB with less MPR than the existing specification
- Around 1dB MPR reduction is expected





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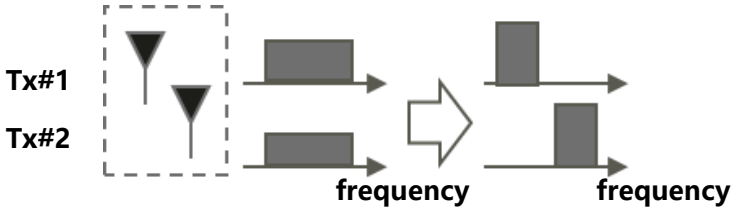
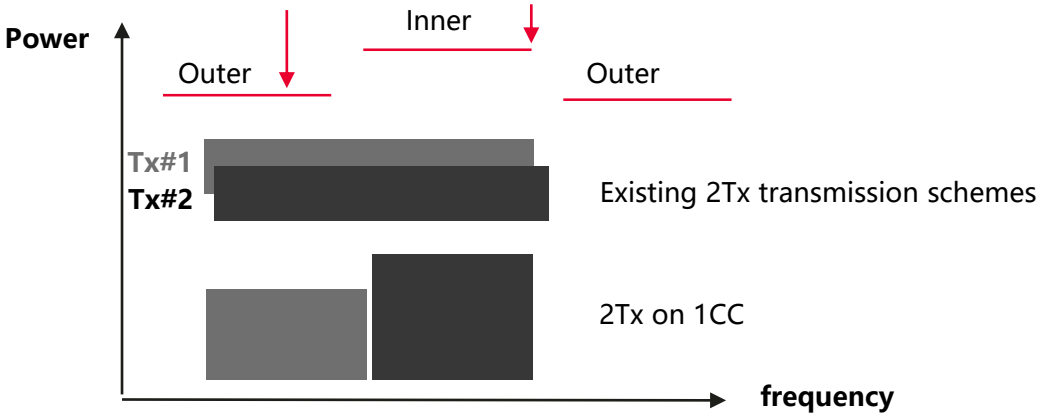
MPR reduction by using two Tx on one CC

- Motivation
  - > The service with higher uplink data rate, e.g. AR, would be popular in the future. Even for cell edge UE, the high uplink data rate transmission in the large bandwidth would also be expected. Thus the improvement of transmission power on the large bandwidth for a cell edge UE would be needed.
  - > The outer region in the MRP table is wider when the large transmission bandwidth is used.
  - > The smaller MPR corresponding inner region can be applied to UE, if UE utilizes the 2Tx to transmit DFT-s-OFDM waveform with the reduced transmission frequency block per Tx, since outer region will be reduced for the smaller transmission bandwidth.
  - > The implementation complexity for DFT-s-OFDM waveform is the similar to DFT-s-OFDM with rank-2.

- Objective
  - > Reduce MPR by using two Tx simultaneous transmissions on one CC for uplink.



2Tx transmission on one CC



Benefit: Less power back-off (potential reduced MPR)

Further UE RF enhancements for FR1

- PC1.5 intra-band contiguous/non-contiguous CA
- 6Rx for handheld UE

UE RF FR1
PC1.5 intra-band contiguous/non-contiguous CA

- Motivation
  - The band combination for PC1.5 intra-band contiguous/non-contiguous CA was already proposed in Rel-18, and it has impact on general requirement
  - Operators show interest for UE supporting this feature to accommodate the deployment demand
    - Example band combination could be n77C, n78C, n79C, n77(2A), n78(2A), n79(2A)

- Objective
  - Specify UE RF requirement for PC1.5 intra-band CA with 2Tx, including scenarios of
    - Intra-band contiguous CA w/ or w/o UL MIMO
    - Intra-band non-contiguous CA
    - Example band combinations: n77/78/79C, n77/78/79(2A)

UE RF FR1
6Rx for handheld UE

- Motivation
  - > 6Rx for handheld UE was discussed extensively at the beginning of Rel-18 for RAN4 scope
  - > Operators show strong interest to enable the feature for handheld UE

- Objective
  - > Investigate and enable 6Rx on higher frequency bands targeting at support of smartphone (RAN4)
  - > Investigate the feasibility whether 6Rx can be extended to the smartphone, and decide which UE type (smartphone and/or FWA/CPE) will be considered
    - Feasibility study includes performance gain and form factor
  - > Consider NR TDD bands higher than 1.8GHz and example bands are n41, n77 and n78 (other bands to be introduced in the release independent way later)
  - > Specify the requirements to support 6Rx subject to the conclusion of feasibility study
    - Specify the UE RF requirements to support 6Rx
    - Specify RLM test cases with 6Rx
    - Specify UE demodulation performance and CSI requirements to support 6Rx
    - Support at least up to 4 MIMO layers, FFS for layer larger than 4

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Further UE RF enhancements for FR2

- FR2 UL coverage enhancement

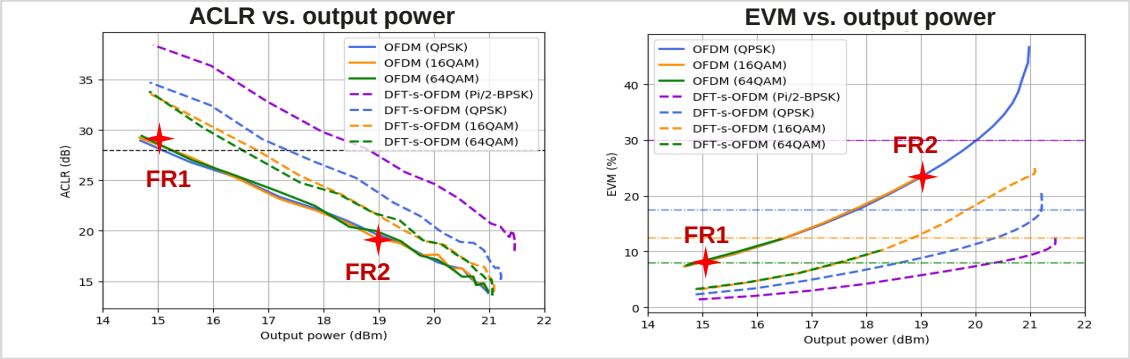
MPR of mmWave terminal reduces UL coverage

- **Motivation: UL coverage of mmWave is limited by large MPR of terminals**
  - UE SINR can be improved significantly by the high BS large antenna array
  - However, UL coverage is limited by PA/RF imperfect effects
  - Due to the PA nonlinearity, the large power back-off is expected for mmWave terminal

Max power reduction of mmWave terminals (38.101)

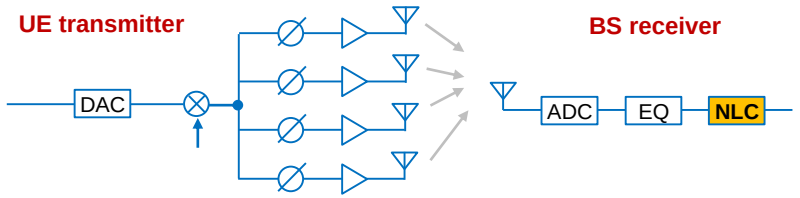
	pi/2-BPSK	QPSK	16QAM	64QAM	256QAM
DFTs	0dB	2dB	3.5dB	5.5dB	[10]dB
OFDM	-	4dB	5dB	7.5dB	[12]dB

- **For coexistence reason, the transmitted signal should meet ACLR requirements**
  - **For FR2**: Even ACLR requirement is met, the EVM is worse than requirement of QPSK



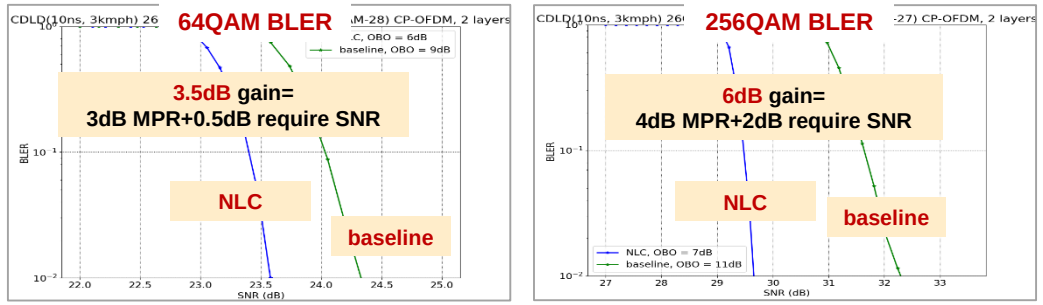
Uplink nonlinearity compensation to improve UL coverage

- **Uplink receiver nonlinearity compensation: Improve uplink coverage by reducing the MPR of terminals**



- **UE transmitter:** Relax the EVM requirement for large transmission power (small MPR)
- **BS receiver**: Perform receiver nonlinearity compensation to improve the EVM

- **Simulation: Performance gain=power gain (MPR reduction)+demodulation gain**



UE RF FR2
FR2 UL coverage enhancement

- Motivation
  - Enabling UE side to transmit more power (with less power back-off) is also a way to enhance the UL coverage in mmWave, i.e., reduce MPR with relaxed EVM requirements for mmWave terminals. Accordingly, gNB side needs to support non-linear receiver to match the nonlinearity of signals.

- Objective
  - To enhance the UL coverage in mmWave, support relaxed EVM on UE transmission to reduce MPR with non-linear receiver at gNB

NTN/IoT NTN RF enhancements

- NTN HPUE
  - PC2, PC1.5, PC1

- IoT NTN HPUE
  - PC2

RRM evolution and enhancements

- Further RRM enhancement on FR2
  - EMR+ Fast SCell activation
  - FR2 unknown SCell activation based on Temporary RS
  - L3 Measurement enhancement for FR1+FR2

- Interruption reduction
  - Interruptions at NR SRS antenna port switching
  - L1/L2 mobility inter-frequency measurement enhancement

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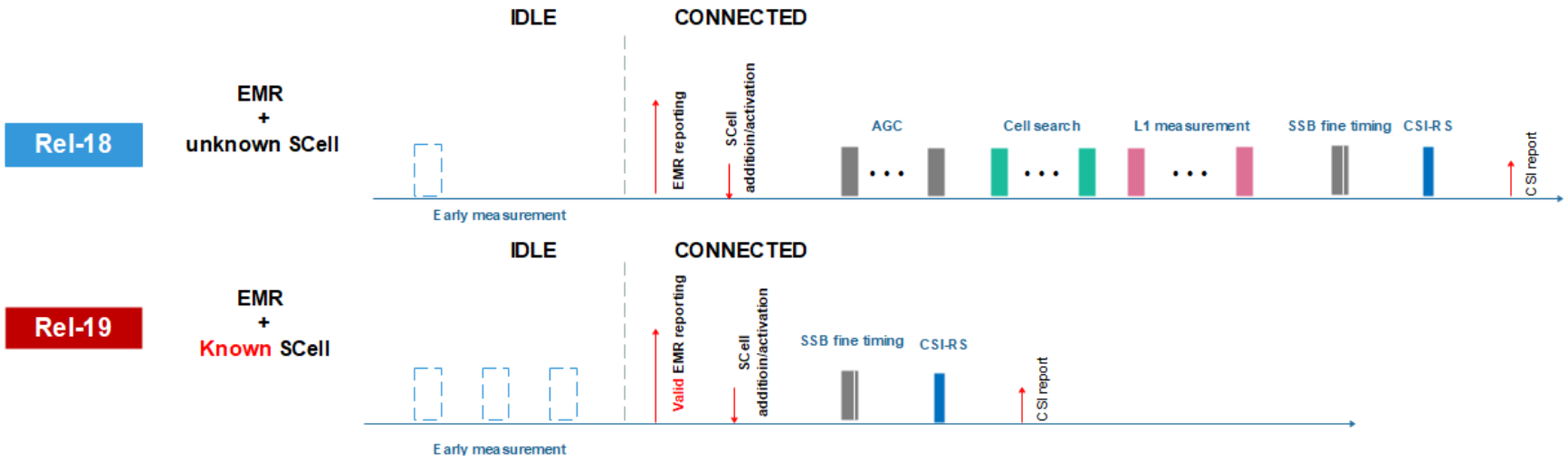
EMR+ Fast SCell activation

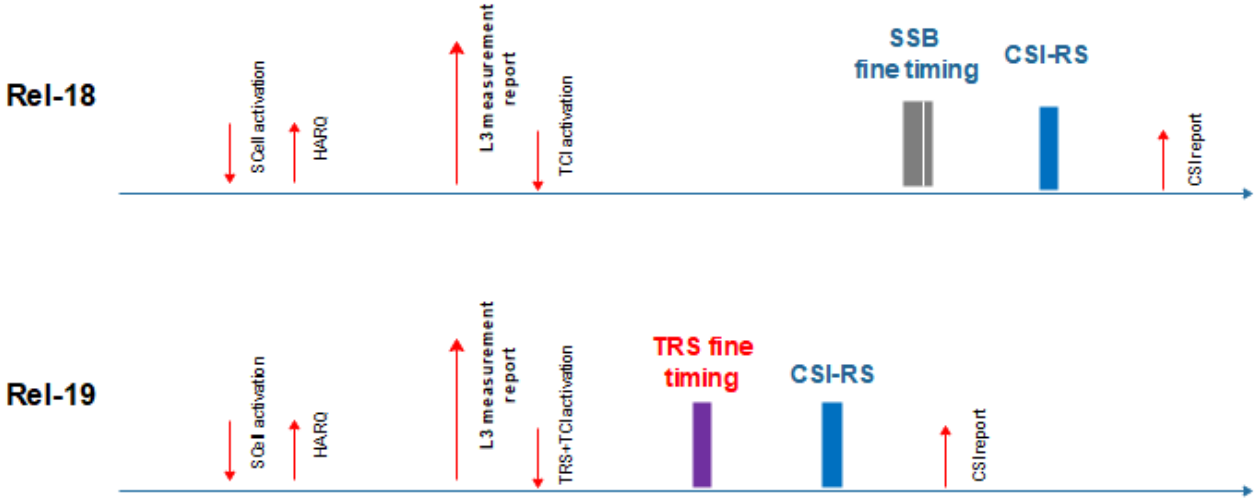
- Motivation
  - > Early measure in IDLE/Inactive mode is introduced in Rel-16 to setup CA upon UE entering connected mode. According to the existing known cell condition, the to-be-added SCell is regarded as “unknown” even if the EMR report is valid, then SCell activation procedure would follow unknown requirements when UE enters CONNECTED mode from IDLE mode.
  - > Fast SCell activation based on EMR is proposed to be enhanced when UE enters CONNECTED mode from IDLE/Inactive mode.



- Objective
  - > Fast SCell activation with EMR reports upon UE enters connected mode
  - > Introduce corresponding signaling if needed.

FR2 unknown SCell activation based on Temporary RS

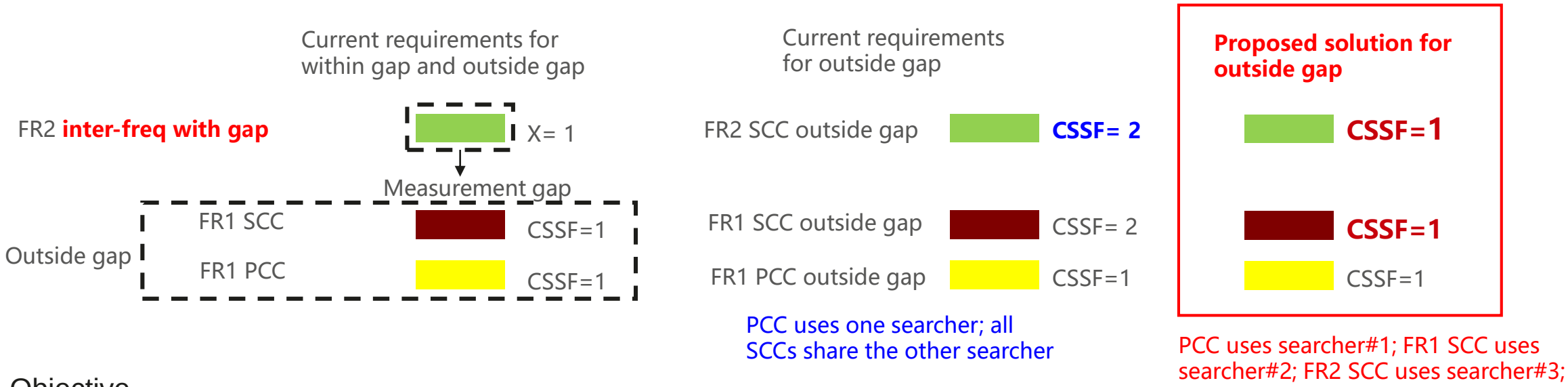
- Motivation
  - > In Rel-18, one enhancement for FR2 SCell activation is to trigger L3 measurement by SCell activation command, and the activation delay can achieve comparable performance as known SCell activation. In Rel-17, Temporary RS is introduced for SCell activation delay reduction, which is not applicable for FR2 unknown cases without active serving in the same band.
  - > If Temporary RS can be utilized based on L3 measurement triggered by SCell activation command, the SCell activation delay can be further reduced.



- Objective
  - > FR2 SCell activation delay further reduction base on Temporary RS and L3 measurement triggered by SCell activation command.
  - > Introduce corresponding signaling if needed.

L3 Measurement enhancement for FR1+FR2

- Motivation
  - > Current status: Delay requirements for measurement outside gap are defined based on 2 searchers assumption for total CCs in FR1 and FR2
  - > Observation: In FR1+FR2 scenario, a UE supporting per-FR gap shall support totally 3 searchers to meet the requirements for measurement within gap in FR2 and outside gap in FR1
  - > Potential enhancement: when no gap is needed, the searcher within gap can be borrowed for outside gap, then 3 searchers are used for measurement outside gap. Shorter measurement delay for serving cell measurement (which is typically measured outside gap) can be achieved.



- Objective
  - > Enhance CSSF (carrier-specific scaling factor) for L3 measurement outside gap in the above case

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Interruptions at NR SRS antenna port switching

- Motivation
  - > In current RRM spec, it is assumed that SRS resource for SRS antenna switching is allocated at the last 6 symbols of a slot. However, SRS starting in any symbol within a slot is already supported since Rel-16. Thus, some SRS antenna port switching scenarios are not covered by current RAN4 requirements.
  - > In Rel-17 interruption requirements at NR SRS antenna port switching, following scenarios are considered:
    - *Scenario 1: when X=1 SRS symbol is configured in a slot for SRS antenna port switching*
    - *Scenario 2: otherwise, using X=6 SRS symbols in a slot as assumption of SRS transmission time*

    Symbol level interruption requirement is only considered for scenario 1 for synchronized case. For all other cases, interruption requirement is defined in number of slots, which may be much longer than the actual interruption length.

- Objective
  - > Interruption requirements at NR SRS antenna port switching when SRS starting in any symbol of a slot
  - > Finer granularity of interruption requirements at NR SRS antenna port switching (i.e. symbol level interruption length for more applicable scenarios)

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L1/L2 mobility inter-frequency measurement enhancement

- Motivation
  - According to current R18 LTM progress, only L1/L2 inter-frequency measurement with Type 1 gap is specified in R18.
  - For UE who supports NCSG, during measurement occasion UE is expected to transmit and receive data on the corresponding serving carrier(s).

- Objective
  - L1/L2 inter-frequency measurement with NCSG (Network Controlled Small Gap)
    - In FR1, SSB based L1-RSRP measurement can be performed simultaneously with L3-RSRP measurement;
    - In FR2, SSB based L1-RSRP measurement is to be shared with L3 measurement with one NCSG, Or define a dedicated NCSG for L1-RSRP measurement

BS specification improvement

- Co-location and co-existence requirements optimization for network nodes

Co-location and co-existence requirements optimization for network nodes

- Motivation
  - With introduction of a new operating band, both co-location and co-ex requirements need to be updated in multiple specifications (e.g. NR BS, MSR BS, IAB). This is done in order for the new band to be protected from the legacy bands, as well as for the legacy bands to be protected from the newly introduced operating band.
  - The main issue with the existing process is it requires ~ 10 CRs for each new operating band.
  - To improve this, it is proposed to shift all existing and new co-lo and co-ex requirements to a new dedicated TS.
  - With the above, new band co-lo and co-ex would be updated in just one TS (legacy specs would refer to dedicated TS).
- Objectives
  - Introduce new dedicated 37-series TS for RF co-location and co-existence requirements, covering the following:
    1. BS, IAB, and Repeaters requirements
    2. NR, E-UTRA requirements
    3. SRAT, and MSR requirements
    4. Core and Performance parts
    5. Conducted and OTA requirements
  - Optimize handling of core TX spur requirements for the following TS: NR BS, NR Repeaters, NCR, NR IAB, MSR, AAS, E-UTRA BS
  - Optimize handling of core TX spur co-ex for the following TS: NR BS, NR Repeaters, NCR, NR IAB, BS, AAS, E-UTRA BS
  - Optimize handling of core OOB blocking co-location for the following TS: MSR BS, AAS BS, E-UTRA BS

Spectrum/basket WI

- Spectrum/Band combination basket WIs should be further considered after approval of non-spectrum WI/SIs after March 2024

- Clear boundary on the general requirements between non-spectrum and spectrum WI proposals
  - > General requirements are supposed to be specified under non-spectrum WIs
  - > Exception could be considered for spectrum WI only for limited exemplary bands/combinations
    - No more band/band combinations could be added later for spectrum WI including general requirements
  - > Basket WIs are strictly limited to band/band combination specific requirements

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Huawei proposals for Rel-19 RAN4 topics

RAN4 BS RF

OTA test enhancement
- Improve the OTA test efficiency

OTA requirements enhancement
- Study on more OTA requirements/options for BS type 1-H

RAN4 UE RF

Further UL enhancement via UE RF evolution
- Improve PA transmission power to enhance uplink coverage
- MPR reduction by using two Tx on one CC

UE RF FR1
- PC1.5 intra-band C/NC CA
- 6Rx for handheld UE

UE RF FR2
- FR2 UL coverage enhancement

NTN/IoT NTN RF enhancement

NTN/IoT NTN HPUE
- NTN: PC2, PC1.5, PC1
- IoT NTN: PC2

RAN4 RRM

Further RRM enhancement on FR2
- EMR+ Fast SCell activation
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Interruption reduction
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- L1/L2 mobility inter-frequency measurement enhancement

BS specification improvement

Co-location and co-existence requirements optimization for network nodes

RAN4 spectrum/basket WIs

Follow similar approach as Rel-18
- Clear boundary on general requirements between non-spectrum & spectrum WIs
- Not considered as a package with non-spectrum WI/SI proposals

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