3GPP TSG-RAN WG4 Meeting #116bis R4-25xxxxx

Prague, Czech Republic, Oct 13 – 17, 2025

**Agenda item:** 8.1

**Source:** Feature lead (Huawei, HiSilicon)

**Title:** WF for 6GR system parameter

**Document for:** Approval

# Topic #1: Waveform

## Framework study for waveform

* Main proposals
  + Close collaboration with RAN1
    - RAN4 must work closely with RAN1 to define evaluation methodologies, assumptions, and a common PA model for simulations.
    - Some proposals suggest postponing detailed RAN4 waveform discussions until 2026, after RAN1 has made sufficient progress.
  + Key Performance Indicators (KPIs)
    - Waveform evaluation should include KPIs like PAPR, Cubic Metric (CM), SEM, ACLR, OBE, EVM, implementation complexity, and compatibility with 5G band combinations.
  + Evaluation metric
    - Propose using "Net Gain" as a starting point for evaluating low-PAPR schemes.
  + Specific studies include:
    - Study Low-PAPR techniques: Investigate both transparent and non-transparent techniques (like CFR-SE) to reduce PAPR and assess their impact on RF requirements.
    - Explore new waveforms for new use cases: Study the feasibility and impact of supporting DFT-s-OFDM in the DL (e.g., for massive IoT) and new waveforms for Integrated Sensing and Communications (ISAC).
* WF
  + The primary purpose of RAN4 study on waveform is to evaluate candidate waveforms and potential PAPR reduction techniques based on agreements and inputs from RAN1
  + To establish the foundational evaluation framework in RAN4 firstly, and RAN4 waveform study should focus on the following aspects
    - Tx assumption including PA model
    - Related RF requirements which should be taken into consideration
    - Both UL and DL are considered
    - Take the candidate waveforms identified/discussed in RAN1 as the baseline
    - Identify the evaluation metric, e.g. net gain
    - Implementation constraints
  + Model and evaluate the RF performance of different waveform candidates and PAPR reduction techniques pending on RAN1 inputs
    - Evaluation cases could be selected step-by-step, based on RAN1 progress
    - Whether to investigate RF impacts of DL DFT-s-OFDM pending on RAN1 agreement

## PA model

* Main proposals (from [116bis][102] 6G general RF and UE RF)
  + Proposal 1: Study improved PA modelling. Further discuss considering
    - PA dimensioning (MPR-0)
    - Pre-distortion
    - Memory effects
    - APT PA model
    - Doherty PA
    - PA model being based on each company’s own choice.
    - Different PA models e.g. for IoT or FWA
    - Better alignment of simulations and measurements
* WF
  + Consider PA modelling at least for the following aspects for RAN4 discussion
    - Memory effects for UE supporting larger CBW
    - Different PA models for different sub-frequency ranges, e.g. around 7GHz (high priority, PC3/PC2) and lower frequency bands (PC3)
    - Calibration conditions
    - RF impairments used for MPR evaluation, e.g. carrier leakage, I/Q imbalance, etc.
    - PA models for different device types, handheld UE is prioritized
    - Applicable requirements
      * 5G-A requirements as starting point
    - PA models for RAN1 waveform evaluation and RAN4 requirements discussion can be decoupled

# Topic #2: Modulation

* Main proposals
  + Supported modulation order:
    - Support QPSK to 1024QAM for DL and π/2 BPSK/QPSK to 256QAM for UL as the baseline for “Day One” 6G specifications.
    - Study the feasibility of optional higher-order modulations, specifically 1024QAM for UL and 4096QAM for DL.
  + Early involvement:
    - RAN4 should be involved early to validate the feasibility of any new modulation schemes agreed upon by RAN1.
    - Some proposals suggest postponing detailed RAN4 discussions on waveform/modulation until sufficient progress is made in RAN1 (e.g., starting in Q2 2026).
  + Studies for enabling higher-order modulations:
    - Conduct studies on MPR, required SNR, throughput, and coverage for high-order modulations.
    - Study advanced UE techniques (like DPD) and sNB (tentatively used ^^) techniques (like advanced channel estimation) to enable UL 1024QAM.
    - Use 5G EVM requirements as a starting point but define more realistic and appropriate requirements for 6G.
* WF
  + RAN4 evaluation work focus on the feasibility study and RF requirements impact
  + To establish the foundational evaluation framework in RAN4 firstly when no solid progress and inputs from RAN1
    - Identify the main affected requirements for modulation evaluations
      * The existing 5G NR requirements will serve as the baseline, which are subject to future updates based on RAN4’s 6G UE RF discussions.
    - Align on the evaluation assumptions
    - Align on the PA model for consistent evaluations on the modulation
    - RF evaluation could be done firstly for 5G supported modulations with new assumptions for 6G study, such as assumed new spectrum, CBW, new PA models, etc. Co-ordination with 6G UE RF study is needed.
    - Both link-level and system-level simulations should be performed as usual for high-order modulations study done by RAN4 in prior releases, pending on the progress of RAN1.
  + [Model and evaluate the RF performance of higher-order from current existing modulations, e.g. 1024QAM on the UL and/or new constellations concurrently with RAN1 studies
    - Evaluation cases could be selected step-by-step, concurrently with RAN1 progress]

# Topic #3: Channel bandwidth

### Sub-topic 3-1: Max Channel Bandwidth

* Main proposals
  + Frequency-range specific max CBW proposals:
    - Sub-6 GHz (FDD): 50 MHz or 100 MHz (using 15 kHz/[30kHz] SCS and 4K/8K FFT).
    - Sub-6 GHz (TDD): 200 MHz (using 30 kHz SCS and 8K FFT).
    - Upper mid-bands (approx. 6-24 GHz): 200 MHz or 400 MHz (using 30/60 kHz SCS and 8K/16K FFT).
      * Several proposals further split above frequency range with different sub-frequency ranges for consideration on max CBW and numerology selection e.g.
        + 6425MHz ~ 7125MHz
        + 7125MHz ~ 8.4GHz
        + ~15GHz around
    - FR2-1 (24-52 GHz): 800 MHz (using 120 kHz SCS and 8K FFT).
  + Implementation and feasibility studies:
    - Study wideband RF impact: Propose that RAN4 studies the RF implications of wide CBWs (200 MHz, 400 MHz, 800 MHz) on requirements like EVM, ACLR, SEM and receiver sensitivity.
    - Study UE implementation paths: For a 400 MHz CBW, study different UE baseband architectures (e.g., single 16K FFT vs. two 8K FFTs vs. two-component carrier aggregation).
  + Flexible and asymmetric support:
    - Different UL/DL CBW: Propose supporting different maximum channel bandwidths for Uplink and Downlink.
    - BS vs. UE asymmetry: Propose introducing wide CBWs (e.g., 400 MHz) only for base stations, not for UEs, to manage UE complexity.
* WF

In the absence of RAN1 agreements, RAN4 could conduct preliminary assessments of the RF feasibility for the candidate maximum channel bandwidths.

* + RF performance evaluation with proposed max CBW
    - Identify the prioritized max CBW scenarios (e.g., TDD/FDD, frequency ranges) for evaluation
    - From transmitter perspective, evaluate the feasibility of meeting out-of-band emission requirements
    - From receiver perspective, study the impact on reference sensitivity, blocking, and ACS when receiving these wide carriers
    - 5G NR requirements could be considered as baseline for the evaluation on existing frequency bands, FFS for the new spectrum
    - [Study the need and impact of specifying large CBW, e.g. from operator spectrum perspective]
    - Assess the implementation feasibility and complexity and power consumption
    - Compare implementation options, e.g., for cases like 200MHz/400 MHz, evaluate the RF performance and implementation trade-offs of the different proposed UE architectures (e.g., single 16K FFT vs. multi-FFT vs. CA). The evaluation cases also depend on the discussion in RAN1.
    - [Study feasibility of flexible and asymmetric support of max CBW]
  + Collaborate with RAN1 on feasibility findings
    - Provide early feedback to RAN1 with RAN4's initial findings on the RF feasibility and trade-offs of the most prominent max CBW/SCS/FFT combinations.

### Sub-topic 3-2: Min Channel Bandwidth

* Main proposals
  + Specific min CBW values proposals:
    - General baseline: Multiple proposals suggest establishing 5 MHz as a general baseline, following the NR approach.
    - Narrowband support: Several companies support for also standardizing 3 MHz as the min CBW, particularly for specific bands or scenarios (e.g., for initial access, FDD bands, or where operator spectrum is fragmented).
    - SCS-dependent framework: Several proposals link min CBW directly to the SCS, suggesting a scalable framework (e.g., 3/5 MHz for 15 kHz, 10 MHz for 30 kHz, 20 MHz for 60 kHz, 50/100 MHz for 120 kHz).
  + Flexible and granular definition proposals:
    - Band-specific definition: A key proposal is to define min CBW on a per-band basis rather than a per-frequency-range basis. This would allow for larger min CBWs in most legacy bands while enabling smaller min CBWs only in bands where operators truly have fragmented spectrum.
    - Device-type specific definition: Another forward-looking proposal is to explore defining different min CBWs for different device types operating on the same band (e.g., a larger min CBW for high-tier devices and a smaller one for massive IoT devices).
* WF
  + Compare options of defining min CBW, considering pros and cons
  + Study the following aspects from RAN4 perspective, meanwhile tracking RAN1/RAN progress
    - Whether 5MHz could be considered as a general baseline while 3MHz is allowed for particular bands
    - SCS-dependent framework
    - Other aspects are not precluded
  + Provide early feedback to RAN1 with RAN4's initial findings on min CBW from implementation and spectrum perspective.

### Sub-topic 3-3: FFT size

* Main proposals
  + FFT size and CBW combination proposals:
    - Baseline FFT size: Several companies suggested to take 8192 (8K) FFT as the maximum size while a few companies brought up the need to further consider even 16K FFT to potentially cover 400MHz Channel BW.
    - FR1 (Sub-6 GHz / <5GHz): Proposals suggest 4K FFT for up to 100 MHz (with 15/30 kHz SCS) and 8K FFT for up to 200 MHz (with 30 kHz SCS).
    - Upper Mid-Bands (around 7GHz up to 15.35 GHz): Proposals suggest 8K FFT or even up to 16K FFT for up to 400 MHz (with 30/60 kHz SCS).
    - FR2-1 (24-52 GHz): Proposals suggest 4K FFT for 400 MHz and 8K FFT for 800 MHz (with 120 kHz SCS).
  + Feasibility study:
    - Multiple proposals recommend studying the feasibility of 8K FFT with associated SCS, especially for wide CBWs in frequencies above 2.4 GHz and in new frequency range higher than 7125MHz.
* WF
  + Consider FFT size, maximum Channel Bandwidth and numerology as a framework to have feasibility and complexity study from implementation perspective, especially for 8K or 16K FFT size considering the associated SCS and also the frequency ranges
  + Provide RAN1 with early RAN4 feedback on the feasibility and trade-offs of the proposed FFT/CBW/SCS combinations to help guide their decisions.

### Sub-topic 3-4: Numerology

* Main proposals
  + "Single numerology" proposals:
    - Most companies prefer to adopt a single SCS per operating band or frequency sub-range for 6G. This aims to drastically simplify specification, implementation, and network management.
    - This principle extends to using the same numerology for both SSB and data channels within a band, simplifying initial access and receiver design.
  + Frequency-range specific SCS values proposals:
    - FR1 (Sub-6 GHz): 15 kHz for FDD bands and 30 kHz for TDD bands are the most proposed values.
    - Upper Mid-Bands (~7-24 GHz): 30 kHz and 60 kHz are the primary candidates, while 30 kHz being favored for the lower part of this range (e.g., around 7 GHz) with several proposals.
    - FR2-1 (24-52 GHz): 120 kHz SCS is universally proposed as the baseline for these mmWave frequencies.
  + Framework linking SCS, CBW, and FFT size:
    - Integrated design: Multiple proposals present a unified framework where SCS, max CBW, and FFT size are defined together. For example:
      * 30 kHz SCS + 8K FFT => 200 MHz CBW
      * 30 kHz SCS + 16K FFT => 400 MHz CBW
      * 120 kHz SCS + 8K FFT => 800 MHz CBW
    - Band group based SCS: Proposals suggest grouping bands by certain frequency range (e.g., "below 2.4 GHz", "FDD bands < 1.6 GHz", etc.) and assigning a single SCS and FFT size combination to each group.
  + Exceptions and special cases proposals:
    - NTN and ISAC: While a single numerology is the baseline, studies are proposed for supporting multiple SCS for special use cases like NTN and ISAC.
    - Asymmetric UL/DL: The possibility of supporting different SCS for Uplink and Downlink is also noted for further study.
* WF
  + Evaluate the following proposals regarding numerology from RAN4 perspective
    - "Single numerology" proposal
    - Frequency sub-range/Band specific SCS values proposal
      * Compare perf gain and implementation complexity for different SCS with same frequency range or specific band
      * Study numerology for SSB of initial cell search from RAN4 perspective
    - Other proposals not presented in this meeting are not precluded
  + Provide RAN1 with early RAN4 feedback on the feasibility and trade-offs of the proposed FFT/CBW/SCS combinations to help guide their decisions.

### Sub-topic 3-5: Spectrum utilization

* Main proposals
  + Foundational principles and framework:
    - Propose to adopt the 5G NR design philosophy of a unified spectral emission mask as a baseline for SU evaluation, but evolve it for 6G.
    - Propose that 6G SU shall not be smaller than 5G NR. Specifically, for the same channel bandwidth, lower SCS should have higher SU than higher SCS.
    - Propose that the guard band for a given SCS and channel bandwidth should not be larger than that of all larger channel bandwidths for the same SCS.
  + Specific studies and evaluations:
    - Study SU enhancement techniques: Study the benefits and RF trade-offs of techniques to enhance SU, such as using larger NRB and advanced spectral confinement.
    - Evaluate SU systematically: Conduct a comprehensive evaluation of SU, considering the trade-offs between improved SU, RF performance (OOBE, EVM, ACLR), and UE/BS complexity under detailed parameter assumptions (PA model, I/Q imbalance, phase noise, etc.).
      * For existing channel bandwidths (e.g.,≤100 MHz), reusing 5G SU as starting point.
      * Study enhanced SU for the existing CBWs, and prioritize enhancing SU for smaller channel bandwidths where it is currently low (<95%).
      * For newly introduced larger channel bandwidths (e.g., 200MHz), a new SU evaluation is necessary.
    - Investigate requirement relaxation: Study the relaxation of ACLR, SEM, and EVM requirements as a method to improve SU.
* WF
  + Agree on a set of common simulation assumptions for SU evaluation, including PA models, RF impairments (e.g., carrier leakage, I/Q imbalance, phase noise, etc.), and baseline RF requirements (e.g., SEM, ACLR, EVM).
    - 5G NR channel bandwidth, requirements can be considered as starting point for the SU evaluation with new assumptions for 6G
  + Evaluate the RF performance impact (complying with the affected requirements) of advanced spectral confinement techniques (e.g., better filtering, windowing) to understand how many RBs can be enabled
    - Considering trade-offs between SU, RF performance, and UE/BS complexity
    - Channel bandwidth and SCS with smaller SU should be prioritized
    - SU for larger channel bandwidth shall be evaluated based on progress on CBW
    - Closely coordinate with RAN1 on different waveform candidates and SCS configurations.

### Sub-topic 3-6: Asymmetric channel bandwidths

* Main proposals
  + All bands can apply symmetric/asymmetric CBW in downlink and uplink in 6G day one.
* Recommended WF
  + RAN4 to check whether the proposal is viable for 6G, meanwhile, take the identified issues for asymmetric CBW in 5G into consideration to establish a framework for both FDD and TDD bands

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| **Company** | **Comments** |
| ZTE | It would depend on the operator demand. |
| OPPO | This feature has already been implemented in NR and is helpful for UE power saving we try to make it mandatory support in 6G day 1. |
| Xiaomi | To early to discuss mandatory certain features in first 6G meeting. We can further evaluate asymmetric channel bandwidth, any enhanced solution can be adopted in 6G and what’s the impact expected instead of jump to make hard decision on supporting. |
| MediaTek | We do not support the proposal without study the FDD/TDD scenarios first.  For FDD bands, there’s REFSENS impact on the asymmetric CBW.  For TDD bands, RAN4 shall confirm whether 5G NR assumptions are re-used. Does shared LO for both UL and DL still baseline assumption? Further discuss on whether asymmetric CBW is feasible case by case |
| vivo | From our view, to support the 400 CBW at UE UL would be very challenging, so we support to consider the asymmetric channel bandwidths from real UE implementation perspective |
| Huawei | It is premature to agree on the first bullet. If we can have a generic approach to handle the irregular channel bandwidth in 6G, it could help to reduce the number of channel bandwidths which would benefit for the UE design and test effort. 5G study is focus on small spectrum block cases, and for 6G, irregular channel bandwidth for wide spectrum block cases should also be considered. |

# Topic #4: Channel arrangement

### Sub-topic 4-1: Channel raster

* Main proposals
  + The SCS-based raster as baseline: A dominant proposal is to adopt an SCS-based channel raster as the primary or baseline method for 6G, especially for new bands and frequencies above ~3 GHz.
  + Unified and finer-granularity rasters: For lower frequencies (typically below 3 GHz), there is a push for rasters finer than 100 kHz to increase channel placement flexibility:
    - 10 kHz raster: Proposed as a baseline for refarmed bands below 2.4/3 GHz, continuing the 5G "enhanced raster" approach.
    - 5 kHz raster: Proposed as a unified "common channel raster" for all refarmed FR1 bands, considering it provides maximum flexibility and is a GCD of common SCS values.
  + Migration and co-existence approaches:
    - Band-specific hybrid approach: Many proposals recommend a dual or hybrid strategy: using a finer raster (5/10 kHz) for refarmed low-band spectrum and an SCS-based raster for new and higher-frequency bands.
    - Raster shifting: Suggesting the use of a fixed frequency shift to align a new 6G SCS-based raster with existing 5G raster points, easing coexistence.
    - Study migration paths: Explicitly proposing to study the migration of existing NR bands from a 100 kHz raster to an SCS-based model.
* WF
  + Study 5G-6GR co-existence impact on channel raster with legacy NR refarmed bands
    - Note that NR bands could have 100kHz channel raster, 10kHz enhanced channel raster or SCS based channel raster
  + Investigate the interaction between the channel raster and the synchronization raster
  + Investigate the necessity of channel raster or alternative ways for the channel configuration
    - If channel raster needs to be specified, further investigate granularity including SCS based raster, and enhanced channel raster
    - Investigate the possibility of migrating to SCS based raster if legacy rasters are still to be supported
  + Study the listed main proposals especially for the migration and co-existence approaches
    - Other options not presented in this meeting are not precluded
  + Provide early feedback to RAN1 with RAN4's analysis on the RF coexistence performance and potential implementation complexity associated with the various proposed channel raster options (5 kHz, 10 kHz, SCS-based).

### Sub-topic 4-2: Sync raster

* Main proposals
  + The "Sparser is Better" principle:
    - Coarser step sizes: The predominant proposal is to design a sparser, coarser-grained sync raster for 6G. This involves using larger step sizes and basing the design on larger assumed channel bandwidths to reduce the total number of raster points.
    - Minimize raster entries: A key goal is to explicitly minimize the number of sync raster entries defined per operating band.
  + Enhanced flexibility and efficiency:
    - Adaptive SSB periodicity: Propose supporting longer and adaptive SSB periodicities (e.g., 40ms, 80ms, 160ms) to enable significant network energy saving, with the possibility of a dual raster (sparse and dense) for different deployment scenarios.
    - Decouple data and sync carriers: A forward-looking proposal suggests studying the feasibility of "pure data channels" that do not contain an SSB, allowing the sync raster to be optimized solely for initial access.
  + Simplified and unified design:
    - Unified Framework: Propose a unified sync raster design that works across different bands, min CBW values, and SCS configurations to avoid the fragmentation seen in 5G.
    - Leverage coarser reference grids: Specifically propose using a "1 RB reference channel raster" to achieve RB-level alignment and eliminate K\_ssb, leading to a significant reduction in sync raster points.
    - Consistent SSB design: Advocate for a consistent SSB design across bands to facilitate harmonized deployment and avoid risk of deployment delays.
  + Prudent timeline and collaboration:
    - Postpone for RAN1 input: Several proposals recommend postponing detailed RAN4 sync raster discussion until after RAN1 has made sufficient progress on the fundamental SSB and initial access design.
    - Early RAN4 involvement: It is also proposed by companies that RAN4 should be involved early in any study related to initial access performance to provide RF and implementation perspectives.
* Recommended WF
  + Evaluation on sync raster from RAN4 perspective:
    - Investigate the interaction between the channel raster and the synchronization raster (especially for SSB placement)
    - Study the listed proposals regarding
      * Enhanced flexibility and efficiency
      * Simplified and unified design
      * Other aspects if identified are not precluded
  + Collaboration and planning:
    - Proactively collaborate with RAN1 to ensure that the evolving SSB design considers the practical RF and implementation constraints related to the sync raster from the outset.
    - Develop a flexible evaluation framework in RAN4 that can quickly assess different sync raster proposals once key parameters (like final SSB bandwidth and min CBW) are stabilized by RAN1.

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| **Company** | **Comments** |
| ZTE | We also need to consider the following aspects:  non-overlapping with 5G sync raster if 6GR SSB design is different from 5G to simplify UE detection,  defining common sync raster design for TN and NTN, and consider NTN Doppler shift impact. |
| OPPO | The sync raster design should be really early RAN4 involved to avoid the lesson of Kssb.  The two principles in 5G needs to further discussed as whether to keep it:   * + Each smallest CBW should have at least one SSB   + Floating sync raster with SCS level alignment of channel raster   RAN1 new concept to be considered together as SCMC/perch carrier concepts.  In our discussion paper, we have proposed one sync raster design for example that can reduce the sync raster points. Get rid of Kssb in 5G, support different operator’s request of the minCBW and also work fine as MRSS. |
| Xiaomi | The recommended WF is fine for us, this sync raster is strongly depending on RAN1 design on SSB, hard to have concrete discussion without input from RAN1. We sugguest to set check point on RAN1 status update i.e. Q2’2026. |
| vivo | We could start the discussion with whether to adopt the current concept and cycle of sync raster and further study how to define a coarser sync raster. The details especially related to RAN1 design for SSB should wait for their further study. |
| MTK | The baseline target for sync raster design in 6G is to ensure that the overall delay associated with 6G sync raster is not worse than 5G.  We also need to avoid the over-design issue of sync raster in 5G by reducing the density of the sync raster entries in 6G. This can be achieved in different approaches but in a high-level approach we need to update the baseline assumptions that was adopted in 5G in terms of step-size or minimum CBW to apply a coarser sync raster. We acknowledge that SSB design in RAN1 will impact the sync raster design in 6G, but this does not prohibit RAN4 to discuss other aspects that can address the high-density issue of sync raster in 6G.  Therefore, we propose to add reducing sync raster density in 6G study in the recommended WF. |

### Sub-topic 4-3: Channel spacing

* Main proposals
  + Simplify the nominal channel spacing framework for 6G by not designing it to support simultaneous mixed numerologies (i.e., different SCS on adjacent carriers).
  + Study in 6GR to develop a proper definition of channel spacing for intra-band CA to support flexible operator deployment scenarios.
* Recommended WF
  + Further study in RAN4 with the observations and proposals regarding channel spacing
    - Other issues relevant to channel spacing if identified are not precluded

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| **Company** | **Comments** |
| Xiaomi | This is pending carrier aggregation schemes, better to hold the discussion after we have clear picture on SCS and channel raster first on single carrier first. |
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# Topic #5: Irregular channel bandwidth

* Main proposals
  + Study and establish a scalable and efficient framework for supporting irregular bandwidths from 6G "Day 1," avoiding the proliferation of specified CBWs.
  + Use 5G solutions and specific concepts from TR 38.844 (like overlapping UE CBW and larger CBW) as a starting point. Other options could also be considered, such as:
    - Option 1 (Define a limited set): Standardize a specific, limited set of irregular CBWs (e.g., up to 10 or 20MHz) just like regular bandwidths.
    - Option 2 (Scaling-based approach): Specify RF requirements for a baseline (min/max CBW) and define scaling factors for other bandwidths.
    - Option 3 (BWP-like approach): A more radical proposal to define RF requirements based on the actual configured/activated bandwidth (e.g., on a per-RB basis or BWP-like basis) rather than the total channel bandwidth.
  + Investigate whether solutions like single-cell multi-carrier operation or Carrier Aggregation can help utilize irregular spectrum.
  + Consider initially enabling irregular CBW only in the Downlink where RF requirements are easier to define.
  + Carefully examine and limit the set of CBWs to balance UE design/test complexity with the flexibility for operators to fully utilize their spectrum.
  + Further study the signaling design and channel raster rules to guarantee flexible CBW works properly.
  + How to reduce test burden is also an important aspect to be studied
* Recommended WF
  + With inputs from operators, to check whether limited set of irregular CBWs could be specified for 6G, like specific channel BW of 7MHz and 6MHz defined in 5G-A
  + Using 5G concepts from TR 38.844 as starting point to study a more generic solution for 6G
    - The listed main proposals and identified issues should be taken into account for the following study of irregular/flexible/scalable channel bandwidths
    - Other options not presented in this meeting are not precluded

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| **Company** | **Comments** |
| Nokia | Do not agree that current operator spectrum holding is the correct guiding principle for 6G. Spectrums can be sold and bought thus those are not carved on stone. Old radio systems die and spectrums can be re-purposed. RAN4 should define flexible bandwidth approach for 6G for future proof purpose. |
| Skyworks | For SU for larger CBW than for 5G but also to support flexible CBW we believe it should be possible to have NRB based on an equation with the CBW as a parameter and still use a limited set of specified and verified CBW (the only issue we see for this is for additional (NS) emissions) |
| ZTE | Firstly, before going to more details, maybe we need to achieve agreement on the regular channel bandwidth definition first. In our understanding, all channel bandwidths that are multiple of 5MHz can be regarded as regular channel bandwidth, and 3MHz is an exception, it can be seen as regular channel bandwidth as well. Otherwise, it is irregular channel bandwidth. Common understanding?  Secondly, need to identify how many irregular channel bandwidth demands. If it is limited, we propose to standardize the irregular CBW as other regular BW in the spec. If not, we agree to use 5G schemes from TR38.844 as a starting point. |
| Xiaomi | The first bullet not ok for us at current stage, we can first collect the irregular BW demand from operators, then how to address such demand considering the trade-off between gNB/UE complexity and flexibility of spectrum usage shall be considered together. We may have more smart way in 6G to address such demand instead of introducing specific channel BW.  In 5G, the major reason we introduce 6MHz and 7MHz was due to SSB placement, no sufficient overlapping region to cover 3.6MHz SSB/4.5MHz coreset.  In 6G, SSB design/Corset and channel mapping is still on discussion in RAN1. There are dependency on this.  Updated recommend WF as following:  “   * + ~~With inputs from operators, to check whether limited set of irregular CBWs could be specified for 6G, like specific channel BW of 7MHz and 6MHz defined in 5G-A~~ Collect inputs from operators on the irregular spectrum/BW demand from spectrum holding perspective especially for below 10MHz   + Using 5G concepts from TR 38.844 as starting point to study a more generic solution for 6G     - The listed main proposals and identified issues should be taken into account for the following study of irregular/flexible/scalable channel bandwidths     - Other options not presented in this meeting are not precluded     - Trade-off between spectrum usage flexibility/efficiency and UE/gNB implementation and conformance test complicity need to be considered   + Tight cooperation with RAN1 on channel mapping rule, SSB placement and channel raster design to facilitate irregular spectrum/BW usage   “ |
| vivo | Before we jump into the solution of irregular CBW, we should discuss what is the regular CBW would be in 6G, e.g., what will be the granularity of nominal CBW for >100MHz |
| Huawei | It is premature to agree on the first bullet. If we can have a generic approach to handle the irregular channel bandwidth in 6G, it could help to reduce the number of channel bandwidths which would be benefit for the UE design and test effort. 5G study is focus on small spectrum block cases, and for 6G irregular channel bandwidth for wide spectrum block cases should also be considered. |

# Topic #6: Number of Tx and Rx

* Main proposals
  + Device-type and frequency-dependent scaling: Proposals define baseline configurations by linking the number of Tx/Rx chains directly to the device type and the operating frequency band/frequency sub-range. The following are just some examples.
    - Massive IoT: A baseline of 1T1R is proposed.
    - Reduced capability UE / Wearable device / Scalable UE: 1T2R
    - Smartphone / Normal UE (Handheld):
      * Low Bands (< 3 GHz): 1T2R or 1T4R.
      * Mid/High Bands (3-7 GHz): 2T4R or 2T6R.
      * Around 7GHz: 2T4R or 2T6R or 4T8R.
    - FWA / Advanced UE: Higher configurations are proposed, with baselines of 2T8R or 4T8R or 8T8R in FR1 or ~7GHz, and even 8Tx/16Rx for new bands, leveraging their relaxed form factor.
  + Architectural evolution and enhanced capabilities:
    - Higher maximum limits: Proposals suggest supporting up to 4Tx and 8Rx/16Rx for capable UEs, scaling beyond 5G's limits from the start.
    - Advanced MIMO and beamforming: There are proposals to support higher-order MIMO (e.g., 8x8 DL, 4x4 UL) and improved digital beamforming with finer granularity.
    - Enhanced architectures: Some proposals study feasibility of unique configurations like "6Rx only" for high frequency range to optimize for downlink-heavy traffic.
  + Specification and requirement framework:
    - Scalable RF requirements:
      * Study scalable requirement versus #antennas based on antenna correlation, antenna coupling and beamforming impairments for UE multi-Tx/Rx and MIMO support
      * Study how to define scalable requirements for different numbers of Rx chains per band.
    - Unified power management: consider MPR specification based on cumulative power across all antenna connectors, independent of Tx chain count
* WF
  + Study the framework of spec impact with different number of Tx/Rx
  + Evaluate number of Tx/Rx from both a performance and implementation complexity perspective.
    - E.g. device size (e.g. foldable smartphone)/form factors constraints, antenna design
  + Co-ordinate with RAN and RAN1 for number of Tx/Rx

# Topic #7: Device types

* Main proposals
  + Category of Device Types: There is common view to define a limited set of device types from 6G "Day One" to avoid market fragmentation. The most frequently proposed categories are (may not cover all diversified proposals):
    - Massive IoT/Type C: For sensors, low-end wearables; characterized by low complexity, 1T1R, 3-20 MHz CBW, and basic modulation.
    - Reduced-Capability/Wearable/Scalable UE/ Type B: For smartwatches, XR; with moderate capabilities (e.g., 1T2R, 100 MHz CBW).
    - Smartphone/Normal UE (including XR)/Type A: The mainstream handheld device; offering improved performance over 5G (e.g., 1T/4R, 2T4R, 200 MHz CBW, 1024QAM).
    - FWA/Advanced UE/Type A+: For Fixed Wireless Access, humanoid robot, etc.; with relaxed form-factor constraints and the highest capabilities (e.g., 4T8R/8T8R, 400 MHz CBW, 4096QAM).
  + Scalable and forward-compatible framework:
    - Mandatory baseline functionality set: A proposal suggests a mandatory baseline functionality set, in which each functionality shall be well justified to be truly mandatory for all device types. And on top of the mandatory baseline functionality set, different device types could be further defined. Several proposals suggest to have mandatory set as per device type basis. Capability-based parameters: Proposals emphasize that device types should be defined by concrete RF/Baseband parameters, including capabilities such as:
      * Number of Tx/Rx antennas and MIMO layers
      * Min and max Channel Bandwidth
      * Supported modulation orders (DL/UL)
      * Power Class
      * Duplex Mode (FDD, TDD, HD-FDD)
      * RRM mobility
  + Enhanced signaling and network optimization:
    - UE capability reporting: Introduce a modular and MAC-layer-assisted UE capability reporting framework to enable efficient, category-based network optimization without excessive per-UE signaling overhead.
    - Dynamic capability update: Study the possibility for UEs to update their capabilities (e.g., for foldable devices or different power modes), requiring cooperation between the network and the UE.
  + RAN4's specific role:
    - Focus on RF-critical attributes: RAN4 should focus on study the RF/RRM/Demod characteristics that differentiate device types, ensuring requirements are achievable, testable and avoid unnecessary specification fragmentation.
* WF
  + The following aspects could be further studied
    - Investigate detailed RF/BB implementation feasibility and constraints related to different devices assumption , for example, size/form factors and use cases (e.g., IoT, Wearable, Smartphone, FWA devices). These should include concrete assumptions, e.g. number of antennas, CBW, power class, and supported modulation per frequency range.
      * Study on the NW impact should also be considered
    - Study how to better support variety devices from RAN4 perspective
      * E.g. differentiate devices, use cases, features
    - Other aspects are not precluded
  + Collaborate on the framework with other WGs:
    - Provide necessary inputs to RAN/other WGs with RAN4's study outcome for the above mentioned issues