**3GPP TSG-RAN4 Meeting #116bis *R4-2514517***

**Prague, Czech Republic, 13th – 17th October, 2025**

**Agenda item:** 8.12

**Source:** Feature lead (vivo)

**Title:** Topic summary for [116bis][110] 6G testability and OTA

**Document for:** Information

# Introduction

This summary covers the discussions of 6G OTA and testability, capture all the proposals in Tdocs from agenda 8.12 6G testability and OTA. Based on 6G SID, the discussion scope includes all the testability issues for **conducted requirements and OTA requirements for 6G UE/BS requirements, both AI and non-AI cases**.

* 6GR core and performance requirements

1. General RF aspects [RAN4]
   * + Intra-3GPP co-existence studies
     + Study RF related system parameters and requirements
2. BS RF requirement aspects including band [RAN4]
   * + BS RF requirement and testing framework aiming at improvements and/or simplification compared to 5G NR, including MSR and AAS operation
     + Study how to improve 6G BS core, conformance specifications, including structure and drafting principles
3. UE RF requirement aspects including band and band combination [RAN4]
   * + UE RF requirement framework aiming at improvements and/or simplification compared to 5G NR
     + Study how to improve 6G UE RF specification(s), including structure, drafting principles, and database for band combination
     + Study UE RF capabilities considering different device types and implementations
4. RRM aspects for 6GR [RAN4, RAN1, RAN2]
   * + RRM requirement and procedure aspects aiming at improvements and/or simplification compared to 5G NR
     + Study how to improve 6G requirement specification, including structure and drafting principles
5. Demodulation and performance aspects [RAN4]
   * + Demodulation and performance requirement framework and key assumptions, aiming at improvements and/or simplification compared to 5G NR for UE and BS
     + Study how to improve 6G demodulation and performance specifications, including structure and drafting principles for UE and BS
6. Aspects related to the testability [RAN4]
   * + Testability methodology framework and key assumptions, aiming to ensure that requirements can be properly tested considering the applicability and feasibility of conductive and/or OTA testing with reasonable complexity
7. Other aspects
   * + Handling irregular channel bandwidths including the definition [RAN4, RAN1]
     + Definition of ‘frequency range(s)’[RAN4]

In this first meeting of RAN4 6G, there were 14 contributions, all the proposals in the Tdocs are categorized into the following topics:

1. **Improved testability of Conducted Requirements**
2. **New test methodologies for new 6GR frequencies**
3. **OTA test methods for Multi-Tx and CA**
4. **Testability for different Device types**
5. **AI/ML OTA testability**
6. **Harmonized testing for TN and NTN**
7. **Improved test methods and metric for SISO OTA**
8. **Improved test methods and metric for DL MIMO OTA**
9. **Test efficiency improvement**
10. **Testability for BS requirements**
11. **others**

General views from FL for the 1st meeting of 6G testability and OTA discussions:

1. Identify scope of each topic for RAN4 future study
2. Lesson learned from 5G and what we could improve in 6GR
3. New metric, methods, UE types, UE features for 6GR

# Topic #1: **Improved testability of Conducted Requirements**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513024**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513024.zip) | Qualcomm Incorporated | **Proposal 6**: **RAN4 could investigate whether compliance with radiated spurious emission limits consistently implies compliance with conducted spurious emission limits and study the feasibility of verifying either radiated or conductive spurious emission requirement for 6G UE.** |
| [**R4-2513210**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513210.zip) | CATT | ***Proposal 2:*** **RAN4 to investigate and extend OTA-based requirements and test methodology for more FR1 transmitter and receiver characteristics in 6G era.** |
| [**R4-2513338**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513338.zip) | Ericsson Korea Partners Co Ltd | **Observation 2.** Some conducted requirements from the previous generations, e.g. Pout, sensitivity, spurious emissions, EVM, MSD and MIMO verification, are not sufficient for guaranteeing device good functioning. OTA testing provides more realistic device-level performance under integrated antenna/beamforming conditions.  **Proposal 3.** Study which conducted tests in the previous generations can be moved or complemented with OTA test in 6G, e.g. Pout, sensitivity, spurious emissions, EVM, MSD, UL MIMO, etc.  **Observation 5.** In FR1 conducted TS 38.101-1, “for UE(s) with an integral antenna only, a reference antenna(s) with a gain of 0 dBi is assumed for each antenna port(s)”. It is worth discussing if the conducted requirement could be related to the OTA requirement by at least assuming a reasonable antenna efficiency, e.g. a typical FR1 antenna efficiency is -5.5 dB.  **Proposal 8.** Discuss a more realistic assumption on antenna efficiency for FR1 band tests, e.g. -5.5 dB.  **Proposal 9.** For the bands that have TRP/TRS requirements, use the value of TRP to derive the real antenna efficiency. |
| [**R4-2513347**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513347.zip) | Keysight Technologies UK Ltd | **Proposal 3: For 6G FR1, consider OTA testing where conducted conformance testing (UE RF, Demodulation, RRM) could either yield testability issues, e.g., lack of physical Tx/Rx ports, and/or highly dynamic nature of multiple Tx/Rx operation, including antenna tuning for impedance and/or pattern**  **Proposal 4: When deciding the testing environment of 6G for the range between FR1 and FR2, take testing aspect pros and cons for conducted vs radiated testing, summarized in Table 1, into account**  **Proposal 5: Conclude on the actual frequency range of 6G operation between FR1 and FR2 early to determine whether existing FR1 or FR2 systems/methodologies should serve as baseline for OTA testing.** |

## Open issues summary

### Sub-topic 1-1 Antenna assumption of FR1 transmitter and receiver

FL: the 0 dBi antenna assumed for conducted requirements is the UE antenna pattern is omni-directional with 0dBi direction-gain. However, this value is not the antenna efficiency used for link budget or other analysis. We should differentia this two parameters discussion.

Based on companies input, FL thinks the intention for discussion is antenna efficiency when calculating some antenna-related requirements, e.g., MSD (antenna isolation is considered, but it is also has coupled-relationship with antenna efficiency which is not seriously considered).

Besides, when using the conducted values for network configuration or power control, the final radiated power also matters. It would be reasonable to consider in 6G whether some requirements should be evaluated based on a reasonable antenna assumption.

**Issue 1-1-1: Whether RAN4 should consider a More realistic antenna efficiency assumption for FR1**

* Observations:
  + In FR1 conducted TS 38.101-1, “for UE(s) with an integral antenna only, a reference antenna(s) with a gain of 0 dBi is assumed for each antenna port(s)”. It is worth discussing if the conducted requirement could be related to the OTA requirement by at least assuming a reasonable antenna efficiency, e.g. a typical FR1 antenna efficiency is -5.5 dB.
  + Since typical FR1 handset antennas rarely achieve 0 dBi effective gain and often exhibit efficiencies around –5.5 dB, it is worth considering whether conducted requirements could be more meaningfully related to OTA performance by factoring in realistic antenna efficiency values. This would help bridge the gap between laboratory conducted tests and real-world device behaviour
* Proposals
  + **Proposal 1:** Discuss a more realistic assumption on antenna efficiency for FR1 band tests, e.g. -5.5 dB**. (E///)**
* Recommended WF
  + -5.5dB was agreed in 5G for NTN antenna assumption, and the LS was sent to RAN1.
  + Discuss and decide whether RAN4 will update this basis assumption for Antenna-involved requirements. This can be decided together with RF requirements discussion.

*Chair guidance: move this discussion to general RF/UE RF from next meeting.*

**Issue 1-1-2: Which value is reasonable for FR1 antenna efficiency assumption for RF requirements**

* Proposals
  + **Proposal 1:** For the bands that have TRP/TRS requirements, use the value of TRP to derive the real antenna efficiency**. (E///)**
* Recommended WF
  + TRP value is results after human body (phantom) absorption effect, if use TRP to derive antenna efficiency, better to use Free Space.

### Sub-topic 1-2 Improve traditional conducted test to OTA

FL: As an example, MSD is widely discussed in UE RF session whether the requirements should be verified via OTA approach to achieve more realistic situation. The discussion on testability would not be replacing conducted MSD requirements or not, but to discuss whether it is feasible and valuable to verify it with OTA method.

**Issue 1-2-1: Whether it is valuable to improve some conducted requirements to be verified via OTA approach**

* Observations:
  + Some conducted requirements from the previous generations, e.g. Pout, sensitivity, spurious emissions, EVM, MSD and MIMO verification, are not sufficient for guaranteeing device good functioning. OTA testing provides more realistic device-level performance under integrated antenna/beamforming conditions.
  + Conductive spurious emission in UE RF requirements and radiated spurious emission are same for frequency range 30MHz to 26GHz. The only different is that frequency range for 9kHz to 150kHz is not tested for radiated spurious emissions. It might be duplicated for UE to pass both conductive and radiated emission requirements.
  + it can be seen that FR1 OTA testing mainly focus on TRP/TRS and MIMO OTA metrics in 5G phase. Since it’s recognised that OTA testing better reflects real-world conditions, RAN4 could consider to investigate OTA-based requirements and test methodology for more FR1 Tx/Rx characteristics in 6G, such as Output power dynamics, Transmit signal quality, etc.
  + OTA testing is critical to ensuring 6G commercial implementations to meet 6G core requirements in realistic.

R&S:the proposals are more requirement related instead of testability. Clear boundary should be defined.

OPPO: OTA is more expensive and time consuming. This should be considered on the decision.

Samsung: agree with R&S.

Qualcomm: need to understand how to better handle the case where both conducted and OTA tests are defined

Ericsson:limitation with existing conduct test need to be addressed.

Xiaomi: similar view as OPPO.

CAICT: open for this discussion. The test framework should be discussed together.

Keysight:OTA may help to address the testability issue of conducted ones.

Huawei: agree with OPPO and Samsung. It should be discussed case by case.

Apple: assume the discussion is limited to FR1. We should also consider the harmonization with non-3GPP partners on the testing.

CATT:OTA test is closer to the real scenario.

Nokia: this can be discussed case by case

* Proposals
  + **Option 1: Yes. (**CATT, E///, Qualcomm, Keysight**)**
    - **Proposal 1**: RAN4 could investigate whether compliance with radiated spurious emission limits consistently implies compliance with conducted spurious emission limits and study the feasibility of verifying either radiated or conductive spurious emission requirement for 6G UE. (QC)
    - **Proposal 2**: RAN4 to investigate and extend OTA-based requirements and test methodology for more FR1 transmitter and receiver characteristics in 6G era. (CATT)
    - **Proposal 3**: Study which conducted tests in the previous generations can be moved or complemented with OTA test in 6G, e.g. Pout, sensitivity, spurious emissions, EVM, MSD, UL MIMO, etc. (E///)
    - **Proposal 4**: For 6G FR1, consider OTA testing where conducted conformance testing (UE RF, Demodulation, RRM) could either yield testability issues, e.g., lack of physical Tx/Rx ports, and/or highly dynamic nature of multiple Tx/Rx operation, including antenna tuning for impedance and/or pattern. (Keysight)
  + **Option 2: No.**
* Recommended WF
  + Generally, yes, and RAN4 will work on this direction.
  + For details of few traditional conducted requirements should be specified/verified via radiated characteristics. Consider the following as starting point.
    - Radiated spurious emission
    - Pout
    - EVM
    - CA MSD
    - Power of UL MIMO
  + Discuss and decide which conducted conformance testing (UE RF, Demodulation, RRM) could either yield testability issues, e.g., lack of physical Tx/Rx ports, and/or highly dynamic nature of multiple Tx/Rx operation, including antenna tuning for impedance and/or pattern.
    - New 6G frequencies
    - Feature with dynamic characteristics

**Issue 1-2-2: Which FR1 conducted requirement can be moved to radiated?**

* Proposals
  + **Proposal 1:** Consider Pout, sensitivity, spurious emissions, EVM, MSD, UL MIMO**. (E///)**
  + **Proposal 2:** Consider OTA testing where conducted conformance testing (UE RF, Demodulation, RRM) could either yield testability issues, e.g., lack of physical Tx/Rx ports, and/or highly dynamic nature of multiple Tx/Rx operation, including antenna tuning for impedance and/or pattern. (Keysight)
* Recommended WF
  + Depends on outcome of issue 1-2-1

# Topic #2: **New test methodologies for new 6GR frequencies**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513024**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513024.zip) | Qualcomm Incorporated | **Observation 1: As the starting point, RAN4 can further study FR3 testability with the splitting FR3 assuming 8.4GHz as the boundary.**  **Proposal 1: For FR3 below 8.4GHz frequencies, conductive test could be considered as the baseline. RAN4 needs to study whether to use OTA test method to verify UE radiated performance with multi-Tx scheme.**  **Proposal 2: RAN4 needs futher study the UE archetechture for the frequencies above 8.4GHz. If OTA testing is needed, RAN4 should assess the feasibility of leveraging existing FR2 test setups (e.g., IFF chambers) or methodologies used for Ka/Ku-band VSAT UEs.** |
| [**R4-2513030**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513030.zip) | Apple Computer Trading Co. Ltd | **Observation 1: 6G frequency range overlaps with existing 5G NR frequency range FR-1 and FR-2.**  **Proposal 1: RAN4 to reuse as much as possible the existing baselines of the NR frequency ranges FR-1 and FR-2 for RF requirements definition and testability of 6G frequency ranges.**  **Proposal 2: Identify the specific frequencies of interest (lower part of 7-24 GHz range seems to have obvious interest) to begin 6G OTA study for SISO/MIMO.**  **Proposal 3: To further discuss the testing methodology for the 6G new frequency spectrum range (~7GHz to 24 GHz), with a primary focus on Standalone (SA) mode.**  **Proposal 4: Include within the scope of the 6G OTA study the feasibility of extending current baseline test methods used for FR1 (SISO/MIMO) OTA performance testing to the upper mid band frequencies (lower part of the 7-24 GHz range) after identifying the specific frequencies that are of initial interest.** |
| [**R4-2513052**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513052.zip) | Samsung | **Observation 1: the trend of mobile communication is to be more and more broaden in terms of functionalities, device types and usage scenarios, the testability study should take the new situation into account in 6G Day 1.**  **Proposal 1: RAN4 to take new spectrum, diverse device types, new feature and functionalities into account in the testability framework study from 6G Day 1.**  **Observation 2: previous RAN4 study on IMT at around 15GHz shows that analog beam forming is not practical to be adopted by handheld UE due to large antenna panel size.**  **Observation 3: discrete antennas with digital beam forming is similar with coherent UL MIMO where conductive requirements and testing are still applicable. A new TRP OTA metric to accommodate such digital beamforming like performance gain in radiation was adopted in TRP TRS work item.**  **Proposal 2: conductive testing is still applicable for RF requirements at around 15GHz. Additional OTA metric can be further studied to accommodate potential multi-antenna performance gain in radiation.**  **Observation 4: frequency is not the only factor to determine the conductive or radiative requirement and test, but UE type and form factor also plays important role, as indicated by the ATG and NTN Ku band examples.**  **Proposal 3: For handheld UE, only conductive testing is considered up to around 15GHz, except traditional OTA requirement and testing.** |
| [**R4-2513130**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513130.zip) | CMCC | **Proposal 1: For the testability around 7GHz, FR1 conduction test should be used as the baseline.**  **Proposal 2: If separate FR is defined for 6GR,**   * **For frequency bands below [10GHz] (the frequency around 7GHz), it is suggested that the testability should take the conduction test of FR1 as the baseline.** * **For frequency bands above [15GHz] (Ku bands), consider using the OTA test of FR2 as the baseline.** |
| [**R4-2513255**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513255.zip) | vivo | **Proposal 7: RAN4 should study the feasibility and complexity of extending FR1 AC system and FR2 IFF/DFF system to cover FR3 frequency range.**  **Proposal 8: For wider CBW in FR3, RAN4 should study a reasonable approach to quantify the flatness of UE radiated performance within the CBW range.** |
| [**R4-2513282**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513282.zip) | Xiaomi | **Proposal 1: RAN4 should have further discussion on the following aspects as part of the 6G OTA Testing:**   * **Frequency ranges for 6G OTA study** * **Assumption for different device type and antenna/antenna array;** * **Channel model for 6G OTA study, e.g. static or dynamic;** * **Test method and metric for ISAC;** * **AI/ML testing**    + **OTA validation for AI/ML-assistant features;**   + **Generalization and AI/ML Robustness Testing;** * **Energy Efficiency evaluation under OTA performance metric;** * **Chamber and Measurement Infrastructure for 6G OTA testing, e.g. chamber size, quiet-zone size, calibration, MU, etc.** |
| [**R4-2513287**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513287.zip) | CAICT | **Proposal 1: For 6G frequency bands that overlap with 5G, the existing 5G NR test system should be reused as much as possible.**  **Proposal 2: It is proposed that RAN4 studies a segmented test approach for the new 7-24.25 GHz band. Define test methods for the lower part (below ~[10]**  **GHz) based on FR1 methodologies, and for the upper part (above ~[15] GHz) based on extending FR2 methodologies.**  **Proposal 3: RAN4 conducts a dedicated study to resolve the test methodology for the [10]-[15] GHz band. This could involve selecting between FR1-based and**  **FR2-based methods, or developing a framework that supports both.** |
| [**R4-2513312**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513312.zip) | Huawei, HiSilicon | **Proposal 1: Study and include new frequency bands such as 7.125 – 8.4 GHz and 14.8 – 15.35 GHz in TRP and TRS tests.** |
| [**R4-2513320**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513320.zip) | OPPO | **Conductive/OTA test framework**  Observation 1: From LTE, the conductive plus TRP/TRS and MIMO OTA framework has been established.  Observation 2: For 5G NR, FR1 reuse similar framework of LTE as conductive test plus TRP/TRS and MIMO OTA.  Observation 3: For 5G NR, FR2 only used OTA tests.  Proposal 1: For 6GR, FR1 like sub-range 1 can reuse 5G FR1 test framework and FR2 like sub-range 3 can reuse 5G FR2 test framework,  Observation 4: The 15GHz connector with feasible insertion loss is on the market.  Proposal 2: For 6GR around 15GHz band, conductive test framework is preferred.  **New frequency range**  Observation 5: Test distance for different test method is needed.  Observation 6: The MU contributors are all frequency dependent.  Observation 7: The quite zone is also frequency dependent.  Proposal 3: For FR3, further study the test distance, measurement uncertainty and quite zone in new frequency range. |
| [**R4-2513337**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513337.zip) | Nokia | 1. There are no OTA test requirements and OTA test methodologies related to 6G spectrum that have been defined. 2. The study for OTA requirements around 7GHz frequencies should be started. Verify if the current OTA test methodology can be reused for 6G bands around 7GHz and new OTA test methodology can be introduced if necessary. |
| [**R4-2513338**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513338.zip) | Ericsson Korea Partners Co Ltd | **Observation 1.** 6G will introduce new 7-15 GHz frequency range and wider bandwidths in mmWave frequency band, and novel channel behaviours.  **Proposal 1.** Study OTA testing for the new 7-15 GHz frequency range and the wider bandwidths in mmWave frequency band with the appropriate channel models.  **Proposal 2.** Study enhancements in existing OTA testing method and associated requirements for frequencies below 7 GHz. |
| [**R4-2513347**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513347.zip) | Keysight Technologies UK Ltd | *Observation 1: It would be desirable to officially give the new frequency range of special interest for 6G a better identifier rather than “the range between FR1 and FR2-1 (including around ~7GHz)”*  **Proposal 1: For 6G FR1, continue the majority of conformance testing (UE RF, Demodulation, RRM) using conducted testing**  **Proposal 2: For 6G FR1, consider novel, select OTA test cases to assess real-world performance to selectively verify the end-to-end performance using OTA methodologies**  **Proposal 3: For 6G FR1, consider OTA testing where conducted conformance testing (UE RF, Demodulation, RRM) could either yield testability issues, e.g., lack of physical Tx/Rx ports, and/or highly dynamic nature of multiple Tx/Rx operation, including antenna tuning for impedance and/or pattern**  **Proposal 4: When deciding the testing environment of 6G for the range between FR1 and FR2, take testing aspect pros and cons for conducted vs radiated testing, summarized in Table 1, into account**  **Proposal 5: Conclude on the actual frequency range of 6G operation between FR1 and FR2 early to determine whether existing FR1 or FR2 systems/methodologies should serve as baseline for OTA testing.**  **Proposal 7: If the focus of 6G conformance testing in the range between FR1 and FR2 is conducted, consider novel, select OTA test cases to assess real-world performance to selectively verify the end-to-end performance using OTA methodologies**  **Proposal 8: If the focus of 6G conformance testing in the range between FR1 and FR2 is conducted, consider OTA testing where conducted conformance testing (UE RF, Demodulation, RRM) could either yield testability issues, e.g., lack of physical Tx/Rx ports, and/or highly dynamic nature of multiple Tx/Rx operation, including antenna tuning for impedance and/or pattern**  **Proposal 9: 6G OTA testability aspects need to be considered together with feature development going forward (regardless of frequency range) as important synchronizations between WIs and SIs and/or RAN4 and RAN5 resulted in unnecessary delays and confusion, e.g., low-UL/high-DL test cases, Ku/Ka bands, various FR2 power classes.**  **Proposal 11: Leverage the UE RF, Demodulation, and RRM test systems and methodologies for 6G FR2 from 5G FR2 as a baseline** |

## Open issues summary

### Sub-topic 2-1 Testability for new 6GR frequency

**Issue 2-1-1: New Frequency range between FR1 and FR2**

* Observations:
  + The appropriate test methodology for FR3 UEs remains uncertain and is highly dependent on UE architecture. Architectural choices at these frequencies should balance implementation feasibility—such as physical constraints for handheld devices—and performance considerations like uplink/downlink coverage. As a starting point, RAN4 proposes further investigation into FR3 testability by segmenting the frequency range at 8.4 GHz.
  + 6G frequency range overlaps with existing 5G NR frequency range FR-1 and FR-2.
  + There are no OTA test requirements and OTA test methodologies related to 6G spectrum that have been defined.
  + 6G will introduce new 7-15 GHz frequency range and wider bandwidths in mmWave frequency band, and novel channel behaviours.
  + It would be desirable to officially give the new frequency range of special interest for 6G a better identifier rather than “the range between FR1 and FR2-1 (including around ~7GHz)”.
* Proposals
  + **Proposal 1:** Study and include new frequency bands such as 7.125 – 8.4 GHz and 14.8 – 15.35 GHz. (Huawei)
  + **Proposal 2:** Identify the specific frequencies of interest (lower part of 7-24 GHz range seems to have obvious interest) to begin 6G OTA study for SISO/MIMO. (Apple)
  + **Proposal 3**:
* Recommended WF
  + Leave it to UE RF discussion. If concluded there, then it will be considered for testability

**Chair guidance: hold this discussion in testability/OTA agenda until sufficient progress is made for the frequency range discussion under the spectrum agenda.**

FL: the Frequency breakpoint is important for Testability discussion, which could be the bottleneck on Conducted or Radiated due to the feasibility of connector for testing. This basic information is also important when discuss the potential baseline metric for bands between 7GHz to 24GHz. RAN4 should work on this aspect and conclude it as early as possible.

**Issue 2-1-2: Frequency Breakpoints of conducted and OTA testing in “FR3”**

* Proposals
  + **Option 1:** Below ~7GHz.
  + **Option 2:** Below 8.4GHz.
  + **Option 3:** Below ~10GHz.
  + **Option 4:** up to around 15GHz.
    - The 15GHz connector with feasible insertion loss is on the market. (OPPO)
  + **Option 5:** lower part of the 7-24GHz.
* Recommended WF
  + RAN4 discuss whether from testability perspective, up to 15GHz can be tested via conducted approach.
  + Whether the requirement is defined based on FR1 conducted or radiated-like, leave it to UE RF discussion.

**Issue 2-1-3: Test methodologies for the frequencies < “frequency Breakpoint”**

* Observations:
  + higher frequency bands introduce increased pathloss and penetration loss compared to sub-6 GHz, presenting new challenges for system design. UEs may employ various multi-Tx schemes—non-coherent, partially coherent, or fully coherent UL MIMO with single-layer transmission—to achieve higher antenna gain, often requiring more Tx chains (e.g., 4T8R). Consequently, RAN4 should assess the suitability of OTA testing for evaluating UE radiated performance under multi-Tx configurations.
  + previous RAN4 study on IMT at around 15GHz shows that analog beam forming is not practical to be adopted by handheld UE due to large antenna panel size.
  + discrete antennas with digital beam forming is similar with coherent UL MIMO where conductive requirements and testing are still applicable. A new TRP OTA metric to accommodate such digital beamforming like performance gain in radiation was adopted in TRP TRS work item.
  + Similarly, the complexity of conducted testing has increased significantly in NR FR1 especially based on the available number of physical Tx and/or Rx ports of the UE, e.g., the number of UE Rx ports were increased from 4Rx (Rel-15) to 8Rx (Rel-18). It is therefore proposed to consider novel OTA test cases to assess real-world performance, especially for mid to high-band operation within FR1, where conducted testing could either yield testability issues due to lack of physical Tx/Rx ports and/or highly dynamic nature of multiple Tx/Rx operation.
* Proposals
  + **Option 1:** Only specify conducted testing for FR1 legacy conducted core requirements.
  + **Option 2:** Consider both conducted testing (baseline) and radiated testing (**additional OTA metric**) for FR1 legacy conducted core requirements.
    - For handheld UE, only conductive testing is considered up to around 15GHz, except traditional OTA requirement and testing. (Samsung)
    - conductive test could be considered as the baseline. RAN4 needs to study whether to use OTA test method to verify UE radiated performance with multi-Tx scheme. (QC)
  + **Option 3:** If testing in the range between FR1 and FR2 is conducted, consider novel, select OTA test cases to assess real-world performance to selectively verify the end-to-end performance using OTA methodologies.
    - When deciding the testing environment of 6G for the range between FR1 and FR2, take testing aspect pros and cons for conducted vs radiated testing, summarized in Table 1, into account.(Keysight)
* Recommended WF
  + Before concluded in UE RF on potential requirement, the testability group should study the testing issues for both conducted and radiated, without down-selection in the beginning.
  + Further study feasibility, pros and cons, complexity for conducted vs radiated testing.

**Issue 2-1-4: Test methodologies for the frequencies > “frequency Breakpoint”**

* Observations:
  + Due to increased frequency and pathloss, uplink coverage is a critical consideration in UE antenna design. An FR2-like array antenna system with analog beamforming may enhance EIRP and mitigate pathloss between UE and base station.
  + The decision of radiated vs conducted requirements for 6G operation between FR1 and FR2 will likely depend on the actual frequency range of operation and whether a physical conducted port/connector is feasible.
* Proposals
  + **Option 1:** Only specify OTA testing.
  + **Option 2:** Consider both conducted testing and radiated testing (as baseline) for different specific frequencies.
    - ***RAN4 conducts a dedicated study to resolve the test methodology for the [10]-[15] GHz band.***
  + **Option 3:** If testing in the range between FR1 and FR2 is conducted, consider novel, select OTA test cases to assess real-world performance to selectively verify the end-to-end performance using OTA methodologies.
    - When deciding the testing environment of 6G for the range between FR1 and FR2, take testing aspect pros and cons for conducted vs radiated testing, summarized in Table 1, into account.(Keysight)
* Recommended WF
  + Study the testing issues for both conducted and radiated, without down-selection in the beginning.
  + However, clear outcome on feasibility of conducted or radiated testing should be provided for UE RF requirements discussion.

**Issue 2-1-5: Legacy OTA metric for new frequency range**

* Proposals
  + **Proposal 1:** Include within the scope of the 6G OTA study the feasibility of extending current baseline test methods used for FR1 (SISO/MIMO) OTA performance testing to the upper mid band frequencies (lower part of the 7-24 GHz range) after identifying the specific frequencies that are of initial interest**.** (Apple)
* Recommended WF
  + Extending current FR1 AC system to cover new frequency range will be studied.
    - FFS upper frequency limitation.

**Issue 2-1-6: New/enhanced OTA test methods for new frequency range**

* Observations:
  + Generally, it is more straightforward to increase the upper frequency of existing test systems rather than decreasing the lower frequency of operation, e.g., due to absorber performance. Especially given the rather different nature of methodologies for FR1 (DFF with distributed-axes systems) and FR2 (IFF with primarily combined-axes systems), it would be desirable to decide on the baseline system/methodology early.
* Proposals
  + **Proposal 1:** RAN4 should study the feasibility and complexity of extending FR1 AC system and FR2 IFF/DFF system to cover FR3 frequency range. (vivo)
  + **Proposal 2：**For wider CBW in FR3, RAN4 should study a reasonable approach to quantify the flatness of UE radiated performance within the CBW range. (vivo)
  + **Proposal 3:** RAN4 should study Chamber and Measurement Infrastructure for 6G OTA testing, e.g. chamber size, quiet-zone size, calibration, MU, etc. (Xiaomi)
* Recommended WF
  + Use FR1/FR2 test system in 5G as a starting point, RAN4 further study potential improvement including the full-package of the test methodology, i.e., test setup, configuration, positioning, procedure, validation/calibration, quiet-zone/test zone, MU, testing time reduction.

### Sub-topic 2-2 Testability for UE configurations in new 6GR frequency

**Issue 2-2-1: UE architecture assumption for new frequency ranges**

* Proposals
  + **Proposal 1:** RAN4 needs further study the UE architecture for the frequencies above 8.4GHz. If OTA testing is needed, RAN4 should assess the feasibility of leveraging existing FR2 test setups (e.g., IFF chambers) or methodologies used for Ka/Ku-band VSAT UEs. (Qualcomm)
* Recommended WF
  + Leave UE architecture final decision to UE RF discussion.
  + From testability perspective, the group could use some of UE types and architecture assumptions for test methodology discussion.

**Issue 2-2-2: SA mode for UE**

* Proposals
  + **Proposal 1:** To further discuss the testing methodology for the 6G new frequency spectrum range (~7GHz to 24 GHz), with a primary focus on Standalone (SA) mode.
* Recommended WF
  + Check whether P1 is common understanding for 6G.

### Sub-topic 2-3 OTA Testability for traditional FR1 and FR2 range

**Issue 2-3-1: OTA test methods for traditional FR1 frequency range**

* Proposals
  + **Proposal 1:** RAN4 to reuse as much as possible the existing baselines of the NR frequency ranges FR-1 and FR-2 for RF requirements definition and testability of 6G frequency ranges. (Apple)
  + **Proposal 2:** For 6G FR1, continue the majority of conformance testing (UE RF, Demodulation, RRM) using conducted testing. (Keysight)
* Recommended WF
  + Consider 5G FR1 methods as starting point, discuss improvement and optimization for 6G

**Issue 2-3-2: General Improvement for 6G FR1 OTA**

* Observations:
  + It is expected that the dynamic nature of multiple active receiver and transmitter operation, e.g., antenna tuners, dynamic switching between transmitters and receivers, etc., is becoming increasingly prevalent going forward which will likely see an increase in conducted conformance test system complexity (including the need for vendor declaration, etc.); still, these assessments are not taking real-world performance into account without the antenna system.
* Proposals
  + **Proposal 1:** For 6G FR1, consider novel, select OTA test cases to assess real-world performance to selectively verify the end-to-end performance using OTA methodologies. (Keysight)
* Recommended WF
  + This could a general principle for 6G study, RAN4 should further work on details of UE configuration and test configuration to **assess real-world performance.**

**Issue 2-3-3: Test method for 6G FR2 OTA**

* Proposals
  + **Proposal 1:** Leverage the UE RF, Demodulation, and RRM test systems and methodologies for 6G FR2 from 5G FR2 as a baseline. (Keysight)
* Recommended WF
  + Consider 5G FR2 methods as starting point, discuss improvement and optimization for 6G.

# Topic #3: **OTA test methods for Multi-Tx and CA**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513024**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513024.zip) | Qualcomm Incorporated | **Proposal 3: For SISO, RAN4 needs study the test method to verify UE radiated performance for multiple Tx scheme with one-layer transmission.** |
| [**R4-2513210**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513210.zip) | CATT | ***Proposal 3:*** **RAN4 to study the OTA test methodology and performance requirements for multi frequency range combinations for FR1 UE in 6G era.**  ***Proposal 4:* RAN4 to study pure OTA test methodology for UE configuring mixed FR1-FR2 operation in 6G era.** |
| [**R4-2513255**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513255.zip) | vivo | **Proposal 3: Test method to verify the radiated performance of devices under multi-carrier condition should be discussed in 6G day-1.** |
| [**R4-2513320**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513320.zip) | OPPO | **Multiple Uplink and CA**  Observation 8: The fixed and average TPMI method has been agreed in 5G for 2TX.  Observation 9: The 3TX is foreseen to be an important feature in 6GR.  Proposal 5: To study the 2TX/3TX UL test method. |

## Open issues summary

### Sub-topic 3-1 OTA for 6GR multi-carrier

**Issue 3-1-1: OTA test methodology for FR1 CA**

* Observations:
  + In 5G phase the FR1 OTA testing and performance metric definition are mainly focusing on single band testing. With larger aggregated bandwidth and more flexible spectrum usage will be defined in 6G, it's time to consider the OTA testing aspects for multi carrier combinations for FR1 UE.
* Proposals
  + **Proposal 1:** Test method to verify the radiated performance of devices under multi-carrier condition should be discussed in 6G day-1. (vivo)
  + **Proposal 2:** RAN4 to study the OTA test methodology and performance requirements for multi frequency range combinations for FR1 UE in 6G era. (CATT)
* Recommended WF
  + Study the test methodology to cover multi-carrier cases.

Samsung: reckon if this should be part of Day1 feature for test.

OPPO: it is not urgent to introduce this in 6G on day 1.

Apple: prefer to prioritizing the single carrier.

TMUS: at least for MSD, we see the benefit to extend OTA to CA.

CATT: given the limited OTA requirements for FR1 single CC case, we are OK to deprioritize this CA case for now.

Nokia: CA can be regional based. We need to consider to introduce limited number of CA BC cases.

Huawei: prefer to prioritize single CC.

Ericsson: support the proposals.

Xiaomi: prefer to prioritize single CC.

**Issue 3-1-2: Testability for multi frequency range combinations**

* Observations:
  + But the fact is that the conformance test for FR1+FR2 band combinations has never been executed in practice. The main reason is the absence of an applicable test system that can simultaneously perform conducted measurements in FR1 and OTA measurements in FR2.
  + In 6G, UL/DL spectrum decoupling will be considered. UE is likely to be configured with FR1 frequency in the UL and FR2 frequency in the DL. It’s essential to study the pure OTA test methodology for UE configuring mixed FR1-FR2 operation in 6G.
* Proposals
  + **Proposal 1:** RAN4 to study pure OTA test methodology for UE configuring mixed FR1-FR2 operation in 6G era. (CATT)
* Recommended WF
  + Study whether it is feasible to measure both FR1 and FR2 radiated performance in the same test system.

### Sub-topic 3-2 OTA for 6GR multi-Tx single carrier

**Issue 3-2-1: OTA test methodology for single carrier with multi-Tx**

* Observation:
  + Further evolution of 5G has already introduced 3TX for UE and this is foreseen to be an important feature in 6GR to achieve higher output power. Besides, the CA of OTA test is also a question.
* Proposals
  + **Proposal 1:** For SISO, RAN4 needs study the test method to verify UE radiated performance for multiple Tx scheme with one-layer transmission. (QC)
  + **Proposal 2:** To study the 2TX/3TX UL test method. (OPPO)
* Recommended WF
  + Multi-Tx can be considered when developing the radiated test methodologies.

# Topic #4: **Testability for different Device types**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513052**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513052.zip) | Samsung | **Proposal 1: RAN4 to take new spectrum, diverse device types, new feature and functionalities into account in the testability framework study from 6G Day 1.**  **Observation 5: The test method and performance metric could be different for different device types due to different form factors, different characteristics and so on.**  **Proposal 4: handheld UE should be the 1st priority and other device types can be included based on commercial needs in 6G testability and OTA work.** |
| [**R4-2513130**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513130.zip) | CMCC | **Proposal 3: New test case should be considered in testability of 6G day1, e.g. A-IoT device, NTN UE.** |
| [**R4-2513210**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513210.zip) | CATT | ***Proposal 1:*** **RAN4 to study and extend the OTA test methodology and performance requirements for more non-handheld device types in 6G era.** |
| [**R4-2513255**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513255.zip) | vivo | **Proposal 9: Study the testability issue and corresponding test method to quantify different 6G device types, e.g., smartphone, CPE, XR, VUEs, wearables, sensing, NTN, AI agents, and robots.** |
| [**R4-2513282**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513282.zip) | Xiaomi | **Proposal 1: RAN4 should have further discussion on the following aspects as part of the 6G OTA Testing:**   * **Frequency ranges for 6G OTA study** * **Assumption for different device type and antenna/antenna array;** * **Channel model for 6G OTA study, e.g. static or dynamic;** * **Test method and metric for ISAC;** * **AI/ML testing**    + **OTA validation for AI/ML-assistant features;**   + **Generalization and AI/ML Robustness Testing;** * **Energy Efficiency evaluation under OTA performance metric;** * **Chamber and Measurement Infrastructure for 6G OTA testing, e.g. chamber size, quiet-zone size, calibration, MU, etc.** |
| [**R4-2513287**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513287.zip) | CAICT | ***Proposal 4: It is proposed to study a scalable and unified OTA test system framework for 6G, with the objective of achieving maximum compatibility across diverse device types and use cases.***  ***Proposal 5: Study testability for emerging 6G use cases, identifying necessary test methodologies and performance metrics for new device types and/or new supported features.*** |
| [**R4-2513312**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513312.zip) | Huawei, HiSilicon | ***Proposal 2: Develop test methodology for wearable devices.***  ***Proposal 7: Consider developing OTA test methodology for vehicles.*** |
| [**R4-2513320**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513320.zip) | OPPO | **Device type and form factors**  Proposal 4: To study device type definition of 6GR on form factors and corresponding OTA test impacts. |
| [**R4-2513337**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513337.zip) | Nokia | 1. New 6G UE category definition will be studied, addressing the development of an increasingly varied set of device categories. OTA test requirements and test methods should be correspondingly adjusted. However, we can wait until those works are done in other parts of 3GPP. |
| [**R4-2513347**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513347.zip) | Keysight Technologies UK Ltd | **Proposal 9: 6G OTA testability aspects need to be considered together with feature development going forward (regardless of frequency range) as important synchronizations between WIs and SIs and/or RAN4 and RAN5 resulted in unnecessary delays and confusion, e.g., low-UL/high-DL test cases, Ku/Ka bands, various FR2 power classes.**  **Proposal 10: For 6G FR2 UE RF OTA testing, consider revisiting the need for beam peak searches to reduce MU and overall test time.** |

## Open issues summary

### Sub-topic 4-1 OTA testability for different device types

**Issue 4-1-1: OTA testability applicability for different UE types in 6GR day-1**

* Observations:
  + The test method and performance metric could be different for different device types due to different form factors, different characteristics and so on.
  + New 6G UE category definition will be studied, addressing the development of an increasingly varied set of device categories. OTA test requirements and test methods should be correspondingly adjusted. However, we can wait until those works are done in other parts of 3GPP.
  + 6G OTA testing should evolve into a multi-dimensional validation framework that integrates new spectrum, advanced antennas, non-terrestrial networks, ISAC, AI/ML, energy efficiency, and enhanced performance metrics to accurately assess 6G devices in realistic, dynamic environments.
* Proposals
  + **Proposal 1:** RAN4 should consider different UE types, new feature/functionalities, new performance metrics and test cases in testability of 6G day1. (CMCC, Samsung, CATT, vivo, Xiaomi, CAICT)
* Recommended WF
  + TBA

Vivo: as an example, TN and NTN requires different test methods as defined in 5G. the existing test system has its own limitation. 6G is an opportunity to revisit the test methodologies for different device types.

R&S: the current system is primarily designed for the smart phone. It can be discussed how to better accomondate the device type beyond the smartphone.

**Issue 4-1-2: Which UE types in 6GR day-1 should be considered in Testability**

* Proposals
  + **Proposal 1: Consider smartphone, CPE, XR, VUEs, wearables, sensing, NTN, AI agents, A-IoT devices and robots.**
  + **Proposal 2: handheld UE should be the 1st priority and other device types can be included based on commercial needs in 6G testability and OTA work.**
* Recommended WF
  + Check whether all the above UE types should be considered, prioritization might be needed, e.g., first focus on smartphone, CPE, XR, wearables, NTN (VSAT), A-IoT.

**Issue 4-1-3: Potential OTA test methodology for above UE types**

* Proposals
  + **Proposal 1:** It is proposed to study a scalable and unified OTA test system framework for 6G, with the objective of achieving maximum compatibility across diverse device types and use cases. (CAICT)
* Recommended WF
  + Targets a unified OTA test method to cover different UE types

### Sub-topic 4-2 OTA testability for different UE features

**Issue 4-2-1: OTA testability applicability for different features**

* Proposals
  + **Proposal 1:** 6G OTA testability aspects need to be considered together with feature development going forward (regardless of frequency range) as important synchronizations between WIs and SIs and/or RAN4 and RAN5 resulted in unnecessary delays and confusion, e.g., low-UL/high-DL test cases, Ku/Ka bands, various FR2 power classes. (Keysight)
* Recommended WF
  + Study testability in parallel with 6G UE feature design (this is RAN4 doing now). Further discuss how to improve the involvement of other WGs.

# Topic #5: **AI/ML OTA testability**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513024**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513024.zip) | Qualcomm Incorporated | **Proposal 5: The the correspoding test method to verify the new AI/ML features such as** **reduced RX beam sweeping factor needs to be further studied in RAN4.** |
| [**R4-2513030**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513030.zip) | Apple Computer Trading Co. Ltd | **Proposal 6: Use the AI/ML test methodology finalized in Rel-19 as a baseline for Rel-20 6G OTA study and further evaluate study of AI/ML testability use cases across RF/RRM/Demod areas.** |
| [**R4-2513130**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513130.zip) | CMCC | **Proposal 5: for AI/ML, it is proposed to consider dynamic test (i.e. environment changes dynamically during the test) in 6GR.** |
| [**R4-2513210**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513210.zip) | CATT | ***Proposal 5:*** **RAN4 to continue to study the OTA test system for** **AI/ML-based beam-management in 6G era.** |
| [**R4-2513255**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513255.zip) | vivo | **Proposal 10: For 6G, an advanced test setup to simulate number of different BS beams and proper multi-path fading spatial channel model should be studied to verify AI/ML based BM.** |
| [**R4-2513282**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513282.zip) | Xiaomi | **Proposal 1: RAN4 should have further discussion on the following aspects as part of the 6G OTA Testing:**   * **Frequency ranges for 6G OTA study** * **Assumption for different device type and antenna/antenna array;** * **Channel model for 6G OTA study, e.g. static or dynamic;** * **Test method and metric for ISAC;** * **AI/ML testing**    + **OTA validation for AI/ML-assistant features;**   + **Generalization and AI/ML Robustness Testing;** * **Energy Efficiency evaluation under OTA performance metric;** * **Chamber and Measurement Infrastructure for 6G OTA testing, e.g. chamber size, quiet-zone size, calibration, MU, etc.** |
| [**R4-2513284**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513284.zip) | CAICT | ***Proposal 1: For AI related treatability study, the common framework in TR 38.843 could be used as baseline.***  ***Proposal 2: Field test data, reference models, and online training could be considered in 6GR testing for AI/ML based solutions.***  ***Proposal 3: For different AI.ML use cases, legacy procedure as discussed in 5G-A could be used as reference.***  ***Proposal 4: A common test environment for FR2 should be supported for AI/ML based use cases.***  ***Proposal 5: Scenario-based testing could be considered in 6GR study to enable multiple AI/ML use cases testing*** |
| [**R4-2513312**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513312.zip) | Huawei, HiSilicon | ***Proposal 5: Develop OTA test methodology for AI/ML beamforming by devices.*** |
| [**R4-2513320**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513320.zip) | OPPO | **Potential 6GR OTA test method for AI BM**  Observation 10: The 5G FR2 3D MPAC system can be one solution for AI-BM test.  Observation 11: The 5G FR2 MIMO OTA system has not been broadly used.  Observation 12: It is hard to correctly model the FR2 multi-AoA channel model and re-establish in chamber environment.  Proposal 6: For AI-BM test in 6GR, to further study the commercial benefit to consider the FR2 deployment, test system complexity and the difficulty to model the channel.  **Decouple of signal acquisition and model performance test**  Observation 13: The over-simplified OTA assumptions being used may offer little practical guidance for field deployment.  Observation 14: With new LCM features, new test setup will always need to be specified which results in endless OTA test setup discussion.  Proposal 7: For 6G, RAN4 could explore whether/how to decouple the signal acquisition testing(e.g., or model inputs) from model performance evaluation (e.g., for model performance) for AI use cases.  Proposal 8: Signal acquisition could continue to be tested via cable or OTA methods, e.g., evaluating BM Set B measurement accuracy.  Proposal 9: Model performance could be assessed using standardized datasets defined by RAN4 (RAN4 specified datasets), enabling a virtual testing environment. |
| [**R4-2513337**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513337.zip) | Nokia | 1. The OTA test methods developed for AIML mobility is for FR1 use case, and AIML BM is for FR2 use case. They can be leveraged as reference points for the continued development of OTA test methods for AI/ML use cases in future releases. |
| [**R4-2513338**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513338.zip) | Ericsson Korea Partners Co Ltd | **Observation 3.** 6G will introduce AI/ML functionalities such as beam prediction, mobility, positioning, and CSI compression/prediction. Robust testing will be required to ensure reliable operation and interoperability of AI/ML based features across vendors, which may necessitate new test setups. Moreover, testing time and reproducibility will be important considerations, and standardized approaches will be critical, as inadequate validation could limit adoption of certain AI-native features.  **Proposal 4.** Study OTA testing for the added AI/ML functionalities with the appropriate channel models as Spatial Channel Model (SCM). 6G study shall take the achievements expected in 5G AI/ML OTA testing into account. |

## Open issues summary

### Sub-topic 5-1 Enhanced OTA test method for 6GR AI/ML cases

**Issue 5-1-1: RAN4 study on enhancement of AI/ML testability for 6GR**

* Proposals
  + **Proposal 1:** The corresponding test method including both OTA and conducted, to verify the AI/ML features (FFS details) should be studied in RAN4. (QC, CATT, CMCC, vivo, CAICT, Huawei, OPPO)
* Recommended WF
  + TBA

R&S: one of the challenges in AI test is how to emulate the CDL channel.

Keysight

Agreement

The corresponding test method including both OTA and conducted, to verify the AI/ML features (FFS details) should be studied in RAN4 in 6G SI.

* The methodologies identified in 5G will be considered as the starting point for both conducted and OTA.

FL: agreed in Rel-19 for AI/ML BM testing, reusing the multi AoA based RRM testing setup as baseline. However, it is identified that there are some limitations on generating the required spatial channel model close to the real-scenarios. Before concluding 6G AI/ML test cases and channel model, improvement of test system can be discussed.

**Issue 5-1-2: Baseline test methodologies/common framework for 6GR AI/ML cases**

* Proposals
  + **Proposal 1:** Use the AI/ML test methodology finalized in Rel-19 as a baseline for Rel-20 6G OTA study and further evaluate study of AI/ML testability use cases across RF/RRM/Demod areas. (Apple)
  + **Proposal 2:** For AI related treatability study, the common framework in TR 38.843 could be used as baseline. (CAICT)
    - Field test data, reference models, and online training could be considered in 6GR testing for AI/ML based solutions
  + **Proposal 3:** For AI-BM test in 6GR, to further study the commercial benefit to consider the FR2 deployment, test system complexity and the difficulty to model the channel. (OPPO)
* Recommended WF
  + The testability improvement from test setup perspective can be discussed early. But for the common framework of AI/ML, e.g, test data, reference model and training, might be postpone until the 6G AI/ML use cases are more clear.

**Issue 5-1-3: Dynamic conditions for 6GR AI/ML testing**

* Proposals
  + **Proposal 1:** for AI/ML, it is proposed to consider dynamic test (i.e. environment changes dynamically during the test) in 6GR. (CMCC)
* Recommended WF
  + TBA

**Issue 5-1-4: Common test environment/setup for 6GR AI/ML cases**

* Proposals
  + **Proposal 1:** A common test environment for FR2 should be supported for AI/ML based use cases.. (CAICT)
    - For different AI.ML use cases, legacy procedure as discussed in 5G-A could be used as reference. (CAICT)
* Recommended WF
  + TBA

**Issue 5-1-5: How to treat** **multiple AI/ML use cases are simultaneously activated**

* Proposals
  + **Proposal 1:** Scenario-based testing could be considered in 6GR study to enable multiple AI/ML use cases testing. (CAICT)
* Recommended WF
  + TBA

**Issue 5-1-6: Whether/how to decouple the signal acquisition testing(e.g., or model inputs) from model performance evaluation**

* Proposals
  + **Proposal 1:** For 6G, RAN4 could explore whether/how to decouple the signal acquisition testing (e.g., or model inputs) from model performance evaluation (e.g., for model performance) for AI use cases. (OPPO)
  + **Proposal 2:** Signal acquisition could continue to be tested via cable or OTA methods, e.g., evaluating BM Set B measurement accuracy. (OPPO)
  + **Proposal 3:** Model performance could be assessed using standardized datasets defined by RAN4 (RAN4 specified datasets), enabling a virtual testing environment. (OPPO)
* Recommended WF
  + TBA

**Issue 5-1-7: others for 6GR AI/ML testing**

* Proposals
  + **Proposal 1:** For 6G, an advanced test setup to simulate number of different BS beams and proper multi-path fading spatial channel model should be studied to verify AI/ML based BM. (vivo)
  + **Proposal 2:** For 6G AI/L testing, consider: (xiaomi)
    - OTA validation for AI/ML-assistant features;
    - Generalization and AI/ML Robustness Testing;
* Recommended WF
  + TBA

### Sub-topic 5-2 Channel models for 6GR AI/ML testing

**Issue 5-2-1: Spatial channel models for AI/ML cases**

* Proposals
  + **Proposal 1:** Study OTA testing for the added AI/ML functionalities with the appropriate channel models as Spatial Channel Model (SCM). 6G study shall take the achievements expected in 5G AI/ML OTA testing into account. **(E///)**
* Recommended WF
  + TBA

# Topic #6: **Harmonized testing for TN and NTN**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513030**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513030.zip) | Apple Computer Trading Co. Ltd | **Proposal 5: Study a harmonized approach (test method/test system) to testing TN/NTN devices in 6G OTA including but not limited to test method and test metric definition, UE positioning guidelines, MU assessment etc.** |
| [**R4-2513287**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513287.zip) | CAICT | ***Proposal 4: It is proposed to study a scalable and unified OTA test system framework for 6G, with the objective of achieving maximum compatibility across diverse device types and use cases.***  ***Proposal 5: Study testability for emerging 6G use cases, identifying necessary test methodologies and performance metrics for new device types and/or new supported features.*** |
| [**R4-2513312**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513312.zip) | Huawei, HiSilicon | ***Proposal 4: NTN OTA tests should use circular polarisation.*** |
| [**R4-2513338**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513338.zip) | Ericsson Korea Partners Co Ltd | **Proposal 6.** Study OTA testing for 6G NTN for different use-cases, bands including VSAT terminals operating in Ku and Ka bands, etc. |

## Open issues summary

### Sub-topic 6-1 Harmonized OTA test methodologies for TN and NTN

**Issue 6-1-1: Harmonized OTA test methodologies for TN and NTN**

* Observations:
  + Harmonized TN and NTN design has been listed as a key consideration in [2] vis-a-vis 6G RAN and there were multiple associated contributions in the 3GPP 6G workshop that suggested ideas on how this can be potentially achieved in 6G.
  + This can be further extended to study whether all aspects of a harmonized OTA system can be used for testing potential 6G harmonized TN/NTN devices especially since there might be several overlapping bands used for both types of testing.
* Proposals
  + **Proposal 1:** Study a harmonized approach (test method/test system) to testing TN/NTN devices in 6G OTA including but not limited to test method and test metric definition, UE positioning guidelines, MU assessment etc. (Apple)
* Recommended WF
  + Targeting a harmonized test system for TN and NTN devices.
  + Further study details of metrics, UE positioning, MU and other aspects.

**Issue 6-1-2: Specific improvement for NTN OTA**

* Proposals
  + **Proposal 1:** NTN OTA tests should use circular polarization. (Huawei)
  + **Proposal 2:** Study OTA testing for 6G NTN for different use-cases, bands including VSAT terminals operating in Ku and Ka bands, etc. (E///)
* Recommended WF
  + CP should be supported.

# Topic #7: **Improved test methods and metric for SISO OTA**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513052**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513052.zip) | Samsung | **Observation 5: The OTA performance metric can be divided into two categories, one is to verify hardware especially antenna performance, and the other is to verify the overall performance under various field conditions.**  **Proposal 5: antenna performance based metric and user-centric performance based metric are not contradicted to each other but can co-exist. TRP TRS metric for handheld UE should not be replaced with new OTA metrics if there is no fully justification** |
| [**R4-2513130**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513130.zip) | CMCC | **Proposal 4: Legacy testability should be revisited in 6G day1.** |
| [**R4-2513255**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513255.zip) | vivo | **Proposal 2: For FR1 TRP/TRS or PRP/PRS single carrier performance verification, the test method should support/allow UE antenna switching. Repeatability issue of the antenna performance should also be studied.** |
| [**R4-2513282**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513282.zip) | Xiaomi | **Proposal 1: RAN4 should have further discussion on the following aspects as part of the 6G OTA Testing:**   * **Frequency ranges for 6G OTA study** * **Assumption for different device type and antenna/antenna array;** * **Channel model for 6G OTA study, e.g. static or dynamic;** * **Test method and metric for ISAC;** * **AI/ML testing**    + **OTA validation for AI/ML-assistant features;**   + **Generalization and AI/ML Robustness Testing;** * **Energy Efficiency evaluation under OTA performance metric;** * **Chamber and Measurement Infrastructure for 6G OTA testing, e.g. chamber size, quiet-zone size, calibration, MU, etc.** |
| [**R4-2513287**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513287.zip) | CAICT | ***Proposal 6: 6G test methodologies should be fundamentally based on test conditions that closely reflect real-world usage scenarios.***  ***Proposal 8 : For SISO OTA test method, study enhanced 6G SISO OTA test methods，such as Tx antenna switching conditions and support for device widths exceeding 92mm, to better reflect real-world device behavior across diverse form factors.*** |
| [**R4-2513337**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513337.zip) | Nokia | 1. TRP/TRS and MIMO OTA requirements for 1Tx/2Tx/4Tx and 2Rx/4Rx RF architecture should be studied first. 2. Folded phones are in high demand in the market. CTIA has developed the OTS test specification for a folded phone based on the unfolded and folded states. However, there is no folded phone OTA test specification defined yet in 3GPP. 3. Refer to the CITA folded phone OTA test plan, study and develop a folded phone OTA test plan related to measurement setup, test procedure, and preliminary MU for 3GPP. |

## Open issues summary

### Sub-topic 7-1 Enhanced OTA test method for TRP/TRS

**Issue 7-1-1: Enhanced OTA test method for TRP/TRS**

* Proposals
  + **Proposal 1:** Legacy testability should be revisited in 6G day1. (CMCC)
  + **Proposal 2:** For SISO OTA test method, study enhanced 6G SISO OTA test methods，such as Tx antenna switching conditions and support for device widths exceeding 92mm, to better reflect real-world device behavior across diverse form factors. (CAICT)
    - *6G test methodologies should be fundamentally based on test conditions that closely reflect real-world usage scenarios*
  + **Proposal 3:** For FR1 TRP/TRS or PRP/PRS single carrier performance verification, the test method should support/allow UE antenna switching. Repeatability issue of the antenna performance should also be studied. (vivo)
* Recommended WF
  + 6GR OTA test method should based on conditions more closely reflect real-world usage scenarios.
  + Further discuss how to ensure above targets, e.g., switching, and other aspects.

**Issue 7-1-2: Enhanced OTA test method for different UE usage scenarios**

* Proposals
  + **Proposal 1:** Folded phones are in high demand in the market. CTIA has developed the OTS test specification for a folded phone based on the unfolded and folded states. However, there is no folded phone OTA test specification defined yet in 3GPP**. (Nokia)**
  + **Proposal 2:** Refer to the CITA folded phone OTA test plan, study and develop a folded phone OTA test plan related to measurement setup, test procedure, and preliminary MU for 3GPP**. (Nokia)**
  + **Proposal 3:** OTA test methods should consider Assumption for different device type and antenna/antenna array. (Xiaomi)
* Recommended WF
  + TBA.

**Issue 7-1-3: 6GR TRP/TRS requirements**

* Proposals
  + **Proposal 1:** TRP/TRS and MIMO OTA requirements for 1Tx/2Tx/4Tx and 2Rx/4Rx RF architecture should be studied first**. (Nokia)**
* Recommended WF
  + TBA.

### Sub-topic 7-2 New Performance metric for TRP/TRS

**Issue 7-2-1: New OTA performance metric to reflect user experience**

* Proposals
  + **Proposal 1:** antenna performance based metric and user-centric performance based metric are not contradicted to each other but can co-exist. TRP TRS metric for handheld UE should not be replaced with new OTA metrics if there is no fully justification. (Samsung)
* Recommended WF
  + TBA.

# Topic #8: **Improved test methods and metric for DL MIMO OTA**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513130**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513130.zip) | CMCC | **Proposal 4: Legacy testability should be revisited in 6G day1.**  **Observation 1: Rel-19 conducted research on the dynamic test methodology for MIMO OTA.**  **Proposal 6: Dynamic test methodologies in MIMO OTA testing should be further studied and supported in 6G day1.** |
| [**R4-2513255**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513255.zip) | vivo | **Proposal 4: Use concept of 5G dynamic channel model and link adaptation as starting point for 6G MIMO OTA test method.** |
| [**R4-2513282**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513282.zip) | Xiaomi | **Proposal 1: RAN4 should have further discussion on the following aspects as part of the 6G OTA Testing:**   * **Frequency ranges for 6G OTA study** * **Assumption for different device type and antenna/antenna array;** * **Channel model for 6G OTA study, e.g. static or dynamic;** * **Test method and metric for ISAC;** * **AI/ML testing**    + **OTA validation for AI/ML-assistant features;**   + **Generalization and AI/ML Robustness Testing;** * **Energy Efficiency evaluation under OTA performance metric;** * **Chamber and Measurement Infrastructure for 6G OTA testing, e.g. chamber size, quiet-zone size, calibration, MU, etc.** |
| [**R4-2513287**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513287.zip) | CAICT | **Proposal 6: 6G test methodologies should be fundamentally based on test conditions that closely reflect real-world usage scenarios.**  **Proposal 7: For 6G MIMO OTA test method, directly incorporate dynamic channel models with link adaption and hand phantom conditions, enabling more realistic performance evaluation under practical usage conditions. For other tests cases based on channel environments, adopt dynamic channel environments as the starting point.** |
| [**R4-2513312**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513312.zip) | Huawei, HiSilicon | **Proposal 3: Develop test methodology for MIMO OTA test under dynamic channels with connections to two Transmission Reception Points.** |
| [**R4-2513337**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513337.zip) | Nokia | 1. TRP/TRS and MIMO OTA requirements for 1Tx/2Tx/4Tx and 2Rx/4Rx RF architecture should be studied first. 2. OTA test specification related to UL MIMO use cases has not been developed yet in 38.151. 3. We can prioritise completing the UL MIMO OTA requirements for 2Tx/3Tx/4Tx use cases based on 5G NR UE types. 4. UEs with multiple Tx and Rx MIMO implementations have been commercial for years, MIMO OTA conformance testing is not yet routinely deployed prior to market release. 5. We suggest a closer collaboration between RAN4 and RAN5 for MIMO OTA test requirements and test methods development. |
| [**R4-2513347**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513347.zip) | Keysight Technologies UK Ltd | **Proposal 6: Focus MIMO OTA assessments in 6G for the range between FR1 and FR2 on more realistic scenarios including dynamic channel models, link adaptation and 3D channel models. FFS whether these aspects should be applied to mid to high bands in 6G FR1 as well** |
| [**R4-2513052**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513052.zip) | Samsung | **Proposal 8: RAN4 to target for a global harmonized standard in conformance testing and OTA.** |

## Open issues summary

### Sub-topic 8-1 Dynamic MIMO OTA for 6GR

**Issue 8-1-1: RAN4 consider dynamic MIMO OTA for 6GR day-1**

* Proposals
  + **Proposal 1:** Dynamic test methodologies in MIMO OTA testing should be further studied and supported in 6G day1. (CMCC, vivo, CAICT, Huawei, Keysight)
    - Dynamic channel model and link adaption
  + **Proposal 2:** RAN4 should have further discussions on Channel model for 6G OTA study, e.g. static or dynamic. (Xiaomi)
* Recommended WF
  + TBA.

Huawei: shall we consider the multi-TRP cases, including the potential cell-free scenario?

Keysight: we support to take dynamic MIMO into consideration in 6G study.

OPPO: both static and dynamic should be considered.

Apple: support proposal 1.

CAICT:support proposal 1

Samsung: OK to study the dynamic OTA

Qualcomm: support proposal 1. Both FR1 and FR2 should be considered.

Xiaomi:OK on the proposal 1. Both static and dynamic should be considered.

FL: single link can be taken as the baseline. Multi-TRP is not precluded.

**Issue 8-1-2: Whether consider 3D dynamic channel models for dynamic MIMO OTA**

* Proposals
  + **Proposal 1:** Consider 3D channel models. (Keysight)
* Recommended WF
  + TBA.

**Issue 8-1-3: Whether consider hand phantom impacts for dynamic MIMO OTA**

* Proposals
  + **Proposal 1:** Consider hand phantom conditions. (CAICT)
* Recommended WF
  + TBA.

**Issue 8-1-4: Whether consider two Transmission Reception Points for dynamic MIMO OTA**

* Proposals
  + **Proposal 1:** Consider two Transmission Reception Points. (Huawei)
* Recommended WF
  + TBA.

**Issue 8-1-5: Views on FR3 for dynamic MIMO OTA**

* Proposals
  + **Proposal 1:** Focus MIMO OTA assessments in 6G for the range between FR1 and FR2 on more realistic scenarios including dynamic channel models, link adaptation and 3D channel models. (Keysight)
    - FFS should be applied to mid to high bands in 6G FR1 as well.
* Recommended WF
  + TBA.

### Sub-topic 8-2 Other conditions for 6GR MIMO OTA

**Issue 8-2-1: Global harmonized test method for 6GR MIMO OTA**

* Proposals
  + **Proposal 1:** RAN4 to target for a global harmonized standard in conformance testing and OTA. (Samsung)
* Recommended WF
  + TBA.

**Issue 8-2-2: UL MIMO OTA testing**

* Proposals
  + **Proposal 1:** We can prioritise completing the UL MIMO OTA requirements for 2Tx/3Tx/4Tx use cases based on 5G NR UE types. (Nokia)
* Recommended WF
  + TBA.

**Issue 8-2-3: MIMO OTA work between RAN4 and RAN5**

* Proposals
  + **Proposal 1:** We suggest a closer collaboration between RAN4 and RAN5 for MIMO OTA test requirements and test methods development. (Nokia)
* Recommended WF
  + TBA.

# **Efficiency improvement (Test and requirements)**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513024**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513024.zip) | Qualcomm Incorporated | **Proposal 4: Study can be conducted in RAN4 to assess whether OTA requirement can be derived without measurement results or with partial measurement resluts. The initial investigation into reduced reliance on measurement campaigns could focus on UE types with more standardized antenna configurations, such as those incorporating glass structures.**  **Observation 2: The OTA inlcuidng both SISO OTA and MIMO OTA requirements for 6G bands will not be defined in 6G Day 1 due to the absence of commercial devices.** |
| [**R4-2513052**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513052.zip) | Samsung | **Proposal 6: testability and OTA in 6G should be designed in a realistic manner with reasonable test cost and test time.** |
| [**R4-2513255**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513255.zip) | vivo | **Proposal 1: OTA test method development in 6G should consider the pain points in 5G and aim to verify the device performance close to the real usage scenario in the network, with using a higher accuracy, reduced cost&complexity, and faster testing methodologies.**  **Proposal 12: RAN4 should study some general solutions (not limited to specific UE type or features) to improve OTA testing efficiency.** |
| [**R4-2513282**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513282.zip) | Xiaomi | **Proposal 1: RAN4 should have further discussion on the following aspects as part of the 6G OTA Testing:**   * **Frequency ranges for 6G OTA study** * **Assumption for different device type and antenna/antenna array;** * **Channel model for 6G OTA study, e.g. static or dynamic;** * **Test method and metric for ISAC;** * **AI/ML testing**    + **OTA validation for AI/ML-assistant features;**   + **Generalization and AI/ML Robustness Testing;** * **Energy Efficiency evaluation under OTA performance metric;** * **Chamber and Measurement Infrastructure for 6G OTA testing, e.g. chamber size, quiet-zone size, calibration, MU, etc.** |
| [**R4-2513287**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513287.zip) | CAICT | **Proposal 9: 6G test systems should consider balance measurement accuracy with test time, cost, and complexity, finding the trade-off between these important factors**. |
| [**R4-2513347**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513347.zip) | Keysight Technologies UK Ltd | **Proposal 10: For 6G FR2 UE RF OTA testing, consider revisiting the need for beam peak searches to reduce MU and overall test time.** |

## Open issues summary

### Sub-topic 9-1 Improvement of OTA testing efficiency

**Issue 9-1-1: Improve OTA test efficiency in 6GR**

* Proposals
  + **Proposal 1:** 6G test systems should consider balance measurement accuracy with test time, cost, and complexity, finding the trade-off between these important factors. (CAICT)
  + **Proposal 2:** RAN4 should study some general solutions (not limited to specific UE type or features) to improve OTA testing efficiency. (vivo)
  + **Proposal 3:** testability and OTA in 6G should be designed in a realistic manner with reasonable test cost and test time. (Samsung)
* Recommended WF
  + TBA.

**Issue 9-1-2: Pain points learned from 5G OTA testing**

* Proposals
  + **Proposal 1:** OTA test method development in 6G should consider the pain points in 5G and aim to verify the device performance close to the real usage scenario in the network, with using a higher accuracy, reduced cost&complexity, and faster testing methodologies. (vivo)
  + **Proposal 2:** For 6G FR2 UE RF OTA testing, consider revisiting the need for beam peak searches to reduce MU and overall test time. (Keysight)
* Recommended WF
  + TBA.

### Sub-topic 9-2 Improvement of efficiency on specifying OTA requirements

**Issue 9-2-1: Simulation + Measurement based approach to specify OTA requirements in 6GR**

* Proposals
  + **Proposal 1:** Study can be conducted in RAN4 to assess whether OTA requirement can be derived without measurement results or with partial measurement results. The initial investigation into reduced reliance on measurement campaigns could focus on UE types with more standardized antenna configurations, such as those incorporating glass structures. (Qualcomm)
* Recommended WF
  + TBA.

# Topic #10: **Testability for BS requirements**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513255**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513255.zip) | vivo | **Proposal 11: RAN4 should study the improvement of BS OTA test methods for FR3.** |

## Open issues summary

### Sub-topic 10-1 BS related testability

**Issue 10-1-1: Study on BS testability**

* Proposals
  + **Proposal 1:** RAN4 should study the improvement of BS OTA test methods for FR3. (vivo)
* Recommended WF
  + TBA.

# Topic #11: **Others**

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2513052**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513052.zip) | Samsung | **Proposal 7: RAN4 to discuss whether UE OTA for some features should be discussed in dedicated OTA SI/WI or discussed in corresponding core SI/WI (e.g., AIML, ISAC, etc.) individually.** |
| [**R4-2513312**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513312.zip) | Huawei, HiSilicon | ***Proposal 6: Develop sensing test methodology and channel models for the following scenarios, namely TRP-UE bistatic, UE-TRP bistatic, UE-UE bistatic, UE monostatic.*** |
| [**R4-2513338**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513338.zip) | Ericsson Korea Partners Co Ltd | **Observation 4.** 6G will introduce ISAC, SBFD, and other new duplexing modes.  **Proposal 5.** Study OTA testing for the added ISAC functionalities and SBFD, including joint validation of communication and sensing KPIs, evaluation of self-interference cancellation and residual effects, and performance under realistic mobility and multipath conditions.  **Proposal 7.** Study OTA testing for the new antenna types ELAA and if considered for 6G RIS, holographic arrays, etc. |
| [**R4-2513282**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513282.zip) | Xiaomi | **Proposal 1: RAN4 should have further discussion on the following aspects as part of the 6G OTA Testing:**   * **Frequency ranges for 6G OTA study** * **Assumption for different device type and antenna/antenna array;** * **Channel model for 6G OTA study, e.g. static or dynamic;** * **Test method and metric for ISAC;** * **AI/ML testing**    + **OTA validation for AI/ML-assistant features;**   + **Generalization and AI/ML Robustness Testing;** * **Energy Efficiency evaluation under OTA performance metric;**   **Chamber and Measurement Infrastructure for 6G OTA testing, e.g. chamber size, quiet-zone size, calibration, MU, etc.** |

## Open issues summary

### Sub-topic 11-1 New requirements/metric for OTA

**Issue 11-1-1: new Energy Efficiency performance under OTA metric**

* Proposals
  + **Proposal 1:** Discuss Energy Efficiency evaluation under OTA performance metric. (Xiaomi)
* Recommended WF
  + TBA.

**Issue 11-1-2: new OTA metric for SBFD**

* Proposals
  + **Proposal 1:** Study OTA testing for SBFD**. (E///)**
* Recommended WF
  + TBA.

### Sub-topic 11-2 Treatment of different OTA topics in RAN4

**Issue 11-2-1: How to treat different radiated requirement and Test methods for different areas**

* Proposals
  + **Proposal 1:** RAN4 to discuss whether UE OTA for some features should be discussed in dedicated OTA SI/WI or discussed in corresponding core SI/WI (e.g., AIML, ISAC, etc.) individually. (Samsung)
* Recommended WF
  + TBA.

**Issue 11-2-2: Sensing testability**

* Proposals
  + **Proposal 1:** Develop sensing test methodology and channel models for the following scenarios, namely TRP-UE bistatic, UE-TRP bistatic, UE-UE bistatic, UE monostatic. (Huawei)
  + **Proposal 2:** Study OTA testing for the added ISAC functionalities. Study OTA testing for the new antenna types ELAA and if considered for 6G RIS, holographic arrays, etc. (E///)
* Recommended WF
  + This is just listed based on contributions. This topic should be discussed in 6G Sensing thread.

# Annex: All contributions and proposals for 6G Testability

## Companies’ contributions and proposals in Agenda 8.12

|  |  |  |  |
| --- | --- | --- | --- |
| [**R4-2513024**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513024.zip) | Qualcomm Views on 6G Testability and OTA | Qualcomm Incorporated | **Observation 1: As the starting point, RAN4 can further study FR3 testability with the splitting FR3 assuming 8.4GHz as the boundary.**  **Proposal 1: For FR3 below 8.4GHz frequencies, conductive test could be considered as the baseline. RAN4 needs to study whether to use OTA test method to verify UE radiated performance with multi-Tx scheme.**  **Proposal 2: RAN4 needs futher study the UE archetechture for the frequencies above 8.4GHz. If OTA testing is needed, RAN4 should assess the feasibility of leveraging existing FR2 test setups (e.g., IFF chambers) or methodologies used for Ka/Ku-band VSAT UEs.**  **Proposal 3: For SISO, RAN4 needs study the test method to verify UE radiated performance for multiple Tx scheme with one-layer transmission.**  **Proposal 4: Study can be conducted in RAN4 to assess whether OTA requirement can be derived without measurement results or with partial measurement resluts. The initial investigation into reduced reliance on measurement campaigns could focus on UE types with more standardized antenna configurations, such as those incorporating glass structures.**  **Observation 2: The OTA inlcuidng both SISO OTA and MIMO OTA requirements for 6G bands will not be defined in 6G Day 1 due to the absence of commercial devices.**  **Proposal 5: The the correspoding test method to verify the new AI/ML features such as** **reduced RX beam sweeping factor needs to be further studied in RAN4.**  **Proposal 6**: **RAN4 could investigate whether compliance with radiated spurious emission limits consistently implies compliance with conducted spurious emission limits and study the feasibility of verifying either radiated or conductive spurious emission requirement for 6G UE.** |
| [**R4-2513030**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513030.zip) | Views on 6G OTA Testability | Apple Computer Trading Co. Ltd | **Observation 1: 6G frequency range overlaps with existing 5G NR frequency range FR-1 and FR-2.**  **Proposal 1: RAN4 to reuse as much as possible the existing baselines of the NR frequency ranges FR-1 and FR-2 for RF requirements definition and testability of 6G frequency ranges.**  **Proposal 2: Identify the specific frequencies of interest (lower part of 7-24 GHz range seems to have obvious interest) to begin 6G OTA study for SISO/MIMO.**  **Proposal 3: To further discuss the testing methodology for the 6G new frequency spectrum range (~7GHz to 24 GHz), with a primary focus on Standalone (SA) mode.**  **Proposal 4: Include within the scope of the 6G OTA study the feasibility of extending current baseline test methods used for FR1 (SISO/MIMO) OTA performance testing to the upper mid band frequencies (lower part of the 7-24 GHz range) after identifying the specific frequencies that are of initial interest.**  **Proposal 5: Study a harmonized approach (test method/test system) to testing TN/NTN devices in 6G OTA including but not limited to test method and test metric definition, UE positioning guidelines, MU assessment etc.**  **Proposal 6: Use the AI/ML test methodology finalized in Rel-19 as a baseline for Rel-20 6G OTA study and further evaluate study of AI/ML testability use cases across RF/RRM/Demod areas.** |
| [**R4-2513052**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513052.zip) | Discussion on testability and OTA for 6GR | Samsung | **Observation 1: the trend of mobile communication is to be more and more broaden in terms of functionalities, device types and usage scenarios, the testability study should take the new situation into account in 6G Day 1.**  **Proposal 1: RAN4 to take new spectrum, diverse device types, new feature and functionalities into account in the testability framework study from 6G Day 1.**  **Observation 2: previous RAN4 study on IMT at around 15GHz shows that analog beam forming is not practical to be adopted by handheld UE due to large antenna panel size.**  **Observation 3: discrete antennas with digital beam forming is similar with coherent UL MIMO where conductive requirements and testing are still applicable. A new TRP OTA metric to accommodate such digital beamforming like performance gain in radiation was adopted in TRP TRS work item.**  **Proposal 2: conductive testing is still applicable for RF requirements at around 15GHz. Additional OTA metric can be further studied to accommodate potential multi-antenna performance gain in radiation.**  **Observation 4: frequency is not the only factor to determine the conductive or radiative requirement and test, but UE type and form factor also plays important role, as indicated by the ATG and NTN Ku band examples.**  **Proposal 3: For handheld UE, only conductive testing is considered up to around 15GHz, except traditional OTA requirement and testing.**  **Observation 5: The test method and performance metric could be different for different device types due to different form factors, different characteristics and so on.**  **Proposal 4: handheld UE should be the 1st priority and other device types can be included based on commercial needs in 6G testability and OTA work.**  **Observation 5: The OTA performance metric can be divided into two categories, one is to verify hardware especially antenna performance, and the other is to verify the overall performance under various field conditions.**  **Proposal 5: antenna performance based metric and user-centric performance based metric are not contradicted to each other but can co-exist. TRP TRS metric for handheld UE should not be replaced with new OTA metrics if there is no fully justification.**  **Proposal 6: testability and OTA in 6G should be designed in a realistic manner with reasonable test cost and test time.**  **Proposal 7: RAN4 to discuss whether UE OTA for some features should be discussed in dedicated OTA SI/WI or discussed in corresponding core SI/WI (e.g., AIML, ISAC, etc.) individually.**  **Proposal 8: RAN4 to target for a global harmonized standard in conformance testing and OTA.** |
| [**R4-2513130**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513130.zip) | Discussion on 6GR Testability and OTA | CMCC | **Proposal 1: For the testability around 7GHz, FR1 conduction test should be used as the baseline.**  **Proposal 2: If separate FR is defined for 6GR,**   * **For frequency bands below [10GHz] (the frequency around 7GHz), it is suggested that the testability should take the conduction test of FR1 as the baseline.** * **For frequency bands above [15GHz] (Ku bands), consider using the OTA test of FR2 as the baseline.**   **Proposal 3: New test case should be considered in testability of 6G day1, e.g. A-IoT device, NTN UE.**  **Proposal 4: Legacy testability should be revisited in 6G day1.**  **Proposal 5: for AI/ML, it is proposed to consider dynamic test (i.e. environment changes dynamically during the test) in 6GR.**  **Observation 1: Rel-19 conducted research on the dynamic test methodology for MIMO OTA.**  **Proposal 6: Dynamic test methodologies in MIMO OTA testing should be further studied and supported in 6G day1.** |
| [**R4-2513210**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513210.zip) | Discussion on 6G OTA and testabilities | CATT | ***Proposal 1:*** **RAN4 to study and extend the OTA test methodology and performance requirements for more non-handheld device types in 6G era.**  ***Proposal 2:*** **RAN4 to investigate and extend OTA-based requirements and test methodology for more FR1 transmitter and receiver characteristics in 6G era.**  ***Proposal 3:*** **RAN4 to study the OTA test methodology and performance requirements for multi frequency range combinations for FR1 UE in 6G era.**  ***Proposal 4:* RAN4 to study pure OTA test methodology for UE configuring mixed FR1-FR2 operation in 6G era.**  ***Proposal 5:*** **RAN4 to continue to study the OTA test system for** **AI/ML-based beam-management in 6G era.** |
| [**R4-2513255**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513255.zip) | Discussion on 6G Testability and OTA | vivo | **Observation 1:** Testability topic was one of the important topics in RAN4, which was comprehensively studied many years to cover the new frequency range, new radiated requirements, new UE types, and advanced/complex UE features.  **Observation 2:** There are some limitations for FR1/FR2 OTA test methods, which should be addressed in the beginning of 6G.  **Observation 3:** Some general aspects studied in Rel-20 OTA WI those related to above 10GHz testing may be reused for FR3.  **Observation 4:** Different device types would be considered in 6G day-1. OTA test method development should cover different device types.  **Proposal 1: OTA test method development in 6G should consider the pain points in 5G and aim to verify the device performance close to the real usage scenario in the network, with using a higher accuracy, reduced cost&complexity, and faster testing methodologies.**  **Proposal 2: For FR1 TRP/TRS or PRP/PRS single carrier performance verification, the test method should support/allow UE antenna switching. Repeatability issue of the antenna performance should also be studied.**  **Proposal 3: Test method to verify the radiated performance of devices under multi-carrier condition should be discussed in 6G day-1.**  **Proposal 4: Use concept of 5G dynamic channel model and link adaptation as starting point for 6G MIMO OTA test method.**  **Proposal 5: RAN4 should study advanced algorithm to create more precise and representative dynamic spatial channel models with a smaller number of probes.**  **Proposal 6: RAN4 can study OTA-based verification of MSD requirement and provide meaningful results to guide network configuration and UE design. Testing efficiency or skipping rule should also be studied to reduce test burden.**  **Proposal 7: RAN4 should study the feasibility and complexity of extending FR1 AC system and FR2 IFF/DFF system to cover FR3 frequency range.**  **Proposal 8: For wider CBW in FR3, RAN4 should study a reasonable approach to quantify the flatness of UE radiated performance within the CBW range.**  **Proposal 9: Study the testability issue and corresponding test method to quantify different 6G device types, e.g., smartphone, CPE, XR, VUEs, wearables, sensing, NTN, AI agents, and robots.**  **Proposal 10: For 6G, an advanced test setup to simulate number of different BS beams and proper multi-path fading spatial channel model should be studied to verify AI/ML based BM.**  **Proposal 11: RAN4 should study the improvement of BS OTA test methods for FR3.**  **Proposal 12: RAN4 should study some general solutions (not limited to specific UE type or features) to improve OTA testing efficiency.** |
| [**R4-2513282**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513282.zip) | Ovewview for 6GR testability and OTA | Xiaomi | **Observation 1: OTA testing is critical to ensuring 6G commercial implementations to meet 6G core requirements in realistic.**  **Observation 2: 6G OTA testing should evolve into a multi-dimensional validation framework that integrates new spectrum, advanced antennas, non-terrestrial networks, ISAC, AI/ML, energy efficiency, and enhanced performance metrics to accurately assess 6G devices in realistic, dynamic environments.**  **Observation 3: 6G OTA testing should overcome critical gaps in frequency coverage, chamber capabilities, dynamic channel emulation, ISAC metrics, AI/ML validation, beamforming complexity, and energy efficiency to meet the demands of 6G core requirements.**  **Proposal 1: RAN4 should have further discussion on the following aspects as part of the 6G OTA Testing:**   * **Frequency ranges for 6G OTA study** * **Assumption for different device type and antenna/antenna array;** * **Channel model for 6G OTA study, e.g. static or dynamic;** * **Test method and metric for ISAC;** * **AI/ML testing**    + **OTA validation for AI/ML-assistant features;**   + **Generalization and AI/ML Robustness Testing;** * **Energy Efficiency evaluation under OTA performance metric;** * **Chamber and Measurement Infrastructure for 6G OTA testing, e.g. chamber size, quiet-zone size, calibration, MU, etc.** |
| [**R4-2513284**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513284.zip) | Discussions on 6GR AI testability | CAICT. | ***Proposal 1: For AI related treatability study, the common framework in TR 38.843 could be used as baseline.***  ***Proposal 2: Field test data, reference models, and online training could be considered in 6GR testing for AI/ML based solutions.***  ***Proposal 3: For different AI.ML use cases, legacy procedure as discussed in 5G-A could be used as reference.***  ***Proposal 4: A common test environment for FR2 should be supported for AI/ML based use cases.***  ***Proposal 5: Scenario-based testing could be considered in 6GR study to enable multiple AI/ML use cases testing*** |
| [**R4-2513287**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513287.zip) | Views on Testability and OTA for 6GR | CAICT. | ﻿***Proposal 1: For 6G frequency bands that overlap with 5G, the existing 5G NR test system should be reused as much as possible.***  ***Proposal 2: It is proposed that RAN4 studies a segmented test approach for the new 7-24.25 GHz band. Define test methods for the lower part (below ~[10]***  ***GHz) based on FR1 methodologies, and for the upper part (above ~[15] GHz) based on extending FR2 methodologies.***  ***Proposal 3: RAN4 conducts a dedicated study to resolve the test methodology for the [10]-[15] GHz band. This could involve selecting between FR1-based and***  ***FR2-based methods, or developing a framework that supports both.***  ***Proposal 4: It is proposed to study a scalable and unified OTA test system framework for 6G, with the objective of achieving maximum compatibility across diverse device types and use cases.***  ***Proposal 5: Study testability for emerging 6G use cases, identifying necessary test methodologies and performance metrics for new device types and/or new supported features.***  ***Proposal 6: 6G test methodologies should be fundamentally based on test conditions that closely reflect real-world usage scenarios.***  ***Proposal 7: For 6G MIMO OTA test method, directly incorporate dynamic channel models with link adaption and hand phantom conditions, enabling more***  ***realistic performance evaluation under practical usage conditions. For other tests cases based on channel environments, adopt dynamic channel environments as the starting point.***  ***Proposal 8 : For SISO OTA test method, study enhanced 6G SISO OTA test methods，such as Tx antenna switching conditions and support for device widths exceeding 92mm, to better reflect real-world device behavior across diverse form factors.***  ***Proposal 9: 6G test systems should consider balance measurement accuracy with test time, cost, and complexity, finding the trade-off between these important factors*** |
| [**R4-2513312**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513312.zip) | Consideration on testability and OTA study for 6G | Huawei, HiSilicon | ***Proposal 1: Study and include new frequency bands such as 7.125 – 8.4 GHz and 14.8 – 15.35 GHz in TRP and TRS tests.***  ***Proposal 2: Develop test methodology for wearable devices.***  ***Proposal 3: Develop test methodology for MIMO OTA test under dynamic channels with connections to two Transmission Reception Points.***  ***Proposal 4: NTN OTA tests should use circular polarisation.***  ***Proposal 5: Develop OTA test methodology for AI/ML beamforming by devices.***  ***Proposal 6: Develop sensing test methodology and channel models for the following scenarios, namely TRP-UE bistatic, UE-TRP bistatic, UE-UE bistatic, UE monostatic.***  ***Proposal 7: Consider developing OTA test methodology for vehicles.*** |
| [**R4-2513320**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513320.zip) | On 6GR testability and OTA | OPPO | **Conductive/OTA test framework**  Observation 1: From LTE, the conductive plus TRP/TRS and MIMO OTA framework has been established.  Observation 2: For 5G NR, FR1 reuse similar framework of LTE as conductive test plus TRP/TRS and MIMO OTA.  Observation 3: For 5G NR, FR2 only used OTA tests.  Proposal 1: For 6GR, FR1 like sub-range 1 can reuse 5G FR1 test framework and FR2 like sub-range 3 can reuse 5G FR2 test framework,  Observation 4: The 15GHz connector with feasible insertion loss is on the market.  Proposal 2: For 6GR around 15GHz band, conductive test framework is preferred.  **New frequency range**  Observation 5: Test distance for different test method is needed.  Observation 6: The MU contributors are all frequency dependent.  Observation 7: The quite zone is also frequency dependent.  Proposal 3: For FR3, further study the test distance, measurement uncertainty and quite zone in new frequency range.  **Device type and form factors**  Proposal 4: To study device type definition of 6GR on form factors and corresponding OTA test impacts.  **Multiple Uplink and CA**  Observation 8: The fixed and average TPMI method has been agreed in 5G for 2TX.  Observation 9: The 3TX is foreseen to be an important feature in 6GR.  Proposal 5: To study the 2TX/3TX UL test method.  **Potential 6GR OTA test method for AI BM**  Observation 10: The 5G FR2 3D MPAC system can be one solution for AI-BM test.  Observation 11: The 5G FR2 MIMO OTA system has not been broadly used.  Observation 12: It is hard to correctly model the FR2 multi-AoA channel model and re-establish in chamber environment.  Proposal 6: For AI-BM test in 6GR, to further study the commercial benefit to consider the FR2 deployment, test system complexity and the difficulty to model the channel.  **Decouple of signal acquisition and model performance test**  Observation 13: The over-simplified OTA assumptions being used may offer little practical guidance for field deployment.  Observation 14: With new LCM features, new test setup will always need to be specified which results in endless OTA test setup discussion.  Proposal 7: For 6G, RAN4 could explore whether/how to decouple the signal acquisition testing(e.g., or model inputs) from model performance evaluation (e.g., for model performance) for AI use cases.  Proposal 8: Signal acquisition could continue to be tested via cable or OTA methods, e.g., evaluating BM Set B measurement accuracy.  Proposal 9: Model performance could be assessed using standardized datasets defined by RAN4 (RAN4 specified datasets), enabling a virtual testing environment. |
| [**R4-2513337**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513337.zip) | OTA and testability for 6G | Nokia | The following Proposals were made on the OTA topics:   1. There are no OTA test requirements and OTA test methodologies related to 6G spectrum that have been defined. 2. The study for OTA requirements around 7GHz frequencies should be started. Verify if the current OTA test methodology can be reused for 6G bands around 7GHz and new OTA test methodology can be introduced if necessary. 3. TRP/TRS and MIMO OTA requirements for 1Tx/2Tx/4Tx and 2Rx/4Rx RF architecture should be studied first. 4. OTA test specification related to UL MIMO use cases has not been developed yet in 38.151. 5. We can prioritise completing the UL MIMO OTA requirements for 2Tx/3Tx/4Tx use cases based on 5G NR UE types. 6. UEs with multiple Tx and Rx MIMO implementations have been commercial for years, MIMO OTA conformance testing is not yet routinely deployed prior to market release. 7. We suggest a closer collaboration between RAN4 and RAN5 for MIMO OTA test requirements and test methods development. 8. Folded phones are in high demand in the market. CTIA has developed the OTS test specification for a folded phone based on the unfolded and folded states. However, there is no folded phone OTA test specification defined yet in 3GPP. 9. Refer to the CITA folded phone OTA test plan, study and develop a folded phone OTA test plan related to measurement setup, test procedure, and preliminary MU for 3GPP. 10. New 6G UE category definition will be studied, addressing the development of an increasingly varied set of device categories. OTA test requirements and test methods should be correspondingly adjusted. However, we can wait until those works are done in other parts of 3GPP. 11. The OTA test methods developed for AIML mobility is for FR1 use case, and AIML BM is for FR2 use case. They can be leveraged as reference points for the continued development of OTA test methods for AI/ML use cases in future releases. |
| [**R4-2513338**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513338.zip) | Discussion on testability and OTA in 6G | Ericsson Korea Partners Co Ltd | This contribution provides our views related to OTA and testability. The contribution makes the following observations and proposals.  **Observation 1.** 6G will introduce new 7-15 GHz frequency range and wider bandwidths in mmWave frequency band, and novel channel behaviours.  **Proposal 1.** Study OTA testing for the new 7-15 GHz frequency range and the wider bandwidths in mmWave frequency band with the appropriate channel models.  **Proposal 2.** Study enhancements in existing OTA testing method and associated requirements for frequencies below 7 GHz.  **Observation 2.** Some conducted requirements from the previous generations, e.g. Pout, sensitivity, spurious emissions, EVM, MSD and MIMO verification, are not sufficient for guaranteeing device good functioning. OTA testing provides more realistic device-level performance under integrated antenna/beamforming conditions.  **Proposal 3.** Study which conducted tests in the previous generations can be moved or complemented with OTA test in 6G, e.g. Pout, sensitivity, spurious emissions, EVM, MSD, UL MIMO, etc.  **Observation 3.** 6G will introduce AI/ML functionalities such as beam prediction, mobility, positioning, and CSI compression/prediction. Robust testing will be required to ensure reliable operation and interoperability of AI/ML based features across vendors, which may necessitate new test setups. Moreover, testing time and reproducibility will be important considerations, and standardized approaches will be critical, as inadequate validation could limit adoption of certain AI-native features.  **Proposal 4.** Study OTA testing for the added AI/ML functionalities with the appropriate channel models as Spatial Channel Model (SCM). 6G study shall take the achievements expected in 5G AI/ML OTA testing into account.  **Observation 4.** 6G will introduce ISAC, SBFD, and other new duplexing modes.  **Proposal 5.** Study OTA testing for the added ISAC functionalities and SBFD, including joint validation of communication and sensing KPIs, evaluation of self-interference cancellation and residual effects, and performance under realistic mobility and multipath conditions.  **Proposal 6.** Study OTA testing for 6G NTN for different use-cases, bands including VSAT terminals operating in Ku and Ka bands, etc.  **Proposal 7.** Study OTA testing for the new antenna types ELAA and if considered for 6G RIS, holographic arrays, etc.  **Observation 5.** In FR1 conducted TS 38.101-1, “for UE(s) with an integral antenna only, a reference antenna(s) with a gain of 0 dBi is assumed for each antenna port(s)”. It is worth discussing if the conducted requirement could be related to the OTA requirement by at least assuming a reasonable antenna efficiency, e.g. a typical FR1 antenna efficiency is -5.5 dB.  **Proposal 8.** Discuss a more realistic assumption on antenna efficiency for FR1 band tests, e.g. -5.5 dB.  **Proposal 9.** For the bands that have TRP/TRS requirements, use the value of TRP to derive the real antenna efficiency. |
| [**R4-2513347**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_116bis/Docs/R4-2513347.zip) | On UE 6G OTA Testability Aspects | Keysight Technologies UK Ltd | *Observation 1: It would be desirable to officially give the new frequency range of special interest for 6G a better identifier rather than “the range between FR1 and FR2-1 (including around ~7GHz)”*  *Observation 2: The key benefit of OTA testing is the inclusion of realism in the device assessment*  *Observation 3: The decision of radiated vs conducted requirements for 6G operation between FR1 and FR2 will likely depend on the actual frequency range of operation and whether a physical conducted port/connector is feasible.*  *Observation 4: Whether significant reductions in MU due to test equipment will be possible for the FR2 range for 6G operation is questionable*  **Proposal 1: For 6G FR1, continue the majority of conformance testing (UE RF, Demodulation, RRM) using conducted testing**  **Proposal 2: For 6G FR1, consider novel, select OTA test cases to assess real-world performance to selectively verify the end-to-end performance using OTA methodologies**  **Proposal 3: For 6G FR1, consider OTA testing where conducted conformance testing (UE RF, Demodulation, RRM) could either yield testability issues, e.g., lack of physical Tx/Rx ports, and/or highly dynamic nature of multiple Tx/Rx operation, including antenna tuning for impedance and/or pattern**  **Proposal 4: When deciding the testing environment of 6G for the range between FR1 and FR2, take testing aspect pros and cons for conducted vs radiated testing, summarized in Table 1, into account**  **Proposal 5: Conclude on the actual frequency range of 6G operation between FR1 and FR2 early to determine whether existing FR1 or FR2 systems/methodologies should serve as baseline for OTA testing.**  **Proposal 6: Focus MIMO OTA assessments in 6G for the range between FR1 and FR2 on more realistic scenarios including dynamic channel models, link adaptation and 3D channel models. FFS whether these aspects should be applied to mid to high bands in 6G FR1 as well**  **Proposal 7: If the focus of 6G conformance testing in the range between FR1 and FR2 is conducted, consider novel, select OTA test cases to assess real-world performance to selectively verify the end-to-end performance using OTA methodologies**  **Proposal 8: If the focus of 6G conformance testing in the range between FR1 and FR2 is conducted, consider OTA testing where conducted conformance testing (UE RF, Demodulation, RRM) could either yield testability issues, e.g., lack of physical Tx/Rx ports, and/or highly dynamic nature of multiple Tx/Rx operation, including antenna tuning for impedance and/or pattern**  **Proposal 9: 6G OTA testability aspects need to be considered together with feature development going forward (regardless of frequency range) as important synchronizations between WIs and SIs and/or RAN4 and RAN5 resulted in unnecessary delays and confusion, e.g., low-UL/high-DL test cases, Ku/Ka bands, various FR2 power classes.**  **Proposal 10: For 6G FR2 UE RF OTA testing, consider revisiting the need for beam peak searches to reduce MU and overall test time.**  **Proposal 11: Leverage the UE RF, Demodulation, and RRM test systems and methodologies for 6G FR2 from 5G FR2 as a baseline** |