

# 5G CHALLENGE

## Official Rules

### 2023 5G Challenge: Advanced Interoperability

Version 1.0

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**ITS**

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# 1 Introduction

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*5G Challenge Vision: To accelerate adoption of 5G open interfaces, interoperable subsystems, and secure, modular, multi-vendor solutions by fostering a large, vibrant, and growing vendor community dedicated to advancing 5G interoperability towards true plug-and-play operation.*

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The National Telecommunications and Information Administration's Institute for Telecommunication Sciences (NTIA/ITS), in collaboration with Department of Defense's Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)), is leading the 2023 5G Challenge to accelerate the adoption of:

- Open interfaces
- Interoperable subsystems
- Secure networks
- Modular, secure, multi-vendor solutions

In 2022, NTIA/ITS conducted the 5G Challenge Preliminary Event: RAN Subsystem Interoperability. This successful event demonstrated end-to-end data communication sessions using multiple protocols across a multi-vendor, interoperable, open RAN architecture.

This document describes the rules for the 2023 5G Challenge: Advanced Interoperability, which in this document is abbreviated to 2023 5G Challenge. The official website for the 2023 5G Challenge is <https://5gchallenge.ntia.gov>.

In the 2023 5G Challenge, NTIA/ITS will award a total prize purse of up to \$7,000,000 in cash and in-kind prizes to high-performing 5G subsystems that showcase multi-vendor interoperability across Radio Units (RU) and combined Central Units and Distributed Units (CU+DU).

Applicants will submit white papers with technical information about their proposed submission. Contestants will be accepted based on white paper score. Contestants must submit a Software Bill of Materials (SBOM) within two weeks after acceptance into the 2023 5G Challenge. If there are known vulnerabilities, the SBOM must include a Vulnerability Exploitability eXchange (VEX) document. Accepted contestants will be informed of their lab testing schedules and integration partners before lab testing begins. This plan may change as the 2023 5G Challenge progresses.

The host lab facilities for the 2023 5G Challenge will be provided by CableLabs and its Kyrio subsidiary, which is the first O-RAN ALLIANCE Open Testing and Integration Centre (OTIC) in the Americas. The host lab will facilitate contestant testing through three stages of integration, each building on the previous stage:

- Wrap-around emulation testing (on each contestant subsystem individually)
- End-to-end (E2E) integration testing, to establish and test an E2E session (CU+DU and RU)
- Mobility testing between two E2E sessions

Contestants are expected to provide an on-site system engineer throughout the host lab testing that involves their subsystem(s). Due to limited host lab resources, contestants' use of the host lab will be staggered. This impacts all major milestones (e.g., acceptance into the 2023 5G Challenge, host lab schedule).

As a part of the testing, which includes adherence to applicable O-RAN ALLIANCE specifications, contestants have the opportunity to receive a badge or certification from Kyrio under its OTIC lab authority. The Kyrio badging and certification is not a part of the prize package or endorsed as a standard of excellence by the National Telecommunications and Information Administration or the Institute for Telecommunication Sciences.

All official 2023 5G Challenge documents are posted on the NTIA 2023 5G Challenge webpage, <https://5gchallenge.ntia.gov>.

Application to, or participation in, the 2023 5G Challenge will have no direct effect on the applicant's eligibility to participate in any other NTIA program (e.g., the Public Wireless Supply Chain Innovation Fund).

## 2 Additional Documents

This rules document refers to additional 2023 5G Challenge documents that NTIA/ITS plan to release:

- Application Template
- Host Lab Configuration
- Host Lab Test Plan Overview
- Participation Agreement
- Frequently Asked Questions (FAQ)

NTIA/ITS may release additional documents with rules updates, procedures, and other information for contestants as needed. These additional documents carry the full authority of the rules in this document.

All 2023 5G Challenge documents, including this rules document, should be considered living documents, subject to updates and clarification throughout the 2023 5G Challenge program. NTIA/ITS has the authority to modify and interpret the rules at any time.

The Host Lab Configuration document identifies the host lab equipment (e.g., vendors and versions of hardware and software).

The Host Lab Test Plans document lists the mandatory tests for Stage Two and mandatory and optional tests for Stages Three and Four (see Sections 5.3, 5.4, and 5.5). An overview version of these documents will be released to all potential applicants prior to the submission deadline. The detailed version of these documents will be released when lab testing begins.

### 3 Interfaces and Subsystems Under Test

#### 3.1 Interfaces and Subsystems

The 2023 5G Challenge will evaluate the 5G subsystems via the interfaces identified in Table 1 and Figure 1. The 2023 5G Challenge uses standalone (SA) Option 2 configuration for both the core and 5G Radio Access Network (RAN), but only 5G RAN subsystems will be evaluated. The host lab will provide the core and user equipment (UE) functionality. See Section 3.6 for more information.

The 2023 5G Challenge will accept either Time Division Duplexing (TDD) or Frequency Division Duplexing (FDD) subsystems, but TDD testing will be a higher priority.

- **Combined Central Unit (CU) and Distributed Unit (DU), abbreviated CU+DU.** The CU and DU can be from the same or different vendors. Contestants having only a CU or only a DU are encouraged to partner and enter their combined CU+DU together. In this case, the F1 integration must be successfully completed *before* submitting the CU+DU to the host lab.
- **Radio Unit (RU).** The RU must have the ability to operate with cabled air interface emulation supporting up to 4x4 MIMO (FR1 only).

Note: these O-RAN ALLIANCE subsystems are abbreviated as CU, DU, and RU throughout this document, not as O-CU, O-DU, and O-RU.

The 2023 5G Challenge will evaluate the following interfaces:

- **3GPP Interface NG (N2/N3) and NAS (N1).** RAN interface to 5G standalone (SA) core. N1 is a transparent interface between the user equipment (UE) and the 5G core. NG control plane is also known as N2. NG user plane is also known as N3.
- **O-RAN ALLIANCE Interface Open Fronthaul (DU to RU).** Includes Control, User and Synchronization (CUS) Plane and Management Plane protocols. Based on lower layer functional split “7-2x” and leverages eCPRI protocols. RU diversity will be tested via this interface.
- **3GPP Interface Xn.** Single-vendor and multi-vendor call and session handover will be tested via this interface and the N2 interface.
- **3GPP Interface Uu.** Logical interface between RU and UE.

Table 1: Interfaces required to be exposed and available for testing.

| Subsystem | NG | Open Fronthaul | Xn | Uu |
|-----------|----|----------------|----|----|
| CU+DU     | X  | X              | X  |    |
| RU        |    | X              |    | X  |

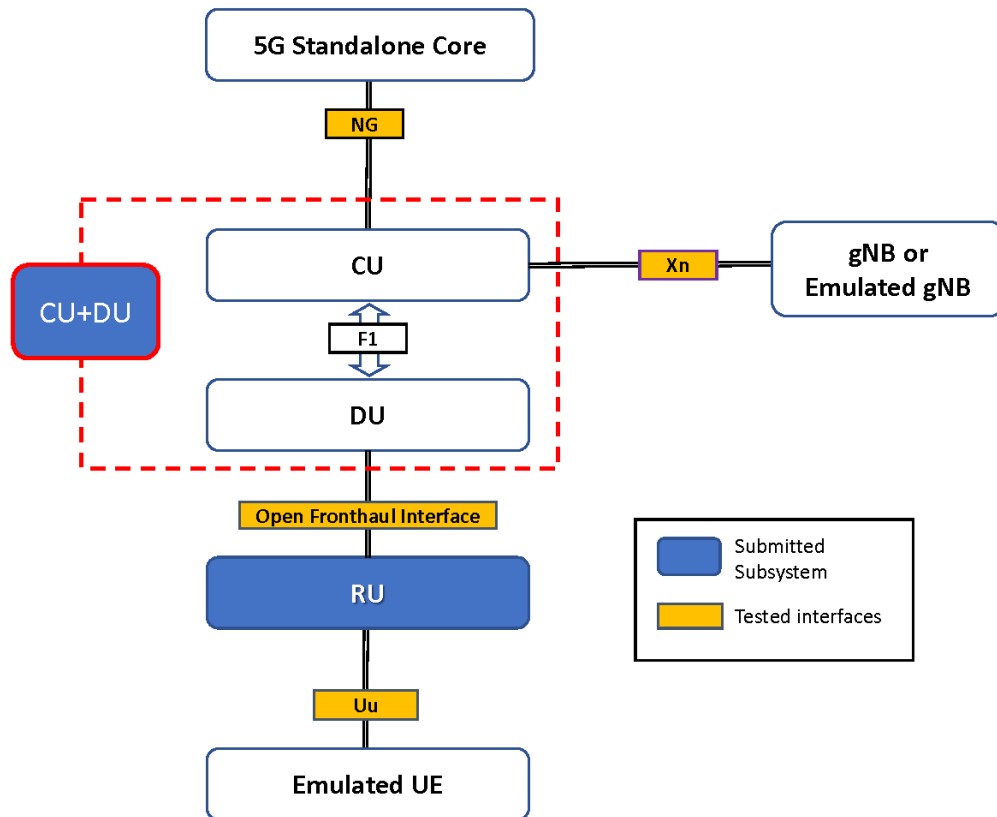


Figure 1: 2023 5G Challenge test environment.

Figure 1 identifies, for each subsystem submitted, the interfaces that must be available for testing and evaluation. Section 10 provides references for the interfaces and operations to be evaluated during the 2023 5G Challenge.

### 3.2 Standards and Specifications

Contestant subsystems must be compliant with the 3GPP standards and O-RAN ALLIANCE specifications listed in Section 10 and be capable of operating with a 5G SA system that adheres to those same specifications for the NG, Xn, open fronthaul, and Uu interfaces. All contestants must, in their application white paper, confirm such compliance.

Additionally, each contestant must state which open fronthaul synchronization configuration(s) the contestant's entry supports and why those configurations were chosen. These synchronization configurations are defined by the O-RAN ALLIANCE Working Group 4 as the LLS-C1, LLS-C2, LLS-C3, and LLS-C4 options. CableLabs can support all four of these configurations but can only test LLS-C1, LLS-C2, and LLS-C3.



### 3.3 Subsystem Delivery Options

The host lab can support the following subsystem delivery options. Regardless of which option is chosen, the host lab can provide remote access to any contestant's subsystem.

- **Delivery Option One:** Cluster delivery and local host lab installation. Contestant subsystem hardware/software servers are staged, pre-tested, and pre-configured, and delivered to host lab for integration and testing.
- **Delivery Option Two:** Remote install onto host lab OpenShift Container as a Service (CaaS) / Platform as a Service (PaaS) cluster. Delivery of contestant subsystem is remotely uploaded and installed into host lab cluster for integration and test.
- **Delivery Option Three:** Remote install onto host lab "bare metal" system. Contestant will be provided remote access to install their desired operating system and, subsequently, upload and install their subsystem software on the host lab hardware for integration and testing.

To mitigate potential issues with delivery and installation, each contestant will submit a backup delivery option in addition to their chosen plan (e.g., subsystem software installed and configured on own hardware brought to 2023 5G Challenge in case installation on host lab cluster is not possible), along with required lab resources and times to implement the backup plan.

### 3.4 Overview of Host Lab Environment

This section provides a high-level overview of the host lab environment. For details, see the documents identified in Section 2.

The host lab will provide two separate 5G test and emulation systems. The 2023 5G Challenge organizers will try to pair contestants with their preferred emulation system, but this will not be guaranteed. Once a contestant is assigned to a 5G test and emulation system, this assignment cannot be changed.

Contestant subsystems that pass the wrap-around emulation testing will be integrated with other contestants' subsystems and with the host lab's baseline system consisting of a 5G SA core and UE emulator. "Plug-and-play" performance will be evaluated using a standard corpus of performance metrics. Prior to integration, testing, and interoperability performance evaluation, the host lab will be made available to all participating contestants for preparation.

The host lab will take reasonable precautions to protect contestant software from other contestants. Contestants can run in a shared environment on OpenShift 4.8 CaaS. By default, the host lab will limit each contestant to a dedicated namespace with role-based access controls (RBAC) allowing only them access to that namespace. Once a contestant's testing is completed, all contents in the namespace will be deleted. Networking connections between the systems will be limited to only ports and protocols needed for operation.

Contestants may also provide their own hardware and CaaS, for which they would be responsible for all system security and access. Networking connections between the systems would be limited to only ports and protocols needed for operation.

### 3.5 Statement of Compliance

Contestants must submit a Statement of Compliance with the host lab, including, among other items, a detailed explanation of contestant capabilities and functionality and how various features and functions are supported vis-à-vis related 3GPP standards and O-RAN ALLIANCE specifications to be tested as outlined in the Host Lab Configuration and Host Lab Test Plans. The host lab will provide contestants with a template for its statement of compliance.

### 3.6 Host Lab Capabilities and Configuration

CableLabs was the host lab for the 5G Challenge Preliminary Event in 2022 and is the host lab for the 2023 5G Challenge. CableLabs is a not-for-profit innovation research and development (R&D) lab. With a state-of-the-art facility and collaborative ecosystem with thousands of vendors, CableLabs delivers innovative network technologies for the entire industry. The 2023 5G Challenge builds on the experience of CableLabs as an independent arbitrator and host of industry interoperability events. The 2023 5G Challenge also builds on the experience of the CableLabs subsidiary, Kyrio, which was the first O-RAN ALLIANCE OTIC in the Americas.

For wrap-around emulation testing, the host lab will provide a Viavi 5G test system and a Keysight 5G test system.

For E2E integration testing, the host lab will provide one SA 5G core: a Mavenir core running on Intel COTS servers (Dell PowerEdge R440 [master nodes] R770xd [worker nodes] using Intel processors).

For more information on the host lab's 5G systems, see the Host Lab Configuration document, published separately. Note that references to the "host lab system" throughout this document may refer to multiple host lab system configurations.

The host lab will verify interoperability and measure performance metrics of submitted subsystems. Details of the host lab capabilities (e.g., systems, set-up) can be found in the Host Lab Specification document. The host lab can perform both emulated UE testing and testing with actual UE handsets. Actual UE limitations may apply, due to inherent characteristics of the host lab UEs (e.g., band limitations, the usage of certain PLMNs).

## 4 Contest Overview and Structure

The 2023 5G Challenge consists of multiple stages during which contestants are evaluated and prizes are awarded. The 2023 5G Challenge organizers reserve the right to make scheduling changes due to unforeseen events.

The 2023 5G Challenge consists of the following stages, which are summarized here and further defined in Section 5.

- Stage One: Application
- Stage Two: Wrap-around Emulation Testing
- Stage Three: E2E Integration Testing
- Stage Four: Mobility Testing
- Results: Closing Ceremony

Contestants are expected to keep their subsystem at the host lab facility from the start of their wrap-around emulation testing until the end of their last E2E integration testing or mobility testing.

#### 4.1 Contestant Requirements for On-site and Off-site Support

Stages Two, Three, and Four of the 2023 5G Challenge will require close collaboration to achieve E2E connectivity and interoperability during the competition. More specifically, multiple contestants and the host lab will jointly debug and troubleshoot integration issues in real-time. To ensure host lab time and resources are used as efficiently as possible, each contestant is required to have system engineering resources on-site for the testing of their submitted subsystems during their various lab phases. NTIA/ITS reserves the right, at its sole discretion, to adjust on-site requirements in response to COVID-19 health and safety protocols.

Additionally, each contestant must make necessary off-site staff available to quickly respond (i.e., within 90 minutes) to troubleshoot and resolve integration issues encountered that cannot be resolved by their staff on-site. The host lab will coordinate on-site staff requirements as part of contestant scheduling.

Both on-site and off-site support will be regularly scheduled during normal business hours of the host lab (Mountain Daylight Time).

Contestants can apply for an exemption if providing on-site support is not possible. In such a case, the contestant must nonetheless provide dedicated remote support during the host lab's business hours (Mountain Daylight Time) throughout their testing windows.

#### 4.2 Overview of Stage One: Application

During Stage One, contestants will apply for participation in the 2023 5G Challenge by submitting a white paper that conforms to Section 5.1.3. All submissions must use the template provided on the 2023 5G Challenge website, available at <https://5gchallenge.ntia.gov>. This white paper will both inform contestant selection (e.g., technical overview, compliance information, security plan) and the host lab schedule (e.g., delivery mechanism, contestant availability).

Contestants are encouraged to participate in mobility testing. This white paper must indicate whether the contestant is willing to participate in mobility testing with other contestant subsystems in Stage Four. Applicants interested in mobility testing may also request specific gNB configurations, but these gNB configurations will not qualify for a Multi-vendor E2E Integration Testing Prize (see Section 7.1).

After the conclusion of the white paper submission period, NTIA/ITS will reject non-qualifying white papers, rate qualifying white papers, and select the initial pool of contestants. White papers not accepted at the outset will be ranked and placed on a waiting list. The waiting list applicants may be selected later in the 2023 5G Challenge. NTIA/ITS will notify applicants if they are selected for admission as walk-on contestants later in the 2023 5G Challenge. See Section 6.1 for details.

The 2023 5G Challenge will remain open for applications during testing. Any applicant accepted during testing will be considered a “walk-on” contestant. Walk-on contestants will only be accepted if the waitlist has no qualified contestants with compatible technical specifications. Walk-on contestants should understand that they are unlikely to participate in mobility testing.

#### 4.3 Overview of Acceptance: Testing Tracks and SBOM Requirements

The host lab will contact contestants with coordination details, including initial lab time assignment schedule for their subsystem(s). This initial lab time schedule will include, for each accepted subsystem, the testing track, testing configuration, partner contestants and subsystems, the lab time schedule, and key equipment settings that enable this configuration.

The testing track can be (a) mobility testing, (b) multi-vendor E2E integration testing, or (c) wrap-around emulation testing.

- **Mobility Testing Track:** The mobility testing track includes Stages Two, Three, and Four. The mobility testing schedule spans approximately 18 to 24 weeks. To be considered for this track, a contestant’s white paper must request mobility testing.
- **Multi-vendor E2E Integration Testing Track:** The multi-vendor E2E integration testing track includes Stages Two and Three. The multi-vendor E2E integration testing track schedule spans approximately 9 weeks. All contestants will be considered for this track.
- **Wrap-around Emulation Testing Track:** The wrap-around emulation testing track includes only Stage Two testing. The wrap-around emulation testing track spans approximately three (3) weeks.

Note: The Wrap-around Emulation Testing Track is intended to provide alternates for contestants who cannot proceed in the Mobility Testing Track. For example, NTIA/ITS may select one of the wrap-around emulation testing track RUs for mobility testing, if one of the RUs that was initially selected for mobility testing fails Stage Two testing or a technical compatibility problem is discovered in Stage Three or Four.

Contestants must submit an SBOM for their subsystems within two (2) weeks of acceptance into the 2023 5G Challenge. If subsystem vulnerabilities are known, the SBOM must include a Vulnerability Exploitability eXchange (VEX) document, as described in Section 5.2. SBOM and VEX must pass compliance, as described in Section 6.2, before lab testing begins.

#### 4.4 Overview of Stage Two: Wrap-around Emulation Testing

During Stage Two, the selected contestants' subsystem(s) will be evaluated in one of the host lab's wrap-around emulators. The focus of the Stage Two testing is confirming the operation of the relevant interfaces for each subsystem, as detailed in Table 1, and confirming basic subsystem operation.

The contestants' must provide on-site system engineer(s) with appropriate technical expertise and resources to ensure interoperability with the emulator. If the subsystem's interface does not interoperate with the host lab's emulator, the host lab will make available technical expertise during the contestants' allotted lab time to work with the contestants to fault isolate and try to achieve interoperation.

Each contestant subsystem must successfully complete Stage Two testing before proceeding to Stage Three.

#### 4.5 Overview of Stage Three: E2E Integration Testing

Some contestants will begin Stage Three: E2E Integration Testing while other contestants may still be competing in Stage Two: Wrap-around Emulation Testing.

Stage Three will demonstrate CU+DU and RU interoperability in various combinations of contestants. The Stage Three testing focus will be E2E integration, interoperability, and performance by first establishing data sessions (PDU) and then confirming performance and stability under various traffic types and loads. The host lab will conduct performance tests and stability tests.

Each specific (CU+DU and RU) pairing must successfully complete Stage Three testing before proceeding to Stage Four.

#### 4.6 Overview of Stage Four: Mobility Testing

In Stage Four, two pairings from Stage Three (i.e., CU+DU and RU) will work together to demonstrate mobility. Mobility testing shall include the handover of a UE (in RRC\_CONNECTED state) from a source gNB to a target gNB (i.e., inter-gNB). Both Xn-based and N2-based handover procedures will be tested.

Stage Four is optional but encouraged. To be considered for Stage Four, contestants must request mobility testing in their white paper. Due to limitations on lab resources and subsystem configurations, NTIA/ITS cannot guarantee that mobility testing will be available to all interested contestants.

#### 4.7 Overall Schedule

Figure 2 shows the process flow for a single contestant subsystem. Contestant subsystems will complete Stages One and Two once. Due to limited availability of host lab resources, contestants will move through these stages asynchronously (i.e., at different times).

Multi-vendor E2E integration testing and mobility testing require subsystems from two or more contestants with compatible configurations (see Section 5.1.3). The expectation of the 2023 5G Challenge organizers is that most contestant subsystems will be scheduled for either (a) mobility testing or (b) multi-vendor E2E integration.

However, some contestant subsystems may be scheduled for more than one E2E integration testing effort (e.g., RUs whose settings enable additional E2E integration testing efforts).

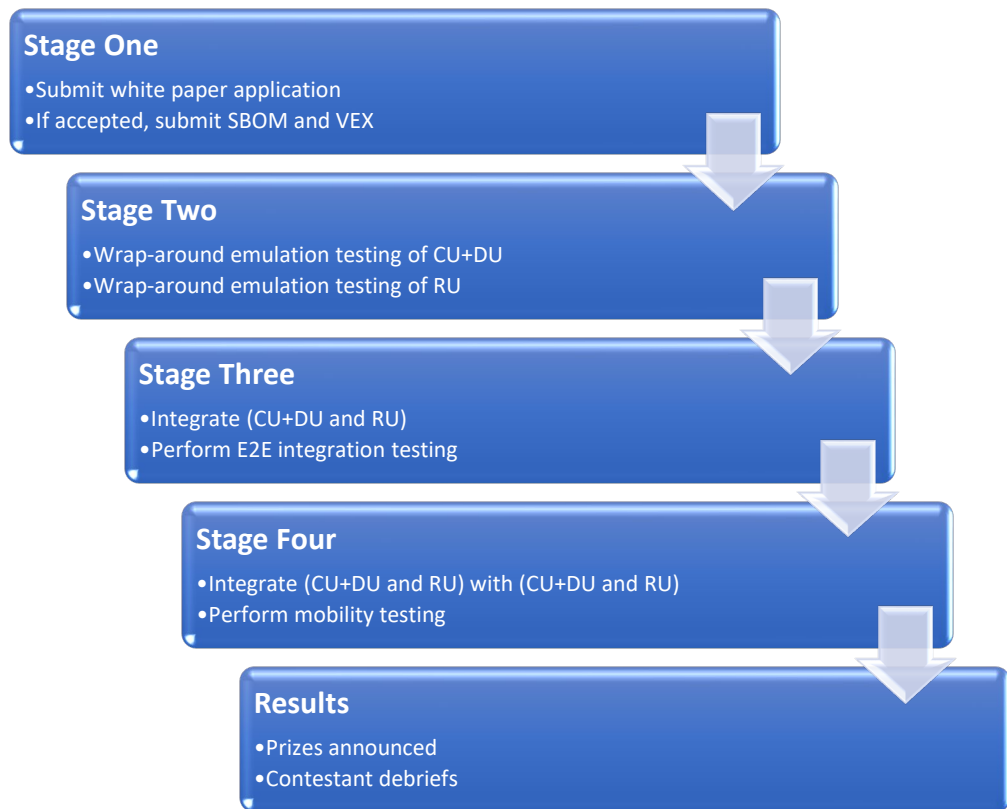


Figure 2: 2023 5G Challenge flowchart.

#### 4.8 Closing Ceremony

NTIA/ITS will host a closing ceremony at the host lab facility in Louisville, Colorado. The Closing Ceremony may be broadcast remotely due to COVID-19 or other health-related concerns. The Closing Ceremony will include:

- A keynote address(es) by the 2023 5G Challenge organizers

- Initial interoperability and evaluation results from Wrap-round Emulation Testing, E2E Integration Testing, and Mobility Testing
- Test vendor presentations
- Contestant panel discussion
- Presentation of Awards
- Questionnaire breakout sessions

NTIA/ITS is currently planning for attendance at the Closing Ceremony to be by invitation only and on a limited basis due to ongoing health, travel, and safety restrictions. Anticipated attendees include contestant teams, 2023 5G Challenge staff and contractors, test vendors, and public officials. NTIA/ITS will extend Closing Ceremony invitations at a date to be determined.

A video of the Closing Ceremony may be made public. At the Closing Ceremony, winning contestants will be interviewed for a video summarizing the 2023 5G Challenge. Contestant participation is voluntary.

#### 4.9 Overview of Prizes

NTIA/ITS will award up to \$7,000,000 in cash and prizes. These will be divided as follows:

- Best Mobility Testing prizes (up to four)
- Best Multi-Vendor E2E Integration Testing prizes (up to four)
- Wrap-around Emulation Testing prizes (up to ten)
- Best SBOM prizes (two)
- Best Collaborator prize

See Section 7 for details.

#### 4.10 Contest Schedule

Table 2 provides major milestone dates. This schedule is subject to change; see the 2023 5G Challenge website for updates.

Table 2: 2023 5G Challenge important dates.

| Event   | Date                             |
|---|----------------------------------|
| 2023 5G Challenge information session webinar       | February 9, 2023                 |
| White papers due                                    | March 1, 2023                    |
| Accepted contestants announced                      | March 6, 2023                    |
| SBOM and VEX submissions due                        | [Two (2) weeks after acceptance] |
| Host Lab Test Plans details released                | March 20, 2023                   |
| Lab testing begins (Stages Two, Three, and Four)    | March 20, 2023                   |
| Lab testing concludes (Stages Two, Three, and Four) | September 15, 2023               |
| Updated SBOM and VEX due                            | September 15, 2023               |
| Judge panel evaluates results                       | September 18–20, 2023            |
| Closing Ceremony and Final Awards                   | September 21, 2023               |

| Event                                   | Date                               |
|---|------------------------------------|
| Contestant debriefs due                 | October 12, 2023                   |
| Window for lab time and security prizes | October 9, 2023, to March 29, 2024 |

## 5 How To Compete

### 5.1 Stage One: Application

To apply to the 2023 5G Challenge, contestants must:

- Have a functioning CU+DU and/or RU that adheres to the Section 3 specifications
- Meet the Eligibility requirements in Section 5.1.2
- Submit a white paper that conforms to Section 5.1.3
- Be prepared to submit an SBOM and VEX two weeks after acceptance, as per Section 5.2
- Commit to providing on-site and off-site system engineering support, as per Section 4.1
- Commit to multi-vendor collaboration during troubleshooting and fault remediation

After the review of all applications, NTIA/ITS will announce contestants for the 2023 5G Challenge. Subject to the applications received and their distribution across components, NTIA/ITS intends to initially select at least four (4) CU+DUs and at least four (4) RUs. The remaining qualifying applicants will be placed on a waiting list. See Section 6 for the application evaluation and acceptance methods.

Contestants that submit multiple subsystems to the 2023 5G Challenge shall consolidate their subsystem descriptions into a single white paper entry.

#### 5.1.1 Fee

There is no fee for entry.

#### 5.1.2 Eligibility

The goal of the 2023 5G Challenge is to incentivize broad participation and encourage new entrants to the market. The 2023 5G Challenge, authorized under Section 105 of the America COMPETES Reauthorization Act of 2010 (Pub. L. No. 111-358), as amended by Section 401 of the American Innovation and Competitiveness Act of 2016 (Pub. L. No. 114-329) and codified in [15 U.S.C. § 3719](#) (hereinafter “America COMPETES Act”), is open to all individuals, nationalities, ages, academic institutions, and business interests, subject to the caveats below:

- An entrant may be an individual, a group of individuals (i.e., “team”), or a contestant representing either a single or a team of multiple businesses or academic institutions.
- At the time the application is submitted, the respective individual applicant, or in the case of a team submission, the contestant Leader, must be at least age 18 and a U.S. citizen or permanent resident of the United States or its territories. In the case of an entity applicant, the entity must be incorporated in and maintain a primary place of business in the United States or its territories.



- Each entrant must provide a current U.S. taxpayer identification number (TIN) to validate eligibility (e.g., Social Security number, employer identification number).
- Applicants may enter under an official affiliation (e.g., a university or corporation). Multiple affiliations may partner under one application (i.e., “affiliate team”), for example one CU vendor and one DU vendor submit a combined CU+DU. If the winner is a team of affiliates, it is the responsibility of the contestant team Leader, not NTIA/ITS, to determine the subsequent division of any prize money.
- Applicants may also have an official set of sponsors. Affiliations and sponsors must be disclosed in the white paper.
- Each contestant team must identify a single individual as the contestant Leader. This individual must meet all eligibility requirements and will serve as the official administrative point of contact for communications with the 2023 5G Challenge team.
- Contestants are to be wholly separate entities that do not share members/affiliations or sponsorship (financial interests) with other contestants. Individuals cannot be members of multiple contestant teams. Contestants may have one or more sponsors. Contestants may not collaborate or share their technical approaches and solutions with other contestants, except during Stage Three pairing. Contestants who do not comply with these guidelines will be subject to disqualification.
- Ownership/Control: 2023 5G Challenge applicants shall not be majority-owned or controlled by a foreign state.
- Federal Acquisition Regulations (FAR): FAR compliant accounting systems are not required.
- Non-Commercial Entities: Academic participation is permitted, provided a path to market for the resulting product is clearly defined.

The following individuals and organizations are not eligible to participate in 2023 5G Challenge events:

- Companies that are suspended, debarred, or otherwise excluded from contracting with the U.S. Government cannot participate.
- Foreign Individuals/Entities: Individuals who are non-U.S. citizens or permanent residents and entities that are not incorporated and maintain a primary place of business in the United States cannot participate.
- Official Government entities (from the U.S. or any other country) are not eligible to participate as applicants, sponsors, or official affiliates.
- Government employees and/or Government contractors (from the U.S. or any other country) acting within the scope of their employment or contract, as applicable, are not eligible to participate as applicants or contestant members.
- Persons or entities that received funds for supporting or advising the 2023 5G Challenge are not eligible to participate.

Government military members or civilian employees may be eligible to participate if they do so in their personal capacity and if the work performed for the contest is NOT related to their

official Government duties. Government military members or employees should consult their supervisors and designated agency ethics officials before participating in the contest.

An individual or entity shall not be deemed ineligible under these rules because the individual or entity used Federal facilities or consulted with Federal employees during the 2023 5G Challenge. Facilities and employees are made available to all individuals and entities participating in the 5G Challenge on an equitable basis.

### 5.1.3 White Papers and Other Entry Submission Requirements

Entry into the 2023 5G Challenge requires submittal and acceptance of a white paper in accordance with the instruction outlined herein, as well as proof of eligibility (submitted separately).

The white papers must include the following sections (this includes information in addition to the evaluation criteria; see Section 6 for evaluation criteria):

- **Subsystem(s):** Type of subsystem(s) to be submitted for testing: CU+DU and/or RU. Contestants are encouraged to submit multiple subsystems of a single type, such as two RUs with different technical specifications.
- **Mobility Testing:** All subsystems will be considered for multi-vendor E2E integration testing. Also indicate whether you are willing to participate in mobility testing. Include the desired configurations (Type A, Type B, or Type C). Multiple configurations may be selected.
  - ▶ **Type A: Single-vendor Pairing.** This contestant submits both a CU+DU and a RU. These subsystems will be paired together as a gNB for mobility testing.
  - ▶ **Type B: Designated Pairing.** This contestant submits a CU+DU that is intended to be paired with another contestant's RU for E2E integration testing, or vice versa. The other contestant's white paper must also specify this designated pairing. This option is for contestants who have previously paired their RU with another contestant's CU+DU, or vice versa, and want to be paired together as a gNB for mobility testing.
  - ▶ **Type C: Cold Pairing.** This contestant's subsystem(s) will undergo cold E2E integration testing with an unknown contestant's subsystems.
- **Technical Overview:** A technical implementation overview with sufficient detail to assess viability and to identify any novel aspects. For each subsystem submitted for testing, include any conditions that may impact the host lab (e.g., computer hardware, operating system, and orchestration).
- **Technical Specifications:** Specify technical details necessary to schedule viable interoperability opportunities. This information must be provided for each subsystem submitted.
  - ▶ CU+DU subsystems must specify: whether the system supports Cat-A or Cat-B RUs, whether the system supports TDD and/or FDD.
  - ▶ RU subsystems must specify: whether the system supports TDD and/or FDD, the band(s) and frequency range supported, max RF output power, any applicable output power control limitations, Tx/Rx configuration, instantaneous bandwidth (IBW), occupied bandwidth (OBW), 5G NR Carrier bandwidth, and whether the open fronthaul supports

Cat-A or Cat-B mode of operation as specified by the O-RAN Fronthaul specification (WG4 O-RAN.WG4.MP.0-v10.00).

- **Compliance:** Identify compliance with the mandatory 3GPP standards and O-RAN ALLIANCE technical specifications specified in Section 10, including any test results where possible. State which open fronthaul synchronization configuration(s) the contestant's entry supports and why those configurations were chosen (options LLS-C1, LLS-C2, LLS-C3, and LLS-C4).
- **Security Plan:** Describe the security plan, including implementation of 3GPP and O-RAN ALLIANCE security procedures, known critical software vulnerabilities, and mitigation plan.
- **Wrap-around Emulation Testing:** Indicate preferred 5G test systems (Viavi or Keysight). Applicants are required to disclose any prior experience interoperating with vendors of the host lab emulation test systems (Viavi and Keysight). Identify previously used test and measurement vendor(s) and summarize the testing results. This information will not be used to score the application.
- **Prior E2E Integration Testing Partners:** Identify vendors that the applicant has interoperated with previously and the type of E2E integration testing (e.g., Plugfest, 5G Challenge Preliminary Event, or commercial launch). This information will not be used to score the application.
- **Delivery:** Identify whether the subsystem will be (a) cluster delivery and local host installation; (b) remote install onto host lab cluster; or (c) bare metal. Additionally, identify and describe your backup delivery plan, as required by Section 3.3.
- **Availability:** Potential delays and conflicts, including how much lead time the applicant's staff will need to support 2023 5G Challenge activities, when the applicant can deliver the hardware/software package, how long the applicant can leave the hardware/software package at the host lab, any preferences or constraints for scheduling of time in the host lab, and conflicting events that will prevent participation (e.g., holidays or specific events).
- **Organizational Support for the 2023 5G Challenge:** Summarize the plan for providing the level of support required by these 2023 5G Challenge rules including job title(s) of staff who will be physically on-site at the host lab during testing; commitment to the host lab's time zone and regular working hours for remote personnel; and affirmation of maximum response time. See Section 4.1 for details.

**Proof of Eligibility:** A statement of eligibility that satisfies the requirements in Section 5.1.2.

This information must be sent separately from the white paper and will not be counted towards the white paper page limit. Contestants must send Proof of Eligibility via a secure email; a secure email link will be provided by NTIA/ITS. Upon receipt of a contestant white paper, NTIA/ITS will send the contestant a link to a secure file collaboration site where the contestant must submit their Proof of Eligibility for evaluation by the 2023 5G Challenge organizers.

**Submission:** White papers shall be no more than 10 pages in length, with standard 1-inch margins and font 10 points or larger. White papers shall be submitted in .docx or .pdf format.

White papers must be submitted via email to [5gchallenge@ntia.gov](mailto:5gchallenge@ntia.gov) by the deadline of 7:00 p.m. Eastern Time on March 1, 2023.

NTIA/ITS will acknowledge receipt of white papers via e-mail. White papers received after the deadline specified herein will be retained for possible consideration as a future walk-on selection, in accordance with Section 4.2. Incomplete applications will not be accepted. Applications may be withdrawn at any time by sending an email to [5gchallenge@ntia.gov](mailto:5gchallenge@ntia.gov).

White papers will not be published externally. The contestant names and subsystems of accepted contestants may be published, as described in Section 8. The names and subsystems of white papers not accepted into the contest will not be published externally.

The other white paper information collected by NTIA/ITS shall be treated as confidential, used for the sole purpose of administering the 2023 5G Challenge, and to the extent permitted by Federal law, will not be distributed to parties outside of the 2023 5G Challenge or released for any other purpose except as noted in this document.

White papers scores (see Section 6.1) will be used to resolve ties, when awarding prizes.

## 5.2 Software Bill of Materials (SBOM) and Vulnerability Exploitability eXchange (VEX)

Applicants are required to submit an SBOM within ten (10) business days of acceptance into the 2023 5G Challenge. If there are known vulnerabilities, the applicant must also submit a VEX record for all vulnerabilities associated with the software components and asserting whether their product is impacted. An SBOM is a nested inventory for software—a list of ingredients that make up software components. Vulnerability Exploitability eXchange (VEX) is a machine-readable companion to an SBOM which communicates the status of vulnerabilities in software components itemized in an SBOM.

Contestants submitting multiple subsystems must submit a unique SBOM for each subsystem. If a contestant's system changes substantially during testing, then a new SBOM (and VEX if there are known vulnerabilities) must be delivered at the end of testing.

General information on SBOM and VEX generation can be found at the following web pages:

- “Software Bill of Materials” by NTIA: <https://ntia.gov/page/software-bill-materials>
- “How-To Guide for SBOM Generation” by NTIA: [https://ntia.gov/sites/default/files/publications/howto\\_guide\\_for\\_sbom\\_generation\\_v1\\_0.pdf](https://ntia.gov/sites/default/files/publications/howto_guide_for_sbom_generation_v1_0.pdf)
- “Survey of existing SBOM formats and standards” by NTIA: [https://ntia.gov/sites/default/files/publications/sbom\\_formats\\_survey-version-2021\\_0.pdf](https://ntia.gov/sites/default/files/publications/sbom_formats_survey-version-2021_0.pdf)
- “Vulnerability-Exploitability eXchange (VEX) – An Overview” by NTIA: [https://www.ntia.gov/files/ntia/publications/vex\\_one-page\\_summary.pdf](https://www.ntia.gov/files/ntia/publications/vex_one-page_summary.pdf)
- “Vulnerability Exploitability eXchange (VEX) – Use Cases” by the Cybersecurity and Infrastructure Security Agency (CISA): [https://www.cisa.gov/sites/default/files/publications/VEX\\_Use\\_Cases\\_April2022.pdf](https://www.cisa.gov/sites/default/files/publications/VEX_Use_Cases_April2022.pdf)
- Blog “A deeper dive into VEX documents” by Derek Kraszewski, Adolus: <https://blog.adolus.com/a-deeper-dive-into-vex-documents>

### 5.3 Stage Two: Wrap-around Emulation Testing

Selected subsystems will be submitted directly to the host lab for wrap-around emulation testing following notification by the host lab.

During Stage Two, the subsystem will be tested in an emulated environment based on test equipment. Figure 3 shows the lab testing configuration for RU testing in Stage Two. Figure 4 shows the lab testing configuration for CU+DU testing in Stage Two. Stage Two testing includes processes that may qualify the contestant's RU or CU+DU for O-RAN ALLIANCE certification or badging from Kyrio, under its OTIC lab authority.

Each Stage Two contestant is eligible for a Wrap-around Emulation Testing Prize. See Section 7 for details.

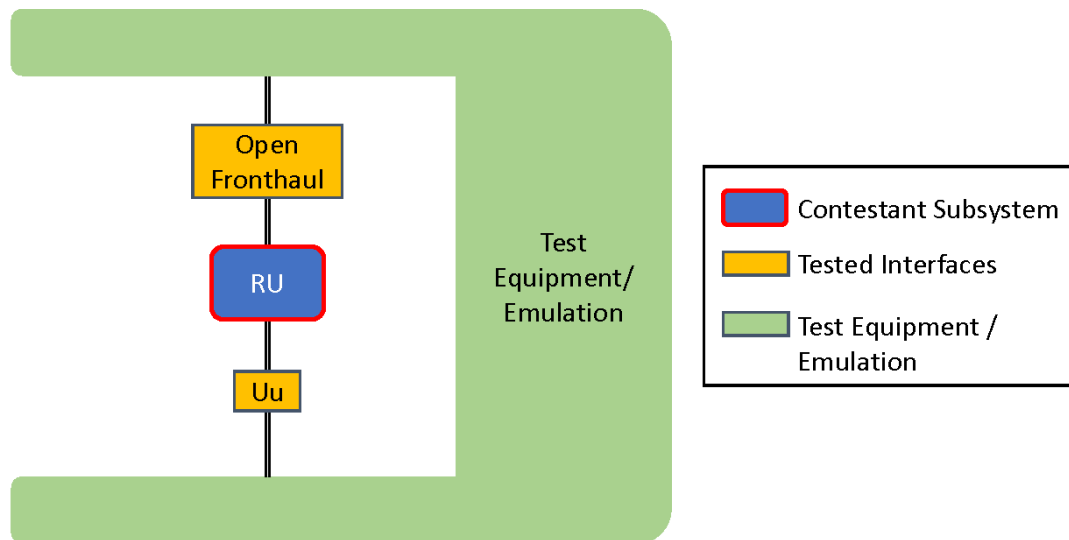


Figure 3. Stage Two uses a wrap-around emulator to test contestant's RU on the open fronthaul and Uu interfaces.

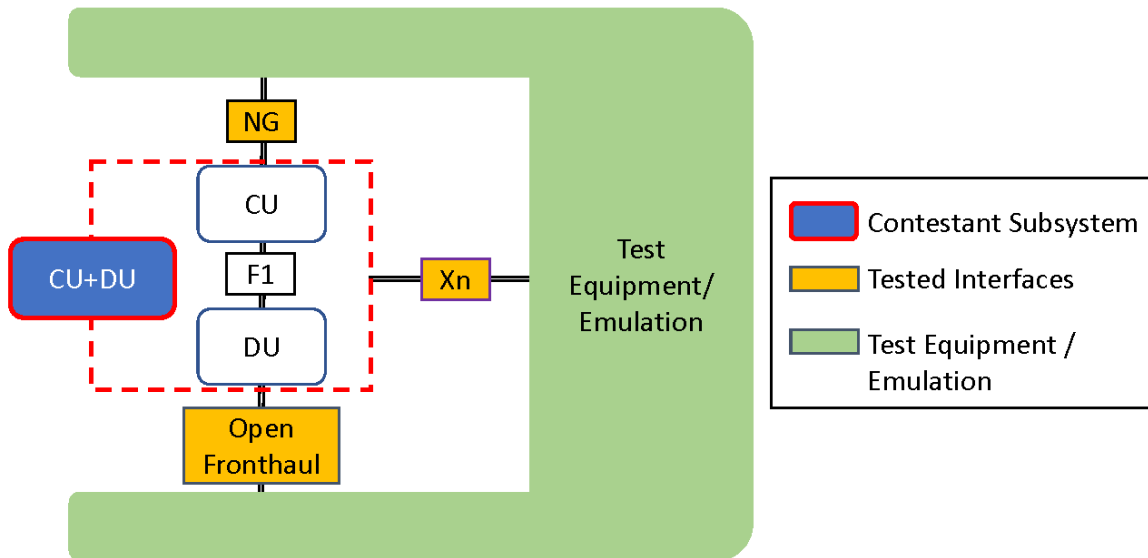


Figure 4. Stage Two uses a wrap-around emulator to test contestant’s CU+DU on the NG, open fronthaul, and Xn interfaces.

### 5.3.1 Subsystem Submission and Delivery

Contestants will submit their 5G subsystems directly to the host lab. The host lab will contact contestants with coordination details. See also Section 3.3.

### 5.3.2 Wrap-around Emulation Testing Schedule

Stage Two provides for contestant subsystems to be installed and integrated with the host lab’s 5G emulated system. Contestant on-site staff will work with the host lab during this testing phase (subject to COVID-19 health and safety protocols).

The initial lab time assignment schedule for each contestant will be released after the initial pool of Stage Two contestants is announced. The lab time schedule will be updated regularly. “Lab time” refers to regular business hours and days, excluding Federal holidays. Host lab engineers will be available for consultation during contestant lab time, as time allows, and shared with other contestants also in the lab. Business day means eight (8) hours of lab time.

By default, in Stage Two, each subsystem undergoing wrap-around emulation testing will be allotted three (3) weeks for testing. NTIA/ITS reserves the right, at its sole discretion, to increase or decrease the amount of time provided for a specific type of wrap-around emulation testing (i.e., CU+DU or RU), based on the observations made during the implementation of the 2023 5G Challenge. Any increase in wrap-around emulation testing time will be offered on an equal basis to all contestants.

NTIA/ITS may, at its sole discretion, terminate a wrap-around emulation testing effort early if the contestant does not provide the level of support specified in Section 4.1 or if the contestant subsystems are not delivered and installed in a timely manner.

### 5.3.3 Wrap-around Emulation Testing

During this testing stage, contestant subsystems will be tested in one emulated environment (Keysight or Viavi). Contestants are permitted and encouraged to modify their code for functionality and performance during this wrap-around emulation testing period but are reminded that code modifications must be made within the allotted wrap-around emulation testing period and may initiate the requirement to restart such testing from the beginning of the test procedure.

To pass Stage Two testing, contestants must pass all mandatory tests within the test procedure.

## 5.4 Stage Three: E2E Integration Testing

Stage Three consists of E2E integration testing and performance evaluations conducted by the host lab in accordance with the test procedures and associated documents provided to the contestants.

### 5.4.1 Types of E2E Integrations

Stage Three will demonstrate CU+DU and RU interoperability in various combinations of contestants. NTIA/ITS will schedule three types of E2E Integration pairs:

- **Type A:** One contestant's subsystems with a *single-contestant* pairing (CU+DU<sub>1</sub> and RU<sub>1</sub>)
- **Type B:** Two contestants' subsystems with their *designated* pairing (CU+DU<sub>1</sub> and RU<sub>2</sub>)
- **Type C:** Two contestants' subsystems with an NTIA/ITS *cold* pairing (CU+DU<sub>2</sub> and RU<sub>3</sub>)

Only Type C pairings will qualify for Multi-vendor E2E Integration Testing Prizes (see Section 7.1). Type A and Type B pairings will only be considered for mobility testing. Figure 5 shows the lab testing configuration for Type A, B, and C pairings in Stage Three, with hypothetical contestants 1, 2, and 3.

During each E2E integration testing pair, contestants will integrate their CU+DU and RU subsystems together and into the host lab's actual core and UE emulator. Type B and C pairings require collaboration between contestants.

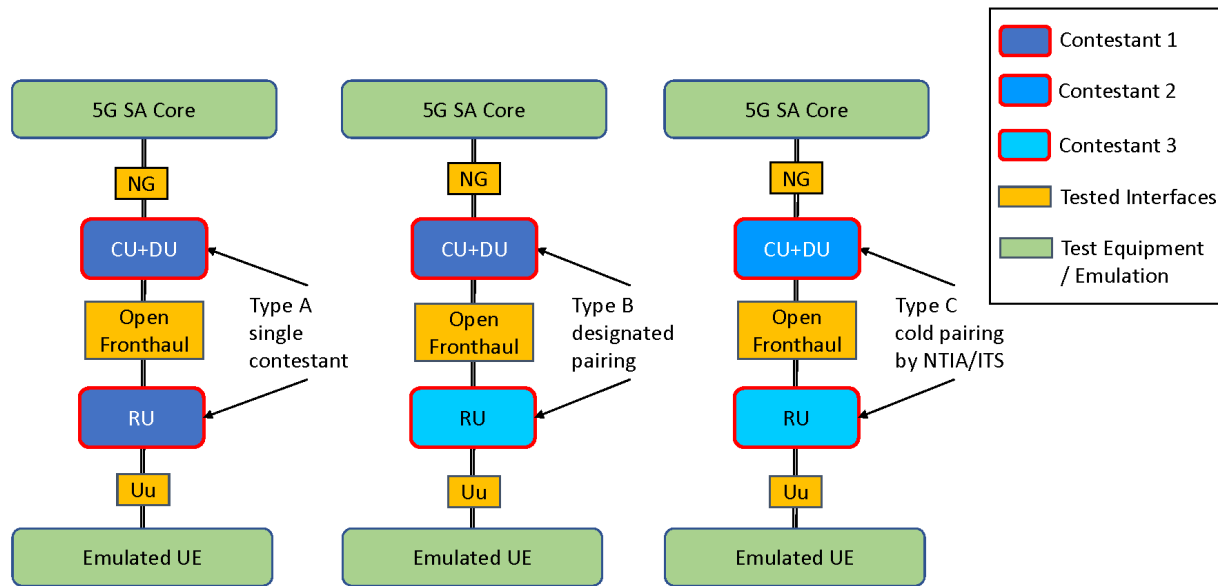


Figure 5. In Type A pairings (left), a single contestant provides both the RU and the combined CU+DU. In Type B pairings (middle), two contestants identify each other as partners for mobility testing in their white paper. In Type C pairings (right), NTIA/ITS chooses cold pairings of two contestants by consulting the technical specifications provided in the white paper. Only Type C pairings qualify for Stage Three prizes. Stage Three testing includes processes that may qualify the CU+DU and RU pairing for O-RAN ALLIANCE certification or badging from Kyrio, under its OTIC lab authority.

#### 5.4.2 E2E Integration Testing Schedule and Gating

During Stage Three testing, contestants will be challenged to integrate with fellow contestants' subsystems. Some contestants may be provided with multiple opportunities to integrate different contestant subsystems.

By default, each combination of Stage Three contestants will be given three (3) weeks for single-vendor integration (Type A), four (4) weeks for integration with a designated partner (Type B), and six (6) weeks for cold integration (Type C). NTIA/ITS reserves the right, at its sole discretion, to increase or decrease the amount of time provided for each type of E2E integration, based on the observed integration efforts.

At the end of each week, the host lab will assess progress toward integration. The host lab will assess progress toward integration against pre-determined benchmarks. NTIA/ITS may, at its sole discretion, terminate an E2E integration testing effort early if one or more of the contestants do not provide the level of support specified in Section 4.1.

#### 5.4.3 E2E Integration Testing

Stage Three testing includes performance evaluations for the combination of contestant subsystems integrated with host lab emulated UE, host lab 5G core, and testing environment (as will be defined in the testing procedure provided to each contestant). The subsystem



combinations and testing schedules will be announced and regularly updated by the host lab. Such updates may include acceleration of the commencement of testing. Contestant on-site staff will work with the host lab during this testing phase (subject to COVID-19 health and safety protocols).

Contestants are permitted and encouraged to modify their code for functionality and performance during this E2E integration testing period. Contestants are reminded that code modifications must be made within the test period and may initiate the requirement to restart such testing from the beginning of the Stage Three testing procedure or even from the beginning of the Stage Two testing procedure.

Should the number of subsystems that successfully complete Stage Two testing be limited, the 2023 5G Challenge reserves the right to include additional and more detailed testing in Stage Three. Should this case arise, the 2023 5G Challenge, the host lab, and the contestant will confer on the scope and type of additional testing but the decision on such testing is solely the responsibility of the 2023 5G Challenge.

To pass Stage Three testing, contestants must pass all mandatory tests within the Host Lab Test Plans. The mandatory tests may be a subset of the total tests identified for Stage Three testing.

#### 5.5 Stage Four: Mobility Testing

During Stage Four testing, two E2E integrated systems from Stage Three will be integrated together to demonstrate mobility with the same host lab emulated UE, host lab 5G core, and testing environment. Figure 6 shows the mobility testing lab configuration with an example of a Type A system integrating with the Type C system.

The subsystem combinations and testing schedules will be announced and regularly updated by the host lab. Such updates may include acceleration of the commencement of testing. Contestant on-site staff will work with the host lab during this testing phase (subject to COVID-19 health and safety protocols).

All types of Stage Three pairings will qualify for participation (Types A, B, and C). Therefore, Stage Four may include two contestants, three contestants, or four contestants. Each pair must successfully pass Stage Three: E2E integration testing with this specific (CU+DU and RU) configuration before proceeding to Stage Four.

Contestants are permitted and encouraged to modify their code for functionality and performance during this mobility testing period. Contestants are reminded that code modifications must be made within the test period and may initiate the requirement to repeat previous tests.

At the end of each week, the host lab will assess progress toward integration. The host lab will assess progress toward integration against pre-determined benchmarks. NTIA/ITS may, at its

sole discretion, terminate a mobility testing effort early if one or more of the contestants do not provide the level of support specified in Section 4.1.

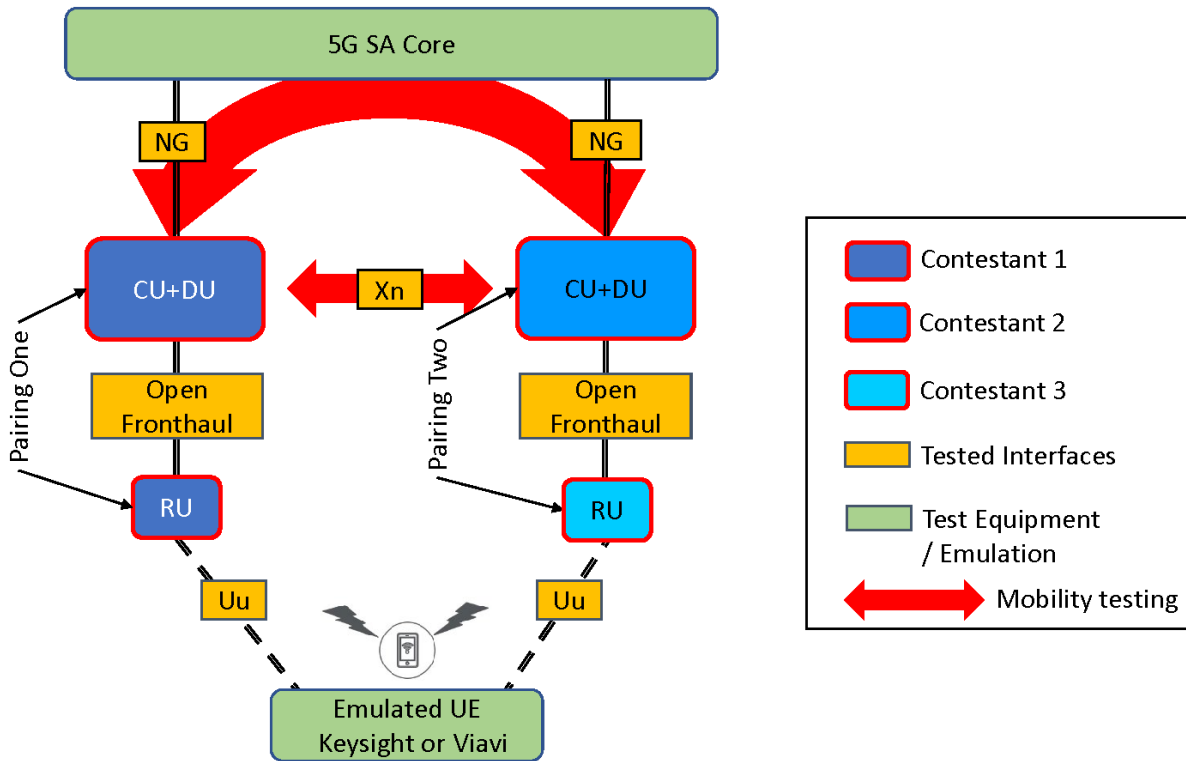


Figure 6. Mobility testing between Pairing One and Pairing Two. In this example, Pairing One (left) is Type A and Pairing Two (right) is Type C.

## 5.6 Lab Testing Schedule

Each contestant will be assigned to one 5G test systems (Viavi or Keysight). Contestants will not have the option to request a change of 5G test system.

### 5.6.1 Schedule for Mobility Testing

When contestants are accepted into the 2023 5G Challenge, they will be informed whether they have been scheduled for mobility testing. This information will include the identity of their partners, the configuration for each individual E2E integration, and the configuration for mobility testing. Each E2E integration testing pair could be Type A, Type B, or Type C.

Table 3 shows the expected schedule for one “swim lane” of mobility testing, presented chronologically. This swim lane will require the dedicated use of a 5G test system (Viavi or Keysight) and a UE emulator (i.e., for the CU+DU wrap-around emulation testing, E2E integration testing, and mobility testing). The group of contestants will share that swim lane to accomplish their tasks, culminating in mobility testing in Stage Four. When one task finishes, the group of contestants is expected to immediately begin the next task. The expected duration

of Stage Three will depend on the type of E2E pairing: three (3) weeks for Type A, four (4) weeks for Type B, and six (6) weeks for Type C.

If contestants *fail* to pass the test criteria for a particular task after the number of weeks shown in Table 3, the 5G Challenge organizers will have the option to provide more time for the task. However, this can only occur if the lab is available in that particular swim lane (i.e., for the 5G test system and UE emulator).

Note that Table 3 shows seven tasks, any one of which could fail. If time permits, the 5G Challenge organizers may choose to alter the mobility test partner configuration and resume testing with the altered configuration. This could involve accepting a new contestant from the waiting list. If time and alternate resources do not permit, the remaining tasks will be canceled—except for Stage Three type C pairings (if any), which will be performed as scheduled to enable their consideration for multi-vendor E2E Integration testing prizes.

Table 3. One mobility testing swim lane (Viavi or Keysight), with tasks conducted serially.

| Stage        | Task  | Estimated Duration    |
|--------------|---|-----------------------|
| Two          | Wrap-around emulation testing of CU+DU <sub>1</sub><br>Wrap-around emulation testing of RU <sub>2</sub>             | 3 weeks (in parallel) |
| Two          | Wrap-around emulation testing of CU+DU <sub>3</sub><br>Wrap-around emulation testing of RU <sub>4</sub>             | 3 weeks (in parallel) |
| Three        | E2E integration testing of (CU+DU <sub>1</sub> and RU <sub>2</sub> )  | 3 to 6 weeks          |
| Three        | E2E integration testing of (CU+DU <sub>3</sub> and RU <sub>4</sub> )  | 3 to 6 weeks          |
| Four         | Mobility testing between (CU+DU <sub>1</sub> and RU <sub>2</sub> )<br>and (CU+DU <sub>3</sub> and RU <sub>4</sub> ) | 6 weeks               |
| <b>Total</b> |   | <b>18 to 24 weeks</b> |

### 5.6.2 Schedule for Multi-vendor E2E Integration Testing

When contestants are accepted into the 2023 5G Challenge, they will be informed whether they have been scheduled for multi-vendor E2E integration testing. Each multi-vendor E2E integration pair must be Type C.

Table 4 shows the expected schedule for one swim lane of multi-vendor E2E integration testing, presented chronologically. This swim lane will require the dedicated use of a 5G test system (Viavi or Keysight) and a UE emulator (i.e., for the CU+DU wrap-around emulation testing and E2E integration testing). The pair of contestants will share that swim lane to accomplish their tasks, culminating in E2E integration testing in Stage Three. Upon successfully completing Stage Two, the pair of contestants is expected to immediately begin Stage Three.

If contestants *fail* to pass the test criteria for a particular task after the number of weeks shown in Table 4, the 5G Challenge organizers will have the option to provide more time to the task.

However, this can only occur if unscheduled lab is available in that particular swim lane (i.e., for the 5G test system and UE emulator).

The 5G Challenge organizers may choose schedule additional multi-vendor E2E integration testing pairs at any point during the lab testing, using either existing contestants or new contestants.

Table 4. One multi-vendor E2E integration testing swim lane (Viavi or Keysight), with tasks conducted serially.

| Stage        | Task  | Estimated Duration    |
|--------------|---|-----------------------|
| Two          | Wrap-around emulation testing of CU+DU <sub>1</sub><br>Wrap-around emulation testing of RU <sub>2</sub> | 3 weeks (in parallel) |
| Three        | E2E integration testing of (CU+DU <sub>1</sub> and RU <sub>2</sub> )<br>Must be Type C                  | 6 weeks               |
| <b>Total</b> |   | <b>9 weeks</b>        |

## 5.7 Results

Contestants are responsible for the following deliverables after the successful completion of their E2E Integration or Mobility testing.

### 5.7.1 Contestant Debriefs

It is important to continuously improve the value and efficiency of the 5G Challenge. Each competitor must participate in a one-on-one NTIA/ITS debrief (typically, a half-hour call) following the conclusion of the event. During this debrief, NTIA/ITS and the contestant will discuss—from the competitor’s point-of-view—what worked, what did not work, and what could be done differently going forward to develop improved future challenges. These topics will also be discussed during the closing ceremony questionnaire breakout sessions.

### 5.7.2 Updated SBOM and VEX

If a contestant’s subsystem was changed significantly during testing, the contestant shall deliver an updated SBOM at the end of E2E Integration Testing. If there are changes to the known vulnerabilities, the contestant shall also deliver an updated VEX at the end of E2E Integration Testing.

## 6 Evaluation Criteria and Acceptance

### 6.1 White Paper Application Scoring and Contestant Acceptance

Contestant white papers will be evaluated as they are received (i.e., the 2023 5G Challenge organizers will not wait for the submission deadline). Applications will be scored using three steps.

**Step 1:** A panel of evaluators will judge the white paper application using a 5-level Likert scale, where 5=excellent, 4=good, 3=fair, 2=poor, and 1=bad. The overall application rating will be computed as the average across all evaluators and all categories.

**Step 2:** If an application receives a rating of 2=poor or 1=bad in any category, the judging panel will examine the application and decide whether to reject or accept the application. All other applications will be determined representative of qualified applicants.

**Selection Criteria:** The following criteria will be used to choose contestants from the qualified applicants:

- Accepting contestants with the highest application score
- Maximizing the number of unique contestants (e.g., one subsystem from two separate organizations is preferable to two subsystems from the same organization)
- Enabling mobility testing
- Enabling the maximum variety of multi-vendor interoperability tests
- Maximizing the effective use of host lab resources
- Prioritizing configurations that dominate the U.S. market (e.g., TDD and Cat-A will have higher priority than FDD and Cat-B)

**Selection Process:** The judging panel will examine the pool of qualified applicants and use the selection criteria listed above to select contestants. The accepted contestants will be announced publicly on the date noted in Table 2.

All remaining qualified applicants, if any, will be placed in a waiting list and informed of their position in the list (e.g., first RU application in the waiting list). If time opens up in the lab schedule, the judging panel may later select new contestants from the list.

## 6.2 SBOM and VEX

Each contestant's SBOM and VEX will be evaluated individually based on field intelligibility, completeness, and how well the documents address security concerns. Evaluators will assign a rating for the SBOM and VEX using the 5-level Likert scale, where 5=excellent, 4=good, 3=fair, 2=poor, and 1=bad. If there are no known vulnerabilities, the VEX is not required and will receive a rating of 4=good. VEX will be evaluated based on the description of vulnerabilities, not the presence or absence of vulnerabilities. To be considered compliant, an SBOM and VEX must receive an overall rating of 4.0 or above. An overall rating will be computed as an average of SBOM ratings and VEX ratings for all judges.

If a contestant's Stage One SBOM or VEX submission is not compliant, NTIA/ITS will provide the contestant feedback. The contestant will have three (3) weeks to submit an updated SBOM or VEX that receives an overall rating of 4.0 or better.

To qualify for a prize, the contestant's final SBOM and VEX must receive an overall rating of 4.0. The final version of each contestant's SBOM and VEX are due by the end of E2E integration testing (see Table 2).

### 6.3 Scoring Wrap-around Emulation Testing and Proceeding to E2E Integration Testing

The Host Lab Test Plans contains the wrap-around emulation testing criteria for each subsystem. An overview of the Host Lab Test Plans will be released prior to the white paper submission deadline, and the detailed documents will be released before Stage Two begins (see Table 2). If the host lab discovers a problem with these test plans after lab testing begins, the 5G Challenge organizers will review the host lab's proposed changes to ensure that the changes are necessary, fair, and equitable.

The wrap-around emulation testing only includes mandatory tests. To receive a passing score, the subsystem must meet or exceed the minimum threshold for all mandatory criteria in that document.

Each contestant subsystem must successfully complete Stage Two wrap-around emulation testing to qualify for a Wrap-around Emulation Testing Prize and proceed to Stage Three E2E integration testing.

### 6.4 Scoring E2E Integration Testing and Proceeding to Mobility Testing

The host lab will provide contestants with the interoperability test criteria for each subsystem.

The testing is divided into mandatory and optional tests. To successfully complete integration, the E2E system must pass all mandatory tests.

The E2E integration testing score will be the number of tests passed, both mandatory and optional. A unique E2E integration testing score will be calculated for each attempted integration.

Each contestant subsystem must successfully complete Stage Three E2E integration testing to qualify for a Multi-vendor E2E Integration Prize and proceed to Stage Four testing.

### 6.5 Scoring Mobility Testing

The host lab will provide contestants with the mobility test criteria for each subsystem.

The testing is divided into mandatory and optional tests. To successfully complete mobility testing, the system must pass all mandatory tests.

The mobility test score will be the number of tests passed, both mandatory and optional. A unique mobility score will be calculated for the overall group (i.e., all contestants involved in a successful integration).

## 7 Prizes

### 7.1 Prizes

**Wrap-around Emulation Testing Prizes:** NTIA/ITS will award prizes of \$100,000 each to up to ten (10) contestants who meet the minimum threshold during Stage Two. This threshold is defined further in Section 6.3.

Contestants that submit multiple subsystems will qualify for multiple Wrap-around Emulation Testing Prizes if any of their subsystems meet the minimum performance threshold during Stage Two.

If more than ten contestant subsystems pass the minimum performance threshold for Stage Two, prizes will be awarded to the first ten subsystems that pass the minimum performance threshold.

**Best Mobility Testing Prizes:** For Stage Four, NTIA/ITS will award the top-performing mobility testing prize (i.e., the highest mobility test score). A \$3,000,000 purse will be divided equally among the contestants involved. There could be two, three, or four contestants in the mobility testing group (e.g., a single contestant could provide both a CU+DU and an RU).

**Multi-vendor End-to-End (E2E) Integration Testing Prizes:** NTIA/ITS will award first and second E2E Integration Testing prizes from a \$2,000,000 purse to the top performers in E2E Integration Testing. Only Type C integrations will be considered. The 1<sup>st</sup> and 2<sup>nd</sup> prizes will be awarded to the multi-vendor E2E integration testing pairs that receive the highest and second highest E2E integration testing scores. These prizes will be awarded identically to each contestant involved (CU+DU and RU).

The Best Multi-vendor Integration Testing Prizes are as follows:

- 1<sup>st</sup> Prize: \$750,000 and Lab Time Prize
- 2<sup>nd</sup> Prize: \$250,000

**Lab Time Prize:** Each winner of this in-kind prize will receive three (3) weeks of host lab testing, with a similar level of support from the 2023 5G Challenge host lab as during the contest.

**Best in Show Prizes:** NTIA/ITS will award up to two (2) Best in SBOM and one Best Collaborator Prize:

- **Best SBOM:** Awarded to the two (2) contestants with the highest rated SBOM and VEX (see Section 6.2). Only contestants who pass Stage Two Wrap-around Emulation Testing will be considered for the best SBOM prize. Each Best SBOM Prize consists of \$100,000 and two (2) weeks of security testing.
- **Best Collaborator:** Awarded to the contestant that receives highest collaboration score. This score will be computed as the sum of (a) the host lab's assessment of the contestant's overall responsiveness during testing; and (b) contestant peer rating (e.g., willingness to collaborate,

expertise, responsiveness, and leadership), averaged across all integration partners. The best collaborator prize is not influenced by success or failure of E2E Integration testing. Only contestants who pass Stage Three E2E Integration testing will be considered. The Best Collaborator Prize will consist of \$20,000 and two (2) weeks of security testing.

**Security Testing Prize:** Each winner of this in-kind prize will receive two (2) weeks of security testing from the host lab.

**Ties:** Ties will be broken using white paper scores. The 2023 5G Challenge is incentivizing vendor subsystems that are built to interoperate with each other. Therefore, the white paper scoring is designed to emphasize this characteristic.

**Alternate Prize Structure:** If mobility testing cannot be conducted due to a lack of viable pairings or if all groups fail mobility testing, NTIA/ITS will award three (3) E2E Integration Testing prizes (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>) from a \$5,000,000 prize purse to the top performer in each subsystem (CU+DU and RU).

The alternate prize structure for Best Multi-vendor E2E Integration Testing Prizes is as follows:

- 1st Prize: \$1,250,000 and Lab Time Prize
- 2nd Prize: \$750,000
- 3rd Prize: \$500,000

If any of the above prizes are not awarded due to a lack of qualified contestants in any of the categories, NTIA/ITS reserves the right to redistribute those prize funds at its discretion.

## 7.2 Dependence on Updated SBOM and Updated VEX

As required by Section 5.7.2, contestants must submit updated SBOMs (and VEX if required) if these have changed since the original submission, to qualify for prizes.

## 7.3 Payment Mechanics

Prizes awarded under the 2023 5G Challenge will be paid by electronic funds transfer to the bank account specified by the contestant Leader of the contestants determined by NTIA/ITS to be the winners of each prize event. If the winner is a team, it is the responsibility of the contestant team Leader, not NTIA/ITS, to determine the subsequent division of any prize money.

All prizes awarded are subject to tax liabilities. NTIA/ITS will comply with the Internal Revenue Service withholding and reporting requirements, where applicable. NTIA/ITS will not provide tax advice to challenge winners. Winners are encouraged to seek independent advice to ensure that the prize money is handled properly and reported accurately for tax purposes.



## 8 Publication Policy

### 8.1 Information Published Externally

Information from 2023 5G Challenge testing and evaluations will be compiled by NTIA/ITS and the results presented to all contestants at a Closing Ceremony. This information may also be published or presented in other venues. The Closing Ceremony will be recorded, and the video openly distributed.

The identities of all Stage Two, Stage Three, and Stage Four prize winners and the names of their winning subsystems will be published externally. The identities of all subsystems that successfully complete Stage Two wrap-around emulation testing may be published externally, including the names of their subsystems. If a contestant withdraws or is disqualified or fails to complete Stage Two wrap-around emulation testing, their anonymized performance results (if any) may be included in publications—but not their identity. Publications that predate the contestant’s withdrawal, disqualification, or failure to pass Stage Two testing will not be modified.

To summarize, the following information may be published at the discretion of the 5G Challenge organizers.

- Contestant names, subsystems, testing tracks, integration partners, and E2E integration type
- Results of the wrap-around emulation testing, interoperability testing, and mobility testing
- Problems associated with the third-party components (e.g., operating systems, hardware, standards, test suites, or pandemic restrictions)
- Lessons learned about the evaluation process
- Lessons learned about interoperability failures, integration, and system configuration
- Observed advantages and disadvantages of development strategies (e.g., tailored hardware vs. commercial-off-the-shelf (COTS) hardware, whether the subsystem included virtualization and a container orchestration platform, or which interface options were selected)

The following information may only be published as anonymized summaries:

- Data on white paper evaluation and acceptance
- SBOM and VEX (e.g., known critical vulnerabilities)

Other information, if any, will only be published in anonymized form (i.e., without naming specific contestants). This includes all feedback received on the administration of the 2023 5G Challenge that could be used to inform future programs (e.g., contestant debriefs).

### 8.2 Information for Internal Use Only

Each contestant will be provided with details of their system’s evaluation. This report may include measurements that are not listed in the “Scoring Guide and Metrics” document (e.g., speed tests, integration effort).

To the extent permitted by Federal law, the following information will be held confidential. This information may be distributed internally by the U.S. Government and the host lab, including their contractors. This information will not be published externally but may be used for other purposes (e.g., to design a future 5G Challenge, for CableLabs internal research purposes, or to guide Federal research).

- Details of white paper applications that are not accepted
- SBOMs and VEX
- Security vulnerabilities and other secure information discovered or disclosed during lab testing
- Detailed results of contestants that withdraw, are disqualified, or fail to complete Stage Two wrap-around emulation testing

## 9 Legal

Nothing in these rules, including information on the 5G Challenge website or communications by NTIA/ITS, DoD, and the 5G Challenge organizers, may be interpreted as authorizing the incurrence of any costs, modifying the statement of work, or authorizing work outside the terms and conditions of any existing agreements or contracts with the U.S. Government.

### 9.1 Event Participation Agreement

Participation in the 2023 5G Challenge will be governed by the 2023 5G Challenge Participation Agreement. This Agreement will define the boundaries of the contest within the event as well as assign intellectual property (IP) rights to data transmitted during the event to NTIA/ITS. Acceptance of the Event Participation Agreement is mandatory for participation in this prize event.

Each individual (whether participating individually or in a group) and entity participating in this contest must comply with all terms and conditions of these rules, and participation in this contest constitutes each contestant's full and unconditional agreement to abide by these rules.

### 9.2 Communications

The official communication channel between 2023 5G Challenge organizers and participating contestants is via email: [5gchallenge@ntia.gov](mailto:5gchallenge@ntia.gov). Any questions, such as rules clarifications, questions about proprietary/sensitive matters, or the logistics of the 2023 5G Challenge events, should be formally submitted to NTIA/ITS via [5gchallenge@ntia.gov](mailto:5gchallenge@ntia.gov). Upon receiving any generally applicable questions, the 2023 5G Challenge organizers will disseminate an appropriate response to all contestants via a FAQ process, published on the 2023 5G Challenge website, <https://5gchallenge.ntia.gov>, to ensure that answers do not give any contestant an unfair advantage. In doing so, 2023 5G Challenge organizers may rephrase questions to anonymize the submitting contestant or make them more generally applicable to all contestants.

### 9.3 Publicity

All contestants that participate in the 2023 5G Challenge contest may be listed on the 2023 5G Challenge website, <https://5gchallenge.ntia.gov>, to enable the Challenge to be tracked by interested members of the public. Public information may include performance results from 2023 5G Challenge events and general information updates. The names and photographs of the 2023 5G Challenge contestants may be posted on the 2023 5G Challenge website; featured on the NTIA/ITS and OUSD (R&E) websites and social media, and in their newsletters or other outreach materials; and released to the media.

During the 2023 5G Challenge, equipment may be used to photograph, record video and sound, and film footage in connection with the production of documentary content by third-party producer(s). Your presence (physically or virtually) at the event is an acknowledgment that you have been informed that you may be photographed, video recorded, and filmed; and that you grant permission for your likeness and voice to be used without compensation, credit, or other consideration in any media now known or hereafter devised, in perpetuity, to include the advertising and publicity thereof. If you do not wish to be subject to the foregoing, please do not attend this event.

The appearance and reference to any person, name, place, film, artwork, or any other images that are used in connection with the 2023 5G Challenge does not constitute or imply endorsement by the U.S. Government, NTIA/ITS, or the Department of Defense.

### 9.4 Disqualification

NTIA/ITS reserves the right to disqualify a contestant whose actions are deemed to violate the spirit of the competition for any reason, including but not limited to, the violation of laws or regulations during participation in the 2023 5G Challenge. In addition, NTIA/ITS may disqualify any contestant who does not meet the eligibility requirements specified herein or fails to comply with the 2023 5G Challenge Participation Agreement.

Examples of disqualifying behavior include but are not limited to (a) using source code from restricted entity sources; (b) using malicious or security-compromised software/hardware; (c) not adhering to basic security expectations of any software or hardware integration process; and (d) sharing confidential host lab testing procedures.

### 9.5 Withdrawal

Contestants can withdraw from the competition by contacting NTIA/ITS in writing. The contestant will no longer be eligible for prizes. See also Section 8.

### 9.6 Intellectual Property

The U.S. Government (DoD and NTIA/ITS) claims no rights to software or hardware developed by 2023 5G Challenge contestants as a result of participation in the 2023 5G Challenge.

The host lab will maintain confidentiality of information disclosed by the contestants to the extent permitted by Federal law. The host lab will disclose test results to the contestants and to 2023 5G Challenge organizers as required by law. The host lab will make an effort to keep the contestants' systems confidential from other contestants through best practices such as limited access to namespaces on shared systems and limited networking functions. The contestants will be responsible for securing access to their own hardware, software, and systems.

### 9.7 Rule Modifications

This version of the rules is subject to change and may be superseded by later versions. NTIA/ITS has the authority to modify and interpret the rules at any time. NTIA/ITS will post any modifications to the rules on the 2023 5G Challenge website and via direct email communication with contestants. Interested parties are encouraged to monitor the 2023 5G Challenge website for the latest information, available at <https://5gchallenge.ntia.gov>.

### 9.8 Contest Subject to Applicable Law

This prize contest is authorized under the America COMPETES Act, 15 U.S.C. § 3719, which authorizes Federal agencies to award prizes competitively to stimulate innovation that has the potential to advance the mission of the respective agency. For more information, see <https://www.govinfo.gov/content/pkg/USCODE-2021-title15/html/USCODE-2021-title15-chap63-sec3719.htm>.

All contests are subject to all applicable Federal laws and regulations. Participation constitutes each contestant's full and unconditional agreement to these official rules and administrative decisions, which are final and binding in all matters related to the contest. Eligibility for a prize award is contingent upon fulfilling all requirements set forth herein. This notice is not an obligation of funds; the final award of prizes is contingent upon the availability of appropriations.

Participation is subject to all U.S. Federal, state, and local laws, and regulations. Contestants are responsible for checking applicable laws and regulations in their jurisdiction(s) before participating in the prize contest to ensure that their participation is legal. NTIA/ITS shall not, by virtue of conducting this prize contest, be responsible for compliance by contestants in the prize contest with Federal Law including licensing, export control, and nonproliferation laws, and related regulations. Individuals entering on behalf of or representing a company, institution, or other legal entity are responsible for confirming that their entry does not violate any policies of that company, institution, or legal entity.

### 9.9 Liability

By submitting their application and acceptance to the 2023 5G Challenge contest, all contestants agree to assume any and all risks and waive claims against the Federal Government and its related entities, except in the case of willful misconduct, for any injury, death, damage, or loss of property, revenue, or profits, whether direct, indirect, or consequential, arising from

participation in this prize contest, whether the injury, death, damage, or loss arises through negligence or otherwise.

**Insurance:** Contestants are not required to obtain liability insurance for this contest.

**Indemnification:** Contestants agree to indemnify the Federal Government and CableLabs against third-party claims for damages arising from or related to contest activities.

By registering and/or participating in the 2023 5G Challenge, each individual (whether competing singly or in a group) or entity agrees to indemnify the U.S. Government and CableLabs from any and all liability and costs arising from or related to the contestant's participation in the contest.

#### 9.10 Verification of Winners

Contestants must comply with all terms and conditions of the 2023 5G Challenge Rules.

Winning a prize is contingent upon fulfilling all requirements contained herein. Winners from the 2023 5G Challenge will be notified by email after the conclusion of the event. Each winner of monetary or non-monetary awards will be required to sign and return the Payment Information Form to claim their prize.

At the sole discretion of the NTIA/ITS, a potential winner will be deemed ineligible to win if (a) the entrant cannot be contacted within 90 days; (b) the entrant fails to sign and return the Payment Information Form within the required time period; (c) the prize or prize notification is returned as undeliverable; or (d) the submission or entrant is disqualified for any other reason. In the event of a disqualification of a winner, NTIA/ITS at its sole discretion, may award the applicable prize to an alternate winner, when applicable.

#### 9.11 Resolution of Disputes

NTIA/ITS reserves the right to disqualify an individual or contestant whose actions are deemed to violate the spirit of the competition for any reason, including, but not limited to, the violation of laws or regulations during participation in the 2023 5G Challenge. NTIA/ITS does not authorize or consent to contestants infringing on any U.S. patent or copyright while participating in the 2023 5G Challenge.

NTIA/ITS is the final decision authority for all matters concerning the 2023 5G Challenge.

NTIA/ITS reserves the right, at its sole discretion, to (a) cancel, suspend, or modify the contest without notice; and/or (b) not award any prizes if no entries are deemed worthy. Decisions by NTIA/ITS are final and binding in all matters related to the contest.

## 10 References

The following references define the interfaces and operations to be evaluated during the 2023 5G Challenge.

- [1] 3GPP TS 38.201 V15.0, NR; *Physical layer; General description*
- [2] 3GPP TS 38.413 V15.6, NG-RAN; *NG Application Protocol*
- [3] 3GPP TS 38.423 V15.6, NG-RAN; *Xn Application Protocol*
- [4] O-RAN.WG1.O-RAN-Architecture-Description-v07.00, *O-RAN Architecture Description*
- [5] O-RAN-WG4.CUS.0-v05.00, *Control, User and Synchronization Plane Specification*
- [6] O-RAN.WG4.MP.0-v05.00, *Management Plane Specification*
- [7] O-RAN.WG4.CONF.0-v05.00, *Conformance Test Specification*
- [8] O-RAN.WG4.IOT.0-v04.00, *Fronthaul Interoperability Test Specification (IOT)*
- [9] O-RAN.WG5.U.0-v05.00, *NR U-plane profile*
- [10] O-RAN.WG5.C.1-v08.00, *NR C-plane profile (NR Standalone)*
- [11] O-RAN.WG5.IOT.0-v05.00, *O-RAN Interoperability Test Specification*
- [12] O-RAN.TIFG.E2E-Test.0-v04.00, *O-RAN End-to-end Test Specification*