UNITED STATES PATENT APPLICATION

For

ARCHITECTED INTEGRATION PLATFORM

INVENTORS:
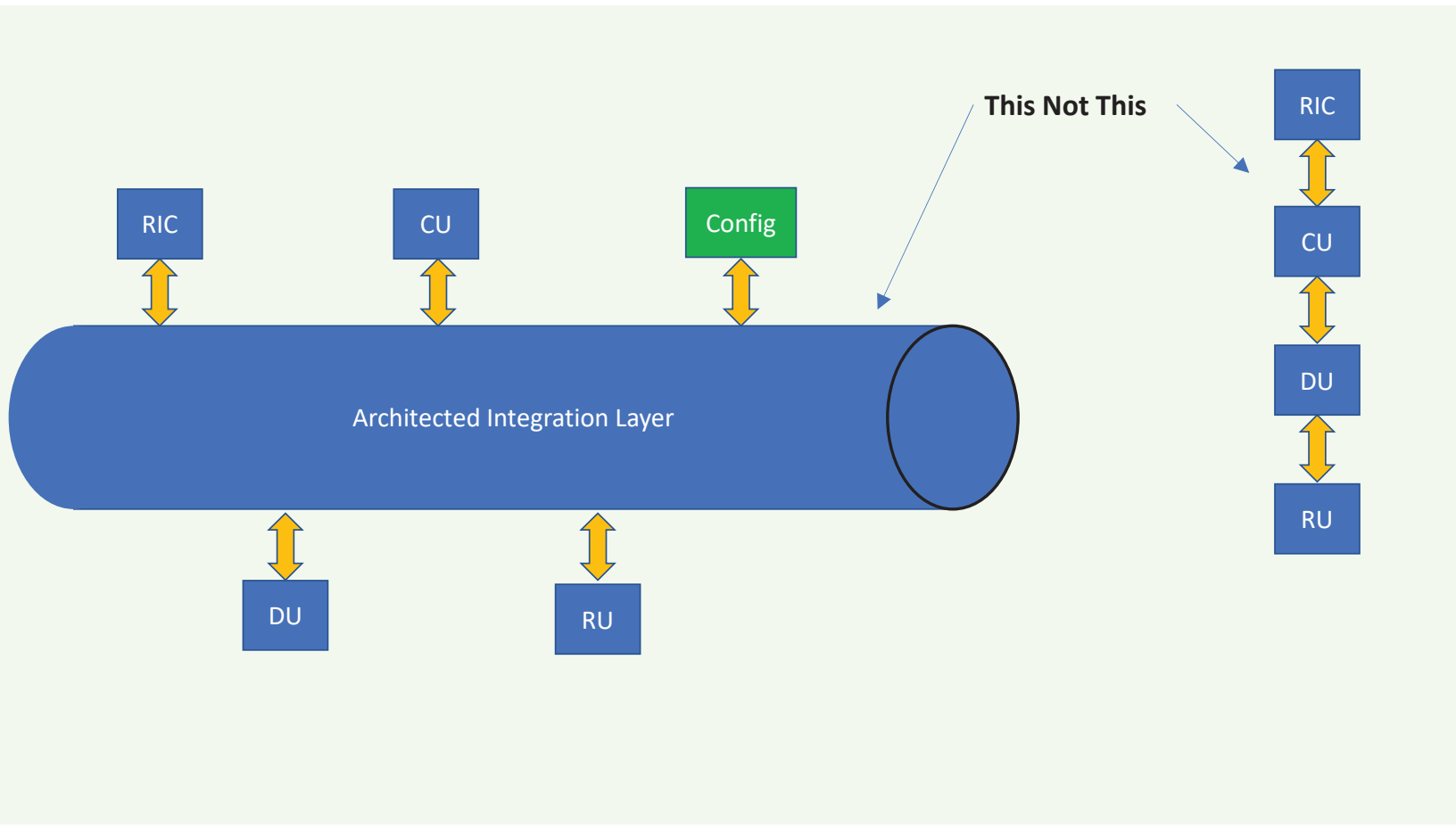
CHAD RILAND

MASSIMILIANO PALA

YUNJUNG YI

MICHAEL SCHWEIGERT

ANNIE GEORGE

RIC

CU

Config

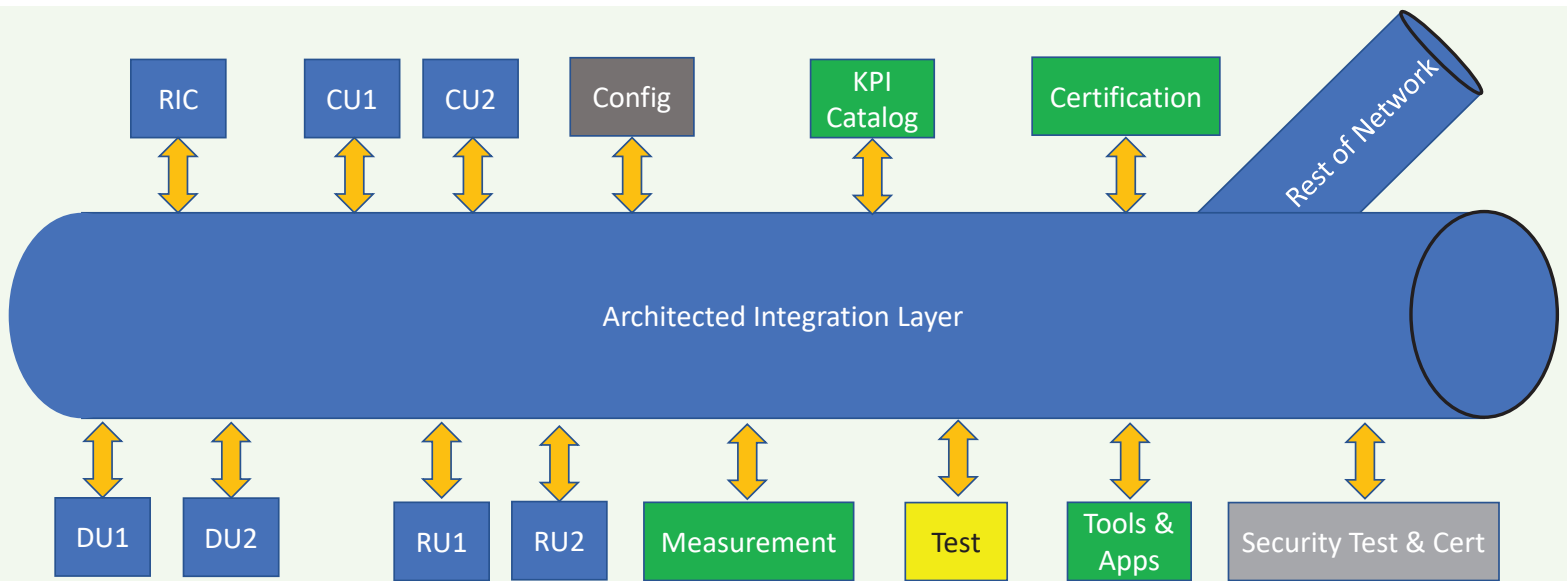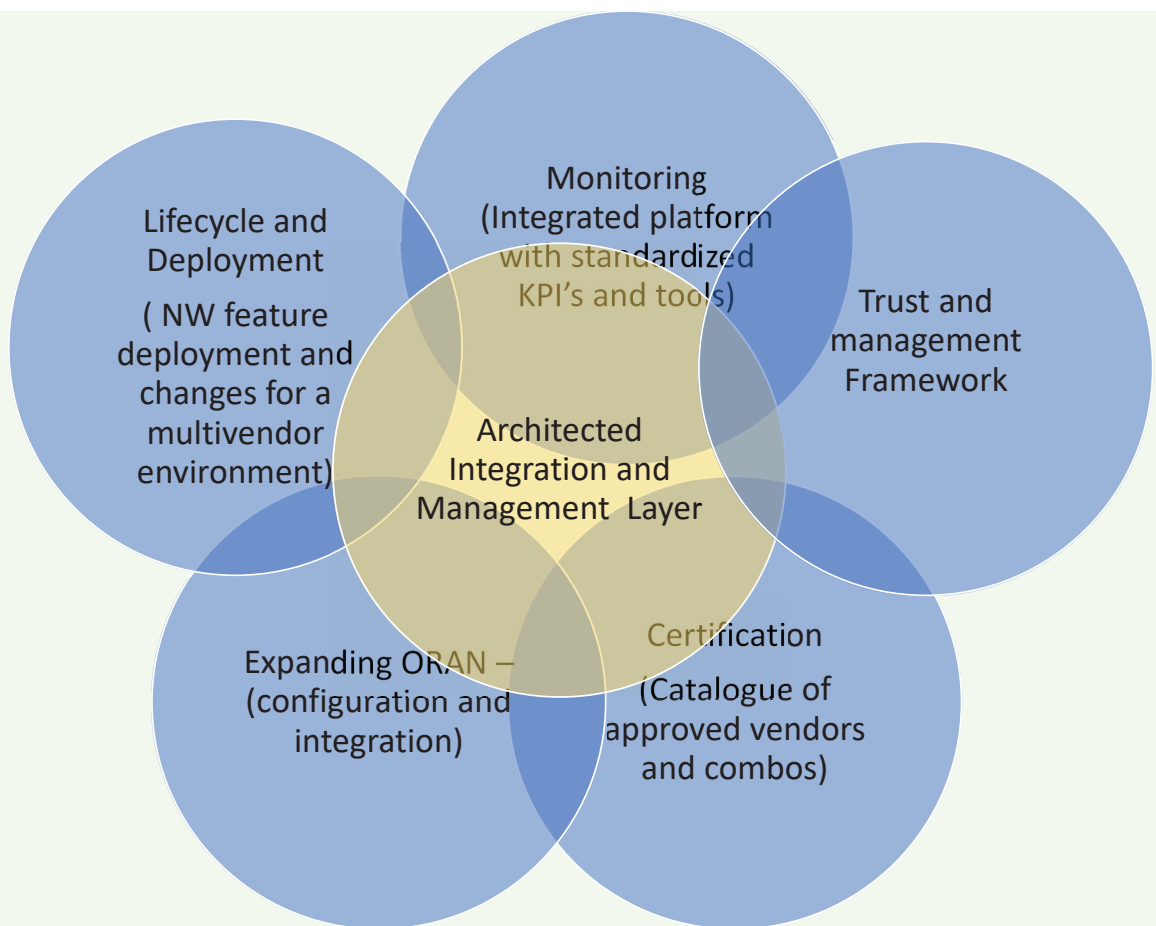Architected Integration Layer

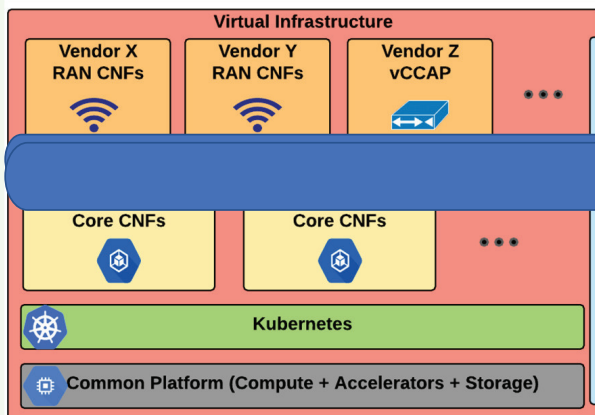DU

RU

This Not This

RIC

CU

DU

RU

RIC | CU1 | CU2 | Config | KPI Catalog | Certification | Rest of Network

Architected Integration Layer

DU1 | DU2 | RU1 | RU2 | Measurement | Test | Tools & Apps | Security Test & Cert
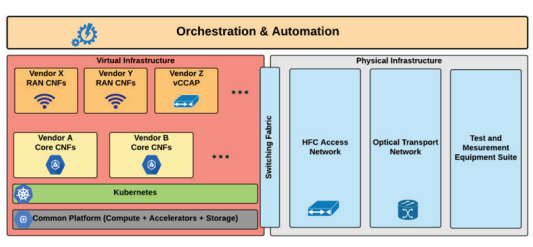
Complies to ORAN interface specs
Digital Twin capabilities
Configuration Memory
Life Cycle Management
Security Keys
Test and KPI extraction layer
KPI Monitoring and certification

Advantages
- Common Platform available for all CL/K customers
- Can be plugged into customers existing architecture
- Allows Plug and Play
- Multi component management over common architecture

Monitoring (Integrated platform with standardized KPI's and tools)

Lifecycle and Deployment

(NW feature deployment and changes for a multivendor environment)

Trust and management Framework

Architected Integration and Management Layer

Expanding ORAN – (configuration and integration)

Certification (Catalogue of approved vendors and combos)

Possibility Implementation
Evolution of our common Infrastructure

Orchestration & Automation

Virtual Infrastructure

| Vendor X RAN CNFs | Vendor Y RAN CNFs | Vendor Z vCCAP | ... |

| Vendor A Core CNFs | Vendor B Core CNFs | ... |

Kubernetes

Common Platform (Compute + Accelerators + Storage)

Physical Infrastructure

Switching Fabric

| HFC Access Network | Optical Transport Network | Test and Mesurement Equipment Suite |

Virtual Infrastructure

| Vendor X RAN CNFs | Vendor Y RAN CNFs | Vendor Z vCCAP | ... |

| Core CNFs | Core CNFs | ... |

Kubernetes

Common Platform (Compute + Accelerators + Storage)

CKAL

RAN Components

Tools and Apps: Test tools, digital twin, monitoring, KIP analytics etc

CableLabs' Technical Proposal: *Launch Ready* Open RAN Testing and Evaluation

I. Executive Summary

Through public and private funding CableLabs will be able to double the capacity available at our vendor and operator neutral lab for testing of mature Open RAN components and provide tailored testing and assistance to new entrants enabling faster adoption and deployment of Open RAN in the United States.

Building on more than two decades of experience in interoperability testing, certification, and testing of communications equipment, including experience as the Host Lab for the DoD and NTIA sponsored 5G Challenge in 2022 and 2023, CableLabs and its wholly owned subsidiary, Kyrio, will create a rigorous Open RAN testing certification process to provide vendors and network operators with certainty about the conformance of tested Open RAN components. Additionally, CableLabs will build a platform to share information with stakeholders to advance testing capabilities and the development and adoption of Open RAN.

Continuing our longstanding relationships with a diverse set of stakeholders will enable vendors to access multiple test plans and the expertise and assistance of an industry neutral lab to move a component to the market.

With support from NTIA, CableLabs will create a strong, long-lasting foundation for the Open RAN ecosystem. The proposal contains a viable plan for commercialization of testing services, certification, and information sharing that will ensure this necessary building block remains available and accessible. The proposal anticipates the need for flexibility to address the changing testing needs of the Open RAN ecosystem.

II. Technical Objectives

A. Introduction

The overall framework of the CableLabs *Launch Ready* proposal is designed to increase the availability, affordability, and accessibility of Open RAN testing and evaluation in the United States to accelerate its development, deployment, and adoption.

The CableLabs' *Launch Ready* Testing Events are designed to efficiently accommodate a large number of vendors, and to help progress quickly toward deployable solutions.

- **Capacity:** Each Test Event will allow up to four concurrent vendor solutions or the flexibility to host up to ten rotational vendor solutions in each of two dedicated test environments per Test Event for the first year of the period of performance, increasing to four test environments by the end of Year 1 to create additional capacity for Test Events and provide access to Technical Assistance and the Neutral Host and Development Environments.
- **Scope:** Test Events will focus on the interoperability, performance, and security of CU, DU, and RU components, paired components, and end-to-end system, in any combination. Additional testing of RIC and service management and orchestration (SMO) interfaces as part of the Test Events or Neutral Host Environment will be available as market demand arises. The Technical Assistance and the Development Environments will focus on aiding vendors' development and to advance test automation. Technical Assistance will be available for small, medium, and new entrants along with socially and economically disadvantaged individual owned businesses (collectively, "SMNE/SEDI vendors").

- **Frequency:** CableLabs will execute one Test Event per quarter, every quarter of the period of performance. Technical Assistance and the Neutral Host and Development Test Environments will be available continuously throughout the period of performance without a set schedule.
- **Efficiency:** CableLabs will combine current test automation solutions from the test equipment vendor community with its own test automation investments, and those of other federated labs that agree to a mutual sharing agreement, to provide repeatable testing with improving efficiency over time.
- **Agility:** CableLabs will provide a test environment for Neutral Host testing and Technical Assistance for vendors that need such services, including SMNE/SEDI vendors. This test environment will be made available with priority for SMNE/SEDI vendors and vendors that encounter issues during a Test Event, so that the vendors can troubleshoot their issues without disrupting the progress of the other vendors in a Test Event.   This environment will also provide the capacity to offer additional testing outside of the priority testing of RU, CU, and DU components identified by NTIA.
- **Openness:** CableLabs Test Events, the Neutral Host Test Environment, and Technical Assistance Services will be available to all entities determined to be eligible based on the eligibility requirements in Section 2.2 of the Notice of Funding Opportunity.

All CableLabs *Launch Ready* Test Events will be conducted in our lab facilities in Louisville, Colorado.

B.   Test Event Details

During the test activities, a lightweight framework will be used to identify and mitigate gaps in specification or standards compliance, provide troubleshooting test support, and technical and development assistance with vendor solutions. If a SMNE/SEDI vendor's solution fails in testing, CableLabs can shift the failing solution to the Technical Assistance test environment if the vendor agrees and there is available capacity. There, CableLabs will help the vendor diagnose the cause of the failure, troubleshoot, and if the failure is corrected, the vendor can re-submit their solution for a future Test Event. The foundation of this framework is addressed in Section III.F and is based on a continuous cycle of test automation, community sharing of test results and test harnesses, and test plan development with industry participants.
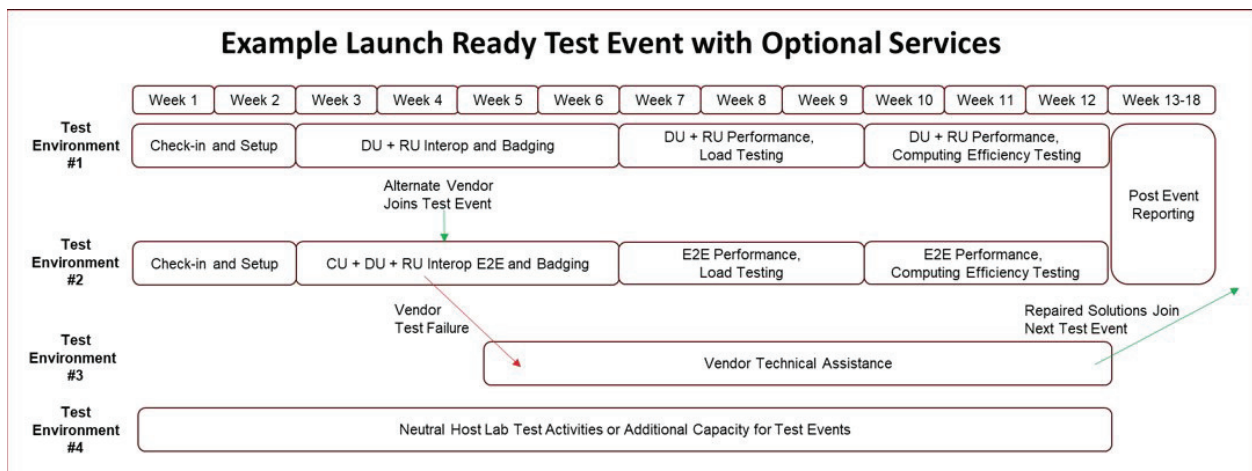
Figure 1 Example Launch Ready Test Event with Optional Services

Each Test Event will have a defined scope of testing, determined at least 120 days in advance in collaboration with a Certification Board composed of network operators and Open RAN stakeholders to

ensure that the testing scope remains aligned with operator needs. Each Test Event's scope will focus on one or more of NTIA's primary objectives: interoperability, performance, and security testing.

The test approach will apply proven test automation frameworks incorporating continuous integration and continuous delivery (CI/CD) practices, utilize industry established test plans, specifications, and requirements, e.g., O-RAN ALLIANCE, 3GPP, Telecom Infra Project (TIP), and provide enhancements to streamline industry processes to accelerate the pace of adoption and commercial deployment of the Open RAN ecosystem. The facilities and equipment used to conduct the work detailed in this proposal are addressed in Section III.P.

C. Test Configurations and Areas

CableLabs/Kyrio selected the test configurations and areas noted below based on the challenges facing the industry today, NTIA's priorities listed in Notice of Funding Opportunity, and input from Open RAN stakeholders. Within each Test Event, CableLabs proposes to test Open RAN subcomponents (CU, DU, RU), subsystems (CU+DU, DU+RU) and systems (CU+DU+RU) as standalone, paired, and integrated configurations.
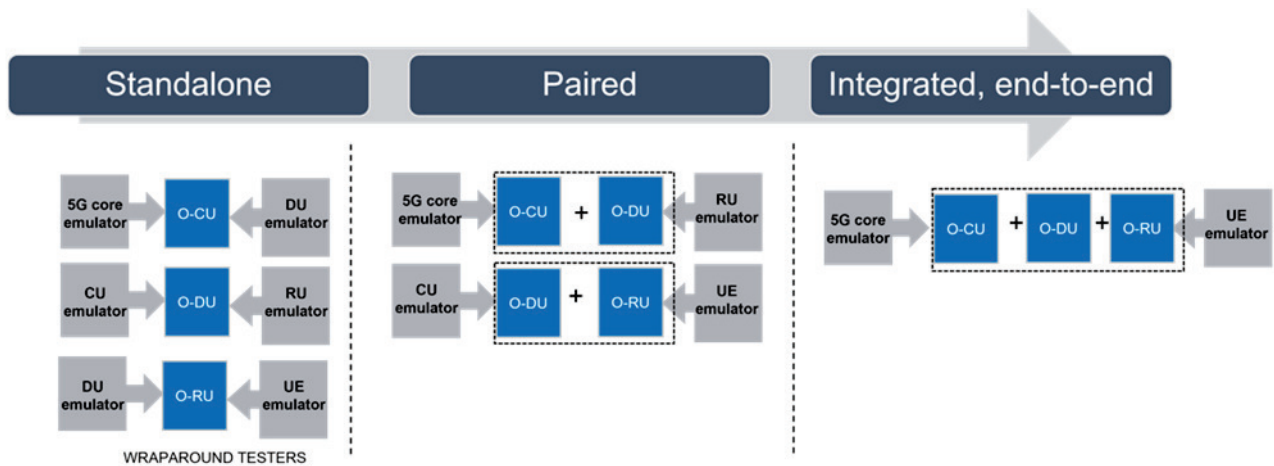
Figure 2: *Launch Ready* **Test Configurations**

The table below provides a summary of each of the test areas requested by NTIA, namely, interoperability, performance, and security with a description of the device under test/system under test (DUT/SUT), interface under test (IUT), and O-RAN Alliance/3GPP Specifications. SMO and 5G interface testing are also supported in these test areas.

Conformance testing is critical to achieving interoperability. A dedicated pre-interoperability conformance test area will be available to streamline the process and reduce the amount of time needed for interoperability testing, which can present a challenge in a multi-vendor environment. Interoperability is integral to operators to ensure that multi-vendor Open RAN systems will work in a particular mobile network. Operators are seeking performance levels in Open RAN technologies to equal or exceed that of mature 5G RAN systems to encourage adoption and large-scale deployment. As the RAN becomes more disaggregated and more open, security must be maintained to protect against bad actors and security vulnerabilities.

	TEST AREA	DEVICE UNDER TEST (DUT)/ SYSTEM UNDER TEST (SUT)	INTERFACE UNDER TEST	O-RAN ALLIANCE, 3GPP SPECIFICATIONS/ TEST CASES
	PRE-INTEROPERABILITY (conformance)	RU	FH	WG4.CONF, 3GPP
		DU	F1, FH	WG4.CONF, 3GPP
		CU	F1	3GPP
		RIC	O2, E2, A1	WG2.A1TS, WG3.E2TS
	INTEROPERABILITY	DU, CU	F1	WG5 IOT
		DU+RU	FH	WG5.IOT, WG4.IOT
		RU+(DU+CU)		
		gNB, gNB	Xn	WG5 IOT
		Near-RT RIC, CU, DU	E2	WG3 E2AP, E2SM-KPM, E2SM-RC
		O-cloud, gNB	O2	WG6.O-Cloud *
		Non-RT RIC, Near-RT RIC, gNB	A1	WG2 A1AP, A1GAP, A1TD *
	SMO	SMO, CU, DU, RU	O1 (SMO)	WG10 O1-Interface *
	5G INTERFACE	CU-UP, CU-CP	E1	3GPP
	PERFORMANCE	gNB, gNB	e2e	TIFG.E2E
	SECURITY	Security	gNB, CU, DU, RU	O-RAN.SFG.Security-Test-Specifications, O-RAN.TIFG.E2E, (3GPP TS 33.511), O-RAN.WG11.Security-Test-Specification
				requires cadence with O-RAN WGs and internal development

Figure 3 *Launch Ready* **Test Area Summary**

1. PRE-INTEROPERABILITY (CONFORMANCE)

Conformance testing of Open RAN subcomponents and subsystems is recognized as a prerequisite for interoperability. CableLabs proposes a pre-interoperability testing stage to enable vendors to bring their products to a basic level of functionality verified by conformance testing before proceeding to full-interoperability testing.   Specifically, this testing will include:

Open Fronthaul interface (applicable to RU, DU, DU+CU combo): Using predefined test signals, the fronthaul interface shall undergo a series of tests, (per WG4.CONF[1]) to verify its conformance to the WG4.CUSM technical specification. Furthermore, dry-run interoperability tests, per WG4.IOT, will be conducted to validate the ability of an RU or DU to interoperate over the fronthaul interface with an emulated DU or RU respectively.

F1 interface (applicable to DU, CU DUT): A series of tests per WG5.IOT, using an emulated DU or CU, shall be conducted to assess F1 interface readiness for further full interoperability testing.

Xn interface (applicable to CU, DU+CU combo DUT): A series of tests per WG5.IOT, using an emulated CU, shall be conducted to assess Xn interface readiness for further full interoperability testing.

E2 interface (applicable to Near-RT RIC SUT): Functional testing of the E2AP Global and Service-related Procedures (per WG3 E2AP), E2 Service Management procedures (per WG3 E2SM-KPM, E2SM-RC) will be conducted using emulated UE, RU, DU and CU.

O1 interface (applicable to SMO SUT): Functional testing (i.e. CM, PM, and NetConf) of the O1 interface (per WG10 O1-Interface) will be conducted using emulated RU, DU and CU.

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[1] *See* O-RAN Technical Work Groups, O-RAN ALLIANCE, available at https://www.o-ran.org/about#technical-workgroup for a description of all O-RAN ALLIANCE Work Groups.

A1 interface (applicable to Non-RT RIC SUT): Functional testing of the A1 interface (per WG2 A1AP, A1GAP, A1TD) will be conducted using emulated SMO.

Additional Testing: Vendor-agnostic support of computing solutions (hardware, virtualization, cloud) will also be evaluated. Vendors will be assessed on their ability to install their solution onto hardware (i.e., local or remote installation on CableLabs' bare metal servers, virtual machines, or cloud hosted platforms). Maturity and ease of use of virtualized and containerized network functions will also be evaluated.

Deliverables:
- For those RUs, DUs and DU+CUs' fronthaul implementation that meets the O-RAN certification criteria, O-RAN conformance certifications will be awarded.
- Post Test Event reports as detailed in Section G Milestone Plan.

2. INTEROPERABILITY

Interoperability tests evaluate an Open RAN interface (i.e., Xn, F1, FH, O1, O2, E1, E2), as implemented by at least two independent vendors. Interoperability testing differs from pre-interoperability and conformance testing, where an Open RAN subcomponent or subsystem is under test using emulated nodes, instead during interoperability testing, the Open RAN subcomponents/subsystems on each end of the interface under test will typically be provided by different vendors but could also be provided by partner vendors or our host lab. Interoperability testing (IOT) will leverage the O-RAN ALLIANCE Interoperability Test Specifications defined in WG4 and WG5, or other industry-accepted specifications as they are created and approved by industry bodies and recommended by the Certification Board (detailed below).

WG4 Interoperability Test Specification specifies the IOT for the FH interface.
- FH tests focus on the M-Plane to validate O-RU start-up procedures from the power-on of O-RU to the availability of service.
- FH tests focus on the S-Plane to validate synchronization status detection and frequency and time error (performance).
- FH tests focus on the C/U-Planes to validate Radio Layer 3 C-Plane establishment and Initial Radio U-Plane data transfer.

WG5 Interoperability Test Specification specifies the IOT for the F1 and Xn interfaces implemented in accordance with the NR C-Plane and U-Plane profiles between the multi-vendor radio access network elements.

- F1 interoperability tests focus on the F1-interface between multi-vendor gNB-CU and gNB-DU.
- Xn interoperability tests focus on the Xn-interface between multi-vendor gNB-CUs.

WG2 O-RAN A1 interface Test Specification introduces A1-P and A1-EI IOT cases for Non-RT RIC and Near-RT RIC

- A1 interface tests focus on disseminating policy and enrichment information to the near-RT RIC

WG3 O-RAN E2 Interface Test Specification specifies the IOT test methodology description and IOT cases for RIC global procedures and functional procedures of E2 interface.

- E2 interface tests focus on access to information exposed by the RAN and modification of RAN operation to execute policies passed down by the non-RT RIC.

WG8 O-RAN Stack Interoperability Test Specification specifies the CU/DU IOT test cases updated for test profiles, O1 configuration, and fronthaul interface procedures.

- O1 interface tests focus on SMO Discovery and O1 Interface establishment between O-DU and SMO, cell activation, alarm notification, and measurement counters.

Additional testing options that may be available in the Test Events or Neutral Host Lab:
The specifications listed below may be added in the near future by O-RAN ALLIANCE and can be incorporated into *Launch Ready*:
- The O1/O2 interfaces are defined by 3GPP and augmented by O-RAN ALLIANCE as needed.
- O1/O2 interfaces together with the fronthaul M-Plane interface, provide OAM functionality.
- The A1 and E2 interfaces are standardized by the O-RAN ALLIANCE.
- Expected future defined IOT specifications for E1 interface between the CU-CP and CU-UP, and O2 interface that interfaces the non-real time RIC with the RAN virtualized platform.

Common challenges that vendors face during full interoperability testing include differences in interpretation and implementation of standards requirements, configuration mismatches between vendors, and compliance to different specification releases. To address these challenges, a comprehensive but lightweight test automation process will be used as part of test preparation to ensure compatibility of these features, and we will provide experienced system integration engineering resources to address issues that might arise in real-time (described in Section III.F.2).

Interoperability testing will help accelerate the open RAN ecosystem by demonstrating the ability of vendors to plug and play, by demonstrating backward compatibility with other radio access network elements conforming to different specification release and version, and by showing the flexibility to accommodate vendor specific implementations while being able to integrate and operate within a single operator deployment.

Deliverables:
- Certifications and badges for successful passing of tests in the O-RAN ALLIANCE, TIP, or other specifications identified for the Test Wave.
- Post Test Event reports as detailed in Section G Milestone Plan.

3. **PERFORMANCE**
Performance testing is the first opportunity for a fully integrated Open RAN system to undergo end-to-end testing. *Launch Ready*'s performance testing will leverage the End-to-End Test Specification as defined by the O-RAN ALLIANCE Test and Integration Focus Group (O-RAN.TIFG.E2E-Test) and other industry-accepted specifications and test plans as they are created and approved by industry stakeholders and recommended by the Certification Board. This testing area addresses Functional, Performance, Services, Load, and Stress tests as described below. Network capacity and network throughput performance will be measured as part of the TIFG Performance tests.

Functional: focus on end-user functionality to addresses the foundational procedures for Registration, Session establishment, mobility (Inter/intra Frequency, Idle Mode/Connected Mode, Inter/Intra-CU/DU), and Carrier Aggregation from a network end-to-end perspective.

Performance: focus on the performance of the radio access network from network end-to-end perspective. The testing is based on end-user performance which is compared against target and

expected performance values. The major area of focus is on downlink/uplink throughput in varying radio conditions and coverage (link budget), aggregated downlink/uplink cell throughput, latency, network capacity, and network throughput performance.

Services: focus on end-to-end services which need to be validated for the end user and can be broadly classified as data services, video streaming service, voice service, video calling service in the multiple service slices like eMBB, URLLC, and mMTC. These tests will be performed under varying radio conditions (stationary and mobile use cases).

Load and Stress: focus on evaluating the performance of the radio access network from a network end-to-end perspective under load based on 3GPP and O-RAN ALLIANCE specifications. The radio access network should have the ability to process various traffic patterns under varying radio conditions over a long duration of time which could happen in the real world.

Additional testing options that may be available in the Test Events or Neutral Host Lab: In addition to conducting performance test cases per the TIFG, CableLabs/Kyrio will create enhanced performance tests that stretch the performance of the end-to-end Open RAN system including:

- **Energy efficiency:** focus on two types of measurements to calculate energy efficiency: data volume and average power consumption for reference disaggregated gNB (or subcomponents) configurations and reference load levels (i.e., PRB utilization: low, medium, full).
- **Computing efficiency**: focus on measuring parameters such as processor utilization, memory usage, disk activity, network bandwidth, and power consumption for reference disaggregated gNB (or subcomponents) configurations and load levels to evaluate the efficiency of computing systems used to host gNB virtualized functions.

The performance test strategy will also include continual implementation of new test cases as they are developed and become available through O-RAN ALLIANCE Work Groups and other industry bodies such as 3GPP and TIP. CableLabs/Kyrio will continue to be active contributors in the Work Groups to develop to help evolve Open RAN requirements.

Deliverables:
- Certification approval for each supplier that passes the O-RAN.TIFG.E2E-Test specification, TIP specification, or other industry specification as defined for the Test Event.
- Post Test Event reports as detailed in Section G Milestone Plan.

4. SECURITY
We propose to conduct comprehensive security testing of Open RAN technologies that consists of multiple stages, including security conformance testing, vulnerability scanning, and Red Team penetrating testing.

Security conformance test: focus on end-to-end and individual Open RAN element validation and conformance to industry-accepted security requirements specified by 3GPP SA3 and O-RAN ALLIANCE, as well as security guidance from other government agencies including NIST, NSA, and CISA. For example, 3GPP SA3 SCAS specifications, including TS 33.511 and TS 33.117, will be followed to test both the security capabilities of Open RAN elements and the end-to-end security protection of communication between the UE and the RAN and between the UE and the 5G core, including support of confidentiality, integrity protection, replay protection, and failure handing in various scenarios. This will include validation of the security protocol (i.e. SSH, TLS, IPsec, OAuth2.0) implementation used among the Open RAN subcomponents.

Security vulnerability scanning: focus on using commercial, open-source, and our own proprietary scanning tools to discover both known and unknown security vulnerabilities in Open RAN elements, including in operating systems, applications such as web servers, and 5G protocol stacks. This also includes security vulnerability scanning for Physical and Virtual Network Functions (PNFs and VNFs) using publicly disclosed vulnerability lists, i.e. NIST National Vulnerability Database, MITRE CVE program.

Red team penetration test: focuses on testing for active exploitation of security vulnerabilities discovered in the Open RAN elements during deployment and/or operation. For example, red teaming may try to gain local or remote access to an Open RAN element, cause service disruption, become a man-in-the-middle of end-to-end communication, and/or downgrade security protection.

Deliverables:
- O-RAN ALLIANCE Security/TIP/Industry Certification or Badge.
- Security Assessment Report.
- Post Test Event reports as detailed in Section G Milestone Plan.

III. Work Plan

Test Environments will be available to evaluate and facilitate the test areas of interoperability, performance, and security using industry-leading Open RAN test equipment. Each test environment will use either Viavi or Keysight Open RAN test equipment (details described in Section P) to support Open RAN DUT/SUTs across the interfaces described in Figure 3. In addition, each test environment will support interfaces under test on a shared rotational basis. How each test area evaluates interoperability, performance, and security is described in Section II.

This Work Plan proposes to build the test environment capacity to four Test Environments before the start of Year 2. Two of four Test Environments will be available for standard Test Event activities, one Test Environment will be available for additional Test Event capacity and Neutral Host and Technical Assistance services, and one Test Environment will be dedicated for test harness/automation development. Test activities will be conducted on a quarterly basis in Test Events, as shown in the Milestone Plan in Section III.G.

Our proposed work plan also includes the creation of a Certification Board to govern the testing process and the creation of a Federated Lab Community Sharing Program to enable the sharing of information amongst Open RAN stakeholders.

A. Ensuring Equity and Repeatable and Verifiable Results

CableLabs/Kyrio has decades of industry experience developing and executing certification testing programs and hosting wireless and wired interoperability tests and Plugfests in a vendor-neutral test environment. When providing lab services and technical assistance to participants through our Data over Cable Service Interface Specification (DOCSIS), On-Go Alliance (CBRS), CTIA (Wi-Fi), and O-RAN ALLIANCE (O-RAN) certified labs as well as the recent 5G Challenge events of 2022 and 2023, we have built policies to ensure equitable access to testing by vendors of all sizes and maturity that will be leveraged during the performance of the *Launch Ready* project.

To ensure repeatable and verifiable results, tests will be conducted using a test harness and test automation process. Information regarding results and test harnesses will be shared with participants, NTIA, and the larger Open RAN ecosystem as described further in Section III.F.4.

B. Test Case Sources

Sources of test cases will be O-RAN ALLIANCE, 3GPP, and other industry sources such as operators and TIP, internal development/enhancements based on our experience in Open RAN events such as the 5G Challenge and Open Testing and Integration Center (OTIC) Plugfests, and learnings from our participation in this project, including participating in the sharing of information with other grantees and the Open RAN ecosystem. CableLabs/Kyrio will remain industry neutral and open to working with other industry-accepted sources not identified above.

In addition to utilizing test specifications from both internal and external sources, our Federated Lab Community Sharing Program, detailed in Section III.F.4 will benefit from contributions to the on-going development and sharing of test specifications and best practices.

C. Recruiting and Screening Participants

CableLabs/Kyrio plans to recruit testing participants using a variety of platforms to reach the diverse stakeholders in the Open RAN ecosystem. We plan to continue our success in recruiting participants to interoperability events, building on our history of DOCSIS, 5G Challenge, and OTIC Plugfest events.

The quarterly Test Events will be announced 90 days in advance via our web site and shared with Working Groups at industry organizations such as O-RAN ALLIANCE, TIP, and the Open RAN Policy Coalition. CableLabs and Kyrio have deep relationships with many organizations in the vendor community and will do individual outreach to them, along with direct email campaigns to our existing list of contacts with a particular focus on SMNE/SEDI vendors. We will promote the Test Events through marketing campaigns that leverage social media, blog posts, and webinars. The scope of each Test Event will be disclosed in advance to provide vendors with the necessary information to evaluate their interest.

Vendors will apply for Test Events through a web-based portal at least 60 days in advance of the start of the Test Event and be required to:

- Provide information based on the eligibility requirements detailed in Section 2.2 of the Notice of Funding Opportunity;
- Self-attest to the maturity and security level of the component or device to be tested;
- Verification of how vendors follow the best practices of secure software development lifecycle; and
- Agree to CableLabs/Kyrio's standard participation agreement terms.

Participant provided information will be vetted through our standard process for compliance with federal government regulations and policies. Eligible applicants will be notified of their acceptance and receive logistical information on participation requirements and deadlines for configuring their solutions for testing in the lab at least 45 days before the Test Event to ensure proper preparation time.

D. Accessibility, affordability, frequency, and duration

As a neutral test lab, CableLabs/Kyrio will accept participants in the Test Events that meet the requirements detailed in Section III.C. During Years 1 through 3 of this project, no applicants will be charged to participate in Test Events. In Year 4, we propose to implement a simple fee structure to start a transition to a commercial offering of test services. As detailed in Section III.O, fees will not be charged to SMNE/SEDI vendors for participation in test events or technical assistance.   Section III.G, the

Milestone Plan, details the frequency and duration of test events that will provide easy accessibility to many vendors.

E.   Remote and Virtual Testing Technical Requirements and Policies

Remote initiation and monitoring of tests executed in the CableLabs' lab will be available to all vendors meeting the requirements detailed in Section III.C to make testing as accessible as possible. If a vendor selects remote testing during the application process additional information will be collected to ensure the vendor follows adequate cybersecurity best practices, has the necessary capabilities to remote access the test environment, and will have staff available during CableLabs/Kyrio's standard operating hours. When an applicant is determined eligible to participate in a Test Event or Technical Assistance, the onboarding process detailed in Section III.C will be followed with additional information pertaining to remote access.

The use of test harnesses and automation will ensure that any applicant using remote testing will receive the same level and type of testing as vendors participating in person and receive the same reports at the conclusion of the test event. Prior to the implementation of test automation, CableLabs staff will ensure that remote participants receive the same level of support.

F.   Additional Information on Testing

A Federated Test Program Framework, as depicted in the diagram below, provides a cyclic process that consists of five functional areas that incorporates industry input and systematic collaborative development with an output of standardized Open RAN subcomponent, subsystem, and system products that are interoperable, highly functional, and meet criteria established by the Open RAN ecosystem. It will leverage, federate, and enhance the current industry established Open RAN specifications, test plans, certifications, and badges (i.e. O-RAN Alliance, 3GPP, TIP).   The five functional areas include: (1) Test Plan Development, (2) Test Process Infrastructure and Automation, (3) Automated Test Orchestration with CI/CD, (4) a Federated Lab Community Sharing Program, and (5) Certification Board.
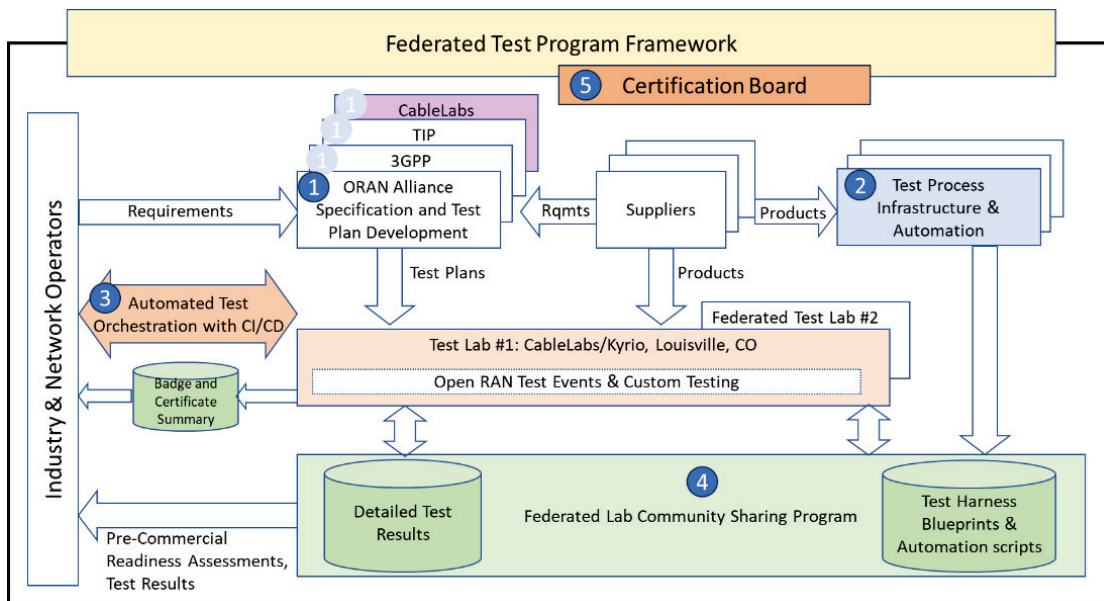

Figure 4 Federated Test Program Framework

The Federated Test Program centers around the *Launch Ready* Test Lab which will conduct the proposed T&E test activities described in previous sections. Additional functional areas include:

1. **TEST PLAN DEVELOPMENT**

As noted in Section III.B, Test Plans will continue to be developed in various organizations. As versions or releases of test plans are approved by industry organizations, they will be submitted to the Certification Board to support developing and furthering common and achievable requirements and features based on operator and industry input.

2. **TEST PROCESS INFRASTRUCTURE & AUTOMATION**

We are proposing a community testing architecture with multiple test harnesses across participating labs to test different 5G Open RAN subcomponents interfaces, subsystems, or systems. The architecture comprises five modules: the test management system, the test harness, the test data management, the test automation engine, and the test reporting and analytics engine. Specifically:

Test Management System: focus on managing the overall testing process, including test planning, test case development, test execution, and test result analysis. It acts as a central control point for the federated system and communicates with other components to coordinate the testing activities.

Test Harness: focus on providing the infrastructure and logic for executing the tests, including test equipment, test scripts, hardware, and network resources.

Test Data Management: focuses on management of the test data, including test scripts, expected outputs, and other test artifacts. It ensures that the data is consistent and available to all modules of the federated system.

Test Automation Engine: This module is responsible for coordinating the execution of the tests across multiple test environments and tools. It monitors the progress of the tests and ensures that they are executed in the correct order and with the appropriate parameters.

Test Reporting and Analytics: This module collects and analyzes the test results to provide feedback on the quality of the software being tested. It also generates reports to help stakeholders understand the testing process and the results.

Test Environment Configuration Management: This module contains a repository for all of the parameters governing the configuration of the test environment, including the configuration of virtual machines, test tools, network switches, and devices/systems under test, together with the software needed for capturing an existing configuration in its entirety, and restoring that configuration at a later time.

Test Audit Engine: This module helps perform periodic and on-demand audits of the test infrastructure and test results to ensure the overall integrity of the test harness system, the test program and the results.

Overall, there are several advantages of using the proposed architecture including modularity, scalability, flexibility, resilience, and integrity.

3. **AUTOMATED TEST ORCHESTRATION WITH CI/CD**

To provide a more efficient testing process and increase the repeatability and consistency of the testing we propose to automate much of the test process by incorporating Continuous Integration and

Continuous Delivery (CI/CD) with a continuous testing framework. The testing automation framework utilizing industry proven tools will connect vendors, test tools, issue tracking, resolution, and notification mechanisms across the test environments and the participating vendors. The security, privacy, and protection of proprietary information protocols mentioned in Section III.I will be built into the automation framework from the start.

The automation tools will enable vendors to submit builds, schedule the testing, configure and kick off the tests, analyze test log, notify vendors and other approved stakeholders of issues when tests fail or have issues, and upon the tests passing, notify the vendors and other approved stakeholders. The tools will be integrated into a CI/CD friendly and secure project management tool to ensure role-based access visibility. These tools are anticipated to be available by the end of Year 2. Learnings from adding this capability to our test environments will be shared with the Open RAN community as referenced in the Federated Lab Community Sharing Program.

4.   FEDERATED LAB COMMUNITY SHARING PROGRAM

In the interest of reducing redundant test automation investment, decreasing the cost of testing, increasing the consistent repeatability of testing, and increasing the speed with which the industry can adopt Open RAN solutions, CableLabs/Kyrio will form a Federated Lab Community Sharing Program (the "Community"), through which CableLabs proposes to coordinate the sharing of Test Automation Harness designs, Test Scripts, and Configuration Management systems and procedures ("Testing Artifacts") with other Federated Test Labs performing similar work. When possible, based on vendor preferences, test results may also be shared. Badges and certifications earned by a vendor are shared publicly through current O-RAN ALLIANCE website or alternative public portal per Community agreement.

Membership in the Community is limited to entities that meet the eligibility requirements detailed in Section 2.2 of the Notice of Funding Opportunity, and limited to labs that sign a reciprocity agreement in which all Members agree to share their Testing Artifacts, and in some circumstances, test results, through the Community. During the period of performance, membership in the Community will be limited to entities that operate labs, agree to sharing in-kind resources to build and maintain Test Artifacts, and commit to sharing test results when permitted.

CableLabs will set criteria for how much sharing, maintenance, and support of Testing Artifacts will be required of each Federated Lab member of the Community in its reciprocity agreement and govern the Community with dedicated staff.

5.   CERTIFICATION BOARD

CableLabs proposes to establish a Certification Program for Open RAN solutions modeled on CableLabs' long-established programs for other communications technologies.[2] CableLabs/Kyrio will form a Certification Board, composed of network operators and Open RAN stakeholders that intend to deploy the communications technologies to be tested. CableLabs shall solicit nominations from all US mobile network operators that have publicly committed to developing, adopting, and deploying Open RAN technologies and additional Open RAN stakeholders. CableLabs shall not refuse appointment of a nominee without reasonable cause. If this proposal is funded, additional rules of governance for the Certification Board will be created based on CableLabs/Kyrio's existing Certification Board standards.

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[2] See https://www.cablelabs.com/wp-content/uploads/2014/01/CWGGuidelines.pdf

The composition of the Board is intended to advance adoption and deployment of Open RAN technologies by vesting interest in the testing process by network operators.

The key responsibilities of the Certification Board are:
1. Review and approve a Test Event Requirements and Guidelines document created by CableLabs that will be shared with the industry at large defining requirements and process for testing.
2. Once established, recommend testing scope for each Test Event, including which Open RAN components (CU, DU, RU) will be tested, which interfaces will be tested, and which capabilities will be tested (interoperability, performance, and security), and according to which versions of the relevant industry specifications. CableLabs will receive the recommendations of the Board and will make the final determination of scope for each Test Event. Before the Board is established or in the case of a lack of agreement by the Board, CableLabs/Kyrio's team of Open RAN experts will determine the scope of the initial test waves to ensure testing is available immediately and continuously.
3. Review test results to determine if a vendor's solution has passed tests required in each successive Test Event.

In support of the Board, CableLabs will hold meetings of the Certification Board, record decisions of the Board, execute test wave participant recruitment, selection, and communication of logistics, test scope, testing activities, and test results for each test wave.

G. Milestone Plan

As noted earlier, Test Events will be held on a quarterly basis with a regular series of activities occurring prior to, during and after the three-month Test Event as illustrated in Figure 5. The Test Events are expected to begin at the start of each calendar quarter (Jan 1, Apr 1, July 1, Oct 1).

Prior to the regular cycle, start-up activities such as initial test plan development, recruiting of participants and test system set-up will be required. CableLabs anticipates implementing a "light" Test Event upon the initial award which will tap into contestants from the 2023 5G Challenge or other known, qualified vendors to participate using previously established test plans. The scheduling and scope of the first Test Event is dependent on the date of the grant award and the time available to establish the *Launch Ready* program described above.

Figure 5 Test Event Cycle Activities and Milestones

In summary, the key milestones are:
- 120 days prior to the Test Event: scope of the Test Event determined by the Certification Board or CableLabs
- 90 days (about 3 months) prior to Test Event: Marketing initiated and applications accepted.
- 60 days prior to Test Event: Marketing and application acceptance closed. Begin screening and vetting process.
- 30 days prior to Test Event: Screening complete and participants notified. Vendor begins preparation for participation in Test Event.
- Test Event start: Begin check-in and set-up of SUT/DUTs.
- 14 days after Test Event start: Check-in and set-up completed. Begin testing.
- 90 days after Test Event start: Testing is completed or before this date issues have been identified and vendors offered the ability to move to Technical Assistance.

The Post Event reporting and results for each test event will be delivered on the following schedule:
- Results delivered to participating vendor: 10 days after Test Event completion.
- Report delivered to NTIA: 30 days after Test Event completion.
- Anonymized results posted to the public: 45 days after Test Event completion.

Additionally, the establishment of the Federated Community Sharing Program (Section III.F.4) and the Certification Board (Section III.F.5) will be completed by the beginning of Year 2 of this engagement. Test automation will be implemented throughout the program with efficiencies being realized by Year 3. As we build capacity in the lab, the Neutral Host Lab and Technical Assistance capabilities will be available at the latest by the beginning of Year 2.

Additional administrative deliverables, such as the Baseline Report, Progress Reports, and Close Out Report will be provided to NTIA by the deadlines set in the Notice of Funding Opportunity or subsequent Grant Award.

H. Related Activities & Unique Aspects of Proposal

Current industry testing efforts promoted by SDOs are aimed around testing the basic building blocks of O-RAN ALLIANCE or 3GPP compliant subsystems (CU, DU, RU). This testing is currently fragmented, not systematic, tests only pieces of specification, and lends itself to closed partnerships instead of full interoperability between vendors. Our proposal will test instead for conformance, interoperability, performance, security, functional tests, and peak performance in a truly open multi-vendor environment. Our proposal provides critical tools and test results to assess the maturity/readiness of solutions and accelerate the deployment into the RAN ecosystem and builds upon the existing building blocks being tested today.

Launch Ready is a unique proposal to create the capacity and scale to truly evaluate Open RAN readiness, providing the necessary information to vendors to accelerate development of Open RAN technologies and the adoption and deployment by operators. Our system integration expertise and experience will help accelerate lab testing giving vendors and operators real time access to information, enabling quick troubleshooting and resolution of issues, leading to true multi-vendor interoperability.

Our proposal contains a unique aspect to enable operators to implement CI/CD in their systems that does not exist today. Development of test harnesses and automation will improve repeatability and

scalability and decrease test time. All of the work proposed will be provided by an industry and vendor neutral lab.

We will use the Federated Test Labs and Community described above to minimize an overlap in testing and test automation. By actively coordinating and working with the diverse stakeholders in the Open RAN ecosystem we can encourage cooperation between Test Labs, SDOs, and specification organizations to increase the availability and accessibility of testing without creating redundant effort.

I. *Record Retention & Data Analysis*

1. INFORMATION SHARING

Detailed individual reports will be made available to each individual vendor and shared through our established information sharing platform for the participating vendors to protect the confidential and proprietary information contained within. As mentioned above, vendors will be asked if they give permission to share their individual reports with the Community to help advance the understanding of the Open RAN ecosystem and update testing practices or offerings. Vendors may decline and CableLabs will retain a copy of this report in a secure server solely for use in future reports that will be de-identified and be available to assist the vendor with future test activities. These reports will be shared with each vendor within 14 days after the end of a Test Event.

After action reports, containing a summary of the test event, lessons learned, and potential changes to future events, each test event will be prepared for NTIA and shared within 30 days of the end of a Test Event.

The results of each test event will be well-documented, then consolidated and de-identified to be distributed publicly through our website. Publicly released reports will protect vendor identities and the confidential portions of the test results by not specifying specific achievements or flaws for specific vendors.   These reports will be made available within 45 days after each event. This de-identified version of the report will be used to influence work in SDOs, specification bodies, work groups, and the Community, including contributions. By sharing this real-time information on test events and lessons learned the Open RAN ecosystem can adapt the focus of testing and vendors can be aware of known issues to better prepare for testing.

2. DATA RETENTION, SAFEGUARD, AND CONTROLS AND PROTECTION OF PROPRIETARY AND CONFIDENTIAL INFORMATION

Data from Test Events, the Community, and the Certification Board will be stored in a secure platform and retained by CableLabs/Kyrio to enable future research and development in the Open RAN space.

Standard procedures used by CableLabs will be implemented to protect proprietary and confidential information and data during this project. These procedures include: non-disclosure agreements for participating vendors, secure information sharing platforms with role-specific access rights, the implementation of the cybersecurity best practices and tools mentioned below to prevent access by malicious parties, and verification of the security levels of remote participants.

J. *Collaboration*

CableLabs/Kyrio has a longstanding relationship as a Contributor with O-RAN ALLIANCE and as an OTIC that hosts multiple O-RAN ALLIANCE Plugfests. We are committed to coordinating with the O-RAN ALLIANCE on future Open RAN test activities and specifications. The O-RAN ALLIANCE is supportive of CableLabs' proposal to the Innovation Fund and sees the potential it provides to advance the Open RAN

ecosystem. We will continue our close coordination with the O-RAN ALLIANCE to ensure that if funded, new testing capacity and capabilities are easily accessible to vendors seeking OTIC badges and certifications.

CableLabs/Kyrio has a longstanding relationship with TIP. We are a TIP Community Lab, providing test services for a range of communications technologies including mobile fronthaul and Wi-Fi. We are coordinating with TIP on future Open RAN activities and support TIP's proposal to the Innovation Fund. The parties agree that if TIP's proposal is funded by NTIA, CableLabs is willing to host testing using the TIP test plans, participate in TIP's working platform. TIP supports CableLabs' proposal and acknowledges the complementary relationship between the two proposals.

CableLabs/Kyrio plans to leverage its existing relationships with many vendors and network operators interested in participating in future Open RAN testing. The following companies have expressed support for CableLabs' proposal and interest in participating as a test equipment vendor, an Open RAN solution vendor, or network operator should this proposal be funded: Comcast, Viavi, Keysight, AT&T, XCom Labs, Nokia, SIXDOTX, Mavenir, Effnet, Benetel, Airspan, Analog Devices, GXC, LIONS, Fujitsu, Radisys, and Aarna Networks. The breadth of the interested companies displays our connection to the Open RAN ecosystem, our ability to work with a diverse set of stakeholders, and the potential for many future collaborations to advance the deployment and adoption of Open RAN.

Finally, as described above we will build additional relationships through our marketing and recruiting efforts for the test events and once established we commit to maintaining these new relationships to encourage a diverse participation in the Open RAN ecosystem.

K. Consultants, Contracts, & Subawards

CableLabs will not be entering into any agreements with any consultant, contractor or subawardee to perform the work proposed above. As mentioned in Section J we are engaged in active coordination with many parties to participate in future testing activities if this proposal is funded by NTIA.

L. Cybersecurity

CableLabs has implemented reasonable and appropriate cybersecurity controls and procedures for an innovation and research and development lab. In developing our controls and procedures, we have leveraged the NIST Cybersecurity Framework, CISA Cross-Sector Cybersecurity Performance Goals, CIS v8, NIST SP 800-53, and other industry best practices and we monitor these best practices to continually advance our controls and procedures as the threat environment evolves.

More specifically, CableLabs has meaningfully implemented controls and procedures under the relevant NIST Cybersecurity Framework Functions. Under Identify, for example, CableLabs has identified and named cybersecurity leadership, has an asset inventory procedure, mitigates known vulnerabilities, and regularly employs third-party penetration testing. Under Protect, for example, we require that any default passwords are changed, employ multi-factor authentication and unique credentials, revoke credentials for departing employees, employ network segmentation for different environments, secure logging of unsuccessful login attempts and other security events, conduct regular cybersecurity training for all employees, employ email and transport layer security, conduct regular backups, and have an updated incident response plan. Under Detect, we employ commercial prevention and detection systems to detect instances of key threats. Under Response, we have implemented necessary incident reporting procedures. Under Recover, we have defined procedures to recover and restore to service organizational systems that might be impacted by a cybersecurity incident.

The activities set forth in this proposal are similar in nature to CableLabs/Kyrio's current testing activities, and we do not anticipate any significant gaps. However, as we plan, design, and implement the proposed project, we will revisit our cybersecurity controls and procedures to ensure we remain in line with current best practices (including a fully segmented network for the work under this proposal), and we will address any gaps identified in that process to ensure the appropriate controls and procedures, including those listed in the Notice of Funding Opportunity, are in place for the proposed project.

M. Cybersecurity Supply Chain Risk Management

CableLabs and its wholly owned subsidiary, Kyrio, Inc. have processes in place to address the NIST C-SCRM Foundational Practices[3] as they apply to the lab testing services CableLabs and Kyrio provide. Specifically, CableLabs has a core multidisciplinary cybersecurity team that develops and manages cybersecurity policy and processes, which includes C-SCRM as applicable for CableLabs and its subsidiaries, including Kyrio. This cybersecurity team has full leadership support for its work and annually reviews its policies and procedures to assess changes in risks and risk mitigation. CableLabs and its subsidiaries currently benchmark security practices to the CIS Critical Security Controls framework. CableLabs and Kyrio have taken measures in its equipment acquisitions and processes to maintain redundancies and security in their operations, so the testing laboratory remains fully operational and maintains the confidentiality, integrity and availability of laboratory test results. Additionally, these laboratories undergo annual ISO/IEC 17025:2005 accreditation to ensure that the laboratory processes, equipment calibration, and procedures meet international standards.

N. Qualification of Applicant

CableLabs/Kyrio has decades of experience in hosting similar test events, sharing information in testing ecosystems, and managing certification processes as a vendor neutral test facility. To accomplish the work proposed above we will provide the expert staff and access to state of the art facilities that enabled us to succeed in the following:
- CableLabs was selected as the Host Lab for both the 2022 and 2023 DoD and NTIA-ITS 5G Challenges to design test events and conduct standalone and end-to-end testing on vendor-participant open RAN subsystems. Results of the 2022 test events demonstrated successful interoperability across a multi-vendor open RAN using E2E bi-directional data sessions with a commercial 5G core and UE emulator in the allocated five-week timeframe, which is notably shorter than industry led test events. In 2023, the 5G Challenge is designed to foster deployment-ready multi-vendor open RAN systems by including mobility interoperability and enhanced performance.
- Kyrio became the first O-RAN ALLIANCE Open Test and Integration Center (OTIC) in the Americas in 2022. In Fall 2022, the Kyrio OTIC Lab hosted the O-RAN Global PlugFest in North America where seven participants were able to remotely conduct their testing activities in a secure and isolated test environment. Results, obtained from three test scenarios, contributed to accelerating the maturity of the O-RAN components to support viable multi-vendor deployment options. In Spring 2023, Kyrio OTIC Lab renewed its participation in the O-RAN Global PlugFest.
- CableLabs hosted the industry's first CBRS interoperability test for the CBRS (now OnGo) Alliance in 2018 where over 15 vendors and various stakeholders evaluated more than 100 test cases to

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[3] Available at: https://doi.org/10.6028/NIST.SP.800-161r1

enable advancements in the CBRS ecosystem. An early result of this testing was the development of the OnGo test certification program with significant input from CableLabs. Kyrio is now an authorized Test Lab for OnGo equipment certification. CableLabs continues to host CBRS testing for stakeholders.

- CableLabs became a certified TIP Community Lab in 2017 and continues to host various vendors at our TIP Open RAN and Open Wi-Fi labs, as well as provide an Easy Mesh demo lab.
- CableLabs became a CTIA Authorized Test Lab (ATL) in 2016 with A2LA accreditation for Wi-Fi radio frequency (RF) testing (TRP/TIS) using our on-site RF anechoic chamber to conduct and certify Wi-Fi devices.

O. Fee Structure

All proposed services will be provided at no cost to vendors for the first three years, with a gradual introduction of fee-based costs to the vendor or operator community starting in Year 4. Services offered to the SMNE/SEDI vendors will remain a grant funded activity to the end of the program in order to maximize the accessibility and expansion of the ecosystem. By retaining no-cost testing for SMNE/SEDI vendors we expect to help advance the maturity of the products provided by these vendors quickly and provide a reliable test service and assistance over the significant amount of time needed to develop Open RAN technologies.

As required by Section 3.2.f.10 of the Notice of Funding Opportunity, fees generated during the program will be offset against billing to the NTIA. These fees and the resulting cost share contribution are contingent on non-SMNE/SEDI vendors participating in test events in Years 4 and 5. We forecast that this cost share contribution could equal up to $3 million during Years 4 and 5. The rates below are intended to build the market for these services, entice participation by a wide variety of stakeholders, and to advance the adoption and deployment of Open RAN technologies by operators.

Lab Offerings	Year 4	Year 5
Single Test Event Participation	$37,500	$39,000
In-person daily lab rental	$5,000	$5,200
13 week test environment rental	$252,000	$260,000
Remote access (12-month license)	$16,600	$17,100

P. Facilities & Equipment

Currently, CableLabs/Kyrio has the equipment and facilities to test four vendors simultaneously or ten vendors on a rotational basis. In this proposal, we will double the capacity within Year 1 with two additional lab environments to provide capacity for additional Test Events, Test Assistance to SMNE/SEDI vendors, Neutral Host Lab capacity, and Development work. The following is a list of equipment that is available now. For information on the additional equipment planned to be purchased and contributed as a cost share for this project please see the Budget Narrative.

• Real 5G Core, Mavenir • 5G SA Core Emulator, Viavi & Keysight • UE Emulator, Viavi & Keysight • CU Emulator, Viavi & Keysight • RU Emulator, Viavi & Keysight • DU FH Emulator, Viavi & Keysight • 5G RAN (UE,RU,DU,CU), A1, O1, E2 Emulator • Network Protocol Analyzer, Wireshark Foundation • Traffic Generator, iPerf, Viavi, & Keysight	• Front/Mid/Back-Haul (xHaul) Transport Switch, FibroLAN • RF Signal & Spectrum Analyzer, Rohde-Schwartz & Keysight • RF Signal Generator, Rohde-Schwartz & Keysight • 5G NR Signal Analysis & Signal Generation SW, Rohde-Schwartz & Keysight • UE Signaling Post Processing Tool (Diagnostic Monitor), Qualcomm • UE Signaling Post Processing Tool (Analyzer), Qualcomm

Q. Long Term Sustainability

Through its subsidiary, Kyrio, CableLabs intends to continue to offer Open RAN testing services and Test Events beyond the period of performance. Kyrio will offer fee-based testing services, potentially including but not limited to:

- Leasing of entire test environments for industry organizations to run their own Test Events
- Leasing of entire test environments to operators and suppliers for customized periods
- Performing interoperability, performance, and security testing on behalf of operators or suppliers for a fee
- Performing fee-based badging and certification services for vendors to test against the specifications of the O-RAN ALLIANCE, TIP, or other industry organizations.

At the end of the period of performance, Kyrio will continue to operate the Federated Lab Sharing Community and will begin to charge fees to recover the cost of operating the Community.

R. Host Facilities for Other T&E

As described in Section II.A, a fully featured Test Environment will be dedicated to providing capacity as a Neutral Host for T&E activities outside the scheduled Test Events, alternating with Technical Assistance for SMNE/SEDI vendors and additional capacity for Test Events.

Test activities made available in this Neutral Host Test Environment will be tailored to the maturity and particular needs of the vendor seeking testing. The breadth of test plans currently available in the Test Events will be available to vendors interested in testing at a different pace or timing than the Test Events. Custom test plans provided by a vendor or operator can be tested in the Neutral Host Test Environment. This test environment will also be made available to Open RAN stakeholders who wish to hold a Test Event or other test activities not provided by CableLabs planned Test Events.

The testing activities described in Sections II.B.3, such as energy efficiency, may be conducted in the Neutral Host Test Environment based on market demand.

As part of our marketing and recruitment of participants for the Test Events we will offer this Neutral Host Test Environment and educate potential participants on the value of the additional services and flexibility of the schedule.

S. *Technical Assistance*

The expert staff at CableLabs/Kyrio established a test and certification lab infrastructure in the Open RAN space through our work on the 2022 and 2023 5G Challenges and as an O-RAN ALLIANCE OTIC. These Challenges and the O-RAN Plugfests involved many SEDI, small, or new vendors. Thus, CableLabs/Kyrio are uniquely qualified to provide technical assistance to small, medium, start up, and SEDI businesses for testing and product troubleshooting efforts. We are also able to play a system integrator role to assist in integrating the supplier equipment to a test environment or to the equipment from other suppliers. In this role, we can also provide research and development assistance and provide resources that these vendors may not have access to within in their company to help bring a product to maturity faster.

Technical assistance may also provide vendors with support on understanding and interpreting the test results, additional assistance in preparing to participate in a test event, analysis of lessons learned and recommendations for future steps a vendor can take to succeed in testing.

We see the value in providing tailored and individual assistance to small, medium, start up, and SEDI businesses to enable a diverse Open RAN ecosystem. We propose to offer the time, expertise, and facilities needed by these companies at no cost for the companies to encourage the development of these vendors and their products. Technical Assistance will be offered both during the scheduled Test Events and as part of the Neutral Host Lab that is not on the same schedule as the Test Events. Small, medium, start up, and SEDI businesses will receive priority access to Technical Assistance at no cost to the companies during the period of performance. We believe this level of expert assistance and resources provides easy accessibility and a path to success for these vendors.

T. *Environmental and Historic Preservation*

The work proposed above will not impact Environmental or Historic Preservation resources.

U. *Research Activities Involving Human Subjects, Data, or Recordings Involving Human Subjects Including Software Testing*

The work proposed above does not trigger the Human Subject Common Rule.

CableLabs Blue Ocean: An Architecture and Platform for Accelerating and Scaling Open RAN Testing R&D Proposal

I. Executive Summary

CableLabs proposes to research, architect, and develop an initial Proof of Concept (PoC) implementation of a novel and innovative Automated Open RAN Accelerated Testing Platform with the objective of:

- Significantly reducing the time required to test a multi-vendor Open RAN system against operator requirements,
- Achieving reductions in the cost of repeatable testing of vendor solutions,
- Increasing the Open RAN ecosystem's ability to scale and replicate test environments to create a significantly increased capacity for simultaneous testing of a large number of disaggregated solutions with reliable and repeatable testing results,
- Increasing efficiency: Increase lab resource utilization by at least 30% by efficiently minimizing downtimes via smart scheduling algorithms orchestrated by the Open RAN Accelerated Testing platform,
- Integrating directly with network operator test labs to eliminate redundancy and increasing operator confidence that a shared testing infrastructure can be an accelerator to their ability to deploy new Open RAN technologies, and
- Offering a reference architecture or template for neutral test labs or other labs, opening the possibility for test labs to play a real-time "in-line" role between producers and operators enhancing confidence to deploy Open RAN solutions at scale.

The time for this investment is now, prior to large scale operator deployments of Open RAN technology, while the ecosystem is still developing. Waiting to build this infrastructure will risk operators and their vendors making large and unnecessarily redundant investments in duplicative test capabilities, reducing the industry's efficiency.

II. Testing Methods Research Area

Under the *Blue Ocean* proposal, CableLabs and its wholly owned subsidiary, Kyrio, Inc., will research an Automated Open RAN Testing Platform Architecture, and develop an initial Proof of Concept of the Platform Architecture (the Platform) that creates several new methods for testing of Open RAN solutions:

- The Platform will allow the dynamic and concurrent testing of multiple vendor solutions through a unique virtual and physical interconnection backplane for rapid reconfiguration of the testing environment, so multiple groups or combinations of CU, DU, or RU solution can be quickly tested.
- The Platform will define a uniform Application Programming interface (API) to integrate with multiple test tools to enable selection of the right test tools dynamically to match the needs of a given test use case.
- The Platform will leverage cloud native test tools to enable re-deployment of the resulting platform under any testing administrative domain.

- The Platform will leverage Continuous Integration/Continuous Testing/Continuous Deployment (CI/CT/CD) principles to automate the testing pipeline for rapid repeatability.
- The Platform will be directly integrated with vendor and operator labs, allowing dynamic software updates to be re-tested immediately upon submission, and allowing both vendors and operators to rapidly achieve their testing needs.
- The Platform will provide direct visibility into testing progress and test results in near real time, allowing rapid iteration of software updates across vendors for re-testing.
- The Platform's capabilities will apply to all of NTIA's test objectives, including interoperability, performance, and security testing, allowing all of these test domains to benefit from the speed, repeatability, and scale of this innovative new testing platform.

Once CableLabs develops an initial Proof of Concept, CableLabs will provide the source code for the solution to any other entity that qualifies for NTIA grants under the Public Wireless Supply Chain Innovation Fund, with the execution of a community source agreement.

III. Identification and Significance of the Problem or Opportunity

Without automating for high scale and for the ability to dynamically mix and match test components the Open RAN ecosystem may suffer from delays in operator adoption, or no adoption at all by the network operator community. In the past, operators relied on their vertically integrated RAN vendors to perform systems integration and testing work on their behalf. In the disaggregated world of Open RAN, there is a greater integration burden, and it now needs to be shared by vendors, operators, test labs, and system integrators. Rather than each of these companies having to bear redundant costs in setting up cloud-native automated testing capability, doing it once and sharing it is a much lower cost and efficient path to success.

While the DoD-NTIA sponsored 5G Challenge and O-RAN ALLIANCE plugfests have been helpful in progressing toward vendor interoperability, CableLabs/Kyrio have learned through experience in operating these programs that there are limitations in the current state of the art of Open RAN testing. Specific challenges include:
- Testing only one set of Open RAN systems on a test tool at a time limits the scalability of testing to a small number of simultaneous vendor participants.
- Troubleshooting of vendor solutions during test events creates significant down time, causing under-utilization of expensive test equipment.
- During test events a test plan is executed with only one test tool being used at a time, again causing under-utilization of expensive test equipment.
- Serialized and manual testing is expensive and time-consuming and requires highly trained engineers.
- Test environments are highly customized and require significant manual effort to set up for each individual vendor solution.

CableLabs/Kyrio are not the only ones to recognize these issues. Others include:

- The National Spectrum Consortium notes, "[f]or interoperability and performance testing, the wireless community needs facilities with a wide mix of commercial equipment (traditional RAN and Open RAN) and software available on demand. It is not enough for labs to work with partners to set up the configuration of hardware and software needed just for a one-time, pre-

planned plugfest. These components must be acquired, installed, and maintained for ongoing usage."[1]

- The Open RAN Policy Coalition states, "[t]he most efficient solution would be for the industry to align on a framework that (1) helps coordinate the entire roadmap and lifecycle process, from the pooling of requirements at an industry level to establishing a 'marketplace' of commercial-ready products and solutions, and (2) creates a system release validation and certification process."[2]
- Attendees at the recent *Open RAN Global Forum* discussed that "a disaggregated radio system lets operators select the best component providers and build an optimal solution; conversely, the ability to mix and match hardware and software vendors means investing in complex interoperability testing and solution validation in an ongoing manner that aligns with the ability to push software-upgrades into a live RAN."[3]

These limitations will be addressed through the Automated Open RAN Accelerated Platform architecture along with a Proof of Concept (PoC) implementation under this proposal.

IV. Rationale for Need

The testing platform architecture proposed by the *Blue Ocean* project will define a new agile testing method for scaling and optimizing Open RAN system testing by operator and vendor neutral test labs. The testing method will adopt software integration, delivery, and testing methodologies proven in the enterprise agile software development ecosystem to meet the unique needs of the Open RAN ecosystem testing.

This proposal will benefit the Open RAN ecosystem by ensuring that testing is an integral "in-line" activity in the evaluation and delivery of Open RAN solutions. This will enable operators to adopt Open RAN systems with greater confidence, knowing that major software releases or solutions have been tested against a known base line feature set. The innovations proposed in the *Blue Ocean* research proposal will work to ensure that the testing process itself is optimized for device under test and the test inputs and deliverables have mechanisms to ensure traceability and repeatability.
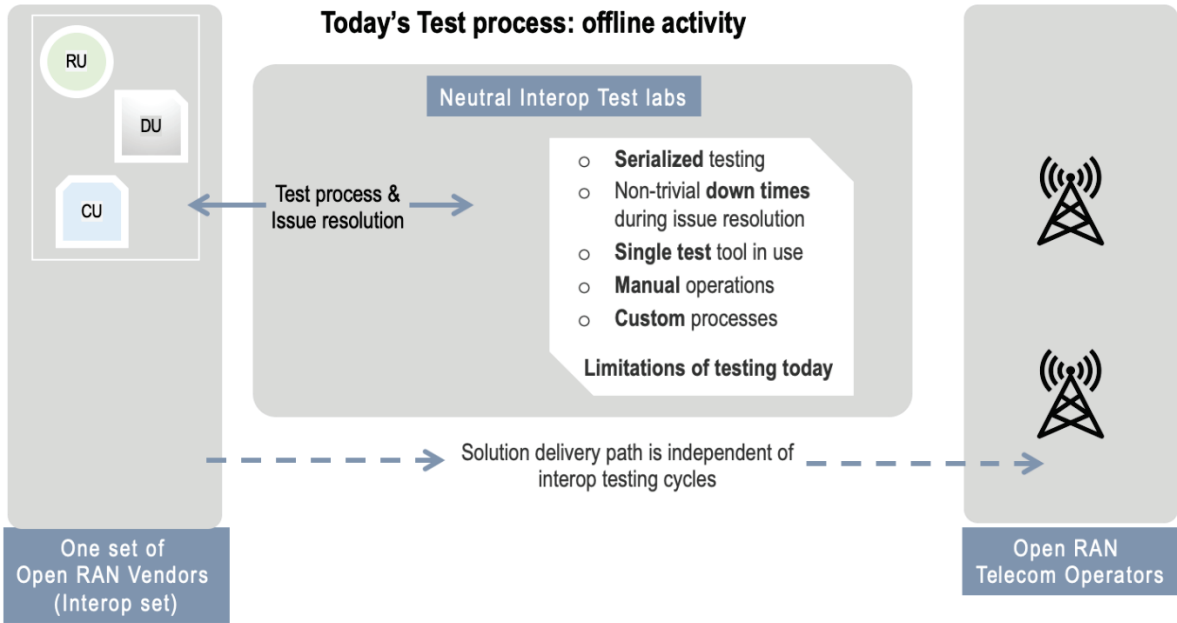
A key benefit of creating a highly efficient neutral test lab capability that can integrate with vendor and operator testing processes is that it removes the need for high investments in redundant test infrastructure by both vendors and operators, allowing them to share the resources at a neutral test lab. This benefit is illustrated in the diagrams below:
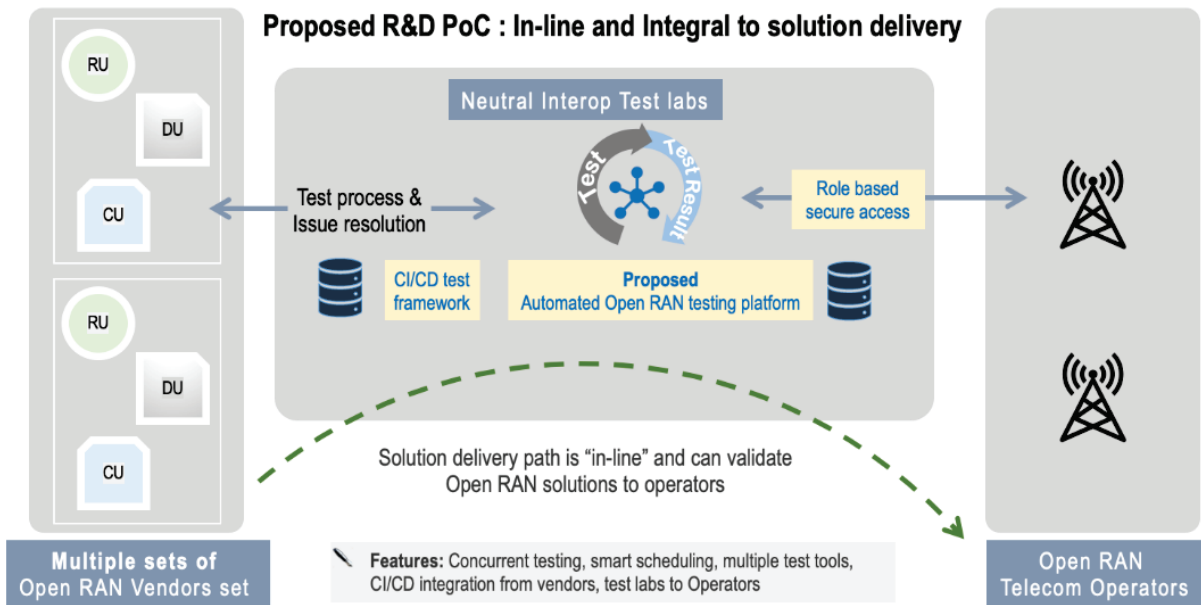
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[1] *See* Report on U.S. Resources and Capabilities for Accelerating Open RAN, National Spectrum Consortium, Jan. 24, 2023, available at: https://www.nationalspectrumconsortium.org/wp-content/uploads/2023/01/NSC-_Open-RAN-Advisory-Group-Report_Executive-Summary_01.24.23.pdf

[2] *See* Comments of Open RAN Policy Coalition to NTIA's Request for Comments on the Public Wireless Supply Chain Innovation Fund, Jan. 27, 2023, available at: https://www.openranpolicy.org/wp-content/uploads/2023/01/ORPC-Wireless-Innovation-Fund-Comments-AS-FILED-1.27.2023-c3.pdf

[3] *See* Kinney, S., *With Open RAN, there's the risk of trading vendor lock-in for system integrator lock-in*, RCRWireless News, Nov. 2, 2022. Available at: https://www.rcrwireless.com/20221102/open_ran/for-open-ran-testing-more-vendors-means-more-problems

Today's Test process: offline activity

Neutral Interop Test labs

Test process & Issue resolution

o **Serialized** testing
o Non-trivial **down times** during issue resolution
o **Single test** tool in use
o **Manual** operations
o **Custom** processes

Limitations of testing today

Solution delivery path is independent of interop testing cycles

One set of Open RAN Vendors (Interop set)

RU
DU
CU

Open RAN Telecom Operators

Today: Neutral Test labs are "**off-line**" and NOT part of the solution delivery process

Proposed R&D PoC : In-line and Integral to solution delivery

Neutral Interop Test labs

Test process & Issue resolution

Test / Test Result

Role based secure access

CI/CD test framework

Proposed Automated Open RAN testing platform

Solution delivery path is "in-line" and can validate Open RAN solutions to operators

Multiple sets of Open RAN Vendors set

RU
DU
CU

RU
DU
CU

Open RAN Telecom Operators

Features: Concurrent testing, smart scheduling, multiple test tools, CI/CD integration from vendors, test labs to Operators

R&D Proposal Objective: Neutral Test Labs capable of **mixing and matching** DUTs and test tools, running **multiple Open RAN interop tests** concurrently and, "**in-line**" and part of the solution delivery process

The *Blue Ocean* project's Platform follows a layered microservices architecture that can be extended to test 5G and future generation services and utilization of new test tools. This is enabled by the ability of the Platform to connect multiple systems together physically and use software to create logical sets of devices under test and dynamically map them to the corresponding test tools for a given set of tests. The Platform will be designed for a multi-vendor environment from the start, leveraging advanced configuration management tools to automate the rapid installation of each vendor's solution into the test bed. This method can be easily adapted to future network test tools and future generations of wireless standards.

V. Technical Objectives

The overall Technical Objectives are aimed at developing a Platform by:

- Developing and documenting an architecture that will dynamically select from multiple test tools and dynamically switch in a variety of vendor solutions to match the testing objective.
- Designing the security and confidentiality architecture for the Platform to accommodate a multi-vendor, multi-test tool, and multi-operator test environment that can be utilized by neutral test labs.
- Creating a testing architecture that can support concurrent test operations.
- Designing application programming interfaces (APIs) to communicate with multiple test tools and vendor solutions to achieve rapid integration with the test environment.
- Creating a Proof of Concept (PoC) that demonstrates the objectives documented in the Platform architecture.

Key questions to be answered by the *Blue Ocean* project include:

- Can a multi-tenant neutral host testing platform be created that preserves the confidential information of each participating operator and vendor?
- Can a multi-tenant neutral host testing platform be created that seamlessly integrates with multiple vendors and multiple operators via a CI/CD testing infrastructure?
- Can a multi-tenant neutral host testing platform be created that sufficiently abstracts the interfaces to testing tools such that different test tools can be leveraged to accomplish the same testing within the platform?
- Can a multi-tenant neutral host testing platform be created such that multiple vendor solutions can be tested concurrently and as needed dynamically switched into and out of a test harness with no manual intervention?

VI. Work Plan

The research will be broken into two phases for Year 1 and Year 2 respectively, as show in the work plan table below:

Task	Objective	Method
Year 1		
Form working group with industry organizations, operators, vendors, and test tool manufacturers to socialize research objectives and incorporate feedback	To get the ecosystem to consider the need for scaling testing capacity and soliciting feedback. Ensuring prioritization of feedback to deliver maximum impact during research window	Collaborate with industry groups like the O-RAN ALLIANCE, Telecom Infra Project (TIP), and other participants in the *Public Wireless Supply Chain Innovation Fund*
Develop and send for review with working group participants - the technical requirements document for the Platform (TRD)	List and prioritize the requirements based on research findings	
Kick off Hackathon	Utilize Hackathons and determine initial technical design for developing an early version of the automation architecture	
Publish a whitepaper	Whitepaper outlining challenges and high-level or interim solutions for increasing test efficiency	Publish paper for *Public Wireless Supply Chain Innovation Fund* community
Year 2		
Finalize R&D technical requirements document (TRD)	Objective will be to feed into Platform architecture design	
Document: Automation design architecture for Platform	Approve automation design of the implementation for Platform	Work with team of automation developers, principal architect and project leadership to conceive Platform architecture
Document: API specification	Define the APIs that will be needed to dynamically select multiple test tools	Work with popular test tool vendors and new entrants to document a library of APIs that can be used by automation tools
Proof of Concept (PoC):	Start and finish PoC demonstrating key concepts highlighted in the objectives	

The diagram below provides a high-level schematic of the proposed Automated Open RAN Accelerated Testing Platform.
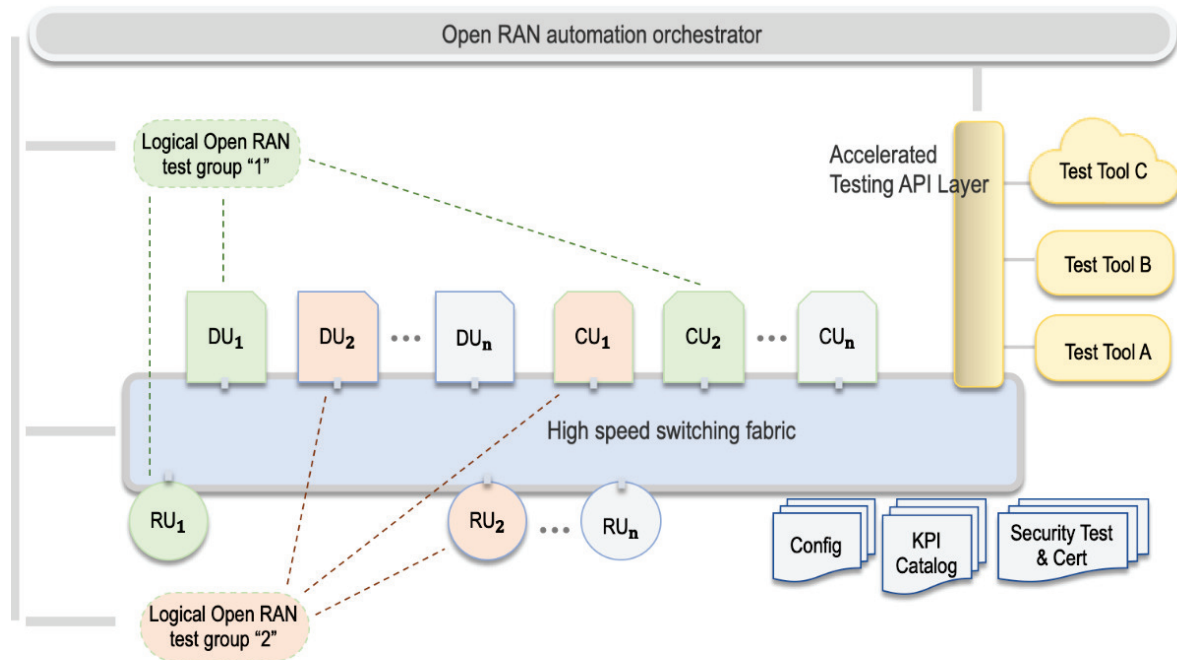
Conceptual picture of the **Automated Open RAN Accelerated testing platform**

The Work Plan will address the following architectural elements:

1) **Always-on concurrent framework:** Multiple RU/DU/CU devices from different manufacturers are connected physically to a switching layer in the test harness. The proposed platform will enable the test setup to logically select a sub-set of multiple devices such as RU, DU, and CUs to form a logical group of "Open RAN devices under test," at any given point of time, as shown in the figure above. This innovation will enable concurrent testing at the same time and significantly reduce test times.

2) **Device Under Test - configuration and integration times:** A major contributor to increased testing time is the complexity of provisioning the Open RAN devices with the appropriate software, configuration files, and other provisioning information. The innovation will address the utilization of software audit tools and automation tools to match the appropriate software to the Open RAN devices ensuring reliability and repeatability of the process.

3) **Plug-and-play test tools**: An important part of an improved Open RAN lab test architecture proposal is to have the ability to dynamically mix and match Open RAN devices with cloud native or on-premises test tools. This will enable labs to utilize multiple test tools via a common API framework that harmonizes the interface to invoke Open RAN tests. The test results from using a set of given test tools can be archived for offline analysis enabling vendors and operators to enable product and network optimization.

4) **Enterprise software testing capabilities**: The innovation will adapt and leverage proven enterprise industry communication tools and automation scripts to trace, track and monitor the status of tests and software, meeting the unique needs of the neutral test labs and if successful, we will add this PoC for use in the CableLabs Launch Ready T&E activities, if funded.

5) **Sharing is caring**: As part of Project *Blue Ocean,* we intend to collaborate with industry groups like Telecom Infra Project (TIP), O-RAN ALLIANCE, the Community proposed by CableLabs in the Launch Ready proposal, and other active Open RAN ecosystem participants in the testing process to share our research goals and the Proof of Concept. We also intend to publish papers and contribute to standards development organizations to share our learnings to advance the implementation of Open RAN testing platforms.

All research and development will be done at our main offices and labs in Colorado and California and remote locations in the United States as necessary.

The research will employ collaboration with other industry partners and be a mix of our own proposals and third-party proposals, validated by our Proof of Concept. We will host meetings at our offices and online to engage Open RAN stakeholders. The team will continue to participate and contribute to the O-RAN ALLIANCE, Telecom Infra Project (TIP), 3GPP, and other industry organizations and will continue to host O-RAN ALLIANCE plugfests in support of developing and furthering common and achievable requirements.

VII. Related Research and Development

The CableLabs and Kyrio team do extensive research on a variety of topics, some of which are relevant to the Open RAN space. We are participating and contributing to O-RAN ALLIANCE and 3GPP Work Groups. The papers and topics discussed provide an excellent source of information for our research. In addition, we are in discussions with Telecom Infra Project (TIP) regarding sharing each other's learnings in the Open RAN space. As part of the ongoing research effort, we will seek to coordinate and collaborate with additional outside parties.

In addition to industry standards and specification groups the team will also study white papers and research articles to ensure that the latest and the most effective methodologies are utilized in the Platform. Research to date has shown the viability of such a test platform but current implementations are vendor specific, leading to the need for the *Blue Ocean* project and the Platform. Some of the reference documents contributing towards our research are:

- S. Zhang, D. Fan, J. He and P. Zhang, "A New Approach for End to End Automation Testing Platform with Cloud Computing for 5G Product," 2021 International Conference on Computer Engineering and Application (ICCEA), Kunming, China, 2021, pp. 322-326, doi: 10.1109/ICCEA53728.2021.00070. Available at: https://ieeexplore.ieee.org/document/9581107

- C. Di Martino and A. Walid, "Continuous Testing and SLA Management of 5G Networks for Industrial Automation," 2021 IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW), Wuhan, China, 2021, pp. 378-386, doi: 10.1109/ISSREW53611.2021.00105. Available at:

https://ieeexplore.ieee.org/document/9700201

- Stradowski S., Madeyski L., "Exploring the challenges in software testing of the 5G system at Nokia: A survey," Inf. Softw. Technol. (2022), Article 107067, 10.1016/j.infsof.2022.107067. Available at: https://www.sciencedirect.com/science/article/pii/S0950584922001768

### VIII.	Key Individuals and Bibliography of Related Work

Chetan Hebbalae is the Vice President of Products at Kyrio Inc., a wholly owned subsidiary of CableLabs. Kyrio helps commercialize CableLabs R&D innovations and functions including testing-as-a-service for telecom operators and the cable industry. In this role, Chetan and his team are responsible for product research and development including automation of test-as-a-service products and 5G & Wi-Fi Convergence solutions. Prior to CableLabs/Kyrio, Chetan led ecosystem and technology development for advancing the role of unlicensed communications at Meta Platforms (formerly Facebook Inc). In addition, as co-chair of the Wi-Fi Solution group at the Telecom Infra Project (TIP) he actively led a coalition of operators, Enterprise IT, and technology vendors to advance the use of a TIP OpenWiFi, a disaggregated Enterprise grade Wi-Fi solution as well as initiatives on multi-radio convergence and coexistence solutions. Chetan's background includes over 25 years of product development and product management experience ranging from building GSM to LTE wireless cellular network products, test automation tools, and Home and Enterprise Wi-Fi products at companies such as Motorola Inc., Ruckus Wireless, and Cambium Networks. Chetan's experience includes serving Operators, Enterprises, Government, Defense, and Public Safety markets across the world.

Chetan holds an MBA from the Kellogg School of Business at Northwestern University, Evanston, IL, an M.S. in Computer Engineering from The Iowa State University, Ames. IA, and a B.S. in Electrical and Electronics from The University of Madras, India.

Annie George is Director of Wireless Engineering and Operations at Kyrio, Inc., a wholly owned subsidiary of CableLabs. Kyrio and CableLabs are dedicated to creating and driving technologies and innovations, including 5G and Wi-Fi 7 testing. One of Annie's main responsibilities at Kyrio/CableLabs is to direct the operations of the 5G lab activities and technical test team that is host to the NTIA 5G Challenge for Open RAN development as well as internal R&D activities and projects. Annie has been active in multiple industry standard organizations, including WBA, CTIA, and O-RAN ALLIANCE, and has contributed to multiple internal Wi-Fi and 5G projects.

Prior to CableLabs, Annie built, managed, and operated 2G, 3G, and 4G networks and managed the device technical team for T-Mobile. She also developed a corporate research lab that focused on network and device performance. Annie has also worked as a Principal PM/Director at Microsoft in the Windows Phone division during which she managed the connectivity layers of the platform from requirements to testing and post-launch support. In these roles she interfaced with key players (from chipset manufacturers to operators) and developed an optimized Software layer for connectivity. Annie is also an entrepreneur that developed an innovative and patented cloud-based system to test, analyze, and optimize wireless networks and devices. This system was used by Tier 1 carriers in the US during 4G and 5G deployment. Annie has been in the wireless industry for over 28 years and is proud to see the networks and products she worked on still in use. Annie received her Engineering degree from

University of Madras, India and has done graduate studies in Electrical Engineering and Communications.

IX. Qualification of Application

CableLabs is uniquely qualified to run the *Blue Ocean* project and develop the Platform due to our technical experience and leadership in the 5G and Open RAN ecosystem and our long history as leaders and contributors to wireless standards organizations such as the O-RAN ALLIANCE, 3GPP, OnGo Alliance, Wireless Innovation Forum, and Wi-Fi Alliance. CableLabs is regarded as a thought leader in the wireless industry and is frequently asked to provide insight to a variety of stakeholders on technical and strategic matters.

CableLabs has a long history of providing a vendor neutral host lab opportunity to the wired and wireless industries to enable development of new technology and vendor equipment (hardware and software). For example, CableLabs has hosted several industry events for the Wi-Fi Alliance (WFA), OnGo Alliance, and Wireless Innovation Forum.

Most recently, CableLabs was selected by NTIA to host the 5G Challenges of 2022 and 2023 to design, manage, and conduct test activities with Open RAN vendors. In doing so, CableLabs gained valuable and unique insight and developed further expertise in system integration and interoperability across Open RAN vendor participants in the Challenge. From this experience, we have developed a deep understanding of the challenges and limitations of Open RAN interfaces, test plans, interpretation, and implementations of Open RAN and 3GPP requirements. We have also developed unique troubleshooting skills and closely partnered with test equipment vendors to lead test and troubleshooting efforts to identify root cause, analyze issues against industry specifications, and bring issues to resolution.

In the Open RAN space, we have a history of sharing lessons learned with NTIA, vendors, and test equipment vendors that are also translated into contributions to the O-RAN ALLIANCE WGs to improve and build upon current requirements and test plans.

CableLabs' wholly owned subsidiary Kyrio, was approved to be an O-RAN ALLIANCE OTIC in 2022 and has conducted two plugfests with industry participants.

With this broad and deep expertise and hands-on experience of Open RAN test and development, CableLabs can leverage its experience as a neutral Host Lab to help the ecosystem coalesce around the most important and widely used baseline criteria for the most common deployment use cases.

The key personnel conducting this R&D project each have over 20 years of experience in the wireless industry that span operator and vendor backgrounds and include design, build, deployment, operations, and test of 4G, 5G, and Open RAN networks. In addition, the project team has many years of experience working with the operator and vendor community and Open RAN stakeholders that will be leveraged to inform the technical questions posed above. The proposal team is well-versed in SDO Working Groups (i.e., in 3GPP, O-RAN ALLIANCE, OnGo Alliance, Wireless Innovation Forum, WFA) as leaders and contributors. This level of expertise and leadership is needed to collaborate with industry to successfully meet the objectives of the *Blue Ocean* project and the Public Wireless Supply Chain Innovation Fund.

X. Facilities and Equipment

Project *Blue Ocean* will be conducted at CableLabs' state of the art Open RAN test facilities using equipment currently in place when necessary. No new equipment will be purchased to conduct the work proposed above. The project team does intend to license Saas services to create the Platform PoC; these software services include:

- Service for managing distributed software development and version control with role-based access controls
- On premise or cloud hosted 5G Open RAN compliant test tools as a service
- Cloud infrastructure hosting services
- Open-source automation server services to consume builds, test, deploy, and trigger event driven actions
- DevOps tool services to build and manage infrastructure across cloud providers
- Visual analytics and report generation services
- On-line project management services
- API test services for project developers to design, build, and test API definitions and functionality
- File hosting and storage services
- 5G network components
- Log collection tools

Project location will be CableLabs' offices in Colorado and California and remote offices in the United States, as needed.

XI. Consultants, Contracts, & Subawards

CableLabs will not be entering into any agreements with any consultant, contractor or subawardee to perform the work proposed above.

XII. Current and Pending Support

The table below provides a list of resources per labor category with individual contributor with workload distribution if the *Blue Ocean* proposal is funded.

The period of performance for the 5G Challenge ends March 29, 2024. Total 5G Challenge 2023 contract award amount was $6,634,502.

The proposed period of performance for the CableLabs Launch Ready project that may be funded by NTIA is five years, starting the date of the grant award with a proposed budget for federal support of $43,447,582.

Key Personnel	Role for Blue Ocean R&D proposal	Blue Ocean proposal (Pending NTIA PWSCIF funding)	CableLabs Launch Ready Proposal (Pending NTIA PWSCIF funding)	5G Challenge (Currently funded by NTIA)	Kyrio funded work
Annie George	Project Leadership	15% (approximately 1.8 months)	20% (approximately 2.4 months)	20% (approximately 2.4 months)	45% Wi-Fi and other wireless testing and innovation (approximately 5.4 months)
Chetan Hebbalae	Program Leadership	10% (approximately 1.2 months)	10% (approximately 1.2 months)	0%	80% on other Kyrio projects (ARC Hotspot ARC Mobile Test Automation Go To Broadband) (approximately 9.6 months)

XIII.   Cybersecurity

CableLabs has implemented reasonable and appropriate cybersecurity controls and procedures for an innovation and research and development lab. In developing our controls and procedures, we have leveraged the NIST Cybersecurity Framework, CISA Cross-Sector Cybersecurity Performance Goals, CIS v8, NIST SP 800-53, and other industry best practices and we monitor these best practices to continually advance our controls and procedures as the threat environment evolves.

More specifically, CableLabs has meaningfully implemented controls and procedures under the relevant NIST Cybersecurity Framework Functions. Under Identify, for example, CableLabs has identified and named cybersecurity leadership, has an asset inventory procedure, mitigates known vulnerabilities, and regularly employs third-party penetration testing. Under Protect, for example, we require that any default passwords are changed, employ multi-factor authentication and unique credentials, revoke credentials for departing employees, employ network segmentation for different environments, secure logging of unsuccessful login attempts and other security events, conduct regular cybersecurity training for all employees, employ email and transport layer security, conduct regular backups, and have an updated incident response plan. Under Detect, we employ commercial prevention and detection systems to detect instances of key threats. Under Response, we have implemented necessary incident reporting procedures. Under Recover, we have defined procedures to recover and restore to service organizational systems that might be impacted by a cybersecurity incident.

The activities set forth in this proposal are similar in nature to CableLabs' current research and development activities, and we do not anticipate any significant gaps. However, as we plan, design, and implement the proposed project, we will revisit our cybersecurity controls and procedures to ensure we remain in line with current best practices, and we will address any gaps identified in that process to ensure the appropriate controls and procedures, including those listed in the Notice of Funding Opportunity, are in place for the proposed project.

XIV.   Cybersecurity Supply Chain Risk Management

CableLabs has processes in place to address the NIST C-SCRM Foundational Practices as they apply to the services CableLabs provides. Specifically, CableLabs has a core multidisciplinary cybersecurity team that develops and manages cybersecurity policy and processes, which includes C-SCRM as applicable for CableLabs and its subsidiaries, including Kyrio. This cybersecurity team has full leadership support for its work and annually reviews its policies and procedures to assess changes in risks and risk mitigation. CableLabs and its subsidiaries currently benchmark security practices to the CIS Critical Security Controls framework. CableLabs and Kyrio have taken measures in its equipment acquisitions and processes to maintain redundancies and security in their operations, so the testing laboratory remains fully operational and maintains the confidentiality, integrity, and availability of laboratory test results. Additionally, these laboratories undergo annual ISO/IEC 17025:2005 accreditation to ensure that the laboratory processes, equipment calibration, and procedures meet international standards.

XV.   Environmental and Historic Preservation

The work proposed above will not impact Environmental or Historic Preservation resources.

XVI.   Research Activities Involving Human Subjects, Data, or Recordings Involving Human Subjects Including Software Testing

The work proposed above does not trigger the Human Subject Common Rule.