

University of New Hampshire InterOperability Laboratory Comments on Public Wireless Supply Chain Innovation Fund Implementation by the NTIA

Overview

As U.S. network operators and industry move towards deployment and support of 5G wireless systems and networks, a number of new and unique opportunities exist to expand and support the collaboration between suppliers, network operators, and academia. Beginning with 5G deployments, the technologies and systems, for the first time, are being pushed into an open and disaggregated design and specification. From the top level standards created within the 3GPP and ITU, definitions of interfaces and reference points are intended to lay out clear foundations for interoperable and heterogeneous networks. Supporting organizations, such as the O-RAN Alliance, have further developed this work, extending the specifications for disaggregation into the RAN and promoting interoperability between their participants.

Within the U.S. some efforts and collaborations between industry and other organizations exist today and have contributed to the early development and success of 5G. These efforts have traditionally focused on the research and development of new technologies necessary to enable 5G. Today, as 5G moves directly into reality and the specification development of Open RAN systems moves towards maturity, the next generation of collaborations will need to focus on topics pertinent to deployment, such as interoperability, integration, and certification. Unfortunately, the current activities in the U.S. are lacking in these “rubber meets road” efforts. As noted in the National Spectrum Consortium’s report, “Report on US Resources and Capabilities for Accelerating Open RAN,” far fewer organizations, test beds, and laboratories, are focused on practical testing, interoperability, or integration efforts. Where those efforts exist today, they are typically tightly coupled to specific network operators, and may be limited to those operator’s specific deployment, testing, or commercial interests.

Investment into U.S. laboratories, testbeds, and work, focused on the development of interoperable, open RAN systems will ensure the industry and U.S. deployments can hit the critical mass necessary to avoid future issues arising from changing supply chains or supplier biases. Further, as the market continues to develop, new participants, startup companies, open source projects, and other disruptors will play an increasing role within the 5G and 6G technology spaces. Ensuring U.S. based resources, test beds, and openly available laboratories are available to the whole industry will accelerate these efforts and technologies.

Question Responses

Questions on the State of the Industry:

1. *What are the chief challenges to the adoption and deployment of open and interoperable, standards-based RAN, such as Open RAN? Are those challenges different for public vs. private networks?*
 - a. *What are the challenges for brownfield deployments, in which existing networks are upgraded to incorporate open, interoperable, and standards-based equipment?*

Deployment of Open RAN based networks will ultimately depend on the availability and maturity of the Open RAN specifications and equipment. The specification development is currently well established and is quickly approaching this level of maturation, leaving open the question of equipment availability and maturation. Multiple companies and open source organizations are developing products according to the specifications, however there is a definite lag in the interoperability between these systems. Industry activities are attempting to address the challenge of interoperability, such as O-RAN Alliance sponsored plugfests. Industry members are able to openly participate in these events, but there are fewer options for longer term, larger scale, interoperability testing in lab environments. Some activities are also taking place in network operator labs, however, those are more typically limited to partners or specific suppliers of the network operator responsible for the lab.

2. *What ongoing public and private sector initiatives may be relevant to the Innovation Fund?*
 - a. *What gaps exist from an R&D, commercialization, and standards perspective?*
 - b. *How might NTIA best ensure funding is used in a way that complements existing public and private sector initiatives?*

Ongoing activities with the O-RAN Alliance, such as interoperability plugfests and the certification program development, as well as activities from the Linux Foundation, such as the development of the 5G Super Blueprint, are directly applicable to the development of an open and interoperability 5G RAN. Specifically, the open nature of these activities encourages and promotes participation industry wide, and by design, prevents monopolization by incumbent suppliers (i.e. it is possible for smaller start up companies or disruptors to participate in efforts).

3. *What kind of workforce constraints impact the development and deployment of open and interoperable, standards-based RAN, such as Open RAN? How (if at all) can the Innovation Fund help alleviate some of these workforce challenges?*

Mobile network technologies, in general, have a steep learning curve. This, coupled with limited access to test beds or learning environments (i.e. non-production networks), can make it difficult for learning institutions or universities to provide opportunities for hands-on training and learning to their students. Providing and developing programs, where universities, or similar institutions, can host and make available test beds, learning / training networks, and develop course materials. It should also be possible for universities and organizations to develop programs available to both traditional university students (i.e. computer science or engineering students) and professional development participants (i.e. a

company employee being sent for specific training). In setting the parameters for the development of training programs, care should be taken to emphasize the development training about the 5G and Open RAN, compared to training for the consumption of 5G services (i.e. building an IOT sensor), as many opportunities for the latter already exist today.

4. *What is the current climate for private investment in Open RAN, and how can the Innovation Fund help increase and accelerate the pace of investment by public and private entities?*

No specific input to this question.

5. *How do global supply chains impact the open, interoperable, and standards-based RAN market, particularly in terms of procuring equipment for trials or deployments?*

Recent global supply chain issues have driven stronger desires from the network operator community to diversify equipment deployed within their network. These efforts will depend on interoperability between the Open RAN components, and is an additional motivation for the plugfests and similar activities. An ideal state would see interoperability between all components within the RAN, such as a deployment using two+ suppliers for the central units (O-CU), distributed units (O-DU), and radio units (O-RU) devices, where any mix of the equipment is supported. Similarly, it should be possible for a network operator to onboard a new, additional, supplier, without having to replace the other components within the existing deployment, preventing future supply chain issues.

Questions on Technology Development and Standards:

6. *What open and interoperable, standards-based network elements, including RAN and core network elements, would most benefit from additional research and development (R&D) supported by the Innovation Fund?*

In the ideal case, all interfaces and reference points, described by the 3GPP and ITU specifications, as well as those described by the O-RAN alliance, the Broadband Forum, and other standards organizations, should be interoperable between implementations from two or more suppliers. This ensures, first, that updates or maintenance within a deployment is not monolithic (i.e. forklift upgrade of all components), and second it can support the selection of best of breed components from different suppliers and supply chain diversity.

In practice, it is likely the initial interoperability and interworking between suppliers will focus on the larger logical / functional components of the network, compared to the more internal interfaces within the architecture. For example, interoperability between the AMF, SMF, UPF, and gNodeB might gain the first focus, while follow-on work might further split the gNodeB into Open RAN components (RU, DU, and CU) from multiple suppliers. Additionally, interoperability between the transport components and protocols within the Open RAN (front-haul and mid-haul), will also be critical to the successful deployment of the disaggregated Open RAN systems. Establishing open laboratory environments focused on interoperability and integration testing will assist and accelerate the solution development for

these challenges, as there are limited laboratory environments available for this purpose today. Interoperability and integration testing could be viewed as the “rubber meets road” efforts, working directly with the larger ecosystem of standards bodies, product developers, and network operators, compared to other laboratory efforts focused on specific research and development efforts, such as antenna designs, software defined radios, or energy efficiency.

In summary, the stated goals of funding should drive to full specification and interoperability of each reference point defined within the open standards. Definition of requirements and test specifications / plans to validate those goals, with open industry review and participation, will create a clear roadmap to achieve the open, interoperable, and disaggregated RANs and 5G networks that are desired, and necessary for the future.

7. *Are the 5G and open and interoperable RAN standards environments sufficiently mature to produce stable, interoperable, cost-effective, and market-ready RAN products? If not:*
 - a. *What barriers are faced in the standards environment for open and interoperable RAN?*
 - b. *What is required, from a standards perspective, to improve stability, interoperability, cost effectiveness, and market readiness?*
 - c. *What criteria should be used to define equipment as compliant with open standards for multi-vendor network equipment interoperability?*

The standards and specifications for mobile networks (and all technology) will always evolve. The mobile and telecommunications industry has adopted a clear model of releases and minimum viable product (MVP) for the features and requirements on the network functions and equipment. The currently frozen release from 3GPP, along with the specifications from the “July 2022 Train,” provide enough information and detail for the industry to implement and produce products for the 5G Core Network and 5G RAN. Products based on these, and earlier released, specifications are already undergoing testing within the lab environments or events (i.e. plugfests).

In both of these standards bodies, vibrant participation from the industry is underway, with companies and organizations from around the world participating in the development efforts. Given this level of participation, we would not recommend allocating or directing funds to the goal of increasing participation.

In answer to part c), O-RAN Alliance maintains a number of specifications that define conformance testing for implementations of the O-RAN components. These specifications are used as part of their certification and lab program. However, vendor / supplier participation within that program, submitting a product for testing and certification listing has been limited to date. Key to the success of any certification program, is the adoption of the program by end users, in this case 5G network operators. Because participation in any testing or certification program represents a cost to the vendor / supplier, many wait until customers issue mandatory requirements for the certification or testing reports, typically as part of the RFP or tender processes.

While the O-RAN testing and certification program has not yet established the ecosystem of tested and certified O-RAN equipment, it has created a number of strong components. The definition of testing, in the form of industry developed and agreed test plans, are readily available. This process ensures the test requirements and methods are developed in a transparent manner, and can represent the interests of the overall industry, in the same manner as the development of standards, as compared to more privately developed, or siloed testing programs that might serve the interests of a specific organization, supplier, or end user.

8. What kinds of projects would help ensure 6G and future generation standards are built on a foundation of open and interoperable, standards-based RAN elements?

One of the key aspects of 5G development was a focus on first developing a common understanding of key use cases intended to be directly supported through 5G. The use cases provided a “compass heading” of sorts, as the development worked focused on meeting those requirements. A second key tenant was a look to forward compatibility, specifically in the radio specification, to avoid challenges that exist today in co-operating 3G with 4G-LTE or 4G-LTE with 5G. At this time, 6G projects should start to focus on research around the use cases to develop requirements on the network.

Questions on Integration, Interoperability, and Certification:

9. *How can projects funded through the Innovation Fund most effectively support promoting and deploying compatibility of new 5G equipment with future open, interoperable, and standards-based equipment?*
 - a. *Are interoperability testing and debugging events (e.g., “plugfests”) an effective mechanism to support this goal? Are there other models that work better?*

Access to interoperability testing, both within lab environments and at scale are critical to the implementation and verification of products based on open specifications. To date, there is very limited access to these testing resources outside of the network operator’s labs. Operator labs are focused on testing of partners and equipment driven by business and commercial considerations of the operator (this is not a criticism, as their primary focus is on the deployment and maintenance of services on their networks).

To support and enable new vendors, equipment, and products beyond the traditional incumbents, it will be absolutely necessary to develop an ecosystem of open laboratories, focused on interoperability and integration testing. It’s similarly important to distinguish these lab activities from those of research and development type activities. Many vendor and academic organizations are already engaged in research activities to develop everything from new antenna designs to AI enabled RICs systems. Interoperability testing and integration laboratories instead focus on verification of interfaces and references points within finished or nearly finished products as they move toward production deployments. These labs may also focus on performance, scale, load, robustness, or efficiency testing, which are critical factors in the deployability of a product or system into production.

Interoperability plugfests are one step along the road for interoperability and integration testing, but do not reach the final destination. Plugfest activities most typically occur earlier in the design or standardization efforts, allowing participants to bring early implementations or proof of concept equipment together, with the goal to validate both those implementations as well as the specifications or standards it was built from. Outcomes from plugfests are typically feedback to the standards organizations, to facilitate improvements within the specification or provide guidance towards future revisions or releases.

An ideal scenario within 5G and Open RAN testing activities would see the combination of longer lived laboratory resources with ongoing plugfest activities. For example, a laboratory supporting long term integration and interoperability testing, with 5G core networks, radio networks, and other resources deployed for on going testing activities could provide those resources to plugfest activities, making it easier for plugfest participants to integrate into existing networks, without needing to “carry in / carry out” all of the infrastructure for each individual test event. To that end, funding that can be allocated to projects to enable development of interoperability and integration testing laboratories should include goals and requirements to also support open plugfest events. Access to the lab, events, and testing resources should follow a RAND (reasonable and nondiscriminatory) approach.

10. How can projects funded through the program most effectively support the “integration of multi-vendor network environments”?

From the National Spectrum Consortium’s report, “Report on US Resources and Capabilities for Accelerating Open RAN,” it is clear the US is missing key laboratory resources focused on interoperability, integration, and performance testing. Most existing laboratory activities have focused on research and development of 5G. Developing and providing funding opportunities to establish laboratories and openly available testbeds will accelerate the availability of interoperable solutions (i.e. it will make possible an Open RAN deployment where components are selected from multiple suppliers, without then requiring dedicated integration and development activities that would be carried out by the network operator or their integrator partner). Open and reasonable access to such testbeds and laboratories will also support the development of an ecosystem that can include “new players.” Where those new participants might bring new approaches or disruptive technologies, and would otherwise face challenges to test their solution or product in labs or test beds dominated by incumbent vendors.

11. How do certification programs impact commercial adoption and deployment?

- a. Is certification of open, interoperable, standards-based equipment necessary for a successful marketplace?*
- b. What bodies or fora would be appropriate to host such a certification process?*

Certification programs can complement and support commercial adoption and deployments, but are not necessarily a requirement or a blocking issue. Development of any certification program should always be viewed similar to a product development cycle, with the first question being, “Who is the consumer of the certification (i.e. the product)?” followed by the question, “What are the pain points of that customer that will be prevented or lessened by

the certification?” To this end, certification programs nearly always represent and embody some form of commercial relationships between the certification consumer and the entity pursuing the certification. That relationship might be driven through market pressures (i.e. product consumers enforce requirements on their suppliers) or external pressures (i.e. regulatory requirements).

In the absence of either of a driving pressure, certification programs tend to not meet their stated goals, as pursuit of a certification (even self testing or self declaration) represents a cost to the parties involved. If not required to meet customer demands, industry participants may judge the costs of participation in the certification as outweighing the perceived value of the certification.

One of the arguments in creating value for/from such programs is through the development of common test plans and requirements, where value of the program is created through products “meeting” the requirements of multiple potential customers. This necessitates the participation of those potential customers in the development of the test plans and the program, as well as their reference to the certification program, its test plans, and requirements. Such efforts have already been started within the O-RAN Alliance, its OTIC (Open Testing and Integration Centres) program, and the development of test plans and requirements based on its specifications. However, the industry has not yet demonstrated commercial demand for the certifications, likely due to the limited number of Open RAN trials or deployments at this time.

It should also be noted, certification programs are not a requisite to develop an open, interoperable technology and market. Most notably, Ethernet has been widely developed and deployed for years (decades), and has seen multiple revisions, enhancements, and technology increases, through the IEEE standards development processes. Throughout its history, there has never been a formal certification program for an Ethernet interface, yet the market, through its desires to promote the proliferation of Ethernet ports, has continuously focused on interoperability as a core requirement of the technology and specifications. This focus on interoperability could be viewed as an informal certification.

12. *What existing gaps or barriers are presented in the current RAN and open and interoperable, standards-based RAN certification regimes?*
- a. *Are there alternative processes to certification that may prove more agile, economical, or effective than certification?*
 - b. *What role, if any, should NTIA take in addressing gaps and barriers in open and interoperable, standards-based RAN certification regimes?*

The largest gap at present is the market pressures driving formal testing and certification. Testing specification, laboratories, and tools currently exist in various states of development, however, there has been limited demand on such services, based on network operator or end user requirements.

The industry has shown some interest and demand on interoperability testing in general, as seen by the global participation levels in events such as the O-RAN Alliance plugfests. These events, which occur twice per year, drive informal testing and opportunities for participants to collaborate and demonstrate the current state of their implementation.

An alternate approach to a formal certification program might be the support and development of “integrators lists,” where companies participating in testing have a means to publicly declare the outcome of that testing. Integrator lists tend to be more informal than certification programs. For example, an integrators lists might allow publishing of both self test results and 3rd party lab results, or may allow for more options within the test plan (i.e. allowing older or newer versions of the test plan).

In any selected case or approach, “buy in” and participation from the industry will be necessary to establish the certification ecosystem and business cycle.

Questions on Trials, Pilots, Use Cases, and Market Development:

13. What are the foreseeable use cases for open and interoperable, standards-based networks, such as Open RAN, including for public and private 5G networks? What kinds of use cases, if any, should be prioritized?

Through the adoption of open and interoperable standards-based solutions, one (of many) use cases that can be supported is greater resilience in the face of disaster recovery. Open and interoperable O-RUs could readily be replaced with those from alternate suppliers should there be a supply chain limitation in the quick restoration of service in impacted areas.

Similarly, as networks are maintained and expanded over time, interoperable, standards based components, can be replaced as necessary, without the need to replace or upgrade the entire network (or a considerable amount of the network).

14. What kinds of trials, use cases, feasibility studies, or proofs of concept will help achieve the goals identified in 47 U.S.C. 906(a)(1)(C), including accelerating commercial deployments?
a. a. What kinds of testbeds, trials, and pilots, if any, should be prioritized?

In the current environment, there is limited availability of test beds focused on interoperability and integration testing of Open RAN technologies. Existing environments tend to be coupled to specific network operators, and may be limited to their technology or supplier partners, or may be focused on their specific market or business considerations. To ensure the development and promotion of open, interoperable networks, and the open market of suppliers into those networks, it will be critical to ensure there is open access to testbeds, laboratory testing, and trial or experimental deployments. As aforementioned, the Ethernet technologies show a clear motivation and example for how large, interoperable markets can be developed around a specific technology with the “buy in” from the industry participants. Establishing US based heterogeneous testbeds, open to the industry, and uncoupled from specific network operator deployments or use cases will accelerate the

development of interoperable products and will likely promote the participation of newer, smaller, or startup, companies that might otherwise not have access to such resources.

15. *How might existing testbeds be utilized to accelerate adoption and deployment?*

As shown in the “Report on US Resources and Capabilities for Accelerating Open RAN,” there are currently very limited testbed resources within the US focused on Open RAN, especially around interoperability or heterogeneous networks. A core focus of funding should emphasize the development of laboratories focused around interoperability and integration testing. These resources should complement many of the existing laboratory resources focused on research that exist today.

16. *What sort of outcomes would be required from proof-of-concept pilots and trials to enable widespread adoption and deployment of open and interoperable, standards-based RAN, such as Open RAN?*

Laboratory testing, trials, and proof-of-concept efforts, should be promoted back to the industry and public, through white papers, seminars, conferences, and other typical means. Striking a clear balance between reporting requirements, while protecting the investment by participants in the testing will be critical to the success of any laboratory. Similarly, establishment of laboratories, testing, and training networks, should also promote the creation of workforce development programs.

Questions on Security:

17. *“Promoting and deploying security features enhancing the integrity and availability of equipment in multi-vendor networks,” is a key aim of the Innovation Fund (47 U.S.C 906(a)(1)(C)(vi)). How can the projects and initiatives funded through the program best address this goal and alleviate some of the ongoing concerns relating to the security of open and interoperable, standards-based RAN?*

- a. *What role should security reporting play in the program’s criteria?*
- b. *What role should security elements or requirements, such as industry standards, best practices, and frameworks, play in the program’s criteria?*

No specific input to this question.

18. *What steps are companies already taking to address security concerns?*

No specific input to this question.

19. *What role can the Innovation Fund play in strengthening the security of open and interoperable, standards-based RAN?*

No specific input to this question.

20. *How is the “zero-trust model” currently applied to 5G network deployment, for both traditional and open and interoperable, standards-based RAN? What work remains in this space?*

No specific input to this question.

Questions on Program Execution and Monitoring:

21. *Transparency and accountability are critical to programs such as the Innovation Fund. What kind of metrics and data should NTIA collect from awardees to evaluate the impact of the projects being funded?*

Given the goal to promote and develop open, interoperable, 5G and Open RAN systems, key metrics around the number and type of partners participating in a funded activity should be monitored. Similarly, tracking the size or scale of heterogeneous testbeds or trial deployments, showing a clear demonstration of the interoperability between the participants within that test should be monitored. Monitoring or requirements should encourage collaboration between the partners and industry participants, to avoid the expansion of siloed or single source networks, testbeds, or trials.

22. *How can NTIA ensure that a diverse array of stakeholders can compete for funding through the program? Are there any types of stakeholders NTIA should ensure are represented?*

No specific input to this question.

23. *How (if at all) should NTIA promote teaming and/or encourage industry consortiums to apply for grants?*

Collaboration will be key to the successful development of open, interoperable, 5G and Open RAN systems. Funding opportunities should strongly encourage organizations to establish partnerships and relationships with both industry and other related organizations.

24. *How can NTIA maximize matching contributions by entities seeking grants from the Innovation Fund without adversely discouraging participation? Matching requirements can include monetary contributions and/or third-party in-kind contributions (as defined in 2 CFR 200.1).*

No specific input to this question.

25. *How can the fund ensure that programs promote U.S. competitiveness in the 5G market?*

- a. *Should NTIA require that grantee projects take place in the U.S.?*
- b. *How should NTIA address potential grantees based in the U.S. with significant overseas operations and potential grantees not based in the U.S. (i.e., parent companies headquartered overseas) with significant U.S.-based operations?*
- c. *What requirements, if any, should NTIA take to ensure "American-made" network components are used? What criteria (if any) should be used to consider whether a component is "American-made"?*

Yes, any funding should include requirements for the primary recipient or principal investigator to reside within the U.S. and report to a U.S. organization or university. Funding should be directed to opportunities to establish testbeds, laboratories, research, and workforce development activities within the U.S.

The pedigree of network components represents a more complex question, for example, if a whitebox hardware product runs software, where the hardware is produced overseas, while the software is "American-made," that end product (i.e. the complete HW / SW) solution likely represents an "American-made" product. Similarly, what level of the components integrated into an end product would be required as "American-made," and does the specificity of the component play a role. For example, would both a common PC or server

and the customized software defined radio card hosted inside be weighted the same in the consideration of the product origin.

Overall, care should be taken to avoid limiting innovation, due to the component sourcing, while focused on building the resources within the U.S. available to the industry.

26. How, if at all, should NTIA collaborate with like-minded governments to achieve Innovation Fund goals?

No specific input to this question.

Additional Questions:

27. Are there specific kinds of initiatives or projects that should be considered for funding that fall outside of the questions outlined above?

No specific input to this question.

28. In addition to the listening session mentioned above and forthcoming NOFOs, are there other outreach actions NTIA should take to support the goals of the Innovation Fund?

No specific input to this question.