

Thank you for the opportunity to comment on the Public Wireless Supply Chain Innovation Fund. It is essential to support a robust interoperable multivendor environment to protect our national interests. We believe these objects are best met by (1) providing cheap and open independent testing and certification so that small businesses can prove that they work and interoperate without barriers to entry, and (2) supporting the Open RAN software community include Open Air Interface, SRS RAN, and other projects both independent and part of the Linux Foundation Networking to limit duplication of effort allowing industry, government, and universities to focus their effort on innovation to improve capacity, capability, reliability, and most importantly security.

A US based end-to-end solution for 5G/FutureG is possible. We are innovating on price, efficiency, and deployment flexibility. We just need US government support into 100% US based small business such as our own, open-source solutions to foster innovation and testing, and independent certification labs to reduce barriers of entry.

Responses are inline and tab to the right. Thank you! Ruffy Zarookian, Founder, Signal System Management, LLC

## Questions on the State of the Industry

Understanding the current state of the telecommunications industry is important to determining how any topics should be prioritized in the Innovation Fund, and what level of funding a topic should receive.

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 certification from an independent lab to ensure that any single O-RAN compliant component is interoperable with any other. Such a certification, which may include security and a made in USA requirements, would allow any component to work with any other creating a truly open interoperable market. I believe this is the way forward for public and private networks.

a. What are the challenges for brownfield deployments, in which existing networks are upgraded to incorporate open, interoperable, and standards-based equipment?

Less than you would think. With the introduction of containerized virtual network functions, any one piece of the network can be removed and replaced by one (or more) virtual network functions. There may be some effort to build adaptors between legacy and modern components, but it can and should be done to upgrade our nation's security posture.

2. What ongoing public and private sector initiatives may be relevant to the Innovation Fund?

US involvement in 3GPP, O-RAN Alliance, and Telecom Infra Project are essential. I believe it was Dr. Rondeau (perhaps it was someone else from OUSD?) who said if you can't secure the specifications your options are limited in securing the implementation. But do not overlook **open solutions** such as Open Air Interface and the Eurocom project. Linux Foundation Networking also contains some interesting components as does Intel's FlexRAN, and SRS RAN.

a. What gaps exist from an R&D, commercialization, and standards perspective?

Interoperability testing, security testing, and hardening of open solutions for productization. In terms of standards, I'd like to see the 3GPP and O-RAN specify more security within the RAN and 5GC to protect data flows and VNF interactions. A zero-trust model is more appropriate with the virtualization and disaggregation of network functions: the RAN and core can no longer be considered trusted.

b. How might NTIA best ensure funding is used in a way that complements existing public and private sector initiatives?

Help create a thriving market with low barriers of entry so that we as Americans can do what we do best: compete and let the best solution win. To do so, we need an open and inexpensive (free?) independent lab with government oversight to certify 5G components and VNFs. This certification would include three aspects, interoperability (adherence to an O-RAN reference solution), security (through white-box analysis and red-teaming), and a made in USA requirement. Supporting open solutions can also help create this thriving marketplace by reducing duplication allowing greater speed of innovation.

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?

The workforce is constrained by a lack of applied telecommunication product development experience. There are knowledgeable network operators and maintainers who deploy what is designed and developed overseas. But the skillset of a network operator is not a good match for a product developer. Currently the best place to hire is from the universities, but you have to bear the risk and cost of training up new grads because there is little applied knowledge taught about commercial cellular networks even at the graduate level. Cellular networks had been expensive and difficult to use as an educational or experimental tool, but this has changed in 5G with the advent of low cost open source 5G solutions.

Open solutions can be an indispensable educational tool to support and maintain a workforce. Think what students can do at university labs with an end-to-end 5G solution that costs less than \$5000. It can be done, if we engage as the Europeans have done with supporting open 5G solutions.

Additionally, direct support of small businesses and establishing a path to market through an independent certification lab can motivate the workforce we currently have in the government sector to engage more with commercial development.

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?

There is some private investment, but right now we have a cooling venture capital market. The innovation fund can make a bold statement that critical national infrastructure will be open and secure by requiring all 5G components to be certified through independent labs to be open standard compliant, secure, and made in USA. If this is done then the private money will follow.

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?

Less than you would think. I can put together an end-to-end system using components from all from US based vendors (though admittedly manufactured in Europe, Malaysia, and Taiwan). We do need to be aware of two critical elements that continue to depend on the global supply chain: (1) the availability of open solutions and (2) micro-electronics. As far as micro-electronics, the NSTXL program exists. But right now, open solutions are dominated by Europe through the Open Air Interface. I'm making a direct ask that the innovation fund promotes US person involvement within the Open Air Interface Software Alliance. In the long term there is a huge opportunity to join efforts with our European partners who too are concerned about their digital sovereignty.

### **Questions on Technology Development and Standards**

Understanding the current state of open and interoperable, standards-based RAN and the standards that inform its development will assist NTIA in maximizing the impact of grants. Questions in this section will be used to assess the maturity of the technology and related standards to help determine which topics should receive additional investment.

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?

Focusing on innovative solutions in the RIC with xApps should be a focus, but for this to occur we need a reference implementation of a 5G network as a testbed. Leveraging open solutions such as Open Air Interface can be the cheapest and most interoperable path forward for creating this reference implementation. With such a reference implementation labs, universities, and commercial vendors can focus on innovating and optimizing instead of duplicating their efforts on implementing the baseline network.

The open innovation fund should look to support not just open standards, but also open solutions across the protocol stack. Currently end-to-end systems exist using open solutions. With more funding these solutions can be the baseline for commercial implementations and a tool for education and innovation. Open implementations of the DU and RU are less mature, but the entire stack including the CU, 5GC, and MANO is important to support. Funding these open solutions will allow even more opportunities for innovation by facilitating development of the RIC and xApps where much of the ultimate value will be created.

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:

The O-RAN standards is mature enough for end-to-end interoperability (we saw this in the 2022 NTIA 5G Challenge). Though during the challenge, we identified that security standards are not well understood or prioritized by existing commercial vendors. We need to (1) support small businesses who focus on open and secure implementations, (2) support competition through low cost independent testing/certification, and (3) incentivize security through the certification process.

a. What barriers are faced in the standards environment for open and interoperable RAN?

A reference implementation of end-to-end O-RAN would be exceedingly helpful in refining the O-RAN standard and creating a testbed to enforce standards compliance.

b. What is required, from a standards perspective, to improve stability, interoperability, cost effectiveness, and market readiness?

A reference implementation where all stakeholders can openly use and contribute will help refine the standards to achieve the objectives of stability, interoperability, cost, effectiveness, and market readiness. If there is a reference implementation with broad support, this can be used as a launching point not only for innovation, but also for conformance testing and standards development.

c. What criteria should be used to define equipment as compliant with open standards for multivendor network equipment interoperability?

With a reference implementation determining interoperability and standards compliance is simple: can the equipment interoperate with a reference implementation. This reference implementation should be fully open source with stakeholders from industry, universities, and government. Testing against a reference allowing vendors to innovate on speed and efficiency and reducing duplication of effort.

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?

Accelerate innovation by using an open source reference implementation to refine specifications. Think of an open source reference implementation as a testbench to certify interoperability, and a research aid to refine the next generation of specification. Perhaps we can coin a new term, "specification as code".

### **Questions on Integration, Interoperability, and Certification**

Challenges associated with systems integration and component interoperability can hinder the adoption of open and interoperable, standards-based RAN. This section will help NTIA structure the NOFOs in a way that most effectively addresses these challenges and facilitates adoption. NTIA also welcomes feedback on the effectiveness of certification regimes in driving open and interoperable, standards-based RAN adoption.

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?

Lower barriers of entry and foster a healthy market by establishing independent certification labs that use an open source reference solution as a testbench. This will encourage small businesses and universities to engage in current product development, refinement of O-RAN, and evolution of 6G/FutureG specifications.

a. Are interoperability testing and debugging events ( *e.g.*, "plugfests") an effective mechanism to support this goal? Are there other models that work better?

Plugfests with O-RAN compliant components should be structured such that integration occurs in a short period of time (say 2 weeks). This “cold” integration shows that the specification is sufficiently designed for maximum interoperability. A plugfest where components are pre-integrated does little to encouraging interoperability beyond the vendors locking in non-compliance and creating barriers to entry.

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

An open-source reference implementation is the best way to define the spec with enough specificity that a “cold” integration can take place. Open-source solutions that are O-RAN compliant are viable as a commercial end to end solution for reference deployment and to be used as a test harness. By a test harness I mean a real working network where a vendor comes in and replaces one or more components and the network continues to work without a hiccup. We should fund US development of an open-source solution and involvement in widely accepted open-source solutions like Open Air Interface.

And we should support a multi-vendor market through independent certification labs!

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

Certification programs are important for a health robust, interoperable marketplace. They encourage small business participation allowing small businesses the same opportunity to show that their products work as larger established vendors. They also encourage interoperability by encouraging vendor’s solutions to be compatible to a reference system instead of relying on piecewise integrations.

The notion that things never work together until after a lengthy integration period has no place in the modern technology development cycle due to advancements in virtualization, containerization, and methodologies. Independent certification labs allows market players who realize this entry into the market without as much influence from gatekeepers such as large system integrators.

a. Is certification of open, interoperable, standards-based equipment necessary for a successful marketplace?

Yes. This is the best way for vendors to *\*prove\** that their solution works. A certification will allow a network operator or system integrator can mix and match vendor components without lengthy piecewise integrations.

Certification labs must have a broad set of stakeholders and not be dominated by established network operators or vendors for a fair and unbiased certification process. A free or low cost to all members of the public will encourage the maximum level of innovation and participation.

b. What bodies or fora would be appropriate to host such a certification process?

Northeastern University, CableLabs, and USC ISI spring to mind. Control of the certification process should include stakeholders in equal measure from small business, universities, government, network operators, and established vendors.

12. What existing gaps or barriers are presented in the current RAN and open and interoperable, standards-based RAN certification regimes?

I believe TIP comes closest to certification through their badging process. But inexplicitly they put up a paywall to get badging and certification. Certification should be cheap, easy, and readily available to small businesses and the general public. With open source solutions, development for industry grade wireless is possible for small business and general public. The notion that telecommunications is expensive and only the domain of large companies need to change.

We need inexpensive or free access to the certification process, and an open-source reference solution to reduce the cost of testing. Additionally, we need this certification process to use a reference implementation based on open source solutions to maximum interoperability and reduce the cost of testing/certification for vendors and the certification facility.

a. Are there alternative processes to certification that may prove more agile, economical, or effective than certification?

Yes, supporting an open source reference implementation that can be used as a test harness and as a basis for commercial implementations. This implementation will codify the standard in a working end-to-end system which will allow for a more agile standards definition and lower costs for vendors by allowing them to integrate directly into the standard compliant solution. And a reference solution encourage vendors to focus on innovation instead of duplicating effort of implementing the standard solution.

b. What role, if any, should NTIA take in addressing gaps and barriers in open and interoperable, standards-based RAN certification regimes?

As described in [47 U.S.C. 906\(a\)\(1\)\(C\)](#), it is within NTIA's direct mission to support open and interoperable interface radio access networks and support O-RAN development, and support a multivendor market.

Specifically, the NTIA is asked to manage integration of multi-vendor network environments and identify objective criteria to define equipment as compliant with open standards for multi-vendor requirements.

I believe that the quickest and most effective way to achieve this mission is to support an open-source reference end-to-end testbench run by an independent certification lab. This would include direct support to US persons to engage with open-source solutions within and outside of the Linux Foundation such as Open Air Interface, SRS RAN, or Osmocom projects to bring this reference implementation to fruition. And this would include supporting a certification lab that will use these use these open solutions to provide easy and inexpensive access to innovators and industry. The lab would have a broad set of stakeholders from government, academia, and industry with a focus on small business. And the certification would include a made in USA requirement.

An additional consideration is that typical commercial network operators can be risk adverse and cautions when deploying new vendor solutions which in general limits innovation. The NTIA

should also support trials in government sponsored testbeds (including DoD sponsored). Other creative solutions to support market diversity would be to engage with private network operators or virtual mobile network operators to support pilots and trials.

### **Questions on Trials, Pilots, Use Cases, and Market Development**

A key aim of the Innovation Fund is to promote and deploy technologies that will enhance competitiveness of 5G and successor open and interoperable, standards-based RAN. We have seen a range of Open RAN trials, pilots, and use cases underway across the United States and internationally to date. This section will inform the types of NOFOs NTIA publishes and administers as the Department works to accelerate adoption.

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?

Focus on use cases that involved multiple non-pre integrated vendors. And uses cases that are full cloud or hybrid cloud. And use cases that include disaggregation of VNF between the physical gNB and cloud.

And security, security, security. Use cases should include common and uncommon attack vectors.

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?

Focus on interoperability. Healthy and robust market with a diverse set of vendors depends on interoperability. Test trials including small businesses at an independent certification lab are essential to supporting multi-vendor deployments, compatibility, and security.

a. What kinds of testbeds, trials, and pilots, if any, should be prioritized?

A small business security focused events, trials, and pilots including dedicated testbeds for small businesses. A set of events might look like (1) provide lab space for small businesses to complete their implementation and integration against a common reference solution, (2) certification of the small business's solution (including red-teaming for security), (3) trials in the testbed including end-to-end testing, (4) usage of the small business's solution in one of the DoD's 6 testbeds, (5) a pilot deployment with a network operator or virtual network operator.

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

CableLabs, Northeastern, and USC ISI have a lot of experience in conducting these kinds of competitions and have labs from previous efforts.

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?

Trials should come with a seal of approval or certification. Deployment into US based networks should require all components to be certified. Small businesses should have preference in these trials.

### Questions on Security

Strengthening supply chain resilience is a critical benefit of open and interoperable, standards-based RAN adoption. In line with the Innovation Fund's goal of "promoting and deploying security features" to enhance the integrity and availability of multi-vendor network equipment, and Department priorities outlined in the National Strategy to Secure 5G Implementation Plan, this section will inform how NTIA incorporates security into future Innovation Fund NOFOs.

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?

Start building a set of tests around established (and new if necessary) standards and support a certification lab that includes these security tests. Red-teaming is paramount. Also build a reporting framework for deployed products and networks so that security incidents are reported to independent or industry response teams. Think MITRE ATT&CK and CVE reporting but for wireless security threats and actual intrusions. The government should provide direct funding to certification, incident collection, and incidence response. Critical physical infrastructure has reporting requirements, response teams, and government investigations by organizations like the NTSB, shouldn't our critical digital infrastructure have the same?

a. What role should security reporting play in the program's criteria?

Products companies and network operators should have a strict requirement for incident reporting. It should be automated and sent to an independent collection and response center. Fines would be in place for security violations or lapses in reporting. The funding should be government supported, or funded by large businesses, to limit the impact on small businesses.

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

Security should be core to the program's criteria. Industry is behind on this, so you may have to slow roll in 2023 and request paper studies from industry on how they plan on adhering to the current guidance by NIST, CIO, and others. In 2024 and beyond the gold standard of independent testing (red teams) should be applied to programs.

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

Historically minimal: security may still be seen as a loss center for some established players. There are specifications for PKI architectures for VNF endpoints. At least this should be used.

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



Support open implementations. An open implementation's security can be vetted by outside entities and by all stakeholders and users. Security testing including red-teaming should happen at independent certification labs.

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?

Zero trust is extremely important. The network can not be trusted nor can devices. Especially with use of virtual network functions. The days of unencrypted and trusted RAN and core network is in the past. All communications should be end-to-end encrypted. Endpoints should be authenticated. No identifiable information and location data should be sent in clear text in the user and data plane (this use to be the case with older technologies and may still be in some corner cases). The collection and sales of commercially available aggregated data should be limited. Even with current "anonymized" these commercially available data can be easily de-anonymized and can tell a story about a user or set of users. This type of collection can be a problem in some use cases.

### **Questions on Program Execution and Monitoring**

The Innovation Fund is a historic investment in America's 5G future. As such, NTIA is committed to developing a program that results in meaningful progress toward the deployment and adoption of open and interoperable, standards-based RAN. To accomplish this, we welcome feedback from stakeholders on how our program requirements and monitoring can be tailored to achieve the goals set out in [47 U.S.C. 906](#).

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?

Interoperability: the number of systems that a product can interoperate with, and the ease of integration are key to interoperability. A diverse and healthy market ecosystem with many players robust to international competition requires a diverse set of products suppliers. Vendor lock in is a huge barrier of entry that discourages innovation. Reducing this vendor lock in with independent certification will lower the cost to the public, keep the USA at the forefront of innovation, and promote a healthy market.

An independent lab that is free or low cost to small companies (supported by funding from large companies or the government) that certifies products as O-RAN compliant and interoperable is critical.

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?

The 5G Challenge was a good test run for how a program can be structured to support a diverse set of stakeholders. There were labs, test set manufacturers, and industry players coming together with government oversight. Initiatives focused on small businesses are more important than initiatives that include established players to support a robust and innovative marketplace.

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

The NTIA should focus on teaming and support for consortiums that include small businesses. Mobile network operators and established players are important to include of course, but other players such as small businesses, mobile network operators, and private network operators may be more important to support NTIA's mission of interoperability, security, and innovation.

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](#)).

Matching contributions should go into setting up independent third party testing that is publicly available to small businesses, directly support US based small business, and support a made in the USA requirement.

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

Open Standards, Open Implementations, Independent Lab Certifications, and direct investment in small businesses. Small businesses should have a seat at the table on standards bodies and independent testing labs. There should be a made in USA requirement to all programs with an emphasis of a full end-to-end made in the USA solution.

a. Should NTIA require that grantee projects take place in the U.S.?

Yes. There plenty of knowledge and infrastructure for all phases of product development and project execution here in the States. Leveraging open source solutions, there no reason a US person can't set up a lab and personnel here in the States. Our Stage Two award at the 2022 NTIA 5G Challenge proves that that an entirely US based company with entirely US based persons can compete with established multi-national vendors.

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?

Support small business based in the USA. Small businesses don't have the size or incentive to off-shore, and we are 100% aligned with the government's goal of supporting US based solutions and growing a US knowledge base. Larger organizations can be accommodated by requiring business units to spin off: see Leonardo DRS as an example among others.

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"?

NTIA should have a strict requirement for American-made. What's the point of this initiative if it's anything else? American made should include hardware, software, and cloud presence. Fab and design work here in the USA by US persons should be required. A phased approach may be appropriate with a percentage of USA made with a sliding requirement over a period of 5 – 10 years. Perhaps some leeway can be given to European/Commonwealth and friendly Pacific

countries that have established telecommunications industries such as Ireland, Germany, France, Sweden, and South Korea.

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

Germany and France fund efforts such as Open Air Interface. Ireland has well-known companies that deal in O-RAN like SRS and Benetel. South Korea is a telecommunications behemoth and Sweden has tons of telecom legacy. These countries efforts should be leveraged to regain digital sovereignty while tightening bonds with friendly nations.

### **Additional Questions**

NTIA welcomes any additional input that stakeholders believe will prove useful to our implementation efforts.

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

Engagement with the 3GPP Standards, O-RAN Specifications, TIP, Linux Foundation, and other bodies should be supported.

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?

Outreach to university students. Perhaps a spectrum challenges using open-source solutions could be a way to encourage universities and students to engage with wireless. With open-source software and cheap SDR such as USRPs a semester length project could reasonably result in some interesting challenges.