| | Comment 1 | Comment 2 |
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| **Questions on the State of the Industry**<br>*Understanding the current state of the telecommunications industry is important to determining how any topics should be* | | |
| 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? | The main challenges are:<br>1) Integrating, validating and managing complex multi-vendor networks<br>2) Validating the interoperability of the multi-vendor RAN components<br>3) E2E Security testing and validation in multiple-component security scenarios<br>4) Deployment and Orchestration of multi-vendor components<br>5) Achieving Optimal RAN performance post-integration of multiple components in an E2E environment<br><br>The main challenge for brownfield deployment is integrating Open RAN into existing vendor-locked 4G systems. Operators who already have Legacy LTE RAN are facing the following two scenarios:<br>Continuing to use their incumbent proprietary solutions while they build out independent Open RAN in greenfield deployments in new areas to fill coverage gaps. This can potentially be an operational challenge, as it can become very expensive for operators to manage two networks independently. The other option is to replace the legacy LTE network with new open and standard interfaces, but this will be very expensive for operators as rip and replace operations will disrupt their existing businesses. This also requires huge CapEx investment. To solve these type of issues, the industry needs to develop innovative solutions to enable Legacy 4G and 5G networks to co-exist with minimal performance and CapEx impact. | |
| 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? | The R&D gap we have today is that the industry doesn't have easily accessible E2E lab infrastructure and tools to test and certify multi-vendor solutions. E2E labs are key to successfully deploying Open RAN solutions that are based on multi-vendor platforms. Labs also provide opportunities for small vendors and operators who can not afford to build their own labs to test and validate their solutions and use cases.<br><br>NTIA would be the perfect organization to incentivize major vendors who have invested in these types of labs to enlarge their E2E labs and potentially offer lab-as-a-service offerings to support small operators and new Open RAN component providers. | |
| 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? | Personnel and expertise required to successfully develop and deploy Open RAN solutions include:<br>1) Software developers who have RAN and wireless solution experience<br>2) E2E System Integrators<br>3) Management and Orchestration (Kubernetes, Ducker, etc.)<br>4) DevOps Development and Operation<br>5) mMIMO SMEs<br>6) Business and use case developers<br><br>Initiatives that target the development of these skillsets would benefit deployment efforts at length. | |
| 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? | Private investment in the Open RAN space is non-existent. Major vendors and operators are working together to define Open RAN specifications, and NTIA can help by targeting funding in the areas of silicon, software, automation, system integration, supply chain resilience, security software and services, among other areas. | |
| 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? | Building a robust supply chain ecosystem of open and interoperable component markets is key to successfully deploying Open RAN solutions. A key piece of this ecosystem is chip manufacturing for component providers. When key pieces are delayed, this can cause chain reactions that then delay testing, which delays deployment, which can delay development of open initiatives. | |
| **Questions on Technology Development and Standards**<br>*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* | | |
| 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? | The following areas would most benefit from additional R&D:<br>Network slicing at the RAN level is still premature and requires more R&D and evaluation.<br>Effective RAN sharing (including spectrum and infrastructure) also requires more R&D.<br>Other areas include optimized mMIMO deployment and inter-vendorcarrier aggregation. | |
| 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… | Yes, Fujistu has deployed and demonstrated that E2E Open RANs based on multi-vendor solutions are highly stable, interoperable. and cost-effective. | |
| a. What barriers are faced in the standards environment for open and interoperable RAN? | Not so much a barrier in standardization, but the unwillingness for RAN vendors to work together during deployment in the operators' networks has historically been a hurdle. | |
| b. What is required, from a standards perspective, to improve stability, interoperability, cost | More all-inclusive interop testing and O-RAN certification of open components is key. | |
| c. What criteria should be used to define equipment as compliant with open standards for multivendor network equipment interoperability? | Minimum criteria need to be defined in the standards specifications. However, conformance and interoperability testing, as well as 3rd-party certification testing, should be key areas of focus. | |
| 8. What kinds of projects would help ensure 6G and future generation standards are built on a foundation of open and | | |
| **Questions on Integration, Interoperability, and Certification**<br>*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* | | |
| 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? | Reference implementation of interfaces in areas of integration pain points will improve current multi-vendor integration and set the foundation for the future open, interoperable, standards-based equipment and software. The reference implementation created by multi-vendors must be simple, extensible, and provide ample documentation and video-based training sessions. The reference implementation can become the de facto standard. Areas that could benefit from the reference implementation include:<br>1) White box servers with accelerators<br>2) Virtualization Environment<br>3) xNF Northbound and Southbound interfaces of Open RAN components (RU, DU, CU, RIC, SMO, and 5G-core)<br><br>Open software has proven that reference implementation can become the de facto standard. Further, third-party oversight of funded projects should be enforced. | |
| 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 and Challenges are helpful, but not the most effective way to improve interoperability. By the time vendors attend the competition, the interfaces are built. During the competition, vendors are trying to make the interfaces work. Starting earlier in vendors' development by providing reference implementation and incentivizing vendors to use them would reduce the need for Plugfests and Challenges while improving interoperability as a part of vendors' development processes. Furthermore, testing and validation of multi-vendor solutions require much larger lab and R&D infrastructure, where small and large vendors as well as component providers can test and verify solutions and use cases. | |

The cost associated with building labs, purchasing test equipment, and hiring staff with multi-disciplinary skillsets inhibits small companies from participating and competing with larger well-funded organizations. Funding common lab infrastructure projects with vendor equipment and supporting staff will enable smaller organizations and improve integration of multi-vendors by increasing the number of vendors who can participate and support open systems. In addition, the lab staff can oversee how well vendors participate in the integration of their components. Honest and independent rating of vendors' participation in open systems should improve the ecosystem.

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

Certification for standards compliance provides is necessary, but provides minimum value. Certification of multi-vendor xNFs interoperability will be more valuable as it will reduce integration costs for operators. Vendors should be incentivized to participate in the certification. Third-party certification facilities do not have the skillsets to test interoperability (at least in this early stage). It is likely more productive and less costly to incentivize the vendors to perform interoperability. Certification processes should be overseen by a third-party and part of evaluation and funding should be tied to the vendor's participation and openness.

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?

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

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

b. What role, if any, should NTIA take in addressing gaps and barriers in open and interoperable,

One gap is the current absence of third-party certification labs.

One effective approach would be allocating funding to the creation of mirror labs.

NTIA can work to allocate funds for the creation of standards-based certification organizations.

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

*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*

Whether from enhanced security from real time video analytics of border security/police bodycams, public safety, or improved efficiency and environmental sustainability of smart city/agriculture/autonomous vehicle applications or the economic growth of improved industrial capabilities, the ideas abound on how to leverage the high-capacity and low-latency capabilities of 5G. Those who benefit from the status quo will (accurately) argue that these applications can be deployed on Closed networks as well as Open ones. However, the past few years have proven how vulnerable society is to disruptions in supply chains. Natural disasters, pandemics, and geopolitical conflicts have proven difficult to predict. As our society becomes increasingly dependent on mobile infrastructure, it becomes increasingly important to the national security to protect it. The vast majority of the radios used in American mobile communications networks come from only three suppliers. Should any unforeseen event disrupt the supply chains of any one of these companies for an extended period of time, it would severely impact the ability of mobile network operators to continue growing the necessary capacity to keep up with our society's ever-increasing demand.

Potential degradation of mobile network capacity could impact the critical applications on which we increasingly rely.To improve the resiliency of critical 5G infrastructure supply chains, the NTIA should prioritize use cases that are deployed on or demonstrate interoperability of multi-vendor Open Radio Access Networks. Priority and support should be given to use cases that address the two primary challenges that impact mobile network operators' wide spread adoption of Open RAN:
1) Use cases that demonstrate interactions between a new Open RAN network and existing brownfield networks, and
2) Use cases that demonstrate multivendor implementation of advanced features needed for high performance.
Incentives and/or subsidies to demonstrate these capabilities might influence a larger number of suppliers to implement them and provide increased confidence to the industry in the process.

Sample 5G Use cases
1) Fixed Wireless Access
a. Provide high-bandwidth internet access to less-advantaged communities where it is not economical for the operators to install fiber.
b. Cell-on-wheels can provide additional capacity for events or disaster areas.

2) Smart Cities
a. Private networks using CBRS can enhance the quality of life for citizens by, for example, providing free WiFi in parks and public areas.
b. Video Analytics applications to enhance security in public places
c. Streaming of Police bodycam data to secure locations
d. Video analytics for critical infrastructure (such as power stations, bridges, so on)

3) Low Latency Applications
a. Autonomous vehicles
b. Robotics and remote inspections

4) Industrial Equipment
a. Remote AI/ML to predict faults, perform diagnostics, and repair faults before breakage occurs
b. Streaming of equipment data to the public cloud to improve performance

Open RAN allows data from the network to be available on the Cloud where it can be easily accessible. Innovative IT companies will be able to participate in this ecosystem, increasing competition and bringing innovative services to networking.

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?

14. What kinds of trials, use cases, feasibility studies, or proofs of concept will help achieve the goals identified in 47 U.S.C.

a. What kinds of testbeds, trials, and pilots, if any,

Wireless RAN vendors have spent millions of dollars building E2E labs to test and verify their products' performance and interoperability. These labs are valuable not only for the infrastructure that they provide, but also the expertise that the vendors provide (often this expertise is lacking in third-party labs). Incentivizing vendors who have the infrastructure ready to open and share their labs and Network Functions (NFs) with smaller, innovative companies that cannot afford to build their own labs will accelerate the adoption and development of new innovative applications and use cases. In addition, smaller companies' participation will increase competition and accelerate the adoption of Open RAN.

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

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?

**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.*

The projects and initiatives funded through the program should not only provide integrity and availability of underlying infrastructure but also should promote operational security through innovation. One such initiative the program can support would be the promotion of Open RAN product vendors to share security vulnerabilities and threats in their products with rest of the Open RAN community including suppliers, vendors, operators, government, and other concerned entities. This would reflect the true openness of Open RAN while enhancing product security.

Knowing security threats in advance helps to implement proactive security measures, avoiding potential security breaches. The existing public/private threat databases can be enhanced to include Open RAN security threats, or a new threat database can be created just for Open RAN security threats—one that can be managed by a government entity, a standard body, or a higher educational institute.

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?

Another initiative is to build a framework to manage software patch updates. For example, if a zero-day vulnerability is identified today, vendors could release patches at different times. If one vendor's device is patched in response to a critical vulnerability, and others are not, it could lead to incompatibility of network devices and loss of network service availability. Therefore, to avoid these incompatibilities, a framework could be developed to coordinate the patch process.

As stated above, security reporting in the program's criteria should include the requirement of sharing threat intelligence and discovery of vulnerabilities in Open RAN products developed by various vendors with the larger Open RAN user community. The sharing of threat intelligence will potentially avoid the same security breaches happening in multiple deployments as operators can promptly implement risk mitigation strategies by fixing or isolating issues.

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?

The program's criteria should include requirements pertaining to some type of security assurance label of Open RAN products developed by vendors. The security assurance label can be based on the compliance level to industry security standards, best practices, and various architectural frameworks. The security label can be determined by an unbiased external audit party.

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| | Companies are already closely following O-RAN Alliance security specifications, 3GPP, as well as NIST security framework and ISO27001. Most vendors are following secure software development life cycle methodology (DevSecOps) and secure supply chain practices by following industry standards. Security monitoring. implementation of security best practices at the operational level, life cycle management of various components, and continuously assessing security risks are also part of the security approaches taken by companies today. |
| 18. What steps are companies already taking to address security concerns? | |
| | The Innovation Fund can promote companies to develop reusable security components and frameworks wherein others can utilize those components to elevate the security level of Open RAN deployments. A company releasing a product with weak security can potentially impact the whole network, but if the vendor can find reusable security components, there is a greater chance of that company releasing products with a high level of security compliance. |
| 19. What role can the Innovation Fund play in strengthening the security of open and interoperable, standards-based RAN? | |
| | Traditional RAN may still be using old security access control and identity management components where trust is verified only once allowing the authorization to many objects. These security components may need to be updated or completely re-architected to operate based on the zero-trust model. Open RAN may not have this issue as it is developing now based on the zero-trust model. |
| 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? | |
| **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? | |
| | NTIA should establish criteria for companies that can participate in the funding. The criteria for funding should include:<br>1) Size of the company – NTIA should help smaller companies compete alongside larger organizations. Large multinational companies who can build multiple components of a 5G system will dominate the industry unless smaller companies with limited funding are supported in participating in the ecosystem. An open system can become closed again if one or two companies dominate multiple components of the network.<br><br>2) Number of U.S.-based employees – U.S.-based employees will help ensure that 5G skills, knowledge, and innovation stay and increase in the U.S.<br><br>3) Openness – Stakeholders that are truly open and promote that openness in their xNFs should get priority over vendors that support Open RAN but will not share their APIs or support open integration.<br><br>4) Cloud-based data – Open systems provide the infrastructure to push network data to the public cloud. Vendors whose solutions bring out the data from network equipment into the public cloud and provide public APIs to access the data will reduce the cost associated with operation and maintenance of the network by allowing IT systems to participate in the ecosystem. Data will be the life blood of innovation. Vendors who provide simple access to network data in the cloud should be given priority in funding. |
| 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? | |
| | Fujitsu suggests NTIA ask industry entities to perform interoperability activities with multiple vendors and include major 5G features, not just interface tests. Feature interoperability tests such as interference, mobility, and radio resource management will require much more complexity than interface standards. This activity will promote stronger teaming and encourage industry consortiums to achieve the true openness potential of 5G RAN ecosystems. |
| 23. How (if at all) should NTIA promote teaming and/or encourage industry consortiums to apply for grants? | |
| 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). | |
| 25. How can the fund ensure that programs promote U.S. competitiveness in the 5G market? | |
| | Since the grants are from the U.S. Government, it is understandable to want a strong U.S. component. Many companies are global in nature and conduct Planning and R&D in many locations. A percentage requirement of U.S. content would limit innovation and require enforcement and proof. What if each grant was U.S.-led instead? For example, a U.S. subsidiary of an approved global company would need to lead the overall effort. That would help ensure Planning and Deliverables would start and end in the U.S. and R&D could take place in the U.S. and/or globally like in the Quad Countries, NATO countries, and so on. |
| 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? | We would advise that the grants be run by U.S. subsidiaries of aligned countries. These subsidiaries would be in charge of processing the application and funding.<br><br>NTIA should see potential multinational grantees as no different from those who operate fully in the U.S. In a global marketplace of ideas, significant advancements in technology and security are not always going to originate at home. Multinational organizations operating in allied nations help facilitate competition, which in turn facilitates innovation. |
| 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"? | The ideal of "American-made" is a nuanced topic that actually can result in reduced competitiveness. If companies source from aligned countries, import it, and repackage or rebrand it in order to meet a percentage, less value is actually created and the end product is more expensive than necessary. A better method could be to favor higher U.S. content in grantees. If all grantee topics have to be led by a U.S. subsidiary, as mentioned above, then those candidates that have 50%+ U.S. content get some preference to those that have 20%+. |
| 26. How, if at all, should NTIA collaborate with like-minded governments to achieve Innovation Fund goals? | Other governments have innovation funding programs but coordination of timing, criteria, and funding among governements can be an arduous task. Another way to consider this conceptually is to add more weight to candidate ideas that are linked to other like-minded governements. For example, if a specific candidate idea builds on or adjacent to a previously funded project from a like-minded governement, the consideration for that project is fast-tracked and ranked above other candidate ideas. |
| **Additional Questions** | |
| *NTIA welcomes any additional input that stakeholders believe will prove useful to our implementation efforts.* | |
| | We believe candidate ideas that involve more than one party should be ranked higher and fast-tracked in the evaluation. For example, if two or more companies co-author a caadidate idea or an idea builds or strengthens an Open RAN ecosystem, it should rank higher than a funding candidate that only benefits one company.<br><br>Also, as 5G deployment advances and more data traffic comes into telecom networks from various connected devices, it's inevitable that telecom operators will need to reinforce multiple network functions and elements accordingly for stable and advanced network operation. When we aim to build up resilient, flexible, and trusted telecom infrastructure, an open and interoperable ecosystem is imperative not only for the RAN space but also for other network layers such as optical transport (e.g. Open ROADM) or network management (e.g. Open Network Automation Platform). So, Fujitsu recommends NTIA focus on other open network technologies in addition to Open RAN. |
| 27. Are there specific kinds of initiatives or projects that should be considered for funding that fall outside of the questions outlined above? | |
| 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? | |