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Re: Docket No. 221202-0260, RIN 0693-XC05: NEC Corporation of America Comments in Response to the National Telecommunications and Infrastructure Administration Request for Comments on Public Wireless Supply Chain Innovation Fund Implementation

Ms. Arnold:

NEC Corporation of America is pleased to submit comments in response to the National Telecommunications and Infrastructure Administration (NTIA) request for comments (RFC) on the implementation of the Public Wireless Supply Chain Innovation Fund (Innovation Fund).[1] As a member of the information and communications technology industry and a major global supplier and developer of 5G Open RAN solutions and a wide variety of other technologies, we are eager to support NTIA's efforts to promote and deploy open, interoperable, and standards-based 5G and next generation wireless networks.

Below, we provide information about NEC and some of our 5G Open RAN and other advanced wireless network capabilities. We also provide perspectives on some of the challenges and opportunities for accelerating Open RAN and recommendations to consider in implementing the Innovation Fund.

I. Overview of NEC and 5G Open RAN and Next Generation Wireless Network Solutions

Headquartered in Irving, Texas, NEC Corporation of America is a subsidiary of NEC Corporation, a global technology firm with nearly $28 billion in annual revenue, a presence in over 160 countries, and more than 110,000 employees worldwide. NEC Corporation has had a presence in the United States since 1963, and, today, our major U.S. offices span 16 states. One of the world's top patent-producing companies, NEC Corporation combines advanced technologies, services, knowledge, and its 120+ years of operating experience to help promote safety, security, fairness, and efficiency and build a more sustainable world in which all people have the opportunity to reach their full potential. We are committed to advancing a wide range of environmental, social, and governance (ESG) initiatives and to ensuring our products, services, and business activities support our goal of serving as a social value innovator.[2]

[1] https://www.federalregister.gov/documents/2022/12/13/2022-26938/public-wireless-supply-chain-innovation-fund-implementation
[2] https://www.nec.com/en/global/csr/index.html

NEC provides a wide range of technological solutions, including artificial intelligence, space platform, undersea cable, advanced computing, 5G Open RAN, and next generation wireless networking capabilities, across the United States and around the world. NEC, both directly, and through the government market-focused NEC National Security Systems subsidiary, deploys, and supports large-scale information technology and communications solution integrations throughout the United States that perform mission-critical services for national security and law enforcement agencies, other government customers, and commercial businesses. NEC is a member of both the IT and Communications Sector Coordinating Councils and is committed to providing reliable and secure solutions for U.S. critical infrastructure customers.

NEC has a long history in wireless communication, and we continue to develop and deploy successive generations of technology around the world. Since our founding in 1899, NEC's technologies and solutions have helped foster growth and innovation in the telecommunications sector. From pioneering switching systems, to evolving mobile infrastructure from the first generation of analog systems, to helping develop and deploy 5G/6G and next generation wireless technologies, NEC remains committed to connecting people and systems around the globe.

NEC has consistently promoted open architecture approaches. NEC was a pioneer in Software Defined Networking (SDN) over a decade ago creating the world's first Openflow based Controller. NEC also championed Network Function Virtualization (NFV) developing and deploying the world's first virtual Evolved Packet Core (vEPC). NEC has continued in this tradition of supporting open networks and has developed radio units for 5G base stations that comply with O-RAN Alliance established Open RAN fronthaul specifications. This effort has included supporting NTT DOCOMO, which has already realized interoperability between base station equipment of NEC and other vendors with O-RAN Alliance compliant fronthaul and X2 interfaces in their 5G commercial service. Further, NEC is mass-producing Open RAN compliant radios for Rakuten Mobile, which is now building the world's first fully virtual multi-vendor 5G radio access network conforming to Open RAN specifications across Japan.

NEC is at the forefront of providing systems integration services to service providers around the globe, and we are making significant investments in establishing global centers of excellence and interoperability testing. Some of NEC's wireless communications research and development (R&D) and product management already occurs in the United States, and we continue to invest heavily in our U.S. 5G business. In 2022, NEC acquired Blue Danube Systems, a U.S.-based radio and integrated chip development startup with over 30 patents, which now operates as a wholly owned subsidiary of NEC Corporation renamed as "NEC Advanced Networks." Furthermore, NEC's global systems integration work will continue to incorporate NEC-based and non-NEC-based U.S. content into Open RAN solutions.

In addition, NEC has had a successful record of public private partnerships. NEC was selected as a Systems Integrator for UK Government's NeutrORAN initiative. The initiative is designed to demonstrate a multi-operator neutral host solution using an Open RAN ecosystem in order to bring cost effective connectivity services to rural communities and bridge the digital divide.[3] NEC was also selected to assist the New South Wales Telco Authority in Australia to build the initial phase of a state-of-the-art 5G innovation lab to test a cloud-native 5G core with Open RAN network and public safety applications.[4]

[3] https://www.nec.com/en/press/202011/global_20201130_02.html

[4] https://www.nec.com/en/press/202210/global_20221018_02.html

II. Question Responses and Recommendations

1. State of the Open RAN Industry and Acceleration Challenges and Opportunities (Questions 1-5)

Wireless cellular communication systems have been evolving for 50 years. Initial system testing began in 1973 and the first commercial system was launched in 1983 in Chicago. The evolution and global impact have been remarkable. The U.S. has been a leader in this technology. This evolution has led to several large suppliers that support the infrastructure market and have implemented proprietary interfaces between the various building blocks of their systems – limiting competition and associated innovation. Changing from closed RAN (Radio Access Network) to Open RAN is necessary to enable the full potential of 5G, 6G and the technologies beyond 6G.

The transition to Open RAN is not without significant challenges. Several of the most important challenges are shown in Figure 1 and explained in depth further below.

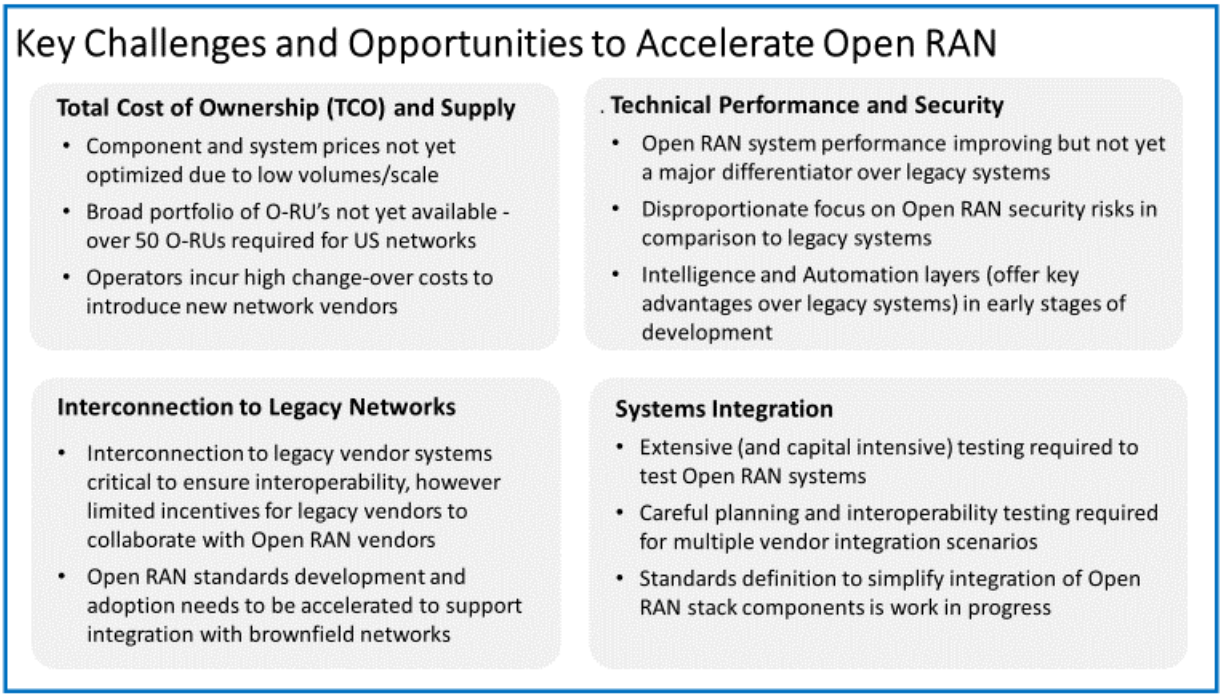

Figure 1: Key challenges and opportunities for Open RAN

Total Cost of Ownership – Network carriers are under continuous pressure to increase speed and capacity, to provide unlimited data to customers, and to do it at a competitive price. New solutions for the network must be price competitive and Total Cost of Ownership must be equal or better over time compared to current legacy systems. Given Open RAN is still in the early stages of being deployed, there is a need for scale and diversity of radio units (RUs) (possibly 50+) to meet US carriers' diverse network requirements.

Technical Performance and Security – Cellular networks have become more reliable over time and are depended upon for many essential services, including emergencies. The technical performance of Open

RAN networks must be equal to or better than legacy networks. Security of the networks in this age of increasing cyber threats is a requirement. Additional features and capabilities to optimize and improve the user experience must be developed as part of the intelligence and automation layers on top of the connectivity layer of an Open RAN stack (Figure 2 below).

Interconnection to Legacy Networks – There are few new greenfield networks being built around the world. In the U.S., Dish Networks is developing the only greenfield network. Legacy networks can only be upgraded gradually, so it is imperative that the Open RAN components of the network interconnect with the legacy network. Methods and standards to operate in a mixed legacy/Open RAN network must be developed and network evolution implemented without impacting service. Additionally, legacy vendors do not have incentives to interconnect with Open RAN vendors which slows the adoption of Open RAN in brownfield networks.

Systems Integration – Network carriers expect the same or a better level of network performance and reliability from Open RAN systems as they have from legacy architectures. To ensure such performance, Open RAN networks require extensive integration and performance testing to meet carriers' exacting operational requirements. Additionally, given that there are multiple vendors of Open RAN network equipment, systems integration and testing needs to be completed for every combination of RU, Central Unit/Distributed Unit (CU/DU), Open RAN cloud capability (O-cloud), Radio Intelligent Controller (RIC) and 5G/4GCore – a significant and continuous effort. Extensive interoperability testing and integration test facilities are required to enable this activity. There will also be requirements for precise system integration and interoperability testing standards, methods, and procedures for implementation in commercial networks.

These challenges illustrate the work that needs to be accomplished to make Open RAN a success. It is also important to consider the priority of work to be completed and timing of funding. There are several key priorities that the market needs to develop, and without these, the current architecture and suppliers will remain unchanged. Figure 2 below shows simplified architectures of Open RAN and legacy systems.

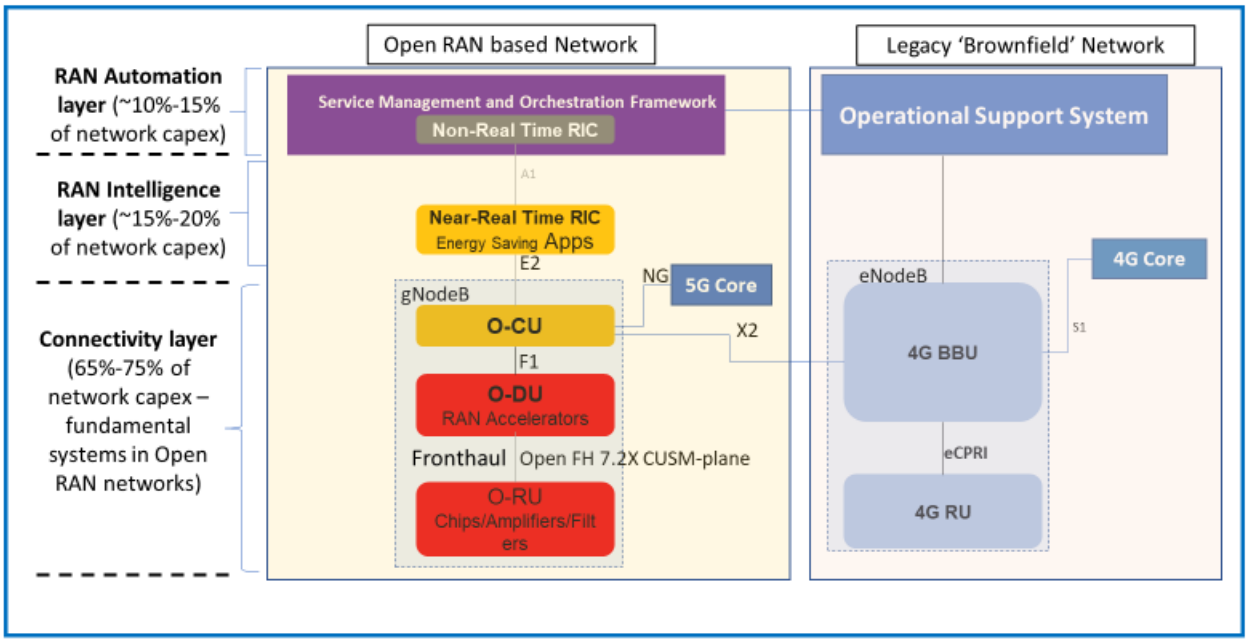

Figure 2: High-level comparison of Open RAN and legacy network architectures

The most expensive and power-intensive element of a cellular network is the radio access. By some estimates, up to 70%-80% of a network capex is allocated to radio access systems. The evolution of the market has led to a limited number of global suppliers of radio access systems. This has reduced innovation and incentives for cost and performance optimization. Stimulating innovation and reducing costs through the introduction of new vendors in the RAN ecosystem is a key aspect of Open RAN. To realize this promise, it is critical that the fronthaul interface to the radios be 'open' and that there are multiple suppliers of radios for all the frequency bands assigned to commercial cellular networks. At this point, there are a small number of open interface radio suppliers and a limited number of frequency bands supported. (See Figure 3 below for U.S. radio requirements). It is also critical that the new open architecture has the capability to interface with legacy, brownfield systems. The 3GPP interface (X2) facilitates this interaction. Initial funding should focus on further developing radios, the fronthaul interface, and the interface between Open RAN radios and legacy systems. It is necessary to develop several cost-effective radio options for carriers to deploy Open RAN networks. Without multiple spectrum band and configuration Open-RU(O-RU) options, the Open RAN ecosystem cannot be fully established. Legacy vendors have built an extensive portfolio of non-Open-RU configurations over the last 30 years. In order to compete effectively and offer viable options to carriers, funding for O-RU development is critical to the success of the Open RAN ecosystem. Current market dynamics will not realize this O-RU development in a sufficiently timely manner.

Beyond O-RU development, NTIA should prioritize funding to advance development of other components of the new open architecture. This includes development of new capabilities such as, advanced security, more efficient control of the overall system to maximize capacity, maximizing use of spectrum, and minimizing energy usage. This will enable 5G deployments and set the stage and prepare for the more advanced capabilities that will come with 6G and technologies beyond 6G.

Figure 1 highlights some of the key challenges to adoption and deployment of open and interoperable, standards-based RAN. For implementation of greenfield networks or private networks there are no fundamental roadblocks as there are few or no legacy systems to integrate. Challenges still exist for testing and interoperating with multiple vendors, but the skill sets to perform this system integration are increasing and integration times are reducing. For brownfield deployments the issues are more complex, and more details are provided in Section 2.

The support for the concept of Open RAN has been increasing and many in the industry have provided support and development to advance standards and the technology. Some of the organizations supporting the Open networks initiative include O-RAN Alliance, 3GPP, Telecom Infra Project, Open RAN Policy Coalition, and NextG Alliance.

Many network operators are supporting Open RAN with 'plug fests', integration testing, and support of component development for Open RAN. Much of this is happening outside the United States. NEC is supporting many of these activities with operators such as NTT DOCOMO, Vodafone, Telefonica, Rakuten Mobile, and Deutsche Telekom.

NEC is committed to overcoming the challenges to realize the long-term benefits of Open RAN. The pace of adoption and of overcoming these challenges, however, has been too slow. The Innovation Fund can help accelerate the adoption of Open RAN and increase the leadership and competitiveness of U.S. industry.

2. TECHNOLOGY DEVELOPMENT AND STANDARDS (QUESTIONS 6-8)

Recommendation #1: Provide funding to develop multiple radios to create a broad portfolio of Open RAN-compliant O-RUs shown in Figure 3.

As shown on Figure 2, radios are key enablers for Open RAN. At this point there are a limited number of radios in the market that are Open RAN compliant. To meet the demands in the United States requires a complete product family of radios from multiple suppliers. Figure 3 below illustrates the types of radios required for Macro sites. These radios are needed to support all the networks including brownfield systems in the United States. Current and planned networks globally will require significantly more radio types.

Open RAN Radios (O-RUs) Required for U.S. Macro sites - including 'Brownfield' Deployments

			FDD				TDD				
			RU		M-MIMO		RU		M-MIMO		AAS
	Spectrum	3GPP band	2T/2R	4T/4R	16T/16R	32T/32R	4T/4R	8T/8R	32T/32R	64T/64R	Multiple
Low bands	600 MHz	B71	✓✓✓	✓✓							
	700 MHz	B12	✓✓✓	✓✓							
		B13	✓✓✓	✓✓							
		B14	✓✓✓	✓✓							
		B17	✓✓✓	✓✓							
	800 MHz	B5	✓✓✓	✓✓							
Mid-bands	1900 MHz	B2/25		✓✓	✓✓	✓✓					
	2100 MHz	B4/66		✓✓	✓✓	✓✓					
		B70		✓✓	✓✓	✓✓					
	2300 MHz	B30		✓✓	✓✓	✓✓					
	2.5 GHz	B41					✓✓	✓	✓✓	✓✓	
	3.5 GHz	B77 3450-3550 "Ambit"					✓✓	✓	✓✓	✓✓	
		B48 CBRS					✓	✓	✓	✓	
		B77 3700-3980 MHz					✓✓✓	✓	✓✓	✓✓	
mm-wave bands	24 GHz	B258									✓✓✓
	28 GHz	B261									✓✓✓
	39 GHz	B260									✓✓✓

Note: Every radio configuration is required in 1-3 different power levels (✓) and in multi-band combinations, resulting in over 50 product variants

Figure 1: Open RAN radios needed in the US

Major network operators in the United States will need to broadly deploy Open RAN radios in order to achieve sufficient volume and scale. These operators have requirements for radios at varying power levels, different sub bands within the spectrum shown on Figure 3, and in some cases multiple bands in one radio enclosure. This increases the number of radios required to over 50 different O-RU configurations. Without an adequate supply of O-RUs in different bands and configurations, broad Open RAN adoption will not be possible.

Notably, Table 3 only includes radios for Macro sites. There are additional low power radios needed for indoor applications and some private networks.

Recommendation #2: Provide funding for new component and integrated circuit (IC) solutions targeting improved performance, reduced power, and reduced cost.

Open RAN compatible radio development should build upon the latest in modern components. This includes amplifiers, filters, advanced ICs and other components as shown on Figure 4. Innovation in these subsystems and components has been limited over the last twenty years as a few vendors with proprietary technologies dominated RU development. U.S. companies have driven many of the component enhancements and these need to be applied to new radios to take advantage of these new capabilities. These new components can improve spectrum efficiency, provide advanced beam forming, increase security, lower overall cost, improve performance, and reduce energy consumption. Providing funding to O-RU vendors to test and validate new components in their design will assist in accelerating Open RAN innovation in the United States and advance the state of the technology.

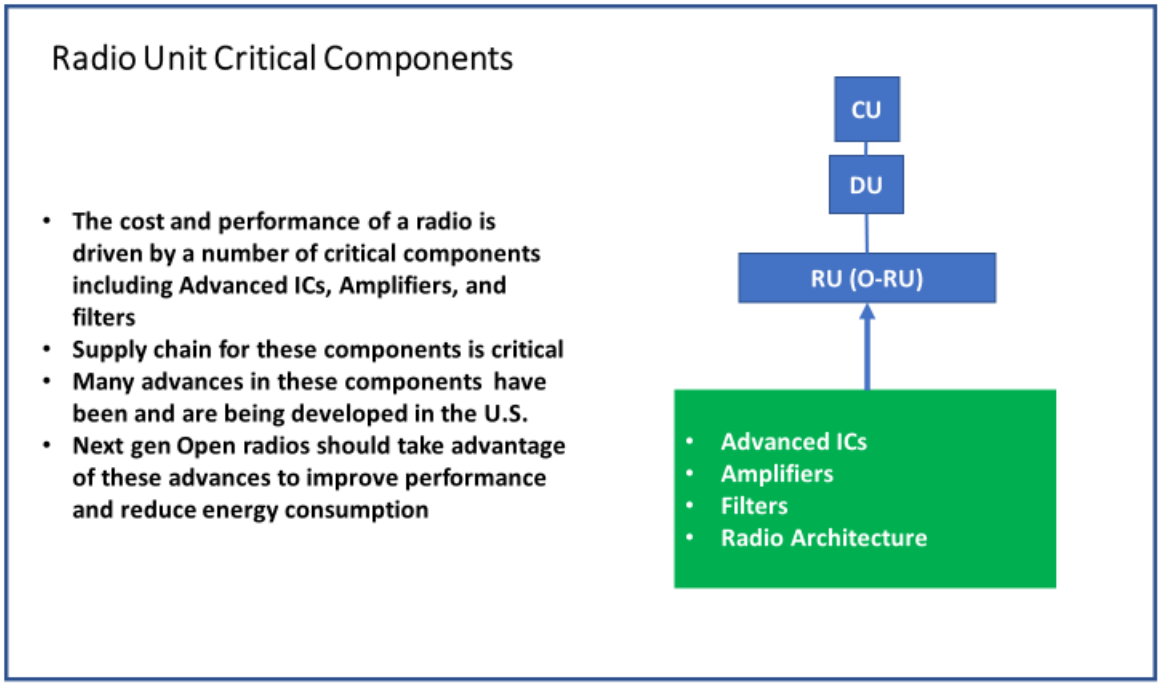

Figure 2: Radio Unit critical components

Recommendation #3: Provide funding for continued development of CU/DU including interoperability testing with multiple RU suppliers and core networks.

As shown in Figure 2, the necessary components for Open RAN include more than radios. The CU and DU that support and control the radio are important elements of Open RAN. Development of the CU and DU equipment by several vendors has started, but faster implementation and more vendor options would be advantageous and accelerate Open RAN adoption.

Recommendation #4: Provide funding for the development and interoperability testing of the required interfaces between an Open RAN system and legacy system to provide for interoperation and migration from legacy to Open RAN.

A CU-to-legacy interface is required to interface between Open RAN systems and legacy systems. In Figure 2 this is depicted as the 'X2' interface between the CU and the legacy BBU. This concept is well developed by the standards bodies and supported by the O-RAN Alliance, but it is an optional capability. Legacy vendors do not offer interoperability with their equipment, so substantial support and extensive testing is required for the X2 interface to be developed and utilized for brownfield deployments.

Recommendation #5: Provide funding for the development of RIC applications and use cases, both non-RealTime and near-RealTime.

The Radio Intelligent Controller (RIC) is a new element introduced in Open RAN architectures. The Open RAN Alliance defines a near real-time RIC to respond to immediate changes required in the radio system and a non-real-time RIC to implement capabilities with a more flexible timescale (~1 second latency). There will be many features and applications in the RIC, often called xAPPs and rAPPs. These APPs will provide improvements in areas such as performance, capacity, spectrum utilization, and energy savings. These APPS can be considered analogous to an app store on mobile phones and are key to differentiating Open RAN from legacy networks. These capabilities will continue to develop and will be fundamental elements of next generation networks. Various entities can develop new and creative functionality that can be easily inserted into Open RAN systems through the open RIC platform. This presents a great opportunity for Open RAN differentiation from legacy RAN.

Recommendation #6: Provide funding for companies and organizations who are committed to Open RAN to support the standards setting bodies.

As mentioned in Section 1, there are several organizations involved in the standards process for Open RAN. Significant work remains in standards development and some representatives in these standards bodies are not fully committed to advancing Open RAN. The O-RAN Alliance lacks experts to proceed with some critical work related to interface and security development. More support is required especially in the O-RAN Alliance and 3GPP to complete the Open RAN standards. The standards process is time consuming and expensive to support and therefore most smaller vendors do not participate. There is a need for support to help smaller companies participate in these bodies.

Recommendation #7: In future efforts, provide funding for 6G projects that require the use of open interfaces.

6G development has already begun and standards activity will begin in early 2024. A more proactive approach toward open interfaces should be taken for 6G.

Early in the introduction of 5G, the Defense Department provided funding for 5G projects and test beds to accelerate the development of 5G capabilities. The government should initiate a similar effort related to 6G. The requirements for this effort should be the use of open interfaces and providing advanced capabilities.

Additionally, efforts should be directed into making Open RAN a mandatory element of 6G requirements and architecture.

Recommendation #8: In future efforts, provide funding for innovative Open RAN development and standards work for advanced capabilities.

Some examples of further study for R&D and standardization areas which can contribute to the Open RAN development and advancement include:

- Artificial Intelligence/Machine Learning (AI/ML) Deployment of "AI/ML Continuous Operation" outside of non-RealTime RIC (in O-RU, O-CU, O-DU); ML model download and upload between non-RealTime RIC and near-RealTime RICs over O1 or A1 interface
- Multiple RICs support with standardized interface between RICs to enable development of xApps and rApps that can be ported across multiple near-RealTime and non-RealTime RICs
- Open RAN support for non-terrestrial (e.g., satellite) networks

- Open RAN support for metaverse use cases: Augmented Reality (AR)/Virtual Reality (VR) etc.
- Further standardization of Open RAN-enabled private networks, e.g., integration with edge systems and local breakouts
- NWDAF/MDAF/non-RT RIC
- Study of further split and interfaces for Open RAN specific use cases (energy saving, beam optimization, coverage analysis, network slicing, RAN node software upgrade etc.)
- Study of further split and contribution of subscriber(s) information to network optimization use cases

3. INTEGRATION, INTEROPERABILITY, AND CERTIFICATION (QUESTIONS 9-12)

Recommendation #9: Provide funding for the repository of RAN data to be used for Open RAN AI/ML algorithm development and optimization.

The wireless industry envisions that advanced AI/ML techniques will power the next generation of Open RAN automation, orchestration, and optimization algorithms. Funded projects should include the establishment of an open repository of RAN data for the development and validation of such Open RAN AI/ML algorithms.

AI/ML algorithms typically require access to a large amount of RAN data for model training and learning to produce optimal results. However, in the traditional cellular network deployment model, these RAN data are held by Network Operators, and are not accessible to third-party AI/ML application developers. It will help accelerate the deployment and adoption of Open RAN AI/ML algorithms if the Innovation Fund provides funding to incentivize Network Operators to contribute anonymized RAN data to an Open RAN data repository. In addition, funding will also be required for the establishment, management, and continued operation of such an open repository of RAN data, where the RAN data is accessible to Open RAN application developers for the purposes of AI/ML algorithm testing and performance validation.

Recommendation #10: Create an end-to-end simulation environment to validate interoperability and performance of RIC Apps.

Open RAN architecture brings additional capabilities such as the RIC and various APPs that can run on the RIC as well as higher levels of orchestration and data analysis. There must be a simulation environment and a test lab to verify operation and performance before commercial service. This testing should use the RAN data from the repository to verify performance and benchmark against other applications.

Recommendation #11: Provide funding for several Open RAN test beds that include all system components.

Open RAN testbed environments allow trusted suppliers to test their equipment interfaces with many Open RAN counterparts. In addition, such an open environment that includes all system components will allow interested vendors to expose key Open RAN interfaces to enable large-scale testing and interoperability verification by any third party. One or more trusted suppliers can manage this integration and testing. A neutral host organization should be established for final certification.

Recommendation #12: Provide funding to evaluate and develop Open RAN migration methods for brownfield networks.

Interoperability with legacy brownfield networks is critical for Open RAN market adoption. U.S. operators have just recently retired their 3G networks after more than 20 years in operation. We can expect the same for legacy 4G networks. Analysis of how to interoperate must be completed and tools and methods must be developed to make a smooth transition from current legacy networks, to mixed legacy and Open RAN networks, to the eventual phase out of the legacy networks.

4. TRIALS, PILOTS, USE CASES, AND MARKET DEVELOPMENT (QUESTIONS 13-16)

Recommendation #13: Provide funding to support one or more operators in establishing a commercially operational system to test end-to-end Open RAN solutions in a live network.
The ultimate goal is to have the majority of networks built or evolved to open, interoperable, standards-based networks. This will allow expanded opportunities for future innovations, enhancements, and vendor diversity. There is no better evidence in favor of a new technology than having actual performance results from live operation.

There are two examples of greenfield networks implemented based upon Open RAN. There are also numerous trials, plug-fests, and early testing of Open RAN equipment. These need to continue and be expanded to include real service deployments particularly in brownfield networks. Other operators need to be incentivized to complete First Office Applications (FOAs) and collect real world performance data. This data should be shared with the Open RAN community to improve future standards and evolution.

5. SECURITY (QUESTIONS 17-20)

Recommendation #14: Complete Open RAN/Network Security Standards and Prove that Open RAN technology is inherently secure.

Security is a major concern of all organizations and networks. Recently, there have been claims that Open RAN is not a secure technology, when in fact Open RAN provides security improvements. Open RAN provides standardized interfaces that enable the vendor community at large to improve compared to legacy proprietary interfaces that are opaque to industry participants. Additionally, network security is a multi-layered task and hence the discussion on Open RAN security must be part of a larger network security challenge. Security must be required for all third party xAPPs used on the RIC.

O-RAN Alliance Working Group 11 is addressing Open RAN security. Currently, the work is partially done, and is mostly concentrated on the following topics:

- Fronthaul C/U/S – Plane security
- Near RealTime-RIC xApps and Non-RealTime-RIC rApps security, incl. App LCM security
- O-Cloud security
- O-RU: Shared O-RU security, Certificate Management Framework security, Centralized User Management Security
- SMO security
- AI/ML security
- Security Log Management

This work must continue and should be a collaboration among government agencies, universities, corporations, and alignment with other countries that have created Open RAN security frameworks to bring consistency to the market.

6. PROGRAM EXECUTION AND COLLABORATION (QUESTIONS 21-26)

This program funding should be provided to organizations and companies with a proven record in supporting Open RAN, as well as their capability to durably influence and promote Open RAN in the United States and internationally. There should be a preference for partnerships and collaboration between the ecosystems to enable the broadest participation possible. Priority should be given to companies that expand the diversity of supply and multi-vendor offerings in the U.S. market.

The proposals submitted should be technically specific and provide detailed development timelines, staffing levels, testing and verification procedures, and performance metrics. As much as possible, there should be operator participation to ensure that capabilities are trialed and introduced in commercial networks.

There should be multiple grants in the critical areas for Open RAN adoption including new radios, advanced radio components, Open RAN to legacy interface, RIC and RIC Apps, CU/DU support, standards support, and security. Issuing multiple grants in each critical area will ensure wide support from numerous organizations. Grants should favor collaboration which could include universities, testing labs, and various size companies.

Additionally, NTIA would benefit from collaborating internationally with like-minded partners to coordinate on funding opportunities for shared benefit. The United States will not sufficiently advance these initiatives without close international partnerships and NTIA can further the Innovation Fund impact by leveraging similar investments from partner countries in the United States and globally.

III. Conclusion

NEC has a long history of support for open networking and has been a leader in Open RAN efforts since the beginning. Much work has been done, but much work remains to be completed. NEC supports the actions of the U.S. Government and NTIA to provide funding for the advancement of Open RAN as well as incentives for multiple suppliers and organizations to participate. In this response we have highlighted fourteen areas recommended for funding. We have also suggested priorities for that funding with initial focus primarily on radio developments to support various spectrum bands, power levels, and radio combinations required by operators in the United States. NEC stands ready to support U.S. government efforts to support this next evolution of wireless communications capabilities.

Sincerely,

Brent Bombach
Vice President
Head of Government Relations
and Public Policy