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The Honorable Alan B. Davidson  
Assistant Secretary of Commerce for Communications and Information  
National Telecommunications and Infrastructure Administration  
1401 Constitution Avenue NW  
Washington, DC 20230

Re: VMware comments on *Public Wireless Supply Chain Innovation Fund Implementation*,  
Docket No. 221202-0260, RIN 0693-XC05

Dear Administrator Davidson:

VMware appreciates the opportunity to submit the following comments in response to the National Telecommunications and Infrastructure Administration's (NTIA) Request for Comment (RFC) on the implementation of the Public Wireless Supply Chain Innovation Fund (Innovation Fund). This generational investment in communications technology infrastructure will be a key contributor to accelerating the development, deployment, and adoption of Open Radio Access Networks (Open RAN) in the United States and abroad.

As a leading provider of multi-cloud services and virtualization, VMware software gives organizations, including telecommunications network operators, the flexibility and choice they need to build and manage the future. Headquartered in Palo Alto, California, VMware has a long history of innovating and modernizing the infrastructure that enables our digital economy. Founded in 1999, VMware was the first to commercially virtualize the x86 architecture – helping enterprises modernize their IT infrastructure.

For nearly a decade, VMware has applied this innovation to the telecommunications industry, working with the world's leading network operators to virtualize their networks. Today, we offer a comprehensive end-to-end portfolio that allows network operators to deploy telecommunications workloads across their networks including the core and the RAN. VMware's software solutions provide the foundation for open networks that will foster innovation and expand the supply chain in telecommunications networks around the world.

Just as network operators are evolving, so too are VMware's offerings. In the Open RAN ecosystem, VMware's Telco Cloud<sup>1</sup> solutions allow virtualized and containerized RAN functions to run efficiently on

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<sup>1</sup> <https://telco.vmware.com/products.html>

Commercial-Off-The-Shelf (COTS) hardware; it is a key ingredient for enabling open, multi-vendor interoperable RAN by providing a neutral platform where RAN software can be decoupled from vendor-specific hardware. VMware has pioneered the use of software solutions for the deployment of real-time RAN workloads, allowing maximum flexibility to deploy, manage, and run these real-time workloads at significant scale. Today, VMware is continuing to innovate by challenging itself to advance its solutions toward a zero-touch, zero-trust, and zero-watt delivery model.

VMware strongly supports the Innovation Fund and appreciates the thoughtful questions NTIA has posed in its RFC. We share NTIA's goals to develop and implement diverse, competitive, and resilient communications networks in the United States and abroad. We believe that the Innovation Fund can successfully make an immediate impact by supporting projects that demonstrate commercial viability today, while also laying a strong foundation for continued innovation by investing in R&D projects that accelerate technology development for next generation communications. We discuss this balance in further detail in the pages below where we provide feedback on the following topics:

- State of the Open RAN industry
  - In this section, we discuss key challenges to Open RAN deployment and adoption.
- Trials, pilots, use cases, and market development
  - In this section, we provide suggestions on how the Innovation Fund can work with industry to address the challenges discussed in the first section.

#### **I. State of the Open RAN industry (Questions 1-5)**

The Open RAN industry has seen rapid development and growth in the past few years, with the first large-scale Open RAN network deployed in the United States last year. While the industry steadily marches towards delivering on the goal of creating an open architecture and open ecosystem of best of breed solutions promoting innovation, there remain several challenges to wider deployment of Open RAN in the United States, as discussed below.

#### ***State of the Industry Summary – Challenges and Opportunities***

##### **a. Inconsistent Definitions and Vision of Open RAN**

First and foremost, measuring the state of the Open RAN industry requires a common understanding of what Open RAN means. As originally envisioned, the goal of Open RAN was not to simply open interfaces in order to be interoperable with selected vendors, but to create a vibrant “open ecosystem”. An open ecosystem implies that operators can be flexible in the vendor selection for the different components and layers of the network, as opposed to an ecosystem where traditional vendors preselect a subset of vendors who meet their specific interoperability requirements. This “dual” openness is the key to accelerating Open RAN innovation and deployment to ensure that the vibrant multi-vendor ecosystem is created to support Open RAN. It is only with open architectures and open ecosystems,

that, for example, startups and other non-traditional suppliers will have the opportunity to enter the market and increase competition.

Unfortunately, today some organizations have focused only on the open interface portion of the Open RAN vision, without addressing the corresponding need to create an open ecosystem as well.

#### **b. Multi-Vendor Interoperability and Operational Complexity**

Optionality in standards and vendor implementation variations can result in interoperability challenges. These challenges are further exacerbated by differing needs from operators in terms of requirements and features, lack of industry agreed test scenarios, performance metrics and benchmarking guidelines. Adoption of Open RAN introduces additional suppliers to operators' RAN supply chain and requires knowledgeable End-to-End (E2E) systems integrators (or a framework for systems integration) to assist in integrating, validating, and operating various components from the resulting multi-vendor ecosystem. In VMware's experience working with multiple vendors in current deployments, we have learned firsthand the need for better coordination of tasks and activities to ensure interoperability for smooth operations and maintenance. These tasks include, but are not limited to, upgrading, troubleshooting, and remediating issues.

#### **c. Workforce Transformation**

As RAN networks are being transformed, traditional network players like operators and systems integrators will need to transform their workforces to adapt to virtualized, software-driven infrastructure. In addition to new RAN-related skillsets, operators will need a skilled workforce trained in programming, devOps, security, and cloud computing to operate and maintain this new infrastructure.

#### **d. Lack of Support for Smaller Ecosystem Players**

One of the benefits of Open RAN is increased competition. This applies to equipment vendors as well as operators by bringing features and innovation parity to operators big and small. However, the complexities and cost associated with the technology can make Open RAN less accessible to small and regional network operators. More efforts to support small and regional operators' adoption of Open RAN is necessary to help achieve deployment at scale.

#### **e. Deploying, Operating, and Maintaining Open RAN Networks at Scale**

While the industry has made great strides in Open RAN deployment, additional work remains to ensure seamless deployment, operation, and maintenance of "carrier-grade" Open RAN networks at scale. For example, a customizable automated deployment process that supports scale and concurrency is key. Other enablers in deployment of Open RAN in carrier-grade networks at scale include Zero Touch

Provisioning (ZTP), network function Life Cycle Management (LCM), E2E automation, and observability and root-cause toolsets in multi-vendor environments.

## **II. Trials, Pilots, Use Cases, and Market Development (Questions 13-16)**

### ***Innovation Fund Opportunities to Accelerate Adoption of Open RAN***

The Innovation Fund can help to address the challenges discussed above in Open RAN development by allocating funds in a targeted fashion. First, NTIA can set forth a minimal set of guidelines and expectations for RAN implementations to be open, interoperable, and standard compliant. This will help ensure proposals meet the criteria of truly being open architectures and open ecosystems. Second, NTIA should support proposals that aim to accelerate technology development and maturation by enabling validation, certification, integration, and deployment. This makes Open RAN technology easier to “consume” (in other words, deploy, operate, and maintain) for network operators, which in turn, lowers the total cost of ownership, drives domestic demand, and accelerates adoption of Open RAN. Third, the NTIA should support project proposals that promote not only horizontal interoperability (i.e. being able to combine network functions from multiple vendors) but also vertical interoperability (i.e. being able to host those network functions on different platforms that are not tied to a specific hardware and software combination). Running virtualized network functions on COTS hardware aided by robust platform software can lessen the impacts of global supply chain fluctuations, compared to purpose-built, highly customized equipment. Finally, NTIA should focus on funding projects that address practical short- and long-term needs. Projects supported by the Innovation Fund should strike a balance to support both technology development, which enables long-term maturation of the industry, as well as process-and-procedure innovations, which accelerates adoption and deployments in the near-term.

#### **a. Open RAN Certification and Integration**

One of the most pressing challenges facing the Open RAN community today is the lack of an end-to-end certification entity that can validate whether a solution adheres to Open RAN’s principles of an open and interoperable ecosystem. While there are many plugfests, testing, and validation efforts, the establishment of an end-to-end certification entity is key to accelerating the development and adoption of Open RAN. Currently, the O-RAN Alliance defines Open RAN specifications and has created Open Testing and Integration Centers (OTIC). A new E2E certification entity is required and can use the specifications defined by O-RAN Alliance or others as a basis. If successful, this entity could help address other challenges in the industry, such as by expanding to provide system integration training, certification services and support.

#### **b. Open, accessible ecosystem collaboration opportunities**

Supporting and facilitating open and accessible collaboration opportunities among Open RAN ecosystem stakeholders will spur innovations and promote market adoption. There are various ways the Innovation Fund can support such opportunities, such as funding industry-led and created entities that

establish open testbeds to test and validate multi-vendor interoperability and Open RAN use cases. The Innovation Fund can also be used to expand the ecosystem by accommodating collaborations with nontraditional RAN ecosystem players such as independent applications developers.

### **1. E2E Open RAN Testing Environments**

Open RAN introduces additional flexibilities and programmability that allow developers to explore use cases and offer truly unique and differentiated user experiences. Currently, it is not easy for independent third-party application and service developers to get access to adequate environments where they can develop, validate, and finetune their solutions. The Innovation Fund can help bridge this gap by supporting projects that construct or provide a fully automated, open E2E Open RAN testing environment. This will foster third party innovations in use cases and applications, driving consumer adoption and demand for 5G and Open RAN.

To be successful, these environments should simulate various multi-vendor architecture options and follow interoperability best practices. This means fully virtual, automated environments are needed to allow open, flexible, and efficient testing and validation. Test network setup, application instantiation, test scenario construction, execution, and analysis should be fully E2E orchestrated and automated.

The creation of E2E environments can also be used to investigate how Open RAN Application Programming Interfaces (APIs) and Key Performance Indicators (KPIs) can be exposed to applications so that they can be “network-aware”. Moreover, the proposed E2E environment does not need to be confined to a facility-based “lab” environment. Outdoor testbeds, pilots, or trials leveraging slices of a live network can also augment facility-based lab environments.

### **c. Workforce Development**

As mentioned above, network transformation necessitates workforce transformation. A virtualized, software-driven infrastructure requires a strong pipeline of workforce talent with skillsets in programming, devOps, security, and cloud computing. Below, we discuss two ways the Innovation Fund can support this transformation.

#### **1. Tooling as workforce development**

To accelerate this needed workforce transformation, funding proposals that include streamlined tooling for operating and maintaining the Open RAN network infrastructure is critical. This streamlined tooling will eliminate unnecessary complexity and improve usability through a combination of:

- Automation
- Intuitive and User-Friendly User Interface (UI)
- Intent-Based Orchestration
- Customizability

- Artificial Intelligent and Machine Learning (AI/ML)

## **2. Open RAN “University”**

The Innovation Fund can also help to accelerate deployment of Open RAN by supporting an “Open RAN University” or “Innovation Center” created by industry members where ecosystem participants—from large and small network operators to software developers and academics—can come together to discuss implementation challenges and share lessons learned. As mentioned above, Open RAN is already being deployed in the United States. Creating a collaborative space to share these lessons would optimize deployments and accelerate adoption.

### **d. Advancing Foundational Technologies**

The Innovation Fund can make a strong, lasting impact by supporting projects that further advance foundational technologies like the RAN Intelligent Controller (RIC) and convergence. These technologies are the key to creating a robust ecosystem that enables innovation in use cases and industry verticals.

#### **1. RAN Intelligent Controller (RIC)**

Increasingly, the RIC is being recognized as one of the keys to unlocking more open, disaggregated networking. It is an important component of Open RAN architecture which could bring cost savings, innovation, differentiation, and new revenue opportunities for network operators. RIC introduces programmability into the RAN in the form of xApps and rApps, so that operators and third-party developers can introduce custom features into the networks. The RIC framework can be leveraged to customize RAN features and behaviors in the context of a user application, offering superior use experience and differentiation. The industry is already seeing the potential for RIC use cases that solve current needs. For instance, VMware conducted a trial with a vendor partner for Spectrum Multiplier and Cloud Scheduler as xApps on VMware’s RIC. This trial successfully improved spectrum efficiency using 5G Multi-User Multiple-Input Multiple-Output (MU-MIMO).<sup>2</sup> This trial demonstrated the potential for RIC and xApps to address the challenge of spectrum access and efficiency – a key concern for large operators and a major barrier to entry for small operators. RIC can benefit tremendously from openness and interoperability; closed and proprietary RIC implementations can restrict the portability of xApps and rApps across RICs from different vendors and limit the programmability of the 5G network. Supporting RIC deployment and adoption will empower independent software developers leading to the development of a vibrant xApp and rApp ecosystem with use cases in numerous verticals in both public and private 5G networks.

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<sup>2</sup> <https://telco.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/microsites/telco/vmware-cohere-spectrum-multiplier-with-ric.pdf>

## 2. Convergence: Expanding Beyond the Mobile Network

Open RAN should be viewed as an enabler for a larger ecosystem beyond just mobile use cases. An open and disaggregated RAN network that is enabled by software can be converged with infrastructure, operations, or applications of other access networks that serve fixed, unlicensed, or enterprise users. From modernizing network infrastructure to targeting new opportunities such as the nascent edge market, convergence allows non-mobile operators and enterprises alike to take advantages of the flexibility, programmability, cost, and competitiveness that Open RAN brings. Examining how 5G and Open RAN features can evolve to enable convergence will expand the Open RAN paradigm to other technologies and increase Open RAN market adoption.

Industry is already moving in this direction as solutions like Service Management and Orchestration (SMO) architecture framework can bring together multi-access, multi-domain, multi-user, multi-vendor orchestration, observability, and assurance. By providing a common data collection framework and common message bus, the SMO can provide the ability to inject data from multi-access RAN, core, transport, and external AI/ML data and inferences from core analytics platforms like Network Data Analytics Function (NWDAF). Such multi-access, multi-domain data availability can be utilized by RIC to enable analytics and programmability to offer superior user experience and service differentiation and can be leveraged as a Multi-Access Edge Computing (MEC) enabler.

### III. Conclusion

Thank you again for this opportunity to provide comments as the NTIA begins implementation of the Public Wireless Supply Chain Innovation Fund. We look forward to continuing the conversation and contributing to this important effort. If you have any questions, please don't hesitate to reach out to me (smariam@vmware.com) or Jay Cho (jacho@vmware.com).

Sincerely,



Mariam Sorond  
Chief Technology Officer, Service Provider and Edge Business Unit