

**Before the  
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION  
Washington, D.C.**

In the Matter of	)	
	)	
Public Wireless Supply Chain Innovation Fund	)	Docket No. NTIA-2022-0003
Implementation	)	
	)	

**COMMENTS OF QUALCOMM INCORPORATED**

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## I. INTRODUCTION AND BACKGROUND.

Qualcomm Incorporated (“Qualcomm”) hereby responds to the National Telecommunications and Information Administration’s (“NTIA’s”) Notice and Request for Comment<sup>1</sup> on implementation of the Public Wireless Supply Chain Innovation Fund (“Innovation Fund”), authorized by the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021.<sup>2</sup> Congress appropriated \$1.5 billion for the Innovation Fund in The Chips and Science Act of 2022.<sup>3</sup> When establishing the Innovation Fund, Congress recognized the critical importance of expediting the development and deployment of Open Radio Access Networks (“Open RAN”).

Qualcomm agrees that expediting the development and deployment of Open RAN must be NTIA’s priority and believes that NTIA can advance this priority through actions it takes with the Innovation Fund. Qualcomm, one of the world’s leading wireless technology innovators, has been the driving force behind the development, launch, and expansion of today’s 3G, 4G and 5G networks. Qualcomm is also at the forefront of developing the foundational technologies and products upon which Open RAN deployments will be built.

Qualcomm has created Open RAN solutions for all types of deployments (e.g., networks using high-, mid-, or low-band spectrum; networks made up of macro cells or small cell

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<sup>1</sup> *Public Wireless Supply Chain Innovation Fund Implementation*, Docket No. NTIA-2022-0003, Notice and Request for Comment, 87 FR 76182 (NTIA 2022) (Notice and Request for Comment).

<sup>2</sup> See Pub. L. 116-283; 47 U.S.C. § 906(a)(1).

<sup>3</sup> See Pub. L. 117-167, Div. A, Sec. 106, 136 Stat. 1392.

deployments; indoor or outdoor networks; and public or private networks). Qualcomm's solutions are already in products that will be an essential part of Open RAN deployments. In particular, Qualcomm has developed the X100 5G RAN Accelerator Card<sup>4</sup> and QRU100 5G RAN Platform,<sup>5</sup> and since September 2022, it has provided this equipment for sampling to global customers and partners for integration and verification of next-generation 5G mobile infrastructure solutions. These technologies will bring innovative, cost-effective, and power-efficient Open RAN solutions to the marketplace and boost the infrastructure ecosystem. The Accelerator Card, for example, turns data centers into high-performance and energy-efficient 5G Open RAN infrastructure, reducing the cost of operating a 5G wireless base station by up to 60%. These Qualcomm technologies are the basic building blocks of large-scale 5G Open RAN deployments and, therefore, their development and deployment marks a significant step in the evolution to full-scale open and virtualized 5G networks.

Qualcomm is working closely with numerous industry partners worldwide on developing, testing, integrating, verifying, and deploying Open RAN technology, equipment, and networks. See [Annex 1](#) for a recitation of the key groups with whom Qualcomm works on Open RAN Elements, Standards, and R&D.

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<sup>4</sup> The X100 5G RAN Accelerator Card is a type of "expansion card" that helps systems that coordinate RAN platforms, transceivers, baseboards, antenna modules, etc. perform at higher speeds and capacities as a customizable plug-in to commercial-grade systems. It won the *5G Innovation of the Year for Wide Area Networks (WAN) Award* at the Mobile Breakthrough Awards in 2022.

<sup>5</sup> The QRU100 5G RAN Platform is designed for high-power, high-capacity radio operation. It is designed to be future-proofed for several generations of signal splitting, providing better flexibility and energy efficiency at peak speeds. It, and the X100 5G RAN Accelerator Card, are designed to simplify at-scale network deployments, including virtual networks.

To expedite the development and successful deployment of Open RAN technology and make Open RAN a mainstay of the wireless ecosystem, it is critical that NTIA make the right immediate choices with the Innovation Fund. Prior to answering NTIA's specific questions in the Notice and Request for Comment, Qualcomm would like to stress two fundamental points.

**First**, time is of the essence. To maximize the impact of the Innovation Fund, NTIA must move quickly, within the next 12-18 months, to collectively establish the criteria for evaluating, reviewing, and approving grant applications expeditiously. Indeed, Congress recognized the importance of fast action by requiring NTIA to begin awarding grants no later than one year after monies were appropriated to the Innovation Fund.<sup>6</sup> NTIA also should frontload expenditure of the \$1.5 billion appropriated for the Innovation Fund. Grants made within the next 12-18 months will have a much greater impact in accelerating the deployment of Open RAN technology than those made beyond that period.

**Second**, NTIA should focus Innovation Funds on projects that will support commercializing Open RAN and foster large-scale Open RAN deployments before the end of 2024. In particular, projects focused on integration, field testing, verification, and deployment of Open RAN should be prioritized, as these are some of today's bottlenecks to widespread, large-scale Open RAN deployments. This is difficult, time-consuming, and resource-intensive work.

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<sup>6</sup> See 47 U.S.C. § 906(a)(1)(E).

With help from the Innovation Fund, companies can add engineers to work with more carriers and vendors on Open RAN integration, field testing, verification, and deployment. Simultaneous and expeditious Open RAN integration and testing work with a greater number of carriers and vendors will accelerate the pace of large-scale commercial Open RAN deployments. Accelerating such deployments is a central focus of the Innovation Fund.<sup>7</sup> A recent economic study highlighted the importance of supporting semiconductor manufacturers and software suppliers, who will have the greatest influence on Open RAN adoption because semiconductor manufacturers “provide a critical foundation for all network equipment,”<sup>8</sup> and software suppliers “orchestrate interactions between components. By providing precise funding to these critical points in the value chain, Open RAN adoption is significantly accelerated by the cascading effects of research and development efforts in the foundational technologies, which ripples throughout the rest of the ecosystem.”<sup>9</sup>

Qualcomm recommends that NTIA’s initial grant funding focus on projects that: (1) support current private sector work to immediately integrate, test, verify and deploy Open RAN and (2) support development of additional security features related to Open RAN. Future tranches of Innovation Funds should address remaining gaps and barriers by funding and coordinating across the nascent US-based national lab ecosystem to enable operators and

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<sup>7</sup> See 47 U.S.C. § 906(a)(1)(C)(ii). “Accelerating commercial deployments of open interface standards-based compatible, interoperable equipment, such as equipment developed pursuant to the standards set forth by organizations such as the O-RAN ALLIANCE, the Telecom Infra Project, 3GPP, the Open-RAN Software Community, or any successor organizations.”

<sup>8</sup> Deloitte, *Accelerating domestic open RAN adoption* (May 2022), on 15.

<sup>9</sup> *Id.*

suppliers to match their requirements and specifications and assess the technical performance, interoperability, resilience, and security of Open RAN equipment.

## II. QUESTIONS ON THE STATE OF THE INDUSTRY.

***(1) What are the chief challenges to the adoption and deployment of open and interoperable, standards-based RAN, such as Open RAN? Are those challenges different for public vs. private networks?***

**Response:** From a general standpoint, the chief challenge to the adoption and deployment of Open RAN technology is skepticism within the wireless industry about whether Open RAN-based networks can perform as well or better than networks relying on proprietary equipment when Open RAN is deployed at scale. To be sure, there are a few early adopters of Open RAN across the globe moving forward with substantial Open RAN deployments.

From a practical perspective, the biggest current challenge to deployment of Open RAN, as described above, is the time-consuming, and resource-intensive integration, field testing, and verification work that needs to be done on a carrier-specific and vendor-specific basis prior to large-scale commercial deployments.

The challenges with respect to Open RAN are different for public and private networks. First, the scale of private networks is generally much smaller than the scale of public networks so it is easier to demonstrate to the operators of private networks that the performance of Open RAN technology in the field will meet their needs. Second, private networks are generally greenfield networks while public networks are generally brownfield networks. This is an important factor because it is much easier for a network operator to choose to employ Open RAN technology when it is building a network from scratch than when it is already operating an

existing network that relies on proprietary equipment and would have to transition to an open RAN approach.

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

**Response:** It is more complicated from a technical perspective to upgrade an existing network to incorporate Open RAN equipment than it is to deploy a greenfield Open RAN network. In particular, where a legacy wireless network is still in place and will be providing both 4G and 5G service, utilizing Open RAN equipment is a complicated task. Rather, for network operators, it is easier to utilize an Open RAN approach in a standalone 5G network.

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

**Response:** There are at least three public sector initiatives that could be well coordinated with the Innovation Fund, and would produce material benefits for the future of wireless networking, consumers, and government funding: (a) NTIA's Broadband, Equity, Access, and Deployment (BEAD) Program;<sup>10</sup> (b) the Federal Communications Commission's (FCC) \$9 billion 5G Fund for Rural America;<sup>11</sup> and (c) the Department of Defense (DoD) and NTIA's 5G

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<sup>10</sup> See NTIA, *Broadband Equity, Access, and Deployment (BEAD) Program Overview* (May 2022), available at [internetforall.gov/sites/default/files/2022-05/BEAD%20Info%20Sheet%20-%20IFA%20Launch%20-%20Final.pdf](https://internetforall.gov/sites/default/files/2022-05/BEAD%20Info%20Sheet%20-%20IFA%20Launch%20-%20Final.pdf).

<sup>11</sup> See *Establishing a 5G Fund for Rural America*, Report and Order, GN Docket No. 20-32, 35 FCC Rcd 12174 (Oct. 27, 2020).

Challenge,<sup>12</sup> and DoD's planned Open RAN deployments at U.S. bases.<sup>13</sup> By adopting a holistic approach to coordinating the Innovation Fund with the funding mentioned above our federal government can truly accelerate the development and deployment of Open RAN technologies and systems.

***(a) What gaps exist from an R&D, commercialization, and standards perspective?***

**Response:** Qualcomm does not see a gap in Open RAN standards or R&D. Industry has worked together well through organizations such as the O-RAN ALLIANCE, Small Cell Forum, and Third Generation Partnership Project (3GPP) to develop key specifications and standards. See Annex 1. Similarly, there is not a large gap, at the moment, in Open RAN R&D. See Annexes 2, 3 and 4 which set forth completed work regarding the relationship between 3GPP architecture and the O-RAN ALLIANCE architecture (Annex 2), the key interfaces for virtualized Open RAN deployments (Annex 3), and the reference implementations for R&D, trials, prototypes and commercial integration (Annex 4).

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

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<sup>12</sup> U.S. Department of Defense, *Department of Defense and NTIA Launch 5G Challenge to Accelerate Development of Open 5G Ecosystem* (Apr. 6, 2022), available at <https://www.defense.gov/News/Releases/Release/Article/2990687/departments-of-defense-and-ntia-launch-5g-challenge-to-accelerate-development-of/>.

<sup>13</sup> U.S. Department of Defense, *DOD Announces \$600 Million for 5G Experimentation and Testing at Five Installations* (Oct. 8, 2020), available at <https://www.defense.gov/News/Releases/Release/Article/2376743/dod-announces-600-million-for-5g-experimentation-and-testing-at-five-installations/>.



**Response:** As discussed above, we are currently in a critical window for the deployment of Open RAN technology. It is important that NTIA focus initial Innovation Fund resources on near-term projects that will be able to accelerate the commercialization and deployment of Open RAN technology in the next 12-18 months. This means that NTIA should award grants to companies who are already actively working on commercializing Open RAN and will use funds to expedite projects involving integration, field testing, verification, and deployment of Open RAN. Congress specifically identified a goal of the fund to “accelerating commercial deployment of open interface, standards-based, compatible, interoperable equipment”. A recent economic study highlighted the importance of supporting semiconductor manufacturers and software suppliers, who will have the greatest influence on Open RAN adoption because semiconductor manufacturers “provide a critical foundation for all network equipment,”<sup>14</sup> and software suppliers “orchestrate interactions between components. By providing precise funding to these critical points in the value chain, Open RAN adoption is significantly accelerated by the cascading effects of research and development efforts in the foundational technologies, which ripples throughout the rest of the ecosystem.”<sup>15</sup>

Additionally, NTIA should use Innovation Fund grants to complement the work that is currently taking place in the private sector on security features related to Open RAN. Indeed, Congress specifically directed that the Innovation Fund support “promoting and deploying security features enhancing the integrity and availability of equipment in multi-vendor

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<sup>14</sup> Deloitte, *Accelerating domestic open RAN adoption* (May 2022), at 15.

<sup>15</sup> *Id.*

networks.”<sup>16</sup> As discussed in more detail below<sup>17</sup> in response to the security-specific questions set forth in the Notice and Request for Comment, Qualcomm and other companies have already developed strong security features for Open RAN equipment, and Qualcomm believes that the distributed and compartmentalized nature of Open RAN architecture will improve network security.

Future tranches of Innovation Fund grants should be coordinated across the nascent US-based national lab ecosystem to enable operators and suppliers to match their requirements and specifications, and assess the technical performance, interoperability, resilience, and security of Open RAN equipment.

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

**Response:** At the moment, the main workforce constraint impacting the development and deployment of Open RAN is the availability of engineering talent. We believe the U.S. can be well positioned for growth in advanced communications, including Open RAN, with a coordinated focus on growing the pipeline with allies and partners, and making significant U.S. investments in advanced communications, including via the National Science Foundation (NSF) and the Department of Energy (DOE).

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<sup>16</sup> 47 U.S.C. § 906(a)(1)(C)(vi)

<sup>17</sup> See *infra*, Section VI.

***(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?***

**Response:** Qualcomm sees domestic and international interest in investing in Open RAN, both in private and public networks. Qualcomm has responded to this market interest by devoting significant resources to developing Open RAN technology and equipment. But more must be done by NTIA and others to create momentum for Open RAN.

***(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?***

**Response:** Global supply chains are critical for the successful development and deployment of Open RAN systems. While Qualcomm strongly supported the CHIPS & Science Act, it will not be possible to successfully deploy Open RAN technology at scale in the near-term without relying, in part, on semiconductors and equipment produced in other countries.

### **III. QUESTIONS ON TECHNOLOGY DEVELOPMENT AND STANDARDS.**

***(7) Are the 5G and open and interoperable RAN standards environments sufficiently mature to produce stable, interoperable, cost-effective, and market-ready RAN products?***

**Response:** The vast majority of basic R&D to develop products that will hasten large-scale Open RAN deployments has already occurred, and the majority of key interfaces necessary to build viable commercial Open RAN systems defined by 3GPP, the O-RAN ALLIANCE, and the Small Cell Forum are mature enough to support viable commercial products.

See [Annex 3](#).

***(a) What barriers are faced in the standards environment for open and interoperable RAN?***

**Response:** The O-RAN ALLIANCE is operating in the balance among the standards bodies that enable interoperation within very complex mobile networks (e.g., 3GPP), vendor-oriented organizations such as the Small Cell Forum, and open-source communities. The O-RAN ALLIANCE has achieved tremendous progress in many complex areas such as the Open Fronthaul and the RAN Intelligent Controller (RIC) automation protocol areas.

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

**Response:** Investment in reference platforms and the associated integration and test programs to validate interoperability can substantially accelerate the emergence of a vital Open RAN ecosystem. However, this needs to happen in a manner that respects the close partnership among all stakeholders in the ecosystem – R&D, system vendors, component vendors, open-source communities, test vendors, and service providers, etc. It is essential to strike a careful balance and to establish close cooperation among standards organizations, vendors of all types, open-source projects, government agencies (from multiple regions and countries), testing and integration projects, and any other key organizations that are creating the ecosystem.

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

**Response:** The O-RAN ALLIANCE has been driving the creation of Open Testing and Integration Centers (OTICs) around the world, and additional efforts are underway to enhance

the level of interoperability with various reference platforms. Carriers, vendors, and test vendors have all contributed to these efforts, and many early plugfests and similar events have already happened. As Open RAN elements reach full commercial viability and scale, a greater investment in these efforts will be required. Standards compliance will be verified by testing against Open RAN specifications.

***(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?***

**Response:** Open RAN stands to provide a future-proofed connectivity infrastructure that generates efficiencies for the telecommunications sector and advantages nearly every industry using telecom – collectively helping to inform and drive 6G R&D. 6G standardization is in very early stages; however, most standards organizations have recognized the need to initiate preliminary study efforts this year. The projects that can best ensure 6G and future generation standards are built on foundational Open RAN are the projects that accelerate immediate Open RAN deployments and drive commercialization. Long term R&D investment in 6G could be useful as the evolution roadmap and trends for use cases, spectrum, radio technologies, backhaul technologies, and cloud native platforms come into focus. In particular, NTIA could invest in certain initiatives to ensure that 6G and future-generation standards are built on a foundation of open and interoperable, standards-based RAN elements.

**IV. QUESTIONS ON INTEGRATION, INTEROPERABILITY, AND CERTIFICATION.**

***(9) How can projects funded through the Innovation Fund most effectively support promoting and deploying compatibility of new 5G equipment with future open, interoperable, and standards-based equipment?***

**Response:** NTIA can promote the compatibility of new 5G equipment with future open, interoperable, and standards-based equipment by encouraging or requiring Innovation Fund grantees to support and participate in existing industry collaboration that is already underway. The O-RAN ALLIANCE, for example, seeks to achieve broadly compatible and interoperable commercial Open RAN solutions and services. As Open RAN elements reach full commercial viability and scale, greater investment and participation in these O-RAN ALLIANCE efforts will be needed, and standards compliance can be verified by testing against O-RAN ALLIANCE 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?***

**Response:** Yes – interoperability testing and debugging events, including plugfests, are an essential mechanism for supporting the development and commercialization of Open RAN. Plugfests support the ecosystem of vendors and operators in testing and integrating their implementations, which, in turn, helps to ensure the openness and interoperability of Open RAN solutions from different providers. In particular, as noted above, the O-RAN ALLIANCE has already conducted a number of global plugfests, including the recent O-RAN Global PlugFest in the fall and spring of 2022, which were successfully completed in six venues across Asia, Europe, and North America, with 106 participating companies.<sup>18</sup> These global Plugfests

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<sup>18</sup> Business Wire, *O-RAN ALLIANCE Advances Testing and Integration with Successful O-RAN Global PlugFest Fall 2022* (Dec. 14, 2022), available at <https://www.businesswire.com/news/home/20221214005850/en/O-RAN-ALLIANCE-Advances-Testing-and-Integration-with-Successful-O-RAN-Global-PlugFest-Fall-2022>.

represent a major platform for enabling efficient progress of the Open RAN ecosystem through well-organized testing and integration, and greatly contribute to the development of commercially available Open RAN systems.

A broadly defined cooperation model, to promote industry and public interests could include:

- **Testbeds:** At a high level, a testbed is a platform composed of elements (including both hardware and software) that implement or reproduce the behavior of a communications system, such as 5G/6G, along with measurement instruments designed to test components of that communications system. NTIA has already undertaken efforts in this arena, including the selection of CableLabs/Kyrrio to host an industry-based 5G Challenge to measure the maturity of Open RAN vendor capability and compliance with Open RAN standards.<sup>19</sup>
- **Labs:** NTIA could also fund and coordinate across the nascent US-based national lab ecosystem to enable operators and suppliers to match their requirements and specifications to assess the technical performance, interoperability, resilience, and security of equipment. To be clear, NTIA should fund and support existing industry lab efforts that are underway rather than create a new national lab that competes for resources.
- **Trials:** In addition, NTIA could launch a series of major Open RAN trials in the U.S. or initiate a major Open RAN trial framework with oversight, to speed the development of Open RAN and lay the foundation for its rollout in U.S. and international networks.

To further complement the initiatives described above, NTIA also could consider funding university nonprofit organizations that train engineers for careers in test and certification roles.

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

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<sup>19</sup> Fierce Wireless, *CableLabs Chosen to Host NTIA, DoD 5G Challenge*, (March 2, 2022), available at <https://www.fiercewireless.com/tech/cablelabs-chosen-host-ntia-dod-5g-challenge>.

**Response:** NTIA and Innovation Fund awardees can promote the integration of multi-vendor network environments by supporting, funding, and coordinating industry lab efforts that are already underway across the nascent U.S.-based lab ecosystem, such as the O-RAN ALLIANCE OTIC and TIP Labs. These industry-driven activities seek to provide a collaborative, vendor-neutral, and impartial working environment to facilitate the following goals:

- Promote the wide adoption of Open RAN specifications and the development of an Open RAN ecosystem by hosting demos, community events such as speaker sessions, workshops, and tutorials, as well as lab and field trials.
- Demonstrate implementations and solutions based on Open RAN specifications via plugfests and proofs of concept (PoC).
- Test and verify the conformity of RAN equipment with Open RAN interface specifications, based on Open RAN conformance test specifications.
- Test and verify the interoperability of RAN equipment from different vendors (or the same vendor) using Open RAN interface specifications, based on Open RAN interoperability test specifications.
- Foster and develop integrator technical capabilities by hosting workshops, tutorials, and other events.
- Conduct functional as well as performance (*e.g.*, load and capacity) tests of both end-to-end systems and sub-systems.
- Provide Open RAN working groups and contributors with feedback about experiences that occur when applying Open RAN specifications during testing activities (*i.e.*, implementation-driven specification).
- Demonstrate the maturity and interoperability of individual products, product combinations, or solutions, including through the Telecom Infra Project (TIP).

***(11) How do certification programs impact commercial adoption and deployment?***

**Response:** The motivating principle of Open RAN certification and badging is to minimize the repetition of fundamental and common tests which should be performed to verify and



validate Open RAN compliant products, systems, and solutions before their deployment in operator networks, thus reducing the test effort. The idea is to test only once and reuse/adopt the test results multiple times whenever possible. In addition, the use of Open RAN certificates and badges for network components can be a very important way to promote the Open RAN ecosystem and to encourage implementation and testing of Open RAN products, systems, and solutions and their deployment in operator networks.

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

**Response:** Certification is a proven approach and has supported the current thriving global ecosystem, which is based on 3GPP technology. Industry-developed, voluntary certification programs, such as offered by the Global Certification Forum (GCF), have a proven track record of facilitating the development of interoperable devices, networks, and services, all of which enable the high-quality, reliable, and secure wireless communications services that users and industries demand across the globe.

***(b) What bodies or fora would be appropriate to host such a certification process?***

**Response:** Both the O-RAN ALLIANCE and the TIP have already developed mechanisms to ensure confidence in O-RAN solutions, which could provide the foundation for a certification regime. Specifically, the O-RAN ALLIANCE has developed a certification and badging system to demonstrate product conformance with Open RAN interface and reference design specifications, as well as product interoperability and end-to-end system integration. Similarly, TIP has developed a three-tier badging system to demonstrate the maturity and interoperability

of individual products, product combinations, or solutions. Under TIP's system, bronze badges demonstrate a vendor's self-assessed compliance with TIP requirements, while silver and gold badges indicate increasing levels of testing for alignment with TIP-defined specifications.

In 2020, the O-RAN ALLIANCE and TIP entered into a liaison agreement to ensure their alignment in developing interoperable Open RAN solutions in an effort to avoid duplication and fragmentation.<sup>20</sup> This agreement allows for the sharing of information, referencing specifications, and conducting joint testing and integration efforts, and includes a process by which TIP can provide input on O-RAN ALLIANCE test specifications to ensure their continued alignment.

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

**Response:** Gaps in the current RAN and open and interoperable, standards-based RAN certification regimes include: (a) the need to develop testbed rules and processes that encompass application, setup, and operation; and (b) the need for formal recognition of testbeds that have already been established – specifically those facilitated by the O-RAN ALLIANCE.

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

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<sup>20</sup> See Fierce Wireless, *TIP, O-RAN ALLIANCE Reach Liaison Agreement* (Feb. 25, 2020), available at [fiercewireless.com/wireless/tip-o-ran-alliance-reach-liaison-agreement](https://fiercewireless.com/wireless/tip-o-ran-alliance-reach-liaison-agreement).

**Response:** NTIA can help address these gaps and barriers by developing and providing funding for a lab ecosystem, which includes key elements such as plugfests, testbeds, and trials that can serve as springboards for start-ups and others in industry to prove out their technology.

## V. QUESTIONS ON SECURITY.

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

**Response:** NTIA can encourage awardees to address security by supporting the establishment of testbeds, as well as by sponsoring “plugfests,” where participants can work together to integrate and test equipment and security features across multiple vendors. Testbeds should allow for the continuous integration and evaluation of new security features and should be made available to domain experts across both industry and academia to further facilitate the enhancement of Open RAN security. Bug-fixes and other errors identified during testing should be fed back into the standards development process going forward.

Additionally, NTIA could organize hackathon events as a means to further verify and/or enhance 5G Open RAN system integrity and could sponsor independent open-source code inspection, as well as establishing security criteria for the relevant reference platforms.

***(a) What role should security reporting play in the program's criteria?***

**Response:** Security reporting – and a process for managing security vulnerabilities as they arise – are essential ingredients to ensure system robustness. Accordingly, NTIA should

develop and implement a streamlined process by which awardees can both report and offer patches for security vulnerabilities as part of the funding program. This process could draw from existing examples such as: (1) the Common Vulnerabilities and Exposures (CVE) list, which is maintained by MITRE and funded by the Department of Homeland Security (DHS); and (2) the GSMA Coordinated Vulnerability Disclosure (CVD) program. Both programs provide a mechanism to report security vulnerabilities as they are discovered.

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

**Response:** Qualcomm recommends that NTIA align its requirements with security best practices such as the OpenSSF Best Practices Badge Program (formerly part of the Core Infrastructure Initiative or “CII”), which allows for self-certification with regard to code testing, verification, and signing to produce high-quality, secure software, and would further improve 5G security. The process of applying these established industry best practices should be recorded to assist awardees in adopting those in real-world deployments.

Additionally, software supply chain security and lifecycle management issues can be addressed by requiring a Software Bill of Materials (SBOM) that provides a nested inventory of all components included in the relevant software, in accordance with existing guidelines from the Department of Commerce and NTIA.

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

**Response:** Industry stakeholders understand the importance of security in Open RAN and have already begun to develop standards for Open RAN platforms, interfaces, and

elements, such as through the O-RAN ALLIANCE. For instance, the O-RAN ALLIANCE has a Security Working Group (referred to as O-RAN WG11), which conducts a deep threat analysis on every single O-RAN component – including both hardware and software – and works to develop appropriate security measures in response to those threats to ensure the continued security of Open RAN technologies. Many industry stakeholders are also actively engaged in discussions with regulators and researchers to address security concerns and make sure they are reflected in the relevant standards.

In addition to the above, a number of other entities have published industry best practices and recommendations relevant to Open RAN, such as the National Institute for Standards and Technology (NIST),<sup>21</sup> the National Security Agency (NSA) and Cybersecurity and Infrastructure Security Agency (CISA),<sup>22</sup> the Cloud Security Alliance (CSA),<sup>23</sup> 5G Americas,<sup>24</sup> and the Federal Communications Commission’s Communications Security, Reliability, and Interoperability Council (CSRIC). Many companies have implemented these best practices and

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<sup>21</sup> See National Institute of Standards and Technology, Special Publication 800-190, Application Container Security Guide (Sept. 2017) (describing potential security concerns associated with the use of application container technologies and providing recommendations for addressing those concerns), *available at* <https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-190.pdf>.

<sup>22</sup> In 2021, NSA and CISA jointly published a four-part series containing cybersecurity guidance to securely build and configure cloud infrastructures in support of 5G. See Security Guidance for 5G Cloud Infrastructures Part I: Prevent and Detect Lateral Movement (Oct. 28, 2021); Security Guidance for 5G Cloud Infrastructures Part II: Securely Isolate Network Resources (Nov. 18, 2021); Security Guidance for 5G Cloud Infrastructures Part III: Data Protection (Dec. 2, 2021); and Security Guidance for 5G Cloud Infrastructures Part IV: Ensure Integrity of Cloud Infrastructure (Dec. 16, 2021), *all available at* <https://www.nsa.gov/About/Cybersecurity-Collaboration-Center/Cybersecurity-Partnerships/ESF/>.

<sup>23</sup> Cloud Security Alliance, Security Guidance for Critical Areas of Focus in Cloud Computing 4.0 (July 26, 2017) *available at* [Security Guidance for Critical Areas of Focus in Cloud Computing | CSA \(cloudsecurityalliance.org\)](https://cloudsecurityalliance.org/).

<sup>24</sup> 5G Americas, Evolving 5G Security for the Cloud (Sept. 2022) *available at* <https://www.5gamericas.org/evolving-5g-security-for-the-cloud/>.

recommendations for cloud security, software supply chain security, and software development life cycle management to help further ensure the security of their products and systems.

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

**Response:** Early grants should support development of additional security features related to Open RAN.

***(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?***

**Response:** From the beginning, Open RAN has been designed to incorporate the zero-trust principle, specifically with regard to Open RAN-defined network functions and their interfaces. Open RAN also incorporates principles such as certificate-based authentication, which uses a digital certificate to identify a user, device, or machine before granting access to an application, as well as Open Authorization (or “OAuth 2.0”), an authorization framework that enables applications to obtain limited access to resources, to further ensure security.

Additionally, 3GPP has introduced a service-based architecture for 5G whereby the control plane functionality and common data repositories of a 5G network are delivered via a set of interconnected network functions authorized to access each other’s services. This service-based architecture implements the zero-trust model at the core of the network where each network function (i.e., service consumer) is authenticated and authorized when invoking an application programming interface (API) offered by another network function.

## VI. QUESTIONS ON PROGRAM EXECUTION AND MONITORING.

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

**Response:** In collecting metrics and other data from awardees to evaluate the impact of their projects, NTIA should focus on obtaining information that demonstrates whether and how Innovation Funds have been used to accelerate actual commercial deployment of Open RAN.

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

**Response:** NTIA can promote U.S. competitiveness in the 5G market by prioritizing funding for accelerated Open RAN testing, integration, verification, and field work aimed at supporting commercialization of Open RAN within the next 12-18 months, with additional early grants to support development of security features for Open RAN.

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

**Response:** No, NTIA should not require that all grantee projects take place in the U.S. Qualcomm is working with network operators that are preparing and/or conducting field trials of Open RAN in several markets. Moreover, carriers in Japan, Germany, and India have wide scale Open RAN deployments and industry integration labs which provide valuable insights on how government investment across the network ecosystem can be leveraged to incentivize meaningful deployments that can be applied in the U.S. Other countries are conducting 5G auctions and rollouts and are choosing 5G standalone equipment that is compatible with Open RAN. Rather than requiring that grantee projects take place in the U.S., NTIA should prioritize funding to support the immediate testing, integration, verification, and field work needed to

support Open RAN commercialization by 2024 wherever that is happening – both within and outside the United States – and include U.S. companies as a part of those efforts. U.S. companies will gain valuable expertise from accelerating deployments in early markets around the world , which can then be applied in the United States when appropriate for U.S. network operators.

Moreover, the Innovation Fund is established under a statute that places the Fund and other initiatives in the context of the global wireless market and expressly contemplates activities in support of those initiatives that extend beyond the borders of the United States. Section 906 establishing the Fund is decidedly global in scope. Its subsections create the Multilateral Telecommunications Security Fund to “establish a common funding mechanism, in coordination with foreign partners, that uses amounts from the Multilateral Telecommunications Security Fund to support the development and adoption of secure and trusted telecommunications technologies,”<sup>25</sup> and requires the promotion of “representation of the United States at international forums that set standards for 5G networks and for future generations of wireless communications networks.”<sup>26</sup> Consistent with these provisions, it is to the advantage of NTIA, the United States, and the wireless industry to support Open RAN commercialization and learnings, wherever that work can take place.

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<sup>25</sup> 47 U.S.C. § 906(a)(2)(B).

<sup>26</sup> 47 U.S.C. § 906(b)(1).



***(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”?***

**Response:** Due to critical trading relationships with global allies, the U.S. government has never imposed a requirement for federal grant recipients to use only components manufactured in the United States without a statutory mandate.<sup>27</sup> While a number of statutes have imposed domestic content preferences on federally-funded transportation projects administered by the Department of Transportation (DOT), and the recently enacted Infrastructure Investment and Jobs Act contains domestic content requirements for certain infrastructure projects, neither statute is applicable to the Innovation Fund.

Because the Open RAN supply chain is global, we encourage the U.S. government to focus on supporting a global, resilient, diverse supply chain among nations with expertise.

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

**Response:** NTIA should transparently communicate its goals, process, metrics, and decisions to a wide audience of other governments interested in Open RAN, and encourage other governments to financially support the testing, integration, verification, field work, and other resource-intensive stages to achieve near-term large-scale Open RAN commercial deployments. Governments need to work together to support development and adoption of secure and trusted telecommunications technologies. Governments also must work together

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<sup>27</sup> See Daniel H. Ramish & Jonathan D. Shaffer, Federal Grant Practice § 27:9, “Compliance Requirements Based on Status as a Recipient of Federal Funding” (Thomson Reuters 2022 ed.).

to support industry-led efforts to set standards for 5G and Open RAN deployments that will benefit future generations of wireless communications networks. Open RAN will help to future-proof critical connectivity infrastructure and will provide a more competitive, flexible, and resilient global supply chain.

\* \* \*

## Annex 1

### Key Groups Working On Open RAN Elements, Standards, and R&D

The O-RAN ALLIANCE, Small Cell Forum (“SCF”), and the Third Generation Partnership Project (“3GPP”) each provide key standards and specifications for Open RAN. Qualcomm is a leading contributor in all of these organizations.

- **3GPP** ([www.3gpp.org](http://www.3gpp.org)) defines the overall architecture for 5G cellular communications, including the Radio Access Network (RAN), Core Network (CN), and Operations, Administrations, and Management (OA&M) aspects. While the extensive set of 3GPP specifications provides a complete framework for interoperability among mobile operators and between base stations and end-user devices, there are a number of additional interfaces, protocols, and reference points required to implement Open RAN systems comprised of elements from multiple vendors. The O-RAN ALLIANCE ([www.o-ranalliance.org](http://www.o-ranalliance.org)) defines the O-RAN architecture with these additional interfaces and reference points.
- The **Small Cell Forum** (“SCF”) is responsible for 5G Functional Application Platform Interface (“FAPI”) specifications, which are used at the L1/L2 interface for small cell solutions and other 5G base station classes, ranging from picocells to macro base stations.
- The **O-RAN ALLIANCE** also defines specifications for a second major architectural aspect that enables the creations of multi-vendor, disaggregated Open RAN implementations – the “O-Cloud” architecture for Cloud Native implementations of 3GPP and O-RAN elements in a virtualized manner on commercial private and public cloud infrastructure. This includes a mapping of the functions and protocols that define how various network elements operate in a Cloud Native deployment, including the specific detailed requirements and functionality necessary for the Cloud Native System Management and Orchestration (SMO) of infrastructure and software components, as well as the definition of key APIs for the Applications that implement the virtualized Open RAN functionality in the SMO, O-CU, and O-DU (e.g., rApps, xApps, and vDU applications in the O-DU).
  - The O-RAN ALLIANCE also defines a set of Hardware and Software Reference designs for the implementation of key Open RAN elements, most notably the O-RU and the O-DU. Closely associated with the Software Reference designs are open-source implementations of the 3GPP/O-RAN architecture that are developed in several organizations, including the O-RAN Software Community and the Open Air Interface project.

In addition, a vibrant set of communities has emerged to support R&D activities related to open and interoperable, standards-based network elements, including RAN and core network elements:

- The Telecom Infra Project (TIP, <https://telecominfraproject.com>): TIP is a global community of companies and organizations that work together to accelerate the development and deployment of open, disaggregated, and standards-based technology solutions. Member companies host technology incubator labs and accelerators, and TIP hosts an annual infrastructure conference known as TIP Summit.
- The Open Air Interface (OAI, [www.openairinterface.org](http://www.openairinterface.org)): OAI is an open software that gathers a community of developers from around the world who work together to build wireless RAN and CN technologies. OAI is administered by the Open Software Alliance, a French nonprofit organization that works to facilitate OAI adoption.
- The O-RAN Software Community (OSC, [www.o-ran-sc.org](http://www.o-ran-sc.org)): OSC is a collaboration between the O-RAN ALLIANCE and Linux Foundation that supports the creation of software for the RAN. OSC is focused on aligning with the O-RAN ALLIANCE's open architecture and specifications to achieve a solution that can be used for industry deployment and works toward the development of open-source software enabling modular, open, intelligent, efficient, and agile disaggregated radio access networks.
- The Open Networking Foundation (ONF, [www.opennetworking.org](http://www.opennetworking.org)): ONF is an operator-driven, community-led nonprofit consortium that fosters innovation in software-defined programmable networks. Through ecosystem building, advocacy, research, and education, ONF is accelerating the state-of-the-art in open networking and catalyzing creation and adoption of open, disaggregated solutions leveraging open-source software.
- SmartRAN Open Network Interoperability Centre (SONIC): SONIC is a lab program established by the U.K. government that provides a commercially-neutral, collaborative environment for testing interoperability and integration of open, disaggregated, and software-centric network solutions and multi-vendor architectures.
- Various open source organizations that support the Cloud Native platforms on which the virtualized 5G Open RAN system depends (many projects including in the CNCF ([www.cncf.io](http://www.cncf.io)) and the Linux Foundation (such as the Linux Networking Foundation ([www.lfnetworking.org](http://www.lfnetworking.org)), [www.nephio.org](http://www.nephio.org) and many others)).

In the US, there also are multiple academic and public/private partnership projects to support the ongoing massive efforts to build and maintain cellular Research Platforms, including 4G, 5G and 6G. These include:

- The Platforms for Advanced Wireless Research (PAWR): PAWR is a program that enables experimental exploration of new wireless devices, communication techniques, networks, systems, and services that aims to revolutionize the nation's wireless ecosystem while sustaining US leadership and economic competitiveness into the future. PAWR manages a public-private partnership to deploy and manage up to 4 city-scale research testbeds and is funded by the National Science Foundation and a wireless industry consortium of 30 companies and associations.
- The Platform for Open Wireless Data-Driven Experimental Research (POWDER): POWDER is a facility for experimentation on the future of wireless networking in a city-scale "living laboratory" run by the University of Utah, in partnership with Salt Lake City and the Utah Education and Telehealth Network. POWDER provides an end-to-end platform for research on mobile wireless networks and supports software-programmable experimentation on 5G and beyond, massive MIMO, Open RAN, spectrum sharing and CBRS, RF monitoring, and more.
- Open6G: Open6G is a US Department of Defense (DoD) supported industry-university cooperative research center focused on future open, programmable, and disaggregated 6G systems. Open6G is housed at Northeastern University's Institute for Wireless Internet of Things.
- Colosseum: Colosseum is the world's largest radio frequency channel emulator, and enables the building and testing of intelligent, autonomous, collaborative wireless technologies for military and commercial use. Colosseum was originally developed by Northeastern University to support DARPA's Collaborative Spectrum Challenge (SC2) and is now supported by a grant from the National Science Foundation. Colosseum is also part of the PAWR program.

A common thread among these projects is the cooperative efforts to build, maintain, and enhance the OAI 5G stack, which has now reached a highly usable form on economical, commercially available research hardware with all layers and elements available in open-source form, implementing all of the key 3GPP, O-RAN ALLIANCE, and Small Cell Forum interfaces.

## Annex 2

### The Relationship Between 3GPP Architecture and the O-RAN ALLIANCE Architecture

The following is taken from the FCC CSRIC VIII report,<sup>28</sup> and depicts the high-level relationship between the 3GPP architecture and the O-RAN ALLIANCE architecture.

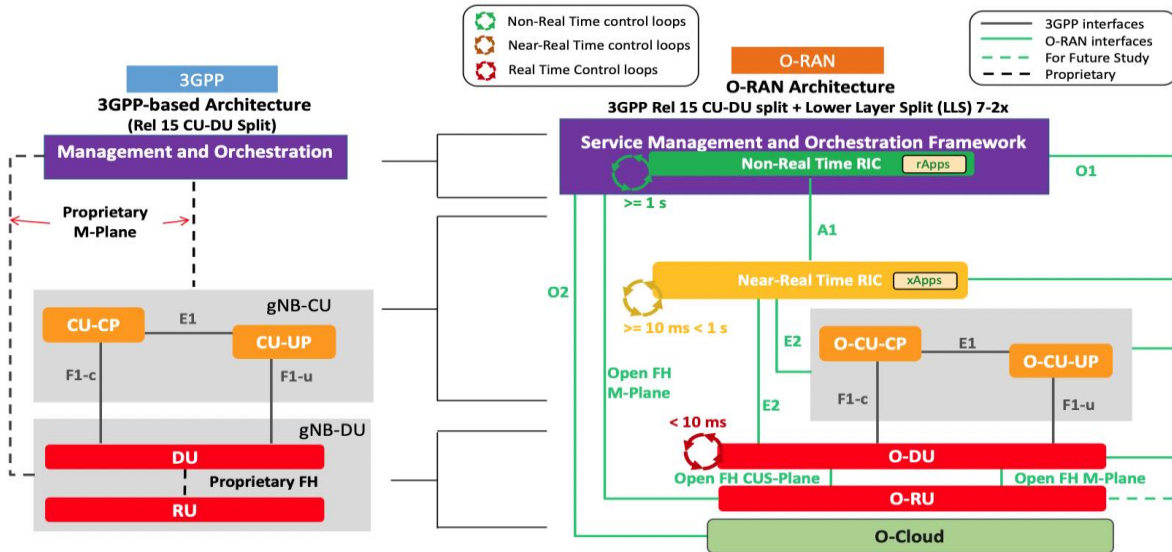


Figure 1. Overview of 3GPP and O-RAN ALLIANCE Architectures

<sup>28</sup> Federal Communications Commission, CSRIC VIII Report Promoting Security, Reliability, and Interoperability of Open RadioAccess Network Equipment (December 2022), page 13, available at <https://www.fcc.gov/about-fcc/advisory-committees/communications-security-reliability-and-interoperability-council-1>.

### Annex 3

Figure 2 -- Key Interfaces for Virtualized Open RAN Deployments

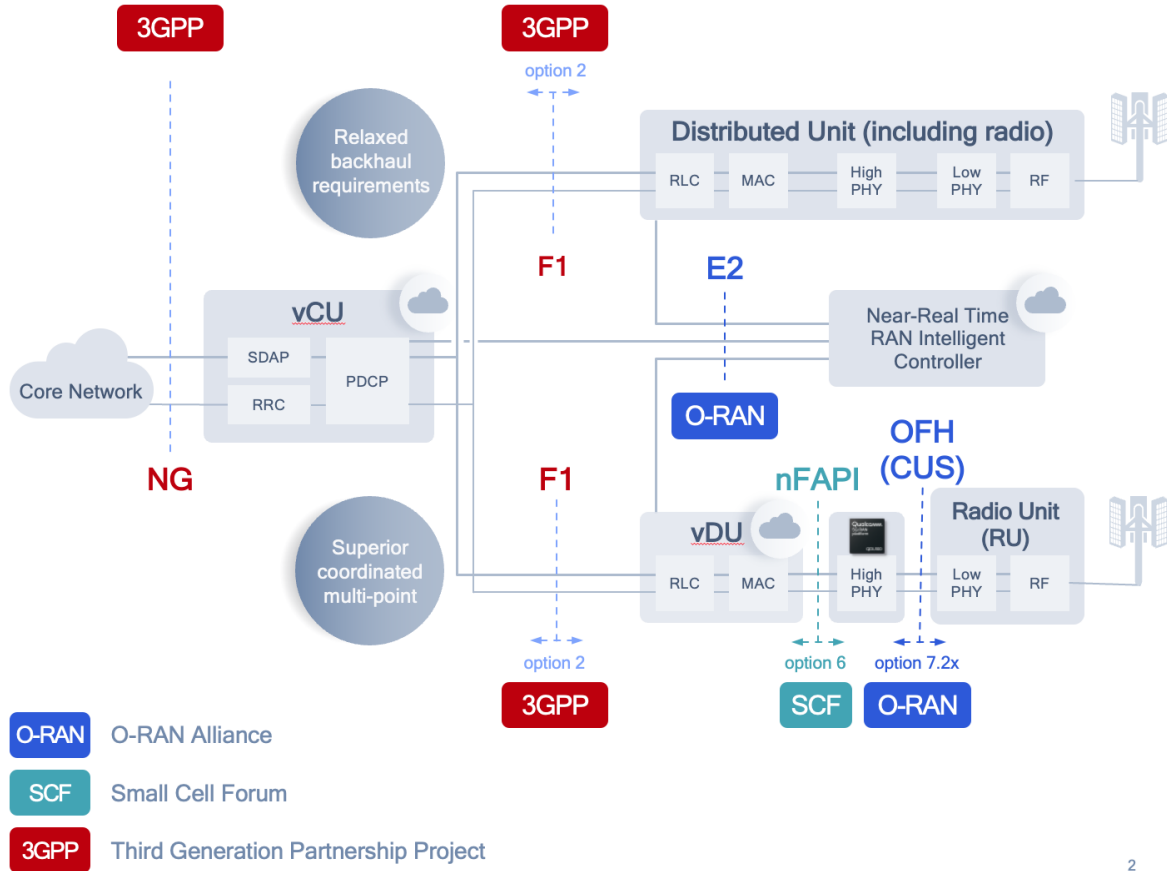


Figure 2. Key Interfaces for Virtualized Open RAN Deployments

### Annex 4

Figure 3. Reference Implementations for R&D, Trials, Prototypes, and Commercial Integration

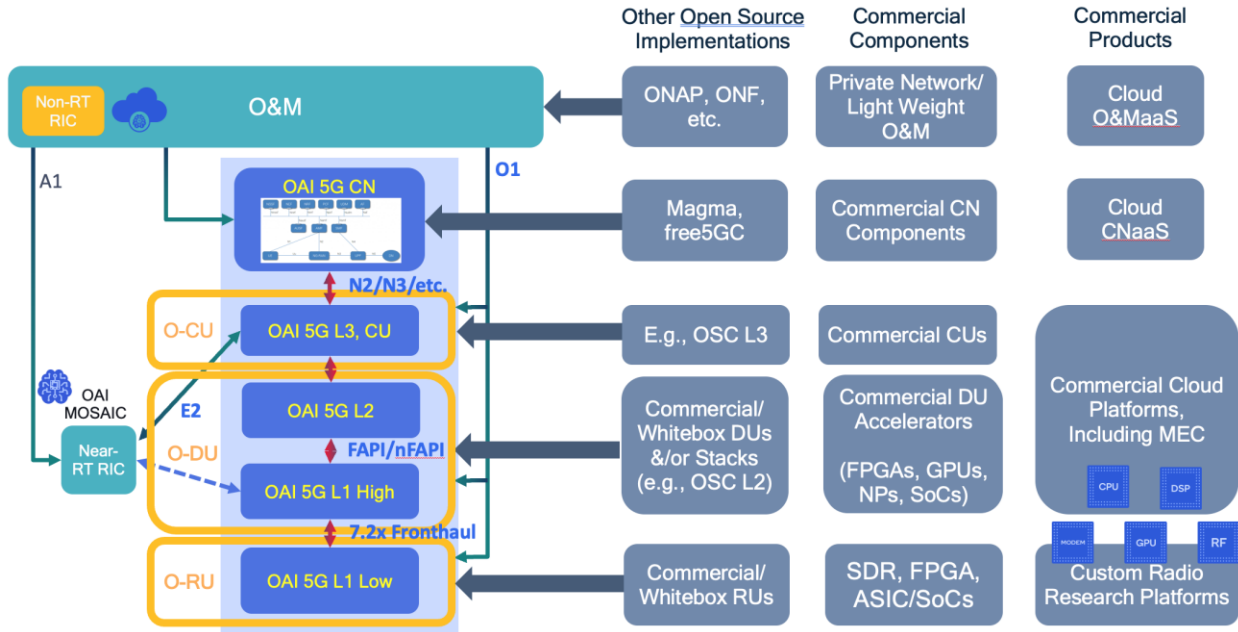


Figure 4. Reference Implementations for R&D, Trials, Prototypes, and Commercial Integration