

Before the
DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Washington, DC 20230

In the Matter of)
)
Public Wireless Supply Chain Innovation Fund) Docket No. 221202-0260
Implementation) RIN 0693-XC05
)

COMMENTS OF THE TELECOM INFRA PROJECT

The Telecom Infra Project (“TIP”)¹ appreciates the opportunity to respond to the National Telecommunications and Information Administration (“NTIA”) request for comment (“RFC”) on implementation of the Public Wireless Supply Chain Innovation Fund (“Wireless Innovation Fund” or “WIF”).²

I. INTRODUCTION AND TIP’S MISSION

TIP is the leading global, community-based non-profit organization working to accelerate the international adoption of open, disaggregated, secure, scalable, and standards-based network solutions that deliver high quality connectivity. Congress explicitly recognized TIP in the statute that created the WIF, directing the fund to support – among several goals – “accelerating commercial deployments of open interface standards-based compatible, interoperable equipment ... developed pursuant to the standards set forth by organizations such as ... the Telecom Infra Project.”³

TIP convenes hundreds of member companies from around the world – from vendors to operators to system integrators – to support this mission.⁴ In 2022, TIP grew to 650 participants, including over 100 service providers, 90 vendors and original equipment manufacturers (“OEMs”) and over 120 integrators, infrastructure providers, and system aggregators. This community has helped deliver over 150 trials and deployments across nearly 50 countries.⁵ Last year, TIP's Open RAN project group published the Open RAN Release 2 Roadmap, continuing

¹ For a list of current members please visit <https://telecominfraproject.com/participants/>.

² Public Wireless Supply Chain Innovation Fund Implementation, 87 Fed. Reg. 76182 (Dec. 13, 2022), Docket No. 221202-0260, <https://www.federalregister.gov/documents/2022/12/13/2022-26938/public-wireless-supply-chain-innovation-fund-implementation> (“Wireless Innovation Fund RFC”).

³ William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, H.R.6395, 116th Cong., § 9202(a)(1)(C)(ii) (2021).

⁴ TIP, Our community, <https://telecominfraproject.com/participants/> (last visited Jan. 26, 2023).

⁵ TIP, *TIP: Facilitating, Accelerating and Enabling Open RAN* (Jan. 16, 2023), <https://telecominfraproject.com/tip-facilitating-accelerating-and-enabling-open-ran/>; TIP, *TIP’s 2022 – Reviewed* (Dec. 19, 2022), <https://telecominfraproject.com/tips-2022-reviewed/>.

to accelerate Open RAN towards commercialization.⁶ This Roadmap harmonizes the prioritized requirements of mobile network operators (“MNOs”), including the four European MNOs who are signatories to the Open RAN Memorandum of Understanding, with vendors’ product readiness categorized in key features and functions, mapping them into a series of incremental releases over time.⁷

With the enactment of the Creating Helpful Incentives to Produce Semiconductors and Science Act – and the establishment of NTIA’s WIF – Congress has made a profound investment in network infrastructure poised to pay dividends for generations to come. Through the WIF, NTIA will work to bolster the development and adoption of open, interoperable, and standards-based networks to help drive wireless innovation, foster competition, upskill the engineering workforce, and strengthen supply chain resilience. In furtherance of its mission to develop, test, and deploy open, disaggregated, and standards-based solutions that deliver high quality connectivity globally, TIP looks to partner with NTIA to achieve this goal.⁸

We draw on this vast experience and deep industry expertise to provide these comments to NTIA on how it can structure and administer grants from the WIF to best accelerate the adoption of open architectures across the global wireless ecosystem and fortify U.S. Open RAN leadership. We also include for supplemental reference the following appendices:

1. Open RAN – Why Efficiencies Must Be Established to Achieve “Liftoff”
2. Certification Efficiencies Theory Tested: TIP’s System Release Certification Pilot
3. The Complementary Roles and Functions of TIP and O-RAN ALLIANCE
4. TIP’s Processes Today
5. Achieving TRL 10: Accelerating Timeline to Reach “Proven Operations”

⁶ TIP, *TIP Publishes Open RAN’s Release 2 Roadmap*, (Feb. 25, 2022), <https://telecominfraproject.com/tip-publishes-openrans-release-2-roadmap/>.

⁷ See GSMA, *Major European operators sign Open RAN MOU*, (Jan. 26, 2021), <https://www.gsma.com/futurenetworks/digest/major-european-operators-sign-open-ran-mou/>. TIP also coordinated with GCC7, a group of operators across the Middle East, which includes e& (formerly Etisalat Group), stc, Zain Group, Batelco, Mobily, Omantel and du, on establishing the region’s first Open RAN test lab, which provides shared access to learnings and progress in this area. In July 2022, the Saudi government announced cooperation with the U.S. on 5G Open RAN through a joint MoU. See TIP, *GCC7 operators collaborate with TIP on a whitepaper that explores opportunities for Open RAN across the Middle East* (Oct. 22, 2022), <https://telecominfraproject.com/gcc7-operators-collaborate-with-tip-on-a-whitepaper-that-explores-opportunities-for-open-ran-across-the-middle-east/>.

⁸ As a global organization, TIP’s mission also aligns with the Commerce Department’s goal to coordinate the acceleration and adoption of Open RAN globally. In particular, TIP supports the recent coordination by the U.S. via NTIA with Australia, Canada, and U.K. on telecommunications supplier diversity. See Press Release, NTIA, *Joint Statement between the United States of America, Australia, Canada, and the United Kingdom on Telecommunications Supplier Diversity* (rel. Dec. 8, 2022), <https://ntia.gov/press-release/2022/joint-statement-between-united-states-america-australia-canada-and-united>. TIP also commends the recent Memorandum of Cooperation between NTIA and Japan’s Ministry of Internal Affairs and Communication on open, resilient telecommunications networks, which reiterates the countries’ continued support for the development and adoption of Open RAN networks, including in the bilateral U.S.-Japan relationship and in multilateral settings such as Japan’s 2023 G7 presidency, the Quad and the Indo-Pacific Economic Framework for Prosperity. See Press Release, NTIA, *Readout of Deputy Secretary Graves’ Meeting with Japan’s Minister for Internal Affairs and Communications Takeaki Matsumoto* (rel. Jan. 18, 2023), <https://www.commerce.gov/news/press-releases/2023/01/readout-deputy-secretary-graves-meeting-japans-minister-internal>.

6. 5G, 6G, and Beyond: Understanding Development Cycles and the Need to Get Open RAN Ready Now for 6G
7. Addressing Skills Gaps and Building an Open RAN Workforce for the Future
8. Only By Prioritizing True Multi-Vendor Open RAN Will the Ecosystem Restore Supply Chain Diversity
9. Accelerating Open RAN Through the RIC

II. OPEN RAN FACES TWO CRITICAL BARRIERS THAT CAN BE ADDRESSED THROUGH NEW STRUCTURAL EFFICIENCIES AND TIMELY INVESTMENTS IN KEY ACTIVITIES.

TIP has been front and center in the global development and deployment of Open RAN from the start. From this unique vantage point, TIP sees two critical barriers that are inhibiting the widespread adoption of Open RAN and creating market inefficiencies:⁹ (1) the lack of MNO purchasing confidence, and (2) supply chain inefficiencies in navigating a newly disaggregated, multi-vendor environment given that wireless systems have historically been closed and controlled by a single vendor.¹⁰

New structural efficiencies can galvanize Open RAN momentum. A far greater number of MNOs need to attain confidence in Open RAN solutions to trigger the level of high-volume purchasing and deployments at scale necessary to impact unit pricing sufficiently to represent a competitive new option in relation to incumbent vendors. Therefore, achieving vendor diversity requires facilitating major structural efficiencies within the supply chain to streamline efforts across hundreds of operators and their vendors.¹¹ TIP has a vision for working across the ecosystem to develop and implement these structural efficiencies at total market scale.

Timely investment in key activities will accelerate Open RAN adoption. Effectively and sustainably solving key challenges requires coordination across the industry and the creation of mechanisms to build technical trust and ease market navigation. Based on TIP's deep expertise in driving open architectures for global wireless competition, TIP recommends that NTIA prioritize the following activities as first-tier investments under the WIF in 2023:

- (1) **Foster a “Whole System” Approach.** Enable continuous system integration and certification of sub-systems and complete end-to-end multi-vendor Open RAN systems and solutions (hardware and software) built upon certified products, components, and designs.¹²
- (2) **Ensure Supplier Diversity.** Provide a digital certification platform and procurement catalog to ease market navigation and stimulate supplier diversity. Design the process

⁹ Addressing Wireless Innovation Fund RFC, Questions #1, 5.

¹⁰ See [Appendix A](#) for additional details regarding why efficiencies are needed to achieve the “liftoff” of Open RAN.

¹¹ Wireless Innovation Fund RFC, Questions #1, 5.

¹² *Id.*, Questions #9-11.

and develop the platform for a diverse and open set of vendors to certify and catalog their products, solutions, and services as market-ready and market-proven.¹³

- (3) **Incentivize Multi-Vendor Open RAN Deployments.** Multi-vendor Open RAN deployments will maximize supplier diversity by providing more opportunities to a greater number of vendors and system integrators.¹⁴ To reverse the effects of vendor consolidation over the last decade, a strong focus on enabling true multi-vendor Open RAN deployments is a vitally important proof-point that moves beyond the current practice of deploying “Open RAN compliant” equipment from a single vendor.¹⁵
- (4) **Build Purchaser Confidence.** Promote solutions that facilitate the buying process for MNOs and lessen the system integration complexity.¹⁶ Open RAN multi-vendor system integrators need to focus on not only the initial deployment, but the entire lifecycle including on-going support, network optimization, and upgrades.
- (5) **Ensure U.S.-Focused Carrier Grade Lifecycle Assurance.** Fully support and benchmark the Open RAN specifications, roadmaps, and requirements, including quality and performance levels, of the U.S. MNOs.¹⁷
- (6) **Think Global. Act Local.** Provide international visibility and independent accreditation for participating U.S. vendors to support and accelerate the export of U.S. products and services. Ensure that the roadmaps of U.S. MNOs benefit from the learnings of Open RAN deployments and roadmaps globally.¹⁸
- (7) **Build on Community-Driven Trust.** Ensure certification and oversight are conducted under the auspices of neutral industry bodies that have earned the trust, engagement, and support of the global ecosystem.¹⁹
- (8) **Bolster Incentives to Accelerate Deployments While Closing Performance and Feature Parity Gaps.** Open RAN deployments require scale to close performance and feature parity gaps. Open RAN can also enable MNOs to realize new value-added capabilities (e.g., RAN Intelligent Controllers (“RIC”)) beyond what traditional RAN can deliver.²⁰
- (9) **Support U.S. Technology Upskilling for Open RAN Deployment.** To accelerate the technological shift to disaggregated networks, prioritize the development of applied

¹³ *Id.*, Questions #10-11.

¹⁴ *Id.*, Question #10.

¹⁵ See [Appendix H](#) for an expanded argument for the prioritization of truly multi-vendor Open RAN solutions

¹⁶ Wireless Innovation Fund RFC, Question #10.

¹⁷ *Id.*, Questions #21, 27.

¹⁸ *Id.*, Question #25.

¹⁹ *Id.*, Questions #12, 23.

²⁰ *Id.*, Question #27.

technology skills focused on evaluating, developing, integrating, testing, deploying, and operating multi-vendor Open RAN and related open and interoperable network solutions.²¹

III. TIP'S VISION: A WELL-COORDINATED ENGINE FOR REDUCING THE COMPLEXITIES INHERENT IN CARRIER-GRADE OPEN RAN SYSTEM INTEGRATION.

Because of the unique challenges of Open RAN highlighted above, and based on TIP's experience, TIP envisions a well-coordinated engine for reducing the complexities inherent in carrier-grade Open RAN system integration. As a trusted neutral party at the center of the global ecosystem, TIP sees the key challenge facing Open RAN deployment – namely, the need for a comprehensive coordination and enablement engine designed to harmonize market fragmentation, drive greater industry coordination, create supply chain efficiencies, and build marketplace confidence through formal certification of Open RAN interoperability at the system level.²² In TIP's observation, an *entire life cycle* approach to Open RAN system integration and validation is required to engender market confidence and catalyze the desired step change in the rate of adoption and deployment of these systems today and for innovation cycles to come.²³

The system certification function should include coordination of the entire system lifecycle from beginning to end – that is, helping operators and vendors to develop system roadmaps, all the way to the point of procurement and benchmarking post-sales customer satisfaction.²⁴ This includes: (1) harmonizing operator requirements; (2) roadmap and lifecycle management; (3) system release certification (“SRC”); (4) solution and integration benchmarking and operational satisfaction surveys; and (5) system procurement, including a readily accessible digital catalog for vendors to showcase their products to MNOs. At the heart of this full life cycle system certification is a federated global network of certification providers (independent labs and system integrators who are TIP-accredited).

Such an SRC function will play a major part in assuring time-to-deployment. SRC for “complete Open RAN systems” (built using multiple vendors’ hardware and software products) will replace “buyer-beware” product compatibility doubts with confidence in proven full Open RAN systems. TIP's theory that a certification process will help restore supply chain efficiencies is backed up by TIP's “SRC Pilot” conducted in 2020, which showed a **60%**

²¹ *Id.*, Question #3.

²² As stakeholders relayed at NTIA's listening session on January 24, 2023 the ecosystem needs solutions that facilitate interoperability and drive down barriers to entry, such as blueprints/reference architectures, testing facilities, and an independent certification body accessible to all vendors regardless of size or revenue. *See e.g.*, NTIA, *Industry Listening Session: Public Wireless Supply Chain Innovation Fund*, at 20:37, 50:00, & 1:06:08 (Jan. 24, 2023), <https://ntia.gov/page/industry-listening-session-public-wireless-supply-chain-innovation-fund> (discussions pertaining to blueprints/reference architectures); *id.* at 53:04, 58:58, & 1:06:13 (discussions pertaining to testing facilities); *id.* at 55:25 & 1:06:45 (discussions pertaining to independent certification bodies).

²³ Wireless Innovation Fund RFC, Questions #1-2.

²⁴ *Id.*, Questions #11-12.

reduction in time to validate an Open RAN Release. The pilot demonstrated the direct value of certification in reducing operator time and effort to achieve successful Open RAN deployment.²⁵

SRC and Open RAN procurement facilitation would go well beyond what TIP or any other entity does today. TIP and the O-RAN ALLIANCE²⁶ (with the overarching policy support of the Open RAN Policy Coalition (“ORPC”)) collectively have laid the foundations and brought many Open RAN products successfully through Technical Readiness Levels (“TRLs”) 1-6.²⁷ While TIP’s current badging of products and solutions²⁸ has been foundational in creating a process that demonstrates, under lab conditions, the increasing maturity and interoperability of individual Open RAN products at TRLs 4, 5 and 6, neither TIP nor any other industry body has yet developed a capability to provide the ultimate level of certification for market-ready, field-hardened, scaled-out, full system-level deployments at TRLs 7, 8 and 9.²⁹

TIP aims to lift Open RAN beyond the foundational steps in which plugfests, interoperability testing, and limited-scale field trials played their roles, toward a comprehensive and federated model of continuous system test/evaluation and certification of end-to-end, commercial-ready, multi-vendor, Open RAN systems within a coordinated rolling release schedule.³⁰ Having laid the foundations for this capability in recent years, TIP now sees the goal for the ecosystem to build a capability to steer Open RAN through TRLs 7, 8, and 9 to attain what TIP defines as *TRL 10: proven operations and lifecycle assurance*. The capability to provide operators and vendors with this type of certification of interoperability and performance for end-to-end Open RAN systems at TRLs 7-10 does not presently exist, and TIP sees it as the necessary – and revolutionary – central ingredient to accelerate Open RAN’s market readiness.³¹ Having such a “ready to launch” capability is indispensable to intercepting the timeline of remaining phases of U.S. 5G deployments and ensuring that Open RAN is built into the upcoming 6G deployment cycle.³²

²⁵ See [Appendix B](#) for a more complete description of TIP’s SRC Pilot.

²⁶ See [Appendix C](#) for additional information on TIP’s and O-RAN ALLIANCE’s respective roles in the current ecosystem.

²⁷ Wireless Innovation Fund RFC, Question #2.

²⁸ See [Appendix D](#) for a full description of TIP’s testing and badging processes.

²⁹ See [Appendix E](#) for a description of Technical Readiness Levels (“TRLs”) and why focusing on TRLs 7-10 should now become the priority for Open RAN to cross the chasm of adoption; Wireless Innovation Fund RFC, Question #12.

³⁰ Wireless Innovation Fund RFC, Questions #11-12; TIP’s 3-tier badging of products and solutions is designed to provide a graded series of steps towards full certification, allowing participants to invest time and resources incrementally. Furthermore, by closing the loop, the experiences of any particular product or solution gained by its early adopters with any one of the mass markets of operators interested in following. In this respect, TIP’s knowledge transfer platform – TIP Exchange – acts like a crowd-sourced “comparison site” for the telecom infrastructure market. Through its vast membership, TIP is well-placed for encouraging and incentivizing this type of knowledge-pooling for mutual benefits to all parties.

³¹ *Id.*, Question #11.

³² See [Appendix F](#) for a deeper look at why we must act now to meet the 6G window.

It bears mentioning that a skilled workforce with the requisite technical training is equally essential to achieving this “ready to launch” capability.³³ A quickening pace in the way telecom networks are designed, built, tested, deployed, and managed requires not only a shift in the way the industry is structured and adopts disaggregated and open network solutions, but also a shift in addressing the knowledge and skills gap in the current workforce.³⁴

Federated labs leverage diverse strengths to support the common goal. Establishing this system certification capability will require tight coordination between the certification body and the federated network of accredited labs.³⁵ Industry can leverage existing lab partners and establish a continuous rolling program of certification, thus avoiding the more costly and time-consuming approach of developing and assembling a lab at the time of each system deployment. While the system certification capability will require seed investment to deploy, there will also be investment requirements for individual specialized labs to ensure they have the right capabilities to offer commercial grade testing – coordinated through the certification body – across the global market.³⁶

SRC and coordinated Open RAN procurement assure a vibrant innovation pipeline. Reshaping the RAN system to incorporate new technologies requires a coordinated, end-to-end approach to align roadmaps across multiple vendors and products. This type of comprehensive system certification would become a vital new industry-wide proxy for the type of full-system roadmap coordination and the corresponding development and testing iterations that were previously only possible within the internal organization of a large, single vendor.³⁷

NTIA can leverage lessons learned from TIP’s experience coordinating many projects at the cutting edge of Open RAN innovation: from nurturing a new ecosystem of artificial intelligence (“AI”)-driven optimization and automation use cases leveraging the RIC; to ensuring the performance of multi-vendor massive multiple-input multiple-output, 5G private networks, neutral host networks, and shared cell architectures; to tackling the energy efficiency challenges

³³ Over 75% of organizations surveyed within TIP's membership indicated an immediate need to address the following industry level issues: (i) common taxonomy in what, why, and how open network solutions are implemented; (ii) a re-skill in today's and tomorrow's telecom professionals with the technical, operational, and strategic knowledge and the skill to evaluate, plan, architect, test, deploy, and manage multi-vendor open network solutions; and (iii) grassroots talent development (from universities, R&D institutes, and within industry) in core skill areas, including software development, network engineering, testing and integration, with the objectives of plugging industry skills gaps and points of failure in the newly forming market structure. Many vendors, system integrators, and operators that are already engaged in Open RAN are building bespoke training programs to upskill their employees and customers in how they implement Open RAN. Although these curricula address an immediate organizational need, they are not designed to build a new breed of certified telecom industry professional, with the proficiency required to either procure or supply in a transforming industry. TIP set up TIP Academy (<https://www.tip.academy/>) in May 2022 with the goal of addressing these issues. See Appendix G for further details.

³⁴ Wireless Innovation Fund RFC, Question #3.

³⁵ *Id.*, Questions #11-12.

³⁶ *Id.*, Questions #14-15.

³⁷ *Id.*, Questions #11-12.

of RAN infrastructure and paving the way towards 6G.³⁸ TIP is uniquely positioned to enable the successful down-streaming and commercialization of new Open RAN technologies – liaising closely with and complementing the upstream roles of academia, fundamental research, and standardization bodies.

Through a coordinated effort, Open RAN innovation can also surpass proprietary closed solutions by using the best-of-breed for each component category. This innovation will require a healthy investment environment with significant Open RAN traction as a prerequisite.

IV. THE TIME FOR SYSTEM CERTIFICATION AND COORDINATED OPEN RAN PROCUREMENT IS NOW.

The ecosystem needs federated labs and coordinated system integration in the immediate term as these are an indispensable prerequisite to accelerating the market by rapidly building purchasing confidence that will result in adoption at scale, leading to lowered costs.³⁹ TIP's analysis of present market conditions suggests that – absent this step – Open RAN deployment will not accelerate sufficiently to reach the “escape velocity” stage in market movement that can provide the scale and traction necessary to ensure that the future of wireless is Open RAN. To be clear, funding deployments proposed by vendors that offer already-integrated Open RAN solutions may technically “check the box” for Open RAN, but it will not achieve NTIA's desired goal of creating true supplier diversity and modular plug-and-play Open RAN optionality that will allow operators to choose the best in breed at each level of the stack.⁴⁰ Only an open process at scale will achieve this goal.

To ensure that Open RAN does not stall out in the coming years under the heavy inertia of incumbency, we need to establish such a system certification function immediately. We must seize the window of opportunity for Open RAN infrastructure investments within the remaining 5G build cycle, including applying Open RAN in the growing domain of private networks, and well before the next major cycle of infrastructure buildout for 6G.

Given necessarily long cycles of RAN development and deployment – where a large-scale roll-out must be preceded by four-to-five years of live trials and smaller scale deployments that generate feedback on both products and processes – the need for establishing this capability is at a critical juncture. Indeed, TIP believes it is the fundamental prerequisite, and we are prepared to launch this capability immediately if we are successful in obtaining WIF federal investment dollars.

³⁸ *Id.*, Questions #8-9, 12-13.

³⁹ *Id.*, Questions #1, 6, 14.

⁴⁰ *Id.*, Question #10.

V. CONCLUSION

TIP appreciates the opportunity to provide these comments and looks forward to continued collaboration throughout implementation of the Wireless Innovation Fund and beyond.

Respectfully submitted,

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January 27, 2023

APPENDIX A

OPEN RAN - WHY EFFICIENCIES MUST BE ESTABLISHED TO ACHIEVE “LIFTOFF”

Open Ecosystem Complexity. The end-to-end, single supplier wireless network RAN design has been the norm since the wireless industry began to flourish. While an operator may have multiple RAN vendors in the same country, each vendor operated their network independently based on a logical or geographical separation. In the traditional fulfillment model, major OEMs were responsible for pre-integrating the full RAN system – pulling together a complex set of subsystems built by multiple internal hardware and software teams and validating the full system on a continuous basis for each major release and interim releases. This OEM-specific SRC process was generally done centrally by a major vendor for a global market of hundreds of operators and was a process fine-tuned over many decades.

Because Open RAN removes this natural efficiency by disaggregating the RAN system into different sub-systems, sourced from different vendors, there are only two viable options for an operator to attain market-ready deployments. First, MNOs can integrate and validate the solutions themselves. This approach requires substantial investments of time and resources, creating a disincentive for Open RAN adoption and unnecessary duplicated efforts. Second, MNOs can rely on the system integrator approach, where an entity will put the pieces together for an operator. It is still an open network – in that it is based on open and interoperable products from multiple vendors – but it delivers operators an integrated solution. This option is also suboptimal because it cannot restore the efficiency of an SRC process that was historically coordinated at total-market scale. As a result, Open RAN system uptake has suffered from a diffuse market of equipment providers which is difficult to navigate and, today, completely bespoke, because of a lack of blueprints to guide integrated system design.

Purchaser Confidence and Cost Issues. Carriers have performance and reliability requirements and must also ensure that they will remain resilient to support national security, public safety, and the national economy. The stakes are high to ensure networks are secure and trusted. Large carriers also carry petabytes of traffic and serve millions of customers requiring sophisticated network management practices to ensure the network remains operational, secure, and on the cutting edge of service delivery. These factors and more lead to a situation where the bar is very high in moving a carrier away from its trusted incumbent supplier.

Cost competitiveness is also critical as margins in the communications market have fluctuated. Government subsidies for certain global suppliers, which allowed them to offer sub-market pricing for buildouts, have also skewed the competitiveness environment on a global scale, leading to additional market concentration.

A trusted, resilient market for wireless infrastructure equipment is essential as global economies soar toward an “everything connected” environment of autonomous vehicles, Internet of Things devices, smart cities, and telehealth advances. To disrupt the trajectory of further consolidation in an already contracted marketplace, strategic investment is necessary. Because of the long innovation cycle for telecom market innovation, venture capital investment has been limited. However, software defined networking and open architecture systems can build additional diversity and resiliency into these critical infrastructure networks, leading to more

rapid innovation, the ability to address flaws more rapidly, and the ability to use AI and other emerging technology enhancements to improve service customization and network optimization. Requiring a shift in the market status quo, however, will require public funding intervention to remove market barriers to adoption at a faster pace.

APPENDIX B

CERTIFICATION EFFICIENCIES THEORY TESTED: TIP'S SYSTEM RELEASE CERTIFICATION PILOT

Major incumbent vendors have over 100 years of systems engineering and SRC experience. They test their RAN system once at the “goods out” stage of deployment for every major release, validating both the functionality and performance of their products. Disaggregation introduces new inefficiencies and means that full systems are no longer tested prior to release to market leading to duplicated efforts for each operator and their vendors.

SRC will play a major part in assuring time-to-deployment. System certification for “complete Open RAN systems” (built using multiple vendors’ products) will replace “buyer-beware” product compatibility doubts with confidence in proven full Open RAN systems.

TIP’s theory that a continuous and coordinated SRC process will help restore supply chain efficiencies is backed up by an SRC pilot it conducted in 2020, which showed a 60% reduction in time to validate an Open RAN Release. The pilot demonstrated the direct value of SRC in reducing operator time and effort to achieve successful Open RAN deployment. The pilot underscored the following benefits of a certification process:

- Benefits to operators:
 - Shortens testing cycle time
 - Shortens time to deployment
 - Lowers funds spent on internal pre-production testing resources
 - SRC is done once, centrally, thus restoring the efficiency lost as a side-effect of disaggregation
- Benefits to vendors:
 - Assurance in meeting global standards & reference designs
 - Identify and prioritize gaps in product releases
 - Certification denotes more than product compliance & quality – it denotes deployable full RAN systems
 - Assure revenues against slip due to late adoption

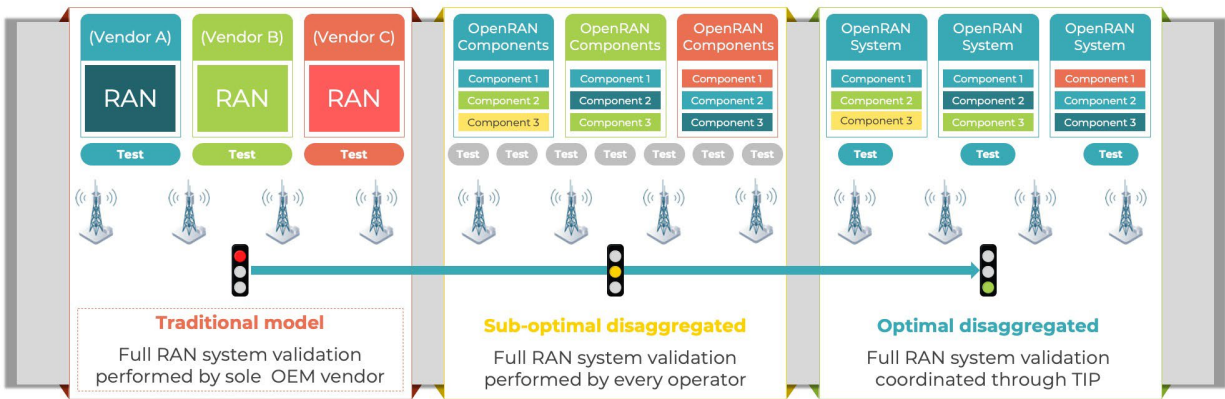
The following slides are an excerpt from the final report highlighting the scope and outcomes of the pilot:

TIP Open RAN System Release Certification Pilot completed in Q1'2020

- ◆ Liaised with participating vendors (Mavenir, Benetel, MTI) and SRC Provider (Aspire Technology) to agree scope & plan
- ◆ Engaged Vodafone as MNO observer
- ◆ Defined test case list and rating criteria
- ◆ Vendors' HW & SW elements deployed into SRC Provider's lab
- ◆ Test cases executed to verify specified use cases
- ◆ Liaised with vendors to iterate testing & tuning of config, interop & performance
- ◆ Defined continuous test schedule for pipeline of use cases derived from multi-vendor release roadmap
- ◆ Delivered Final Test Report
- ◆ Delivered Market Impact Assessment (acceleration with SRC vs current forecast)

Scope	Duration	Result	Conclusion
3 RAN Vendors	16 weeks	56 issues found and fixed in timely manner across multiple products, processes, and specifications impacting multiple vendors	60% faster to test a release centrally with SRC, versus per operator
45 Test Cases	4 weeks actual test execution	Details are under NDA between pilot participants	Creates confidence in functional, performance and operational capability of a specific combination of Open RAN products, combined into a full, deployable RAN system

TIP's vision for achieving Open RAN Supply Chain Process Efficiencies at Total Market Scale



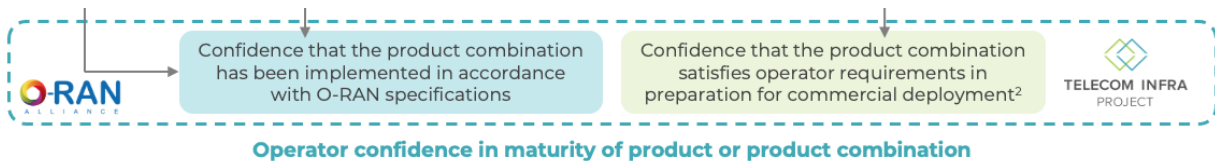
TIP System Release Certification for Open RAN — "Test once; Deploy many times"

APPENDIX C

THE COMPLEMENTARY ROLES AND FUNCTIONS OF TIP AND O-RAN ALLIANCE

TIP and O-RAN ALLIANCE were formed by industry in 2016 and 2018, respectively. The organizations have an existing liaison agreement defining collaboration so that the organizations' missions are complementary, mutually reinforcing, and collectively beneficial to the industry. TIP and O-RAN ALLIANCE are continuing to strengthen their relationship to drive an industrialized approach to transform the RAN towards open, disaggregated, intelligent and fully interoperable RAN.

- TIP focuses on the development and aggregation of operators' technical requirements, roadmaps, blueprints and test plans for single products, product combinations and end-to-end solutions that meet operators' defined use cases. The TIP test plans reference 3rd Generation Partnership Project ("3GPP"), O-RAN ALLIANCE and other relevant specifications and are developed further to assess the levels of maturity, performance, stability, and operability against TIP technical requirements. TIP's "badges" are conferring formal and credible evidence of such product, product combination, or solution verification.
- O-RAN ALLIANCE focuses on the development of technical and test specifications for O-RAN related solutions. The test specifications are used to verify compliance of O-RAN implementations with O-RAN technical specifications, to verify interoperability of O-RAN implementations, and to demonstrate end-to-end functionality and performance. The O-RAN certificate and badge are formal and credible evidence of such verification.



Working together through regular collaborative liaison meetings, TIP and O-RAN ALLIANCE are well aligned to steer Open RAN through to commercial readiness.

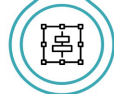
Summary



O-RAN ALLIANCE and TIP are fully committed to realizing the vision of an open, intelligent, virtualized, and fully interoperable RAN



Activities of both organizations are aligned and fully complementary



Both organizations work together to jointly serve the entire open RAN ecosystem

#FYU22

fyuzevents

APPENDIX D

TIP'S PROCESSES TODAY

TIP has done critical foundational work to help build purchaser confidence and address supply chain efficiency issues vis-a-vis its (1) Open RAN Project Group, (2) its badging of products and solutions, and (3) its marketplace processes, called “TIP Exchange.”

The Open RAN Project Group – in cooperation with leading operators, vendors, systems integrators, and other stakeholders throughout the world – seeks to harmonize requirements for Open RAN solutions that comprise radio units (“RUs”), distributed units (“DUs”), and centralized units (“CUs”), as well as the RIC platforms and applications and many other components of Open RAN networks. Like other TIP project groups, the Open RAN Project Group emphasizes building, testing, and validating products at scale.

TIP's process encompasses technical roadmaps, test and validation activities, and the resulting list of a range of deliverables in TIP Exchange and its marketplace, including blueprints for integrated network design. This flow consists of three major stages: (1) technical roadmaps, where operator requirements, commercial priorities, and use cases are identified and translated to definitions and feedback loop with participating vendors, ensuring that all inputs from the industry are accounted for; (2) testing and validation, with the “build,” “test,” and “release” steps to ensure that components integrated for the solution can operate as a complete telecommunication system and be deployed in a live network; and (3) blueprints and TIP Exchange, where blueprints, badged products, and solutions are published in the TIP Exchange. TIP Exchange enables participating operators to identify suitable solutions and vendors to promote their products and services based on documented results from their participation in the process. By scaling this process for integrated system level certification, NTIA can fund a critical path step to achieving market confidence for disaggregated RAN systems.

Technical Roadmaps. The TIP process begins with community discussions regarding operator requirements, wherein commercial priorities shape the technical roadmap. This informs other operators, as well as technology providers, who can use it for their own internal product roadmaps. This deliverable includes use cases, definitions, and, most importantly, which industry standards and specifications will be used. For example, a specific operator requirement may necessitate the use of specific 3GPP standards specifications, as well as O-RAN ALLIANCE interfaces.

Testing and Validation. This phase includes testing products from different suppliers while ensuring interoperability, security, stability, scalability, and carrier-grade performance. The common test plan for each release is going to be based on what features and requirements can be defined and delivered within that release. This enables technology suppliers to initially validate their products and ultimately list them on the TIP Exchange, badged according to maturity versus requirements. The test and validation strategy, including both lab and field testing, is designed as a progressive testing, from an individual product tested by the solution provider, to testing a combination of products in labs, to the integration of a set of products into a

solution that is ready for field deployment. This process provides feedback so that subsequent releases produce additional improvements based on operator inputs.⁴¹

Blueprints and TIP Exchange. Finally, vendors publish on TIP Exchange the products, solutions, and blueprints that have been tested and validated. Open RAN includes product releases and blueprints that encapsulate all learnings from the previous phase into a format that can be used by other operators (and the rest of the ecosystem stakeholders) globally. There are three parts to this phase:

1. **Products.** Products are listed on TIP Exchange, with their technical specification and their level of maturity through the badges they have earned. In the context of Open RAN, such products would primarily be RU, DU, or CU.
2. **Product blueprints.** Product blueprints highlight sets of products that have been integrated and tested together, and for which requirements, configurations, and similar documents are available to help deployment. In the context of Open RAN, a typical product blueprint would be an RU, a DU, and a CU tested together as an integrated network layer.
3. **Solution Blueprints.** Solution blueprints also consider sets of products that have been integrated and tested together, but within an end-to-end setup. In the context of Open RAN, this may include multiple RUs, multiple DUs, multiple CUs, and transport nodes between them as well as interfaces to other network nodes, such as operation and maintenance. The output of this phase provides everything an operator needs to deploy this solution.

Blueprints are a vital output component of the TIP Open RAN Project Group and range from products to integrated network layers and end-to-end solutions and is the final piece of the TIP Open RAN Project Group process. Key elements of these blueprints are pre-integration of key network elements and functions, focusing on specific deployment scenarios that will be described by test, validation, and build guidelines. This aims to provide common processes throughout the TIP process. The TIP Exchange distills findings from the TIP workflow for suppliers to showcase their capabilities and for operators to be able to assess products and solutions in a consistent manner. The TIP Exchange is a vital component of the TIP community, where operators can review and assess products, solutions, and blueprints, and solution providers can demonstrate their capabilities.

Releases. The TIP process is iterative, reflecting continuous release management, so that the output is continuously improved. Releases are a key aspect of how the TIP process is achieved for all TIP project groups and for the TIP Open RAN Project Group specifically, improving the group's work and output using existing findings and learnings. This process is triggered by aggregating input from operators and technology suppliers to determine what must be prioritized and what can then be delivered within a release timeframe. This translates into

⁴¹ See TIP, *Upgraded TIP Testing and Validation Framework accelerates deployment of open and disaggregated solutions* (Oct. 26, 2022), <https://telecominfraproject.com/upgraded-tip-testing-and-validation-framework-accelerates-deployment-of-open-and-disaggregated-solutions/>.

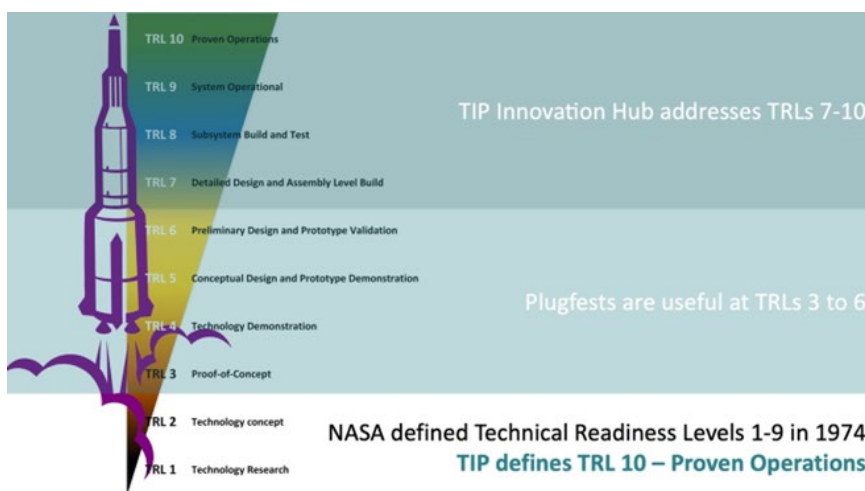
release-based blueprint deliverables that are finalized every year, while a new release is kicked-off every six months during the test and validation stage of the previous release. TIP aims to speed up the process to get open, disaggregated network products to the right maturity stage, through a rigorous and efficient test and validation framework that makes it possible for diverse operators, technology suppliers, and system integrators to work together and reduce the time-to-market for these solutions. The cadence and scope of each of the releases described in the previous section illustrate how the TIP Open RAN Project Group meets that goal and expands with each wave.

APPENDIX E

ACHIEVING TRL 10: ACCELERATING THE TIMELINE TO REACH “PROVEN OPERATIONS”

TIP’s Open RAN Project Group currently gathers and consolidates the technology requirements of MNOs to efficiently align priorities across the Open RAN industry. TIP’s SRC Pilot shows the potential for reducing the existing fragmentation of the Open RAN ecosystem that is generated by the multiple test and validation activities that are taking place in multiple different vendors, operators, and Open RAN labs, without a common framework. Going forward, TIP seeks to deliver an industry certification framework for Open RAN systems against industry test plans and criteria that designs Open RAN systems that are commercial-grade and ready for deployment.

In 1974, NASA defined nine levels of Technology Readiness (“TRLs”).⁴² TIP proposes a tenth: *Proven Operations*.



Collectively, TIP and the O-RAN ALLIANCE (with ORPC’s significant policy support) have been instrumental in driving Open RAN through the low-to-mid TRL stages of development. For example, plugfests have been a useful way to demonstrate interoperability of Open RAN systems at TRLs 3 to 6 (Proof-of-Concept to Prototype Validation). Plugfests can provide a public demonstration of interoperability at a snapshot in time. However, they are not designed to offer any form of rolling release management, continuous validation, or regression testing and their results can therefore quickly become outdated. They do not generally form a sufficient basis of confidence to proceed with deployments.

TIP believes that a concerted effort is now required to build and coordinate efficient processes at market scale that are focused on TRLs 7-10 (Detailed Design to System Operational to Proven Operations) that will minimize duplicated efforts for each operator, reducing Time to Proven Operations by 60% (*see* Appendix B, above).

⁴² Jeremy Straub, *In search of technology readiness level (TRL) 10*, 46 *Aerospace Science and Technology* (2015), <https://doi.org/10.1016/j.ast.2015.07.007>.

APPENDIX F

5G, 6G AND BEYOND: UNDERSTANDING DEVELOPMENT CYCLES AND THE NEED TO GET OPEN RAN READY NOW FOR 6G

To ensure that Open RAN deployments do not stall out in the coming years under the heavy inertia of incumbency, we need to remove all the barriers for deployment as soon as possible. We must seize the window of opportunity for Open RAN infrastructure investments within the remaining 5G build cycle, including applying Open RAN in the growing domain of private networks, and well before the next major cycle of infrastructure buildout for 6G.

Successive generations of mobile/cellular technology have launched approximately every 10 years (1G: 1983; 2G: 1991; 3G: 2001; 4G: 2010; and 5G: 2020). And with these successive generations there is a necessary research and development cycle that starts well before the launch and is often driven by the most innovative MNOs that hope to leapfrog each other and lead the industry in being the first to deploy. This R&D cycle has already begun with 6G with some innovative MNOs planning for trials in 2026 and commercial deployments in 2028. Open RAN technology largely missed the early 5G deployment cycle and needs to avoid missing the early 6G window.

It takes a full decade or more to build out a generation of technology and reach a global critical mass, so Open RAN still has the potential to play a major role in 5G deployments in many countries around the world. However, given necessarily long cycles of RAN development and deployment – where a large-scale roll-out must be preceded by four-to-five years of live trials and smaller scale deployments that generate feedback on both products and processes – the need for making Open RAN “easy-to-deploy” is at a critical juncture.

APPENDIX G

ADDRESSING SKILLS GAPS AND BUILDING AN OPEN RAN WORKFORCE FOR THE FUTURE

Open RAN has gained significant global momentum in Open RAN trials and deployments with several leading telecom operators, vendors, and system integrators leading the charge, in conjunction and independently of TIP. The transfer of the knowledge and expertise gained so far (and in the future) from Open RAN leaders in the industry to those who are not yet ready to productize or to deploy Open RAN solutions is an important element to globally scaling Open RAN implementations and to building a richer and more perfect telecom supply economy.

Vendors, system integrators, and telecom operators are individually building Open RAN curricula to help their employee base and their customers to understand the fundamentals of what Open RAN is, what it brings, and how their individual products and strategies lend well to driving relevant solutions. For suppliers, their individual Open RAN training programs act as a pre-sales tool for their customers. For operators, more altruistically, training drives talent within and acts as a recruitment vehicle.

The challenge at an industry level is that a comprehensive approach to knowledge transfer, upskilling and talent development presently does not exist. The ecosystem could benefit from an industry-wide program which tackles three primary issues:

- (i) Common taxonomy in what, why, and how open network solutions are implemented;
- (ii) A re-skill in today's and tomorrow's telecom professionals with the technical, operational, and strategic knowledge and the skill to evaluate, plan, architect, test, deploy, and manage multi-vendor open network solutions; and
- (iii) Grass roots talent development (from universities, R&D institutes and within industry) in core skill areas (e.g., software development, network engineering, test and integration), with the objectives of plugging industry skills gaps and points of failure in the newly forming market structure.

To address the industry issues at hand, TIP launched the TIP Academy in collaboration with Accenture in May 2022.⁴³ Governed by the TIP Board, TIP Academy is a learning and development platform, focused on upskilling and certifying (similar to the well-known “Cisco Certification”) for telecom professionals as well as engineering students. The courses are delivered through a combination of self-paced e-learning and instructor-led classroom teaching. The TIP Academy could be leveraged through WIF funds to reach a broader audience, create expanded curricula, and accelerate the upskilling needed to assure that today’s workforce has the knowledge and skills ready to deploy and operate Open RAN solutions.

⁴³ TIP Academy, www.tip.academy (last visited Jan. 26, 2023).

APPENDIX H

ONLY BY PRIORITIZING TRUE MULTI-VENDOR OPEN RAN WILL THE ECOSYSTEM RESTORE SUPPLY CHAIN DIVERSITY

Over the last two decades, the telecommunications equipment industry experienced significant market consolidation. In the early 2000s, Nortel, Ericsson, Lucent, Alcatel, Nokia, Motorola, and Siemens comprised a robust, competitive marketplace for telecom equipment. This competitive landscape and the vendor choice and resilience it offered, however, has been reduced over time through successive rounds of merger and acquisition, and sub-market financing which impacted the survivability of established firms.

To shore up vendor choice and to advance innovation, the telecom sector is now striving to re-diversify the market. A key enabler for catalyzing diversity is the adoption of Open RAN systems. Yet the reality is that alternative vendors offering full end-to-end Open RAN solutions today is rare. Subsystem specialists are emerging whose focus is on one or perhaps several of the disaggregated elements of the Open RAN architecture, but rarely on all elements. This marketplace reality produces several implications for NTIA to consider as it contemplates how to stimulate a robust, competitive wireless market through strategic public investment.

To restore the healthy level of diversity once enjoyed across the telecom supply chain, NTIA, through the WIF, should prioritize a thoroughly interoperable, multi-vendor approach to Open RAN. To settle for endorsing only single-vendor RAN deployments described as “Open RAN compliant” or “Open RAN ready” would be near-sighted and could at best result in only an incremental improvement in vendor diversity – not the robust, modular, interoperable market for RAN equipment that will encourage shorter innovation cycles and telecom supply chain resilience envisioned by the WIF legislation.

Given this imperative to prioritize truly multi-vendor Open RAN implementations, WIF should expedite grant funding toward the following foundational activities to accelerate market readiness: (1) the independent certification of full end-to-end multi-vendor Open RAN systems; and (2) the establishment of a whole-ecosystem release & lifecycle management process for such multi-vendor Open RAN systems. This will put the ecosystem on a path to provide equivalent offerings to the major single-vendor OEM systems built over the last several decades.

APPENDIX I

ACCELERATING OPEN RAN THROUGH THE RIC

Zero Touch Networks (“ZTN”), Self-Organizing Networks (“SON”) concepts and their corresponding use cases – that were initiated in legacy networks but whose full potential was never realized due to the closed nature of RAN network deployments – are now being revisited and refreshed in the Open RAN era. The Open RAN Service and Management Orchestration (“SMO”) and RIC functions are key to realizing ZTN and SON principles.

Traditional RAN relies on configuration and optimization solutions that are far removed from other network elements that perform call control, scheduling, and mobility functions. This distance results in non-optimized systems whereby quality-of-service targets are met through overprovisioning of spectrum and computing resources, which decreases spectral and energy efficiency. SONs were originally intended to fix this problem, but due to closed and proprietary systems for sharing data, they have not delivered the promised efficiencies. However, by opening the interfaces in an open architecture, SON-like solutions can be implemented closer to network elements. This allows for tighter control of spectrum and computation assets, vastly alleviating prominent spectral and efficiency problems.

Open RAN architecture permits the disaggregation of traditional base stations into subcomponents, which are then coordinated and controlled by a RIC. However, the RIC is not simply a controller; it is also a platform that allows specialized software from different vendors to be deployed for network management and optimization, including through artificial intelligence and machine learning (“AI/ML”) approaches. This enables incumbent and new vendors to design and provide interoperable solutions for RAN optimization and efficiency, solving long-standing problems in mobile network optimization where the onus fell on one vendor to solve all network issues. The RIC’s promotion of interoperable solutions is vital to solving complex connectivity problems, create new capabilities, and accelerate the deployment of disaggregated networks to solve the capacity, coverage, and low-latency requirements of the future. Success in resolving this challenge would thus remove a significant barrier for individual and smaller companies to enter the vendor market and to scale.

RIC as a Stepping Stone for Incumbent Vendors

Incumbent vendors have end-to-end solutions in place and may not immediately see the need to create open interfaces. Supporting all aspects of Open RAN also means rearchitecting their HW and SW which comes at a high cost and could take a long time. For incumbent vendors, aligning with “new” and “differentiated” aspects of the Open RAN architecture and expediting the necessary integrations to these parts of the solution needs to be emphasized and driven to completion. To this end, the RIC and SMO solutions are areas that incumbent vendors can expand into, realize their benefits, and then evaluate other parts of the Open RAN architecture that can be made open with clear benefits. NTIA should encourage incumbent vendors to create open RIC platforms and ensure that a rich smorgasbord of RIC applications (“xAPPs/rAPPs”) and SMO functions are developed by a strong ecosystem of third-party players. TIP’s Open RAN RIA and ROMA Project Sub-Groups have 30+ active vendors that are

building RIC platforms and RIC xAPPs/rAPPs.⁴⁴ Bringing the initiatives to trials through NTIA funding is a first important step to show the value of these multi-party integrations and grow a sustainable ecosystem.

RIC as a Competitive Edge for New RAN Vendors

New vendors have the advantage of starting with the Open RAN architecture but have a few challenges of their own. First, they lack the full feature set of incumbent vendors. Second, they lag in areas of performance and capacity. Also, when different products are built by different vendors (RU, CU/DU, RIC, SMO, Core etc.) there is a need for end-to-end integration and test specifications and more importantly, access to third party (neutral) test facilities that can perform Systems level Integration and Testing. NTIA should prioritize funding the creation of Systems integration and performance test facilities where different configurations (blueprints) can be defined, tested, and certified in a vendor neutral manner.

Automation and the Zero Touch Network

R&D that promotes machine learning based automation that takes away human effort to deploy, manage and optimize wireless networks needs to be promoted by NTIA. RIC is an important component that brings in this level of AI/ML based automation. Initiatives by TIP, ONF and university labs have active projects that can be scaled through NTIA funding.

An Entry Point for Small and Medium Enterprises

NTIA has a unique opportunity to firmly establish a leading role for xAPP/rAPP development on RIC platforms by small and medium enterprises. RIC opens an entry point for these companies to translate their collective experience and expertise regarding network optimization into xAPPs/rAPPs operating on an RIC platform.

Enabling Agile CI/CD Technology Introduction Processes and Preparing for 6G

Open RAN pioneers are not only innovating in the 5G build, but also using the RIC to create foundational results framing what 6G will look like. The RIC is being used to ingest data and train for greater levels of network intelligence throughout the network. And as we collectively prepare for scaling Open RAN deployments in 5G and ultimately throughout 6G, we must contend with the complexity of pushing software updates from multiple vendors in an organized and efficient manner. To this end, real world environments must be created first in a lab where testing can occur with direct deployment to the field using CI/CD practices. These real-world representations in a lab are achieved through the creation of digital twins. Digital twins that are most successful are those that employ ML models to learn from realistic environments and “close the loop,” bringing back representations of deployed networks into existing simulation tools. NTIA should define and fund the creation of digital twin representations to accelerate 5G and 6G Open RAN deployments, making them ready to market in the shortest period of time.

⁴⁴ See TIP, Open RAN MoU Group Page, (last visited Jan. 26, 2023) <https://telecominfraproject.com/openran/>.