Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Promoting the Deployment of 5G Open Radio Access Networks	)	GN Docket No. 21-63
	)	

COMMENTS OF
THE TELECOM INFRA PROJECT

Dileep Srihari
Senior Policy Counsel
ACCESS PARTNERSHIP
1730 Rhode Island Ave Suite 512
Washington, DC 20036

Attilio Zani
Executive Director
David Hutton
Chief Engineer
TELECOM INFRA PROJECT
401 Edgewater Pl Suite 600
Wakefield, MA 01880

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TABLE OF CONTENTS

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The Telecom Infra Project (TIP)[1] respectfully files these comments in response to the Notice of Inquiry (NOI) in the above-captioned proceeding.[2]

INTRODUCTION AND SUMMARY

As the leading global association for the development and deployment of open network architecture solutions, TIP welcomes the Commission's effort to begin a comprehensive proceeding on Open Radio Access Networks (Open RAN) and other open architectures. TIP and its member companies have worked for years to develop and promote open and disaggregated architectures, which provide greater flexibility and lower costs for operators alongside a more diverse ecosystem of technology providers characterized by greater competition and innovation. Those efforts are now bearing fruit as commercial deployments of Open RAN have started around the world, with field trials occurring in even more countries. In addition to the RAN, TIP's efforts are also helping to open other parts of the network, including open optical and packet transport (OOPT), open cloud-native core, and open Wi-Fi solutions.

[1] TIP is a global community founded in 2016 that includes hundreds of companies, from service providers and technology partners to systems integrators and other connectivity stakeholders. TIP and its members work together to develop, test, and deploy open, disaggregated, and standards-based solutions. Visit https://telecominfraproject.com for more information.

[2] Notice of Inquiry, *Promoting the Deployment of 5G Open Radio Access Networks*, FCC 21-31, rel. Mar. 18, 2021 ("NOI").

Over the past 18 months, interest in Open RAN and related technologies has exploded, with operators and governments alike making firm commitments. Unlike the market for traditional RAN infrastructure, U.S. companies are playing a key role in nearly all of the early deployments – from established telecom vendors to new entrants to companies from other technology fields who recognize the opportunity that a virtualized, software-driven ecosystem represents. The new ecosystem is standards-based, but also leverages the work of TIP to go beyond standards and focus upon real-world productization to help ensure that interoperability actually becomes a reality.[3]

In addition to the greater flexibility and lower costs that interoperability creates, open architectures also enable the use of advanced technologies within networks, including artificial intelligence and machine learning (AI/ML). Open and disaggregated architectures also enhance network security and promote energy efficiency, and a rapidly-expanding group of system integrators is providing operators of all sizes with solutions they can actually deploy. Meanwhile, all of these companies – operators, vendors, and integrators – are among the hundreds who participate globally in TIP. That participation includes technical project groups that develop usable frameworks, testing and validation through laboratory and field trials, a badging program, development of RFIs for procurements, and a marketplace for products and solutions, among numerous other activities.

As networks begin moving toward software-driven Open RAN and open network architectures – mirroring a change that has already occurred in the wider technology space – the

[3] Congress has recognized the important role TIP plays in advancing Open RAN, mentioning the organization by name in the USA Telecommunications Act that was eventually incorporated into the FY21 NDAA. *See* William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, Jan. 1, 2021, at § 9202(a)(1)(C)(ii), public law text not yet available, *see* H.R. 6395 enrolled bill at pp. 1401-02.

Commission should encourage the transition. Specific steps should include incentivizing virtualization, replaceability, and gradual upgradability; modifying regulatory structures to build operator confidence; facilitating testbeds and industry partnerships; and working to promote more rapid development and deployment of the technology around the world.

On behalf of the TIP global community, we thank the Commission for initiating this proceeding. We look forward to working collaboratively with the agency as it seeks to promote Open RAN and other open architecture technologies in the months and years ahead.

I. OPEN NETWORK ARCHITECTURES ARE A COMMERCIAL REALITY.

The suggestion mentioned in the NOI that Open RAN is "still in its most formative stages" is incorrect.[4] To the contrary, Open RAN and other open architecture solutions are being deployed worldwide and growing rapidly. As described below, some projections indicate that Open RAN will represent more than half the global market within five years and will be deployed at two-thirds of all mobile sites. Deployments or commercial trials have commenced or been announced in Europe, Asia, Africa, Latin America, and the Middle East, with operators and governments around the world making commitments to the technology. While the U.S. has seen limited deployment to date, there is both an opportunity and need for U.S. leadership, not least because other countries are seeking to claim that mantle for their own industries.

A. Global Demand for Open and Disaggregated Architectures is Accelerating and Deployments Are Happening Worldwide.

The market for open network infrastructure is expanding very rapidly around the world, and the speed of that growth will only accelerate in the years to come.

[4] NOI at ¶ 2 (citing Ericsson).

Open RAN. Open RAN is a fast-growing market globally. At least one assessment indicates that Open RAN technologies will accelerate from today's early deployments to comprise 10 percent of the entire wireless market in the next three years – an astounding rate of growth that would follow its 250% growth rate in 2020.[5] A different analysis contains even more dramatic forecasts, concluding that by 2026 Open RAN will account for over $32 billion in annual RAN spending – accounting for 58% of all RAN spending – and will be deployed at 65% of all mobile sites.[6]

Turning back to today, both greenfield and brownfield commercial deployments are underway. New greenfield network buildouts based upon Open RAN technology include DISH's planned network in the United States and Rakuten's network in Japan.[7] Brownfield deployments include Vodafone sites in Ireland along with the company's commitment to 2,600 mobile sites in the U.K., while Telefónica field trials are under way or planned in several

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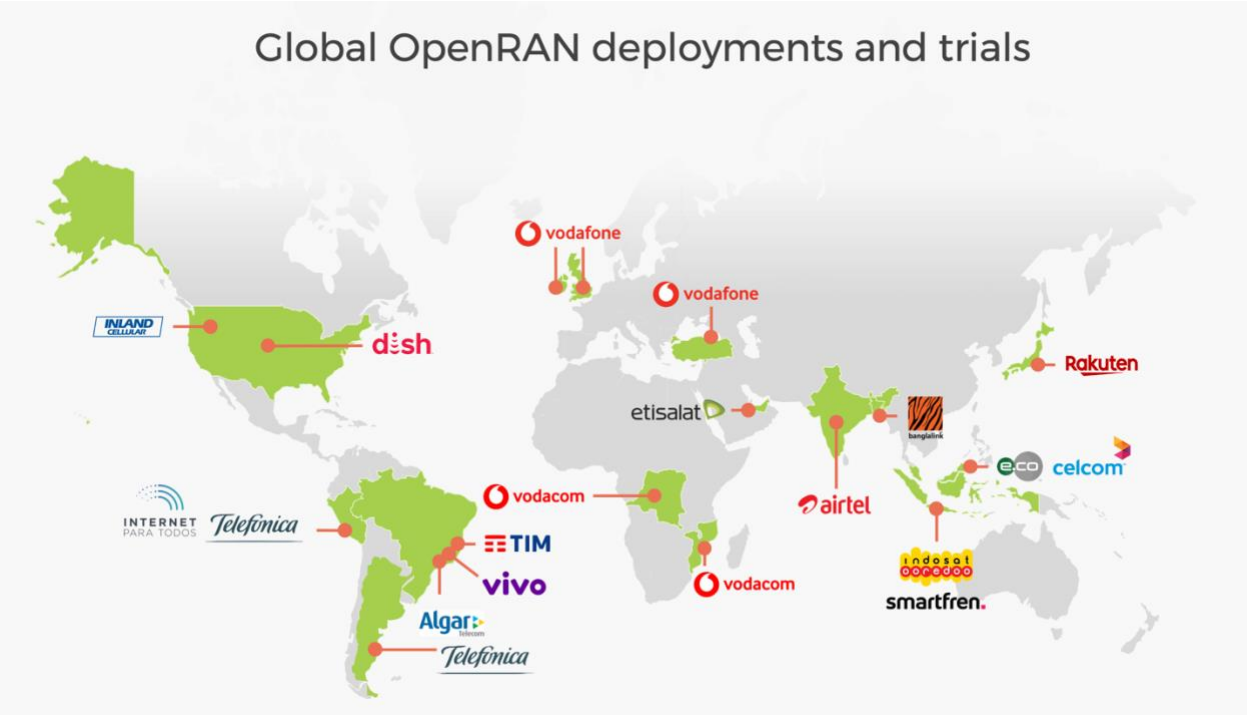
[5] Iain Morris, *Open RAN Will Be a $3.2B Market in 2024, Says Omdia*, Light Reading, Dec. 4, 2020, https://www.lightreading.com/open-ran/open-ran-will-be-$32b-market-in-2024-says-omdia/d/d-id/765889; Melanie Mingas, *Open RAN Growth to Reach 250% Year on Year*, Capacity Media, Dec. 8, 2020, https://www.capacitymedia.com/articles/3827157/open-ran-growth-to-reach-250-year-on-year.

[6] Joe O'Halloran, *Almost Two-Thirds of Cell Sites Set to Deploy Open RAN by 2026*, Computer Weekly, Oct. 20, 2020, https://www.computerweekly.com/news/252490738/Almost-two-thirds-of-cell-sites-set-to-deploy-open-RAN-by-2026.

[7] *See* Press Release, *DISH Completes Successful 5G Field Validation and Deploys Open RAN Radio Units from MTI*, Dec. 8, 2020, https://www.prnewswire.com/news-releases/dish-completes-successful-5g-field-validation-and-deploys-open-ran-radio-units-from-mti-301188457.html; Ray Le Maistre, *DISH Commits to Open RAN for US 5G Rollout, Enters Retail Mobile Market*, TelecomTV, Jul. 1, 2021, https://www.telecomtv.com/content/5g/dish-commits-to-o-ran-for-us-5g-rollout-enters-retail-mobile-market-39068/; Iain Morris, *Rakuten Turns 5G Revolutionary As It Nears World's First Open RAN Launch*, Mar. 19, 2020, https://www.lightreading.com/asia/rakuten-turns-5g-revolutionary-as-it-nears-worlds-first-open-ran-launch/d/d-id/758349.

European markets including the U.K., Germany and Spain.[8] Elsewhere in the world, a wide number of commercial deployments or trials are actively underway in Latin America, Africa, the Middle East, India, and Southeast Asia, as shown in the map below:[9]



Notably, some of these early deployments have come despite significant obstacles. First, Open RAN vendors often needed to educate operators – and in some cases, governments – on the benefits of the technology. Second, there has often been pushback based on the need to integrate

[8] Iain Morris, *Vodafone to Launch Open RAN in Ireland Next Month*, Light Reading, Nov. 19, 2020, https://www.lightreading.com/open-ran/vodafone-to-launch-open-ran-in-ireland-next-month/d/d-id/765496; Scott Petty, Vodafone, *OpenRAN: Why Vodafone is Taking the Lead*, Nov. 4, 2020, https://newscentre.vodafone.co.uk/viewpoint/openran-why-vodafone-is-taking-the-lead/; Bevin Fletcher, *Telefónica's O2 Trials Open RAN with NEC Using Altiostar Software*, Fierce Wireless, Feb. 1, 2021, https://www.fiercewireless.com/tech/telefonica-s-o2-trials-open-ran-nec-using-altiostar-software; Juan Pedro Tomás, *Telefónica Deutschland Tests O-RAN Tech in Bavaria*, RCR Wireless, Dec. 28, 2020, https://www.rcrwireless.com/20201228/5g/telefonica-deutshland-tests-oran-tech-bavaria.

[9] Source: TIP, based on internal data.

Open RAN into operators' existing networks. Despite these challenges, Open RAN deployments are rapidly accelerating, with more and more announcements each month in 2021.

Open Transport / DCSG. TIP's Open Optical and Packet Transport (OOPT) work, including its Disaggregated Cell Site Gateways (DCSGs), have moved ahead rapidly over the past 18 months. For example:

- In Africa, VTS has deployed commercially in Burkina Faso, while Vodacom has launched a DCSG commercial trial in South Africa.[10] MTN is finalizing plans to execute field trials in South Africa and is having conversations in Uganda regarding opportunities for a larger deployment.[11] Africell recently announced that it will deploy TIP-compliant DCSGs in the Democratic Republic of the Congo.[12]

- In Europe, Telefónica has worked with TIP to deploy DCSG commercially in Germany.[13] Vodafone has finished a lab trial in Romania and plans to initiate a field trial, and has a lab test currently underway in Germany.[14]

- Asia has seen commercial deployment in Taiwan, while in India, Airtel is in Phase 2 lab trials of TIP's DCSG as the operator prepares its transport network for Massive MIMO LTE deployments and further 5G NR.[15]

- In Latin America, there have been commercial deployments in Chile, Peru, and Ecuador with field trials underway in Brazil.[16]

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[10] Attilio Zani, *TIP Community Achieving Significant Momentum on the Path to Open, Interoperable, Disaggregated and Standards-based Networks*, Oct. 6, 2020, https://telecominfraproject.com/tip-community-achieving-significant-momentum-on-the-path-to-open-interoperable-disaggregated-and-standards-based-networks/ ("TIP October 2020 Update").

[11] *Id.*

[12] Press Release, *Aviat Signs Multi-Million Dollar Agreement with Africell for 5G-Ready Disaggregated Transmission Network and Services*, Apr. 19, 2021, https://investors.aviatnetworks.com/index.php/news-releases/news-release-details/aviat-signs-multi-million-dollar-agreement-africell-5g-ready.

[13] Linda Hardesty, *Telefónica Commercially Deploys Disaggregated Cell Site Gateways*, Fierce Wireless, Nov. 12, 2019, https://www.fiercewireless.com/tech/telefonica-commercially-deploys-disaggregated-cell-site-gateways.

[14] TIP October 2020 Update, *supra* n. 10.

[15] *Id.*

[16] *Id.*

Open Core. Open core network architectures can drive core network simplicity and agility through the use of cloud-native and microservice-based architectures, lowering barriers to entry for new vendors and providing improved operational efficiencies for service providers and enterprises. TIP's Open Core Network (OCN) project group is currently focused on developing end to end blueprints for deployable 5G networks.

One of the reference implementations underlying TIP's OCN work, Magma, now has multiple deployments globally.[17] In the United States, rural operator WiConnect Wireless is partnering with U.S.-based vendor FreedomFi to expand its network in Wisconsin using an open core solution.[18] AccessParks, the only broadband provider licensed by the National Park Service, is deploying open core-based 5G networks across national and state parks.[19] Muralnet, an operator focused on indigenous communities, is also using an open core for LTE and 5G networks.[20] Globally, TIP is aware of open core platforms being deployed in Latin America (Brazil, Peru, Nicaragua) and Africa (Rwanda), as well as lab and field trials underway in several European markets, including Italy, France and Germany.

Open Wi-Fi. One of TIP's newest workstreams, the TIP Wi-Fi Project Group's efforts are already leading to trials globally including in the United States, Brazil, Germany, India, and

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[17] https://www.magmacore.org (visited Apr. 27, 2021).

[18] Linda Hardesty, *FreedomFi Offers Private Wireless Using Open Source Code*, *Fierce Wireless*, Oct. 26, 2020, https://www.fiercewireless.com/private-wireless/freedomfi-offers-private-wireless-using-open-source-code (describing partnership with WiConnect Wireless).

[19] Press Release, *In Time for Summer: US National and State Parks Getting High Speed Wireless Access*, Apr. 7, 2021, https://www.globenewswire.com/news-release/2021/04/07/2206119/0/en/In-Time-for-Summer-US-National-and-State-Parks-Getting-High-Speed-Wireless-Access.html.

[20] YouTube, *MuralNet and Tribal Spectrum to Sustainable Tribal Networks*, Feb. 3, 2021, https://www.youtube.com/watch?v=c-31ck5bpdg (jump to 6:34 in video) (describing role of Magma).

South Africa. Operators like Boingo, American Bandwidth, MTN, Vodacom, and Deutsche Telekom, along with industry organizations like CPQD (Brazil) and Cablelabs (U.S) have initiated trials based on the TIP OpenWiFi platform. TIP is also collaborating with organizations like the Wireless Broadband Alliance (WBA) to build solutions.

B. Operators and Governments Around the World Have Committed to Open RAN.

Operators and governments are strongly signaling their support for Open RAN. As the Commission notes in the NOI, four major carriers – Vodafone, Telefónica, Deutsche Telekom, and Orange – signed a Memorandum of Understanding in January 2021 signaling their commitment to deploy Open RAN across Europe, and Telecom Italia joined the agreement weeks later.[21] But the story does not end there. For example, Etisalat, which serves markets across the Middle East, has taken several concrete steps toward Open RAN deployments, including planned deployments in the UAE and even in Afghanistan.[22] In Indonesia, all five of the country's mobile operators are engaged at some level in trials, and in testing facilitated by TIP's Community Lab based in the country.[23]

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[21] NOI ¶ 29; Press Release, *Major European Operators Commit to Open RAN Deployments*, Jan. 20, 2021, https://www.orange.com/en/newsroom/press-releases/2021/major-european-operators-commit-open-ran-deployments; Press Release, *TIM Joins the European Initiative for the Development of Open RAN Solutions*, Feb. 5, 2021, https://www.gruppotim.it/en/press-archive/corporate/2021/PR-TIM-ORAN-en.html.

[22] *See* Iain Morris, *Etisalat to Build Open RAN 'Across UAE'*, Light Reading, Jan. 6, 2020, https://www.lightreading.com/5g/etisalat-to-build-open-ran-across-uae/d/d-id/756571; Ray Le Maistre, *Dish, Etisalat Advance Open RAN Plans*, TelecomTV, Apr. 9, 2021, https://www.telecomtv.com/content/open-ran/dish-etisalat-advance-open-ran-plans-41208/ (discussing plans to deploy Open RAN in Afghanistan).

[23] Ray Le Maistre, *Indonesian Operators Put Open RAN to the Test*, TelecomTV, Feb. 3, 2021, https://www.telecomtv.com/content/open-ran/indonesian-operators-put-open-ran-to-the-test-40766/.

Governments have been encouraging this trend, some with an eye to promoting their own domestic industries. As the Commission notes in the NOI, Germany plans to make a substantial investment to prioritize Open RAN research and development, but the plan recognizes that "Germany and Europe need to urgently strengthen their competences and develop industrial ecosystems for Open RAN … technologies, including hardware and software."[24] The UK's 5G Supply Chain Diversification Strategy, which the NOI mentions briefly, states that the "long term vision" is for a market where "network supply chains are disaggregated" and "open interfaces that promote interoperability are the default."[25] The UK Government has committed £250 million to implement the strategy.[26] In July 2020, the European Commission commissioned a formal 11-month study on 5G supply markets and Open RAN whose results are expected soon.[27] Meanwhile, Russia's largest mobile operator, MTS, has announced the creation of a 5G Open RAN pilot project with plans to use Russian-developed hardware and software that implements the international standard.[28]

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[24] NOI ¶ 28; Laurens Cerulus, *Berlin's €2B Plan to Wean Off Huawei (Nokia and Ericsson Too)*, Politico, Feb. 2, 2021, https://www.politico.eu/article/germany-huawei-telecoms-plan/.

[25] UK Department for Digital, Culture, Media & Sport (DCMS), *5G Supply Chain Diversification Strategy*, rev. Dec. 7, 2020, https://www.gov.uk/government/publications/5g-supply-chain-diversification-strategy/5g-supply-chain-diversification-strategy.

[26] Kavit Majithia, *UK Pledges £250M to Diversify 5G Supply Chain*, Mobile World Live, Nov. 25, 2020, https://www.mobileworldlive.com/featured-content/top-three/uk-pledges-250m-to-diversify-5g-supply-chain.

[27] European Commission, *European Commission Launches Study on 5G Supply Markets and Open RAN*, July 24, 2020, https://digital-strategy.ec.europa.eu/en/news/european-commission-launches-study-5g-supply-markets-and-open-ran.

[28] MTS Blog, *MTS and Skoltech Launch 5G Pilot Zone in Moscow*, Oct. 21, 2020, http://ir.mts.ru/ir-blog/mts-blog-details/2020/MTS-and-Skoltech-Launch-5G-Pilot-Zone-in-Moscow/default.aspx.

C. There is an Opportunity and a Need for United States Leadership.

As the Commission recognizes in the NOI, there has been very limited deployment of Open RAN technologies by U.S. *operators* thus far, even as U.S. *vendors* have played leading roles in deployments globally (*see* Section II-A below).[29] To be sure, DISH's commitment to a cloud-native Open RAN greenfield deployment is highly significant, and Inland Cellular has demonstrated the promise of Open RAN to provide real cost savings to a small operator.[30] Meanwhile, major U.S. operators like AT&T and Verizon have moved more cautiously in comparison to major European-based operators; for example, Verizon plans to deploy Open-RAN compliant hardware later this year, but sourced only from major traditional vendors.[31]

Against this backdrop, the Commission needs to do more to encourage operators of all sizes to adopt the technology, especially at a moment when nations around the world – including both allies and adversaries – are trying to promote their own domestic industries. Meanwhile, countries around the world are seeking to enhance their citizens' broadband connectivity, especially in emerging from the COVID-19 pandemic, and many are seeking to help their operators diversify their supply chains to lower costs, promote flexibility, and (in some cases) address potential national security risks. The United States has a significant opportunity to

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[29] NOI ¶ 27.

[30] *Id.*; Jeanne Whalen, *A Remote Corner of Idaho has Become the Best Hope for the U.S. Challenge to Huawei*, Washington Post, June 29, 2020, https://www.washingtonpost.com/business/2020/06/29/huawei-alternative-oran-idaho/.

[31] Mike Dano, *AT&T Opens Up About Open RAN*, Light Reading, Dec. 11, 2020, https://www.lightreading.com/aiautomation/atandt-opens-up-about-open-ran/d/d-id/766059 ("We believe that open RAN is going to be a good benefit for us, and we actually plan to implement it in our network"); Mike Dano, *Verizon to Start Deploying Open RAN Gear This Year*, Mar. 11, 2021, https://www.lightreading.com/open-ran/verizon-to-start-deploying-open-ran-gear-this-year/d/d-id/768021 (describing deployment of "open RAN-compliant" equipment from Ericsson, Samsung, and Nokia").

provide global leadership, and U.S. policy will serve as an influential model for the rest of the world.

II. THE TECHNOLOGY ECOSYSTEM IS VERY ROBUST.

There has been tremendous growth in the ecosystem for open and disaggregated network technologies over just the past year. For example, the TIP Exchange – which itself is only a sample of the whole – has quickly grown to include over a hundred products and solutions, including offerings from companies like Fujitsu, Infinera, Mavenir, Parallel Wireless, and many more.[32] Importantly, many of these products and solutions have obtained various badges through TIP's test and validation program (*see* Section V-C below). U.S. companies are playing leading roles by leveraging standards, frameworks, and validation processes from organizations like TIP. These frameworks have opened the ecosystem to competition and innovation by many new entrants, including small businesses.

A. U.S. Vendors Are Playing Leading Roles in Open RAN Deployments.

Unlike the traditional RAN marketplace, U.S. companies are leading the way in the movement toward open network architectures. Disaggregation and virtualization are allowing major U.S. companies from non-telecom domains to enter this space, including vendors like AWS, Dell, IBM, HPE, and more.[33] For example, IBM is the system integrator for a deployment

[32] TIP, *Marketplace*, https://exchange.telecominfraproject.com/marketplace (visited Apr. 25, 2021).

[33] *See, e.g.*, Press Release, *Nokia and AWS to Enable Cloud-Based 5G Radio Solutions*, Mar. 15, 2021, https://www.globenewswire.com/news-release/2021/03/15/2192762/0/en/Nokia-and-AWS-to-enable-cloud-based-5G-radio-solutions.html; Mike Hazen, Dell, *It's Time to Open Up Your RAN*, Dec. 16, 2020, https://www.delltechnologies.com/en-us/blog/its-time-to-open-up-your-ran/; Steve Canepa, IBM, *IBM Accelerates Global Telco Transformation with Open RAN*, Mar. 26, 2021, https://newsroom.ibm.com/IBM-Accelerates-Global-Telco-Transformation-with-Open-RAN; Press Release, *Hewlett Packard Enterprise Paves Way for Mass Deployment of Open RAN in 5G Networks With Industry-First Open RAN Solution Stack*, Feb. 24, 2021, https://www.hpe.com/us/en/newsroom/press-release/2021/02/hewlett-packard-enterprise-paves-

by Telefónica in Argentina.[34] U.S. semiconductor companies like Intel, Marvell, and Qualcomm are either developing Open RAN-optimized offerings and/or are benefiting from the move toward virtualized architecture running on generic hardware.[35] Meanwhile, longstanding telecom vendors like Cisco and Infinera are also playing important roles in the core and transport aspects of open network architectures.[36]

Open RAN software platform vendors. U.S. companies including Altiostar, Mavenir, and Parallel Wireless have been playing leading roles in developing software-based solutions based upon Open RAN interfaces, including system integration to varying degrees. For example, Mavenir acts as an end-to-end systems integrator to simplify engagement for operators, creating an offering on par with that of traditional vendors.[37] Parallel Wireless provides an Open RAN

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way-for-mass-deployment-of-open-ran-in-5g-networks-with-industry-first-open-ran-solution-stack.html.

[34] Monica Alleven, *IBM Launches Open RAN Trial With Telefónica Argentina*, Fierce Wireless, Mar. 26, 2021, https://www.fiercewireless.com/tech/ibm-launches-open-ran-trial-telefonica-argentina.

[35] Press Release, *Intel Fuels RAN Innovation for 5G Network Transformation*, Feb. 11, 2021, https://newsroom.intel.com/articles/intel-fuels-ran-innovation-5g-network-transformation/; Press Release, *Marvell Expands 5G Technology Leadership with End-to-End Open RAN and Virtualized RAN Platform Solutions*, Dec. 8, 2020, https://www.marvell.com/company/newsroom/marvell-expands-5g-technology-leadership-with-end-to-end-open-ran-virtualized-ran-platform-solutions.html; Press Release, *Qualcomm Introduces New 5G Infrastructure Platforms to Drive Cellular Ecosystem Transition to vRAN and Interoperable Networks*, Oct. 20, 2020, https://www.qualcomm.com/news/releases/2020/10/20/qualcomm-introduces-new-5g-infrastructure-platforms-drive-cellular.

[36] *See, e.g.*, Bob Everson, Cisco, *Open vRAN Collaboration to Accelerate Solution Deployments*, Apr. 8, 2020, https://blogs.cisco.com/sp/open-vran-collaboration-to-accelerate-solution-deployments; Infinera, *Open Optical Networking*, https://www.infinera.com/solutions/open-optical-networking (visited Apr. 25, 2021).

[37] Mavenir, *OpenRAN*, https://mavenir.com/portfolio/access-edge-solutions/radio-access/openran/ (visited Apr. 25, 2021).

software platform with fully orchestrated Open RAN hardware,[38] while Altiostar provides Open vRAN software in conjunction with a variety of ecosystem partners who provide baseband hardware, network function virtualization (NFV), radio hardware, systems integration, and core networking.[39] Each of these companies is involved in numerous Open RAN deployments or trials around the world in Asia, Africa, the Middle East, and Latin America.

B. Open Deployments Are Leveraging a Well-Developed Set of Industry Standards and Frameworks from TIP and Its Partner Organizations.

In the NOI, the Commission asks about the state of Open RAN standards development and the challenges inherent in developing these specifications.[40] In brief, there is a well-defined group of organizations working on these issues and they have partnered with each other. For example, TIP and the O-RAN Alliance have a liaison agreement that involves information being shared between the O-RAN Alliance, which develops standards, and TIP's OpenRAN project group, which focuses on productization and test & validation. Meanwhile, TIP also continues to lead the way on developing frameworks for open transport and open core solutions, as described in Section IV-A below.

Notably, the vast majority of ecosystem participants have at least some degree of buy-in with these established technical frameworks. While implementation approaches may vary – hardware vs. software, proprietary vs. open-source – the underlying work toward open interfaces and architectures appears to be funneling toward commonality based around the work of TIP and

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[38] Parallel Wireless, *Coverage Wireless Solutions*, https://www.parallelwireless.com/solutions/coverage/ (visited Apr. 25, 2021).

[39] Altiostar, *OpenRAN Ecosystem*, https://www.altiostar.com/new-network-model/new-supply-chain/openran-ecosystem/ (visited Apr. 25, 2021) (listing Altiostar's ecosystem partners in each of these domains).

[40] NOI ¶ 24.

the O-RAN Alliance. The work of the two organizations is largely complementary, with the O-RAN Alliance focused on specifications while TIP focuses on end-to-end solutions and practical implementation. Indeed, TIP and the O-RAN Alliance are two of the four organizations that were specifically recognized by Congress in the recently-enacted FY21 National Defense Authorization Act as key players in this space.[41]

In essence, the move toward open network technologies has not yet presented the challenge of dueling architectures in the marketplace, as happened in the past with LTE vs. WiMAX, Blu-Ray vs. HD-DVD, or VHS vs. BetaMax. This is due in significant part to TIP's global reach, which now encompasses hundreds of member companies from around the world, and to TIP's collaboration with the O-RAN Alliance and others. Thus, the Commission would most effectively achieve its eventual policy objectives by leveraging the existing industry frameworks, rather than searching for new frameworks or attempting to create them.

Common Public Radio Interface. The Commission asks whether the Enhanced Common Public Radio Interface (eCPRI) is a "sufficient alternative" to Open RAN.[42] The answer is no, because eCPRI is an interface to send data between the Radio Unit (RU) and the Distributed Unit (DU),[43] while Open RAN permits much more disaggregation that allows a traditional base station to be separated into more subcomponents. For example, Open RAN relies on Open FrontHaul, which defines more of the implementation details, making the interface between the

[41] William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, Jan. 1, 2021, at § 9202(a)(1)(C)(ii), public law text not yet available, *see* H.R. 6395 enrolled bill at pp. 1401-02. The other two organizations mentioned in the law are the 3GPP and the Open-RAN Software Community, the latter of which is itself a collaboration between the O-RAN Alliance and the Linux Foundation. *See* O-RAN Alliance, *O-RAN Software Community*, https://www.o-ran.org/software.

[42] NOI ¶ 24.

[43] Specifically, eCPRI refers only to Open FH interface option 7.2 from the O-RAN Alliance.

RU and DU more open than when relying on the eCPRI specification alone. Meanwhile, the original CPRI has essentially become proprietary with different major vendors having their own implementations that are not interoperable in practice.[44]

To be sure, eCPRI is now intended to be a standard defining how information is carried over, and some interoperable multi-vendor implementations are being released, both among vendors and semiconductor companies. This is a positive development and eCPRI should ideally continue its evolution as a truly open interface. However, there remain some aspects of the eCPRI specification that are open to interpretation, which means eCPRI could eventually devolve into a non-interoperable proprietary scheme like its predecessor. Indeed, this is where TIP's role in end-to-end solutions testing and validation may play a role in developing workable blueprints to ensure compatibility, for even eCPRI includes multiple "IoT profiles" that could hinder this. In any event, eCPRI is not yet mature, and its focus solely on the RU / DU interface makes it an incomplete substitute for OpenRAN.

C. Open Architectures Are Promoting Competition, Innovation, and Participation by New Market Entrants, Including Small Businesses.

By leveraging disaggregation, virtualization, and common interfaces, open architectures significantly reduce the barriers to entry for new participants including small businesses. *First*, disaggregation into smaller sub-elements allows for a larger number of ecosystem players in the same space, creating competition. *Second*, virtualization moves the complexity of telecom infrastructure away from the hardware layer and into the software layer. Thus, any firm can effectively become a telecom network vendor simply by being a software company, which

[44] Linda Hardesty, *What is eCPRI, and Why is it Important for 5G and Open vRAN?*, Fierce Wireless, Oct. 15, 2019, https://www.fiercewireless.com/tech/what-ecpri-and-why-it-important-for-5g-and-open-vran

greatly reduces the cost of market entry. Some notable Open RAN software solutions vendors such as Altiostar, Mavenir, and Parallel Wireless are orders of magnitude smaller than their large competitors, in some cases having just a few hundred employees.

These changes also promote innovation because the move toward software allows network infrastructure to benefit from broader technological advances being made in other areas. For example, AI and machine learning solutions can be more easily incorporated into a software-driven, virtualized network. The process of virtualization that is now well-entrenched in the broader technology world, including scalable compute and storage through the cloud, will now benefit the telecom domain as well. These changes are helpful not just to smaller operators, but also to enterprise / private networks that benefit from cloud-native architectures, flexible on-premises solutions, and edge cloud solutions, among other functionalities.

III. THE BENEFITS OF OPEN ARCHITECTURES FAR OUTWEIGH ANY PURPORTED COSTS.

As the Commission has recognized in the NOI, open architectures will bring a wide variety of benefits to the ecosystem. Greater supplier diversity will lead to less fragile and more flexible supply chains, reducing the risks of disruption for operators and creating incentives for investment. It will lead to greater innovation in network functionalities as a growing community of suppliers create new products that enhance performance and address current challenges for connectivity. It will also improve the overall business case for connectivity by reducing the total cost of ownership or by enabling new revenue streams for service providers. As explained below, open architectures will also enhance security and provide significant energy efficiencies, while benefiting from a rapidly expanding ecosystem of system integration.

A. Open and Disaggregated Architectures Provide Operators with Flexibility and Avoid the Problem of Vendor Lock-In.

Open network architectures are designed to permit operators to disaggregate traditional components of their networks, such as separating a mobile "base station" into its constituent functions. Disaggregating network infrastructure into smaller elements, each connected across standards-based interfaces, provides operators with flexibility as they deploy their networks. This is particularly important as 5G networks are seeing ever-greater amounts of network technology being shifted either from the network core closer to the edge, or vice-versa, facilitating performance improvements in lower latency and lower energy consumption, among other benefits.

Open architectures also help solve the problem of vendor lock-in. Under legacy deployment paradigms, telecom operators have been forced to obtain their RAN infrastructure from a small number of vendors. Equipment from those vendors is typically not interoperable, making it difficult for operators to switch vendors or upgrade their networks gradually. By using standards-based interfaces and specifications from groups like 3GPP or the O-RAN Alliance, and by adhering to productization, testing, validation, and delivery requirements from TIP, open architectures lead to an ecosystem that provides operators with flexibility to mix-and-match solutions from different vendors.

B. Open and Disaggregated Architectures Reduce the Cost of Infrastructure, Promoting Buildout and Ultimately Benefiting Consumers.

Open and disaggregated network architectures, including OpenRAN and other disaggregated systems, will significantly reduce costs for operators. While some deployments *may* initially be more expensive, especially in cases where third-party integration is involved, the

one-time transition to a multi-vendor model will yield significant benefits over time that outweigh any extra initial costs.

Increased vendor competition. As noted above, competition among traditional vendors is currently very limited, especially in the 5G RAN infrastructure space with just five major players globally and only three in the United States. Open architectures will significantly lower the barriers for new entrants, enabling more competition, more innovation in product and service offerings, and ultimately lower costs for operators to deploy infrastructure.

Gradual upgrades over time. When using a traditional vendor, many network operators may perform significant upgrades to their networks very infrequently, perhaps only every ten years as major new generations of wireless technology have been released (2G → 3G → 4G). However, as 5G deployments become more common, the trend is toward new features being released more frequently, with major new 3GPP releases (for example) being finalized more often than once per decade. By eliminating vendor lock-in, open architectures allow vendors to respond to these trends by upgrading their systems gradually. Importantly, this spreads out an operator's deployment costs over time, significantly lowering costs compared to conducting a once-per-decade complete overhaul of equipment.

Software-based upgrading through NFV. An important trend facilitated by open architectures is the movement toward software-based network solutions, or network function virtualization (NFV). This typically involves deploying networking software that runs on general-purpose processors (*i.e.*, x86 chipsets) rather than custom chipsets. Significantly, moving away from highly specialized hardware lowers the costs of network deployment, as software-based solutions can be more easily upgraded remotely and potentially without need to modify or replace any physical infrastructure. In addition, to the extent that disaggregation is

permitting RAN functions to be moved closer to the core, network operators may also benefit from the rapid scalability that cloud computing affords.

Network architecture flexibility. Disaggregation of network components provides operators with much greater flexibility to design and deploy their network architectures to meet specific use cases. Rather than being tied to one-size-fits-all solutions such as a traditional "base station" from a traditional vendor, open architectures allow operators to make creative decisions about where to locate and segment various network functions. This design flexibility will enable operators to lower their deployment costs.

Replaceability. If a certain product, or all products from a particular vendor, must be removed from a network, open architectures make it easier to do so much more cost-effectively. The one-time transition to a virtualized multi-vendor model would ideally be the last time any operator needs to execute a "rip-and-replace" of most of its equipment.

C. Open and Disaggregated Architectures Lead to Technological Benefits Based Upon AI and Machine Learning.

In the NOI, the Commission correctly recognized that AI and machine learning (AI/ML) techniques are a significant potential benefit of open architectures and Open RAN in particular.[45] In July 2020, the TIP OpenRAN project group created a RAN Intelligence & Automation (RIA) subgroup to promote the development of platforms that can host AI/ML driven applications for RAN performance optimization.[46] Similar to other TIP efforts, the goal is to help platform and application vendors develop solutions that satisfy operator-prioritized use cases and align these use cases with the introduction of Open RAN solutions in their respective markets. The RIA

[45] NOI ¶ 44.

[46] Carlos Ubeda and Richard Mackenzie, *OpenRAN Begins Work on AI/ML Applications for Radio Management*, TIP, Jul. 28, 2020, https://telecominfraproject.com/openran-begins-work-on-ai-ml-applications-for-radio-management/.

subgroup is initially targeting Self Organizing Network (SON) applications with AI/ML techniques. By bringing together industry experts from the telecom and AI/ML spaces, the group will focus on optimizing Massive MIMO, and more generally Radio Resource Management. In less than a year, membership in the RIA subgroup has grown very rapidly and now includes more than 30 different operators.

To be successful in a RAN, this work will depend upon two key attributes. First, it depends upon open interfaces to enable an ecosystem of developers who are honed in the art of AI/ML for RAN applications; without them, third-party developers would be unable to participate and innovate. Second, AI/ML typically depends upon large volumes of data to train, validate and test machine learning models. However, in cases where data from currently deployed networks is unavailable, a "digital twin" of a RAN – a common construct in IoT / ML applications – can potentially be developed. Such a RAN DT could also help attract a broader ecosystem of developers and data scientists to develop better RAN algorithms to achieve higher levels of performance.

D. Open and Disaggregated Architectures Enhance Network Security.

Security holds a prime place of importance to all network ecosystem participants, including the TIP community. Many of TIP's members are major telecom operators and vendors, and they expect *at least* the same levels of security from open architectures as they would from traditional approaches. And indeed, open architecture solutions (including Open RAN) will significantly enhance security, for many of the same reasons that such architectures are generally advantageous in other aspects – flexibility, transparency, competition, innovation, upgradeability, and more.

Continuous improvement and development. The comparative security of a particular architecture or approach should not be evaluated at a static point in time, but rather by comparing frameworks that allow for continuous improvement over time to respond to ever-evolving threats. This foundational philosophy was incorporated into the NIST Cybersecurity Framework, which continues to gain wider acceptance across a variety of industries and applications. Modern software engineering is built around the model of Continuous Integration and Continuous Deployment (CI/CD), but Continuous Security is also necessary to ensure software integrity from development to testing to deployment. TIP has several CI/CD initiatives that are embracing this methodology.

To be sure, the CI/CD/CS philosophy means that the security of any technology will be linked to its maturity – but this is true whether it is built upon an open architecture or not. At the moment, the vast majority of vendors – open and traditional alike – are embracing virtualization and the move to cloud-native architectures. While some vendors may choose not to open their architectures, they too will need to develop and rigorously improve their security implementations for new environments and new threats.

Transparency. An open and disaggregated approach provides more visibility into how the elements of a given network function have been implemented, helping to reveal any security issues that may arise. At a process level, the participation of multiple companies working collaboratively through organizations like TIP allows for sharing findings and identifying solutions in a joint manner, quite unlike the closed / single-vendor model. Some may argue that transparency actually creates attack vectors, but the comparative security advantage of platforms based on a core of open-source code vs. wholly proprietary platforms in recent decades – including the dominance of Linux in enterprise settings – has become clear. Although not

exactly analogous to an architecture of open *interfaces*, this has nevertheless demonstrated that "security through obscurity" is ultimately an illusion, and not true security at all.

Competition and innovation. In a closed architecture, a security solution can only be provided by the vendor itself. In contrast, a disaggregated approach allows a much larger number of companies, including third-party experts, to provide security solutions. Thus, open architectures will ultimately leverage the best security practices and solutions from a wide variety of different industries, including not just areas closely related to telecom like cloud services and IT, but also other specialized software domains like finance, health care, and critical infrastructure. The TIP community already benefits from the participation of security experts and "hyperscalers" (colloquially, data center operators that offer scalable cloud computing) that have extensive experience applying advanced security techniques. These techniques will ultimately be adapted into the network architecture domain.

Replaceability. To the extent that any security flaws are identified that cannot be managed through a continuous improvement process, a disaggregated architecture makes it far simpler to replace outdated or defective modules as necessary. This would also be relevant if the Commission or other federal agencies were to identify particular vendors or products that they deem inherently untrustworthy, as has occurred in recent years.

E. Open RAN is Energy-Efficient.

The TIP community fully recognizes that energy efficiency is an important factor for consideration by operators; TIP's operator members are pushing their vendors (of all types) very hard to deliver efficiencies. However, as a general principle, the degree of openness of a particular solution is not inherently related to its energy efficiency. If anything, the open architecture will create new opportunities for efficiencies through various means, as described

below. Moreover, to the extent that any near-term inefficiencies may exist, they will rapidly disappear as ecosystem players optimize their products. For example, semiconductor companies like Marvell and Qualcomm have announced new Open RAN-optimized products in recent months that will quickly enable more energy-efficient platforms.[47]

Cloud-based efficiencies. Open and disaggregated network architectures allow for moving some or all of the processing capacity to the cloud (or edge cloud). This creates potential advantages compared to legacy systems for at least two reasons. First, in the RAN context, by moving some of the RAN components away from each cell site toward more pooled and centralized locations, power consumption at each site is reduced. Second, processing at the central locations benefits from economies of scale and statistical multiplexing – and thus, lower overall energy consumption. Third, at the processing centers, cloud-based implementations will benefit from the use of the same or similar tools to control energy consumption that have been well-established for non-telecom IT workloads.

Efficiencies based on openness. As with security, the nature of open architectures creates a more competitive and innovative ecosystem that will provide ever-greater energy efficiency benefits over time, including the new semiconductor products mentioned above. TIP and its members are exploring several additional potential paths toward greater energy efficiency:

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[47] Press Release, *Marvell Expands 5G Technology Leadership with End-to-End Open RAN and Virtualized RAN Platform Solutions*, Dec. 8, 2020, https://www.marvell.com/company/newsroom/marvell-expands-5g-technology-leadership-with-end-to-end-open-ran-virtualized-ran-platform-solutions.html ("Marvell's O-RAN platform now … address[es] capacity, *power*, cost and time-to-market challenges presented by current architectures….") (emphasis added); Press Release, *Qualcomm Introduces New 5G Infrastructure Platforms to Drive Cellular Ecosystem Transition to vRAN and Interoperable Networks*, Oct. 20, 2020, https://www.qualcomm.com/news/releases/2020/10/20/qualcomm-introduces-new-5g-infrastructure-platforms-drive-cellular ("Flexible vRAN architecture with hardware accelerators … designed to enable high throughput low latency network processing for *superior power efficiency* and compact equipment designs.") (emphasis added).

- The use of Self Organizing Network (SON) algorithms based on AI and machine learning technology. To that end, Power Saving by Load-Adaptive Mode is an energy efficiency use case currently being driven by TIP's OpenRAN PG Radio Intelligence and Automation (RIA) subgroup.

- Virtualization permits remote software upgrades and zero-touch provisioning to enable a longer life of the installed hardware base, thus contributing significantly to overall sustainability. It allows fewer truck rolls to cell sites, leading to fewer CO_2 emissions and higher energy efficiencies for regular maintenance and upgrades.

- In situations where an operator is attempting (or required) to meet energy-efficiency standards or quotas by a certain date, the closed model might require replacing an entire vendor or product line all at once, making compliance either impossible or very costly. Disaggregation allows for upgrading components sooner, which realizes efficiencies more rapidly.

- The use of massive MIMO allows significantly improving network coverage and capacity with fewer sites compared to traditional architectures, thus contributing to energy efficiency.

Efficiencies compared to older networks. Setting aside current debates regarding which among the newest technologies may be superior, today's Open RAN technology is almost certainly more efficient than the older legacy technologies still being used by many small and rural operators. For example, the TIP-facilitated trial of Open RAN technology by Vodafone in Turkey concluded that the new systems were more efficient than older cabinet-based 2G systems.[48] Thus, if the Commission were to encourage wider adoption of Open RAN technology immediately based on products available today (or in the next few months), the efficiency gains would likely already be significant.

F. System Integration Options are Expanding Rapidly.

Systems integration has always played a significant role in the network infrastructure ecosystem in several ways, long before the advent of Open RAN. First, the largest operators

[48] TIP, *Playbook – OpenRAN Trials w/ Vodafone Turkey*, at 32, https://cdn.brandfolder.io/D8DI15S7/as/c5tx5crn45cch6w3nrz39s/OpenRAN_VF_TK_Playbook_FINAL.pdf.

effectively do their own integrations of equipment, often from different vendors for the different network domains, *i.e.*, RAN, transport, and core. Second, even with a single vendor, that vendor has typically done its own proprietary integration of subcomponents to build a product – and that integration cost is baked into the product. Third, particularly for smaller operators, third-party systems integrators are often responsible for testing, validation, planning, procurement, installation, commissioning, integration with a service provider's operations support systems (OSS) and network operations center (NOC), and much more.

None of this is inherently different with an Open RAN architecture. Rather, the arguments that some may make against Open RAN based upon the need for integration are ultimately more about *product-level* integration of elements like the RU / DU / CU / RIC. To fill this need, companies like Amdocs, Dell, Fujitsu, IBM, and Tech Mahindra are among those who have already entered this space, with more likely to come.[49] Importantly, these companies are developing the necessary skillsets to ensure that end-to-end integrations will be curated by an increasingly diverse set of American (or Western-aligned) companies, and by doing so are eliminating operator dependency upon a narrow set of non-U.S. vendors.

TIP's role. TIP has been a key player in reducing friction in the ecosystem because of its relentless focus on integration, test and validation. As the technologies are deployed, TIP's

[49] Amdocs, *Open Wireless Networks*, https://www.amdocs.com/open-wireless (visited Apr. 24, 2021); Dell, *It's Time to Open Up Your RAN*, https://www.delltechnologies.com/en-us/blog/its-time-to-open-up-your-ran/ (visited Apr. 24, 2021); Fujitsu, *Open, Integrated 5G Network Solutions*, https://www.fujitsu.com/us/products/network/solutions/wireless.html (visited Apr. 24, 2021); Steve Canepa, *IBM Accelerates Global Telco Transformation with Open RAN*, Mar. 26, 2021, https://newsroom.ibm.com/IBM-Accelerates-Global-Telco-Transformation-with-Open-RAN (describing an integration it is doing for Telefónica in Argentina and its creation of a Center of Excellence in Spain to drive adoption across Europe); Tech Mahindra, *Virtual and Open RAN Solution*, https://www.techmahindra.com/en-in/network-services/virtual-and-open-ran-solution/ (visited Apr. 24, 2021).

continuous feedback loop has helped ensure that the maturity of the technology continues to accelerate. TIP also brings a diverse set of players and tools – including system integrators and companies providing automation tools – to the table to ensure that disaggregation happens as smoothly as possible. Importantly, TIP's badging system helps ensure that multi-vendor RU/DU products (and more) are tested and verified, fulfilling a function that traditional vendors conduct in their own proprietary lab environments. (*See* Section V-C below.)

Single vendor solutions based on open standards. In recent years, vendors like Altiostar, Mavenir, and Parallel Wireless have been building and deploying single-vendor software solutions that are based upon open technology standards and architectures. These deployments have helped to validate the underlying standards and technology, and could also serve as an intermediary step for some operators that may eventually wish to adopt a multi-vendor solution. Moreover, in any truly open market, some operators may ultimately decide to retain a single-vendor solution from one of these companies, or others. But if so, that will be a voluntary choice rather than one driven by the inherent difficulty of making any substitutions.

Ultimately, generating major change in a global ecosystem can be complex and multifaceted, and the initial switchover to multi-vendor environments will require short-term changes and some integration. Many similar changes have occurred in the past, such as when network attachments like telephones were disaggregated from control by the operator, or when IBM created its Personal Computer (PC) allowing an ecosystem of third-party devices and software to thrive, or even when the Commission "disaggregated" phone numbers by implementing number portability. In each case, there was some initial friction due to disaggregation, but this was a natural part of the change cycle and the resulting ecosystems are

now multi-faceted and smooth. The Commission should recognize this, facilitate it, and not be dissuaded by any short-term friction that will rapidly dissipate.

IV. THE COMMISSION SHOULD TAKE ACTION TO ENCOURAGE OPEN ARCHITECTURES.

The Commission possesses significant power to shape the future of network infrastructure deployment in the United States. The agency already oversees the Universal Service program, including the ongoing rip-and-replace program for Huawei and ZTE equipment, and may soon play a role in the distribution of major additional funding currently under discussion in Congress. If used carefully, the agency may have a significant opportunity to exercise its authority to advance open network architectures for the benefit of the entire telecommunications ecosystem.

A. The Commission Should Consider Not Just the RAN, But Also Other Elements of the Network.

While the NOI is primarily focused on the RAN, it also seeks comment on the need for, and interest in, advancing open architecture network solutions generally, including open optical and packet transport (OOPT) and open cloud-native core.[50] Many of the benefits of RAN disaggregation – including virtualization, ease of product replaceability and upgradability, promoting greater competition and innovation, lowering costs, obtaining energy efficiencies through cloud-native architectures, providing flexibility to operators in selecting an architecture, and avoiding vendor lock-in – are also equally relevant to the OOPT and open core contexts.

TIP and its members have played a leading role in advancing this work. The OOPT work has seen major progress on disaggregated cell site gateways (DCSGs) over the past 18 months, with commercial deployments becoming a reality when Telefónica announced its plans in late

[50] NOI ¶ 83.

2019 for deployments in Germany and Ecuador.[51] Since then, Vodafone has finished a lab trial in Romania, Airtel has conducted lab trials of TIP's DCSG in India, MTN is finalizing plans to execute field trials in South Africa, and there is also activity elsewhere in Asia, Latin America, and Africa.[52] The TIP OOPT group has also produced technical requirements for an open and disaggregated broadband network gateway (BNG) device that operators can deploy to provision *fixed* broadband services.[53] The rapid success of these efforts is demonstrating that the OOPT initiative is filling a real and significant market need.

Meanwhile, the TIP Open Core Network (OCN) project group is now working to develop an open, cloud-native, and converged core that is a collection of services implementing various core network functions.[54] The group includes growing participation from both American and global companies and is built upon code provided by several of the participating companies.[55] In 2020, TIP's OCN group published the first release of its Technical Requirements for 5G Fixed Wireless Access (FWA) use cases, which includes core network functions, orchestration, cloud-native infrastructure, and deployment automation.[56] One of TIP's Community Labs is now launching the first 5G Open Core lab trial – with Peruvian operator Entel as the lead operator –

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[51] Ray Le Maistre, *TIP Advances Give Router Vendors Another Wake-Up Call*, Light Reading, Nov. 13, 2019, https://www.lightreading.com/optical-ip/tip-advances-give-router-vendors-another-wake-up-call/d/d-id/755598.

[52] TIP October 2020 Update, *supra* n. 10.

[53] TIP, *Open BNG Technical Requirements*, https://cdn.brandfolder.io/D8DI15S7/as/jx5654t6f5bx94crvfxwm57w/TIP_OOPT_Open_BNG_Technical_Requirements_v10docx.pdf.

[54] TIP, *Open Core Network*, https://telecominfraproject.com/open-core-network/

[55] *See generally* Amdocs, *Open Core: The critical path to 5G services realization* (Nov. 23, 2020); FreedomFi, Help Us Build Open Future for 5G; Facebook Connectivity, Magma; Wavelabs, *Wavelabs to Play a Role in Helping TIP Achieve Open & Disaggregated Networks*.

[56] TIP October 2020 Update, *supra* n. 10.

with the goal of integrating and demonstrating a 5G "minimum viable core" with commercial 5G radios.

Commission policy. As described above, there is strong alignment in the benefits of open architectures from the edge to the core, and there is a clear need for open non-RAN architectures as demonstrated by the rapid uptake by major global operators of these efforts. Thus, the Commission should ensure that any policies it adopts to advance open architectures promote not just the RAN, but other elements of the network as well. Indeed, most (if not all) of the proposed steps for Commission action described below can and should be extended to OOPT / open core / open Wi-Fi approaches as well as RAN.

B. The Commission Should Adopt Incentives to Promote Virtualization, Replaceability, and Gradual Upgradability.

TIP and its members do not support mandates requiring specific standards or frameworks – even those developed collaboratively by TIP and groups like the O-RAN Alliance – since this would violate the Commission's longstanding principle of technology neutrality. However, there are several specific steps the Commission could take to encourage open architectures by instead targeting the underlying problems confronting operators. These steps would promote open architectures indirectly and/or would spur changes in the marketplace through responses from traditional or single-vendor solution providers.

Promoting virtualization. Without mandating particular architectures or standards, the Commission could simply incentivize the deployment of any hardware that is capable of running software (for all relevant functions) from more than one software vendor. While perhaps not completely neutral, this is a common-sense intermediate step that would target the problem of vendor lock-in by giving operators the option to change or upgrade software without needing to replace hardware, lowering costs. Also, while virtualization is a key tenet of the movement

toward open architectures, traditional vendors would have the option of qualifying by opening up their existing hardware platforms to other software. Vendors in other contexts have experienced success in the past by growing their ecosystems – for example, Apple made its OSX kernel (Darwin) available for free to facilitate development of software for its devices, and Google made the Android platform widely available.

Promoting replaceability. The Commission's recent experience with Huawei and ZTE has clearly demonstrated the difficulties and costs that arise when a particular product, or all products from a particular vendor, are installed and later deemed untrustworthy by the government. To reduce the impact of similar occurrences in the future, the Commission should incentivize the installation of products that would mitigate the cost of replacement (if ever needed) in comparison to a complete rip-and-replace.

Different types of vendors could meet such a requirement in different ways. Open architecture and/or multi-vendor solutions might benefit from only requiring one component to be replaced, or (thanks to virtualization) by requiring only a software change, depending on the security issue. However, a traditional vendor might also qualify by undertaking a contractual obligation to cover replacement costs should its products be deemed untrustworthy by the Commission. Thus, the Commission's ultimate goal of achieving security and reducing or eliminating future rip-and-replace costs can be achieved in a technology-neutral way.

In some cases, operators with Huawei or ZTE equipment may be having technical challenges in replacing that equipment without obtaining support from those very companies. To prevent this problem in the future, the Commission should also incentivize solutions where, if a replacement is eventually needed, no support from the existing vendor would be required.

Promoting gradual upgradability. As the Commission is well aware, commercial mobile networks are often upgraded in ten-year cycles (2G → 3G → 4G etc.). This step-change paradigm has created unnecessary economic friction that leaves operators and their customers behind, especially since the pace of technology is advancing more rapidly. For example, 3GPP issues new releases every 1-2 years, but many operators – especially smaller operators – may not benefit from these changes for a decade or more.

The Commission can and should target this problem with policies favoring solutions that permit more gradual upgradability. Disaggregated solutions would clearly benefit, since if a particular hardware sub-component becomes upgradable more quickly, an operator's cost to implement the upgrade would be reduced. Virtualized solutions would also benefit since upgrades might only require a software replacement rather than hardware replacement. However, a traditional vendor could also qualify (or compete) by undertaking a contractual obligation at the outset to provide appropriate upgrades. Again, this would incentivize changes in the ecosystem that would permit greater flexibility and innovation, benefiting operators and their consumers alike.

Form of incentives. The incentives above could be granted in a wide variety of forms that would not constitute a hard mandate. For example, the Commission could provide favorable treatment in calculation formulas for universal service support, perhaps analogous to the "Designated Entity" preference the agency grants to certain small entities in spectrum auctions. Alternatively, targeted regulatory relief could be provided to operators who adopt or transition to new infrastructure consistent with the principles above. If Congress enacts broadband infrastructure legislation in the near future, then depending upon statutory limitations, the

Commission could potentially give more favorable treatment when evaluating any grant applications for funding that may be administered by the agency.

C. The Commission Should Take Concrete Steps to Build U.S. Operator Confidence in Open Solutions.

While operators of all sizes are moving ahead with commercial deployments globally, many U.S. operators – especially smaller operators – still have little-to-no experience regarding Open RAN or other open architectures. Building operator confidence in the new technology is therefore very important, and perhaps even more important than providing direct or indirect financial incentives of the type discussed above. Adoption by a few U.S. operators will build greater domestic experience, and will likely lead to more rapid adoption by others who are more willing to follow than to lead.

Fortunately, the Commission is well-positioned to facilitate activities that will help push open solutions past the tipping point. This could include holding additional forums and engaging in direct outreach with smaller operators, including via industry-sponsored conferences and activities. The Commission can also provide technical assistance, for example by highlighting RFI templates that an operator in search of an open solution might use, either on its own or in connection with a systems integrator. The Commission can also work with TIP and its members to provide greater visibility to successful case studies involving open architecture deployments.

Beyond using its convening power, there are other steps worth considering. The Commission could provide support to systems integrators that are willing and able to help smaller operators deploy open solutions. A modicum of direct support to systems integrators would help accelerate the ecosystem of firms that have the capability to install end-to-end solutions, which could prove more effective than simply providing incentives to operators who are reluctant to use them due to lack of familiarity. In addition, the Commission could formally

recognize that the (possibly) higher costs of an operator's initial transition to a multi-vendor environment will be offset over time, and adjust any calculations of cost effectiveness, *e.g.*, in universal service programs, to account for this.

Secure Networks Reimbursement Program. Regarding the smaller pool of operators who will be participating in the Secure and Trusted Networks Reimbursement Program ("rip and replace"), the Commission could:

- Clarify that any operator selecting an open architecture solution will be eligible for a six-month "individual" extension under Section 4(d)(6)(C) of the Secure Networks Act if the newer technology requires additional coordination time between multiple vendors and integrators, even if a traditional vendor would have been able to complete the operator's transition without the extension.

- Clarify that one of the "purposes of the Program" under Section 4(d)(6)(B) of the Act is to promote newer and more flexible virtual architectures, as evidenced by Section 4(d)(1)(A) of the Act. Thus, if it does take somewhat more time for Open RAN solutions to be deployed, the Commission would have grounds to grant a general six-month extension even if traditional vendors would have been able to transition all affected operators without the extension.

- Identify and work closely with one or two small providers on a pilot project for more rapid deployment of an open architecture solution in the coming months.

- Make clear that operators in the Reimbursement Program that select Open RAN approaches can use reimbursement funds for OPEX over time, since some Open RAN benefits may not be achieved via upfront CAPEX in the initial transition to a multi-vendor solution.

D. The Commission Should Promote Further Technological Development by Incentivizing True Interoperability.

In any technology ecosystem, the development of standards is only the first step towards true interoperability. Some companies may choose to adhere to standards in their specific implementations only to a certain degree, or they may add, remove, or modify certain key features in a way that renders them effectively closed despite being built upon an "Open RAN-compliant" foundation. Even where all participating vendors have made serious efforts toward

full interoperability, some issues may not be discovered until two products from different vendors are actually attempting to communicate with each other.

One of TIP's primary objectives is to solve this problem by focusing upon real-world productization, field trials of interoperability, and end-to-end testing, for those are typically the only methods for such issues to be discovered. Meanwhile, products or solutions should not "check a box" for interoperability merely by being mostly designed around a particular standard, nor even by using a particular common codebase. To avoid this, the Commission should incentivize vendors to develop (and maintain) solutions that are truly interoperable in practice.

E. The Commission Should Facilitate Testbeds and Industry Partnerships, But Should Not Authorize Equipment.

Although Open RAN is a commercial reality today, the philosophy of continuous integration and continuous development (CI/CD) means that virtualized, software-based solutions are constantly being improved by incorporating new features and increasing efficiencies and overall robustness. The Commission is thus correct to consider promoting testbeds, potentially in collaboration with industry partners like TIP. The NOI specifically referenced the United Kingdom's SmartRAN Open Network Interoperability Centre (SONIC), and one of the four stated objectives of SONIC is to facilitate testing with organizations including TIP.[57] The recent enactment of the USA Telecommunications Act as part of the FY21 NDAA and the prospect of funding being appropriated this year may potentially create opportunities for public-private partnerships built around testing and validation.

Having been founded in 2016, TIP and its members have developed significant experience over time with various aspects of interoperability testing and solutions validation.

[57] NOI ¶ 80; *see* UK5G Innovation Network, *SONIC*, https://uk5g.org/discover/testbeds-and-trials/sonic/ (visited Apr. 22, 2021) (mentioning the Telecom Infra Project).

These have ranged from basic "plugfests" that test products across specific interfaces to the development of more sophisticated blueprints and evaluation of end-to-end solutions. TIP's test and validation processes, including the TIP badging program, go beyond basic standards compliance (3GPP, O-RAN Alliance) and are designed to provide assurance to operators that both components and end-to-end solutions will meet real-world commercial needs. The Commission should seek to leverage this experience, and TIP is open to further discussions with the agency and creative ideas about how to accomplish this objective.

Equipment authorization. The Commission should *not* attempt to use its equipment authorization process to certify particular solutions as being compliant with particular open standards. First, industry groups like TIP are already engaged in test and validation activities, and TIP's badging program is continually growing more robust as additional specifications are developed over time. Second, the Commission's equipment authorization program and the staffing of its Office of Engineering and Technology (OET) are largely focused on RF emission limits. That is a fundamentally different type of testing in comparison to evaluating the interoperability and product readiness of multi-vendor virtualized software implementations. Developing the necessary expertise would be a major undertaking, and there is no need for the agency to do so.

F. The Commission Should Collaborate with Congress and Other Agencies to Promote Open and Disaggregated Deployments at Home and Abroad.

As the Commission knows, its Notice of Inquiry is one part, albeit a very important part, of a whole-of-government initiative that touches upon 5G, security, and Open RAN. Congress has enacted the USA Telecommunications Act and may consider additional measures this year, while NTIA and DoD have established a "5G Challenge" that appears significantly (if not

completely) focused on open architectures.[58] All of this activity is very helpful, but the Commission should work to ensure that its own activities are closely coordinated. For example, if NTIA establishes a testbed for the 5G Challenge, the Commission should ensure that its own testbed and development support is coordinated.

Meanwhile, the confluence of 5G deployment and supply chain security concerns has led to heightened global interest in this topic, including fora in which the Commission has participated such as the Prague 5G Security Conference.[59] Whenever opportunities arise, the Commission should use its influence to actively promote open and disaggregated network architecture solutions with its counterparts abroad, and in multilateral fora, to highlight the advantages. Since American companies are poised to benefit from open architectures, this would also be broadly consistent with the federal strategic objectives identified in the Secure 5G and Beyond Act.[60]

V. TIP AND ITS MEMBERS PLAY A LEADING ROLE IN THE OPEN AND DISAGGREGATED NETWORK ARCHITECTURE ECOSYSTEM.

Founded in 2016, TIP is a community of diverse members that includes hundreds of telecom companies, from service providers and technology partners to systems integrators and

[58] NTIA, *5G Challenge Notice of Inquiry*, Jan. 11, 2021, https://www.ntia.doc.gov/federal-register-notice/2021/5g-challenge-notice-inquiry.

[59] Government of the Czech Republic, *Prague 5G Security Conference Announced Series of Recommendations: The Prague Proposals*, May 3, 2019, https://www.vlada.cz/en/media-centrum/aktualne/prague-5g-security-conference-announced-series-of-recommendations-the-prague-proposals-173422/.

[60] *See* Secure 5G and Beyond Act of 2020, Pub. L. No. 116-129, at §§ 3(a)(2), 3(c)(4), 4(8), 4(11)-(14), 134 Stat. 223, 223-226 (generally calling on the United States to, *inter alia*, work closely with other nations on these issues, including providing technical assistance, promoting responsible global development and deployment of 5G and future generations of wireless communications, engaging diplomatically with allies, creating joint testing environments, and coordinating on research and development issues).

other connectivity stakeholders. TIP and its members work together to *develop*, *test* and *deploy* open architecture solutions based on industry standards. Where bodies including 3GPP and the O-RAN Alliance are focused on standards, TIP's focus is on real-world productization and commercialization of open architecture solutions that are driven by operator needs. As part of this focus, TIP works toward validating end-to-end solutions by verifying that products are interoperable in practice, not just in theory.

TIP's work is wide-ranging. As explained below, our programs include technical project groups that help companies develop common open-architecture solutions, programs to promote innovation and testing in the open-architecture space, and programs to help companies bring their validated open-architecture solutions to market.

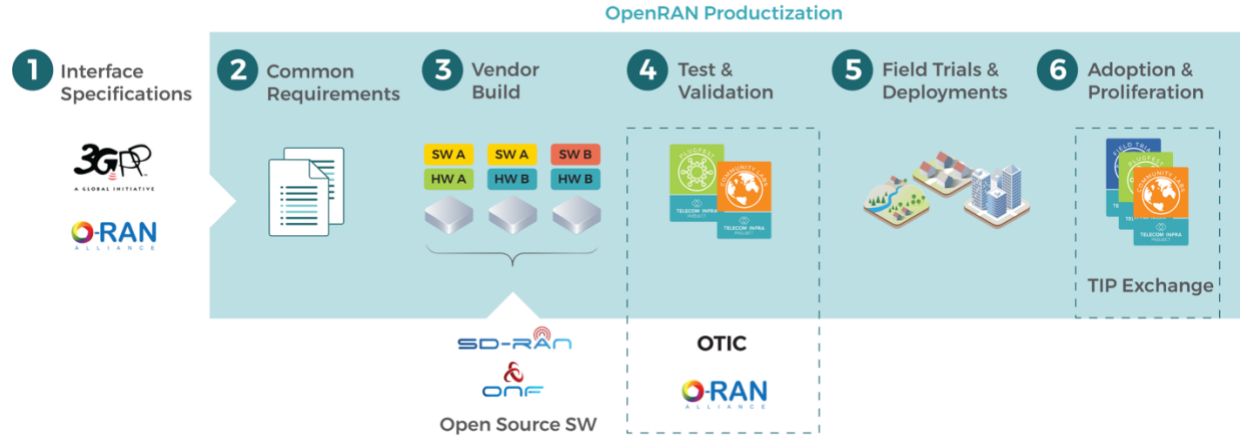
A. TIP Technical Project Groups Have Advanced Real-World Productization of Open Network Solutions.

TIP has ten different product groups that are product-oriented and focus on the development of requirements, minimum viable products (MVPs), white papers, and lab and field trial results.[61] While the standards process can occasionally find itself ahead of the marketplace, TIP's product groups are driven by operators' demonstrated commercial priorities and form the heart of TIP's technical work. Four groups of particular interest and relevance are highlighted below: TIP OpenRAN, TIP Open Optical & Packet Transport (OOPT), TIP Open Core Network (OCN), and TIP OpenWiFi. Other TIP groups include solutions groups focused on issues such as connected cities and open automation.

TIP OpenRAN. The TIP OpenRAN product group supports the productization of disaggregated and interoperable solutions ranging from 2G through 5G NR based on service

[61] TIP, *Project Groups*, https://telecominfraproject.com/project-groups/ (visited Apr. 28, 2021).

provider requirements.[62] Essentially, the work of TIP OpenRAN begins where the work of standards specification groups like 3GPP and the O-RAN Alliance ends. TIP OpenRAN's productization work focuses on developing common requirements, testing & validation, field trials, and promoting adoption, as represented by the blue rectangle in the figure below:[63]



The OpenRAN project group includes several subgroups, including subgroups focused on 4G/5G whiteboxes for the Radio Unit and the Distributed Unit + Centralized Unit, OpenRAN Orchestration and Management Automation (ROMA) as well as RAN Intelligence & Automation (RIA), among others. (*See* Section III-C above.) Participation in some subgroups is limited to companies that are members of *both* TIP and the O-RAN Alliance, which is illustrative of the well-defined collaboration between the two leading technical organizations in this space. The OpenRAN project group played an important role in TIP's field trial work with Vodafone in Turkey. (*See* Section V-B below.)

OOPT and Open Core. As discussed in greater detail above, TIP's Open Optical and Packet Transport (OOPT) project group has been successful in its work on a Disaggregated Cell

[62] TIP, *OpenRAN*, https://telecominfraproject.com/openran/ (visited Apr. 28, 2021).

[63] *Id.*

Site Gateway (DCSG), while TIP's Open Core Network (OCN) project group is developing an open, cloud-native, and converged core. (*See* Section IV-A above.)

OpenWiFi. OpenWiFi is one of TIP's newest project groups.[64] The group is working on a community-developed, fully disaggregated Wi-Fi system, including Wi-Fi Access Point (AP) hardware, an open-source AP network operating system (NOS), and a software development kit (SDK) to build cloud-native Wi-Fi Controller software for use by operators and enterprises. Goals include helping to improve the business case for carrier and enterprise-grade Wi-Fi by lowering costs, accelerating innovation, and creating favorable economics.

There has already been a strong demand signal for OpenWiFi, with both Wi-Fi and cellular operators moving to test the platform for their specific use cases, and with industry organizations preparing to collaborate in trials. Fourteen access point SKUs are already available for indoor and outdoor use cases, and the number will grow to approximately 30 by the end of 2021. Products compliant with the OpenWiFi technology stack and APIs will be identified with the OpenWiFi logo.

B. TIP Community Labs, Integration Testing, Field Trials, and Acceleration Centers Have Promoted Testing and Innovation in the Open Network Ecosystem.

As an important part of productization, TIP has established an extensive framework of programs that promote testing and innovation in the open network ecosystem. TIP programs include field trials to prove Open RAN and open architecture concepts in real-world settings, a network of Community Labs hosted by service providers and others, a test and integration project group for interoperability testing, and TIP Ecosystem Acceleration Centers (TEACs) to promote innovation by smaller vendors.

[64] TIP, *Wi-Fi*, https://telecominfraproject.com/wifi/ (visited Apr. 27, 2021).

TIP Field Trials. TIP has facilitated field trials of Open RAN and other open architecture solutions as an important element of product testing and validation. For example, Vodafone issued an RFI based upon its partnership with TIP in 2018 that led to the selection of Parallel Wireless for a field trial in Turkey based around Open RAN technologies.[65] The project concluded that over time, Open RAN systems "will yield both CAPEX and OPEX cost efficiencies" for operators, while also suggesting best practices and identifying challenges in need of work.[66] In Indonesia, TIP has supported Indosat Ooredoo in its recent Open RAN field trials, and the carrier has also been engaged in TIP's Community Lab in the country.[67]

TIP Test and Integration Group. The TIP Test and Integration project group tests TIP-fostered technologies that have been developed by the substantive project groups in end-to-end environments to evaluate product maturity toward commercial readiness of such technologies.[68] This group coordinates with other groups towards the development of test materials, test plans, or other documents that will support phased evaluation of TIP technologies leading to product maturity. In 2020, the group collaborated with the O-RAN Alliance to hold a joint plugfest with 28 manufacturers and three operators, focusing on Open Fronthaul (OFH) interface, associated

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[65] TIP, *Playbook – OpenRAN Trials w/ Vodafone Turkey*, at 6, https://cdn.brandfolder.io/D8DI15S7/as/c5tx5crn45cch6w3nrz39s/OpenRAN_VF_TK_Playbook_FINAL.pdf.

[66] *Id.* at 30, 33-35.

[67] Press Release, *Indosat Ooredoo Becomes the First Cellular Operator in Indonesia to Run OpenRAN Field Trials on Video Grade 4G Network*, Apr. 19, 2021, https://indosatooredoo.com/portal/en/corppressreleasedetail?_id=20004631; TIP, *The Telecom Infra Project Inaugurates New Community Lab in Indonesia*, Feb. 1, 2021, https://telecominfraproject.com/telecom-infra-project-inaugurates-new-community-lab-in-indonesia/.

[68] TIP, *PlugFest*, https://telecominfraproject.com/plugfest/. The former PlugFest group is being re-chartered as the Test and Integration group.

transport options, and multi-vendor interoperability.[69] In 2019, the group held an event focusing on interoperability between selected RAN partners (eNodeB) and commercial Evolved Packet Core (EPC) at the S1 interface.[70]

TIP Community Labs. TIP coordinates a network of 14 TIP Community Labs, including four labs in the United States hosted by CableLabs, Facebook, and T-Mobile, for various TIP project groups to share best practices, infrastructure blueprints, processes, and experiences with each other. The space and basic equipment are sponsored by individual TIP member companies, but the labs are dedicated to TIP projects. Each TIP Community Lab must satisfy a set of criteria that includes specific requirements regarding physical space, lab equipment and tools, and networking.[71]

TIP Ecosystem Acceleration Centers (TEACs). TIP has partnered with three of the world's largest service providers to host TEAC programs in Germany (Deutsche Telekom), South Korea (SK Telecom), and the United Kingdom (BT).[72] Since the program launched in 2018, over 25 startups have been selected for programs at the three global TEACs. TEAC UK's areas of focus include 5G, while TEAC Germany's areas of focus include Open RAN and network disaggregation.

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[69] O-RAN Alliance, *O-RAN & TIP Plugfest*, https://plugfestvirtualshowcase.o-ran.org/venue_europe.html (visited Apr. 27, 2021).

[70] *Id.*; *see also* ETSI TS 136 410 (explaining the S1 interface), https://www.etsi.org/deliver/etsi_ts/136400_136499/136410/09.01.01_60/ts_136410v090101p.pdf.

[71] TIP, *TIP Community Lab License Criteria*, https://telecominfraproject.com/wp-content/uploads/TIP-Community-Lab-Criteria_url.pdf (visited Apr. 28, 2021).

[72] TIP, *Startups – TEAC*, https://telecominfraproject.com/teac/ (visited Apr. 28, 2021).

C. TIP Badging, the TIP Exchange, and TIP RFI Templates Have Helped Bring Open RAN and Other Open Architecture Solutions to Market.

To facilitate the final steps in bringing open network solutions to market, TIP operates a badging program for vendors and products to indicate that their solutions are ready for integration into a commercial network. The TIP Exchange is a marketplace for vendors to showcase their offerings, and TIP makes RFI templates and resources available to facilitate actual procurements of open solutions by operators.

TIP Badges. As noted above, TIP facilitates product-level testing, end-to-end testing, and field trials of open solutions. TIP also manages a series of badges used to validate the level of maturity toward commercial deployment of the various network elements developed by the TIP community.[73] For example, TIP Field Trial badges identify products and solutions used in TIP Field Trials that provide evidence of meeting criteria agreed upon with the service provider hosting the trial, and that are deployment-ready.

TIP Exchange. The TIP Exchange is an online database for companies to showcase their TIP-qualified offerings, allowing service providers to easily evaluate technology and potential partnerships.[74] Vendors and products in the database are searchable based upon, for example, their association with various TIP project groups such as those described above, or their achievement of TIP badges. Curating a list of equipment and solutions is an important step in giving service providers and system integrators the assurance that they will be able to fully source all necessary network components, particularly in situations where a single-vendor solution is being transitioned to a multi-vendor solution.

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[73] TIP, *TIP Badges*, https://exchange.telecominfraproject.com/about-exchange/badges (visited Apr. 28, 2021).

[74] TIP, *TIP Exchange*, https://exchange.telecominfraproject.com (visited Apr. 28, 2021).

TIP RFI Templates. As part of its Exchange, TIP makes several Request for Information (RFI) templates and resources available to its members to facilitate sourcing (procurement) of disaggregated open-architecture solutions.[75] Several of the templates include detailed specifications for particular components to satisfy. For example, TIP is currently in the process of launching Open RAN templates to support operators' RFI / RFP needs. These templates include technical specifications for Open RAN components (both hardware and software) for the Radio Unit (RU), Distributed Unit (DU) and Centralized Unit (CU), RAN intelligent controller (RIC), Layer 1 to Layer 3 software, and more. The RFI and RFP templates cover 2G to 5G technologies, related feature sets, performance KPIs, and end-to-end RAN functions.

Another example is TIP's template for a disaggregated cell site gateway (DCSG), which includes a technical specification for an open white-box device that operators can widely deploy in current 2G/3G/4G cell sites, but that also supports the port speeds and densities required for 5G networks.[76] These and other RFIs help operators procure open and disaggregated solutions and transform their networks, ultimately benefiting their customers.

[75] TIP, *RFI templates*, https://exchange.telecominfraproject.com/rfi (visited Apr. 28, 2021).

[76] TIP, *RFI template for DCSG*, https://exchange.telecominfraproject.com/rfi/dcsg (visited Apr. 28, 2021).

CONCLUSION

The time for Open RAN and other open network architectures has arrived, and the Commission was right to begin this inquiry. TIP thanks the Commission once again, and we look forward to collaboration as the agency moves forward in the months and years ahead.

Sincerely,

/s/ Dileep Srihari

Attilio Zani
Executive Director
David Hutton
Chief Engineer
TELECOM INFRA PROJECT
401 Edgewater Pl Suite 600
Wakefield, MA 01880

Dileep Srihari
Senior Policy Counsel
ACCESS PARTNERSHIP
1730 Rhode Island Ave Suite 512
Washington, DC 20036

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