

Cirrus360 Corp.'s response to

Public Wireless Supply Chain Innovation Fund Implementation Request for Comments

National Telecommunications and Information Administration [Docket No. 221202-0260] RIN 0693-XC053

<https://www.cirrus3sixty.com>

Summary Recommendations for PWSCIF Implementation:

- **Create MARKET PULL for open RAN from multiple market segments. Promote technologies that facilitate agile system composition (including PHY and MAC) to adapt to end user's business goals rather than creating monolithic reference stacks.** For open RAN to be successful at scale, it must directly lead to business advantages for end users in both macrocellular and private 5G markets and address a diversity of use case requirements across industry 4.0, agriculture, transportation, defense, and others.
- **Promote and fund OPEN SOFTWARE FRAMEWORKS (in addition to open interfaces and interoperability testing) to accelerate system integration -- open RAN's biggest challenge.**

To overcome this obstacle, we need to go beyond interfaces between black boxes (RU, DU, CU) and interoperability testing. We need an intellectual property protected OPEN FRAMEWORK especially for Layers 1 and 2 – the hardest parts of RAN! This concept of a software FRAMEWORK, supported by abstraction and automation, has been so successful in the machine learning field (with frameworks such as TensorFlow and PyTorch), to integrate all kinds of innovations in silicon, in software, and in algorithms in an automated way. Let's follow a similar methodology and apply it to open RAN.

- **Enable small companies with expertise in specific technologies (algorithms, tools, SW components, etc.) to add value and generate revenue, without depending solely on partnering with and integrating with products from bigger companies.** US innovation is at its most potent when the market enables large and small companies to cooperate. We need open FRAMEWORKS that integrate contributions from small sized innovators in specific areas (SW, tools, algorithms), along with large companies as well as academia.
- **Fund programs where participants contribute new ideas and solve problems that are not widely recognized concerns today but will be extremely important once open RAN reaches a certain scale.**
- **Funding programs that help US owned companies to develop the ability to construct a complete deployable RAN solution is critical.** Without increased **system integration and lifecycle management expertise and tools, especially in Layers 1-2 (PHY/MAC)**, the US will remain on the periphery of 5G and 6G infrastructure development and remain vulnerable to embargos on this expertise, no matter how much we know about algorithms, circuits for RF, spectrum management, silicon platforms, and so on.

Our startup, Cirrus360 Corp., has developed a **RAN Domain Specific Language (RDSL™) and cloud-based automation framework** (platform name: GABRIEL™) for development, deployment, and upgrades of RAN components, starting with the Distributed Unit (DU). We are currently engaged with open RAN industry leaders with whom we have jointly proven the significant efficiencies to be gained from our platform. For macrocellular deployments, GABRIEL™ enables hardware/software system level composition, optimizing total cost of ownership (TCO). For Private 5G, GABRIEL™ enables use case optimized connectivity, addition of new QoS and security guarantees to 5G systems, extending open RAN and 5G standards from consumer to customized enterprise use, to making 5G work for security sensitive DoD applications and use cases.

Questions on the State of the Industry

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

System integration remains the largest challenge for a multivendor and open system. The system integrator in cellular networks traditionally are part of or closely aligned to the equipment OEM, leading to a close single vendor relationship with the operator. Operators have become used to this relationship and have structured their organizations around managing such a vendor. Changing this may require the Innovation Fund to incentivize purchase from multi-vendors, and fund technologies to simplify and accelerate system integration.

For private networks, the main challenge for open RAN adoption is customization to specific business needs and market segment specific use cases. For open RAN to be successful, it must directly lead to business advantages for the end customer in diverse market segments.

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

Existing RAN components will not interoperate with new components from other vendors. Even if ORAN interfaces are used there will be specific algorithms that cross the ORAN interface boundaries that will not perform optimally. The incumbent traditional vendor will use this as leverage to remain the only vendor.

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

a. What gaps exist from an R&D, commercialization, and standards perspective?

A framework to develop components of the RAN (e.g. DU, CU, RU, RIC apps) that allows the system integrator to optimize the overall RAN performance by modifying certain aspects of the components. Current multivendor open RAN deployments struggle to meet cost and performance compared to their single vendor competition because of the “bolting together black boxes” approach.

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

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

The need to tune and optimize the complete system by hand requires large centralized organizations, which in turn leads to dominance of the industry by a handful of vendors (OEMs) who have the scale to deploy armies of engineers. US innovation is at its most potent when the market enables small companies to cooperate, innovators to get their product to the customer and the startup mentality. The Innovation Fund can support the development of an open framework that truly allows a collection of small companies to offer a competitive RAN solution to operators. This is only possible with automation and an open box approach to development. The development of TensorFlow and associated frameworks and the impact it has had on the speed of development of new Machine Learning businesses is a great example of what US innovation can do in this kind of environment.

4. What is the current climate for private investment in Open RAN, and how can the Innovation Fund help increase and accelerate the pace of investment by public and private entities?

Venture Capital will not invest in startups whose main customers are large cellular telcos. This is because the path to revenue and profit is too long. The Innovation Fund can help nurture early stage startups with innovative ideas and also support a path to implementation and deployment, perhaps within specialized telco markets, for instance under served communities, small to medium sized businesses in private 5G. Once new ideas get a profitable foothold in some markets the funding environment can change.

5. How do global supply chains impact the open, interoperable, and standards-based RAN market, particularly in terms of procuring equipment for trials or deployments?

Operators need to be able to deploy RAN using a diversity of hardware. If open RAN can ensure that deployment is flexible enough to allow a deployment with multiple vendors (both hardware and software and mix and match between the two) then it will be more robust to supply chain issues.

Questions on Technology Development and Standards

6. What open and interoperable, standards-based network elements, including RAN and core network elements, would most benefit from additional research and development (R&D) supported by the Innovation Fund?

The development of an open box solution for the existing components in the ORAN standard (DU especially) will allow system integrators to tune the performance of the RAN and choose from a variety of hardware platforms while still deploying with a multi-vendor solution. Therefore, funding and encouraging progress in an open box approach to RAN component development will do the most to enable open RAN to compete with the current solutions.

7. Are the 5G and open and interoperable RAN standards environments sufficiently mature to produce stable, interoperable, cost-effective, and market-ready RAN products? If not:

a. What barriers are faced in the standards environment for open and interoperable RAN?

We need to move beyond standardizing interfaces between closed boxes to an open box framework. The success of Machine Learning with TensorFlow and other open frameworks is a great example of such an approach.

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

A certain amount of alignment of the way RAN component functionality is described will have a dramatic impact on the flexible use of hardware platforms. The use of P4 in the Software Defined Networking space is a great example.

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

Plugfests that emphasize multivendor solutions and focus on system performance will encourage compliance once a basic framework is in place for a true multivendor solution.

8. What kinds of projects would help ensure 6G and future generation standards are built on a foundation of open and interoperable, standards-based RAN elements?

Plugfests and test beds that force vendors to interoperate, and for system integrators to deploy third party components while still maintaining world class performance goals. If successful, these will also demonstrate that a multivendor solution is competitive. Supporting small companies in the standardization process, that is expensive and time consuming, and often dominated by a few large players in the telco space, would also be beneficial.

Questions on Integration, Interoperability, and Certification

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

Maintaining open platform spaces where small companies can come to test their new ideas in a multivendor environment is important. Getting data on performance and interoperability is often only possible if you have the scale to invest in such an endeavor and is therefore only possible in large, existing, telco vendors.

a. Are interoperability testing and debugging events (e.g., “plugfests”) an effective mechanism to support this goal? Are there other models that work better?

Yes, but only if they focus on system integration with tuning and performance as the goals. Simply showing that two components talk to each other does not make for a market ready product at the RAN system level.

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

Focus must be on the ability of the System Integrator to compose, tune and deploy the components in a competitive manner. We believe that only an open box component approach can satisfy this requirement, so projects must encourage open box component solutions and some level of standardization around how the open box is exposed to the System Integrator so that interoperability and integration with performance tuning is possible.

11. How do certification programs impact commercial adoption and deployment?

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

b. What bodies or fora would be appropriate to host such a certification process?

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

a. Are there alternative processes to certification that may prove more agile, economical, or effective than certification?

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

Questions on Trials, Pilots, Use Cases, and Market Development

13. What are the foreseeable use cases for open and interoperable, standards-based networks, such as Open RAN, including for public and private 5G networks? What kinds of use cases, if any, should be prioritized?

Use cases where open RAN will truly shine are those that require market specific customizations such as defense, industry 4.0, agriculture, transportation. These use cases and their market segments are challenging for large OEMs as they do not have the organization and business structure to adapt quickly to new market requirements.

14. What kinds of trials, use cases, feasibility studies, or proofs of concept will help achieve the goals identified in 47 U.S.C. 906(a)(1)(C), including accelerating commercial deployments?

a. What kinds of testbeds, trials, and pilots, if any, should be prioritized?

The Radio Access Network Layer 1 (RAN L1 or PHY) and Layer 2 (L2) represent the lion's share of the R&D time, as well as CAPEX and OPEX in today's cellular systems. This is because of a set of unique constraints in the RAN related to firm real time, security, power, and robustness in the field. If L1 and L2 are not disaggregated and opened, both from a hardware to software, and software to software perspectives, progress in opening up the higher layers will do little to move the market beyond its dependence on a few large players.

The Innovation Fund implementation of testbeds, reference stacks, and trials should have a deliberate focus on an open, modifiable, and productizable Layer 1.

15. How might existing testbeds be utilized to accelerate adoption and deployment?

16. What sort of outcomes would be required from proof-of-concept pilots and trials to enable widespread adoption and deployment of open and interoperable, standards-based RAN, such as Open RAN?

Maturation of an open 5G ecosystem requires that software innovators can focus on one aspect of the stack and successfully introduce a product without dependence on support from larger players in the ecosystem, (who may want to protect their position in one layer by leveraging their position in another). Also, hardware innovation must allow for the software stack to be ported to disparate platforms. This is especially true in the lower layers of the stack (L1, L2) where real time requirements and power constraints lead to heterogeneous, accelerated hardware solutions.

[A] Therefore, pilots and trials should focus on automation and architecture structures that allow the open disaggregation of software components from each other and also from hardware, even when there is heterogeneity and power constraints in the hardware architecture.

[B] Metrics to evaluate progress in the trials could include time taken to adapt to a new set of requirements, number of significant code commits, cross layer test cases – as measures of agility and flexibility of the integration.

[C] A successful trial should allow for software disaggregation especially in L1/L2 (PHY/MAC) and to allow for these layers to be transparent to higher layer network optimization strategies. Trial outcome should demonstrate the ability of contestants to manage component updates, demonstrate CI/CD, and integrate new algorithms.

[D] Market development: Pilots and trials that require teaming between open RAN technology providers and use case consumers in both private 5G and macro, and an outcome that connects the benefits of open RAN to business advantages for end users in a diversity of markets such as industry 4.0, agriculture, transportation, and others.

This way, the Innovation Fund will create MARKET PULL for open RAN from multiple market segments by promoting technologies that facilitate system composition (including PHY and MAC) with agility, to meet end user's business goals rather than creating monolithic reference stacks.

Questions on Security

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

- a. What role should security reporting play in the program's criteria?
- b. What role should security elements or requirements, such as industry standards, best practices, and frameworks, play in the program's criteria?

Even though security has been a key priority for 5G standardization, the promising capabilities of 5G also create new cybersecurity considerations for all aspects of the infrastructure, including the Radio Access Network (RAN). These considerations become all the more vital with adoption of multi-vendor, disaggregated open RAN technologies.

In addition to security protection provided by the 5G standard, each RAN implementation must have the means to detect and mitigate against anticipated vulnerabilities such as Distributed Denial-of-Service (DDoS) attacks caused by MIoT botnets or a compromised RAN component allowing a Rogue Base Station (RBS) threat. With open RAN implementations, the attack surfaces get multiplied with the introduction of new interfaces, hardware (HW)/software (SW) dis-aggregation, and the use of commercial-off-the-shelf (COTS) HW.

Manual development of RAN components requires a large amount of effort and therefore the current practice is to develop a generic as possible solution and reuse it for many use cases. This means the solution is a large state space, most of which is unused in a given application. This in turn leads to a greater vulnerability to attacks using invalid input that take the component out of its intended state space, opening up the RAN to follow on attacks. This type of attack is already observed in internet protocols. To minimize the threat surface we must minimize the state space. Evaluation of RAN components for security must therefore focus on the development of use-specific RAN solutions with limited state space that is easier to monitor. Formal checking of protocols is also useful. In addition, solutions that are layered and can catch invalid input before it damages the system are also desirable.

Innovation Fund programs should pay special attention to these security related concerns regarding open RAN in two ways: (1) make security an integral part of any trials with tests and challenges focused on specific security attacks, (2) promote architectures and FRAMEWORKS (as defined in the Summary section) that allow customization and modifications of the RAN PHY to be more resilient to security attacks such as jamming and detection as well minimizing the opportunity to damage the state of the system through invalid messaging from, for instance, invalid or overwhelming control signaling.

18. What steps are companies already taking to address security concerns?

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

20. How is the “zero-trust model” currently applied to 5G network deployment, for both traditional and open and interoperable, standards-based RAN? What work remains in this space?

Questions on Program Execution and Monitoring

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

Performance and the ability to support a diverse set of use cases are critical metrics. Independent testing and independent System Integration can also provide data on how challenging integration of new technology into the RAN is. Effective systems integration and automation of integration is critical to success of open RAN.

22. How can NTIA ensure that a diverse array of stakeholders can compete for funding through the program? Are there any types of stakeholders NTIA should ensure are represented?

Small companies have traditionally struggled to make an impact on the Telco space. Enabling innovators in startups to contribute will be a large impact on the open RAN evolution.

23. How (if at all) should NTIA promote teaming and/or encourage industry consortiums to apply for grants?

Ideally there would be a diverse group of company types in any consortium and that would include startups, or at least there would be a preference for startups.

24. How can NTIA maximize matching contributions by entities seeking grants from the Innovation Fund without adversely discouraging participation? Matching requirements can include monetary contributions and/or third-party in-kind contributions (as defined in 2 CFR 200.1).

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

The US is at its best when there is an active and thriving start up community surrounding a technology. Today telco is mainly dominated by a few very large companies and that makes it difficult to unlock the enormous potential of US innovation, or indeed encourage entrepreneurs and investors to participate. So encouraging and supporting small and innovative startups is critical for US competitiveness. This can be done by encouraging startup participation as a requirement in a consortium, providing funding to attend standards and participate fully and focusing on new technologies that enable new markets rather than simply supporting the existing companies in the space to do what they are already doing.

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

b. How should NTIA address potential grantees based in the U.S. with significant overseas operations and potential grantees not based in the U.S. (*i.e.*, parent companies headquartered overseas) with significant U.S.-based operations?

If we are to rebuild the telco ecosystem in the US the core R&D and system product lifecycle support must take place in the US. Graduates in the US in telecoms must be encouraged to pursue telecoms as a career rather than moving to other fields and this can only be done with jobs in the US. As we have mentioned earlier, Layer 1 (PHY) development and System Integration is at the heart of RAN development and though many foreign companies have R&D labs in the US, none to our knowledge take part in these critical aspects of the RAN solution development.

c. What requirements, if any, should NTIA take to ensure “American-made” network components are used? What criteria (if any) should be used to consider whether a component is “American-made”?

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

Additional Questions

27. Are there specific kinds of initiatives or projects that should be considered for funding that fall outside of the questions outlined above?

Projects that focus on new innovative ideas that go beyond the current trajectory of open RAN. Examples:

- The OPEN FRAMEWORK mentioned earlier in this document is a good example of such a novel approach.
- Another example is addressing security concerns anticipated in the future for open RAN solutions, such as impact of compromised code, open source or proprietary, malicious configuration of RAN at run time, and others.

Funding relatively open-ended programs where participants can contribute new ideas and solve problems that are not an immediate concern today but will be extremely important once open RAN reaches a certain scale.

Funding projects that help US owned companies develop the ability to construct a complete RAN solution is critical. Without system Integration and lifecycle management tools and expertise, especially in Layer1 and Layer2 (PHY and MAC), the US will remain on the periphery of 5G and 6G product development and remain vulnerable to embargos of this expertise, no matter how much we know about algorithms, circuits for RF and so on.

28. In addition to the listening session mentioned above and forthcoming NOFOs, are there other outreach actions NTIA should take to support the goals of the Innovation Fund?