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In the Matter of	)
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Implementation of the National Spectrum Strategy	)

Spectrum Policy and Innovation for and by Rural America

— Comments by ARA PAWR Rural Wireless Living Lab

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About ARA PAWR Rural Wireless Living Lab

The National Science Foundation Platforms for Advanced Wireless Research (NSF PAWR) program has been supporting the development and operation of the ARA rural wireless living lab to enable research, education, and innovation in agriculture- and rural-focused wireless technologies and applications. ARA is committed to the development and deployment of 5G-and-beyond technologies for rural America, and it is led by the Iowa State University (ISU) Center for Wireless, Communities and Innovation (WiCI). The mission of WiCI is to advance the frontiers of wireless systems and applications while addressing the broadband gap between rural and urban regions at the same time. To this end, WiCI has been collaborating with 65+ public-private partners from industry, academia, government, and communities to drive ARA-enabled wireless and applications technology development, deployment, and adoption, and it serves as a neutral entity in wireless research, education, and innovation. WiCI is a member of the O-RAN Alliance and Next G Alliance, and it has led the establishment of the ARA O-RAN Open Testing and Integration Center (ARA OTIC) to focus on Open RAN for rural America.

ARA deploys advanced wireless, edge, and cloud equipment across the Iowa State University (ISU) campus, City of Ames (where ISU resides), and surrounding research and producer farms as well as rural communities in central Iowa, spanning hundreds of square miles of rural area [1]. Wireless platforms featured by ARA have demonstrated promising performance so far, for instance, up to 3 Gbps wireless access throughput, up to 10 km effective cell radius, and close to 10 Gbps throughput across a wireless backhaul link of over 10 km.

Spectrum innovation is a core focus area of ARA and WiCI, and WiCI is in the process of joining the National Spectrum Consortium. Building upon ARA, WiCI is leading the ARA National Radio Dynamic Zone (ARA-NRDZ) project to focus on spectrum sharing and innovation for rural America.

More information about ARA and WiCI can be found at arawireless.org and wici.iastate.edu respectively, and inquires can be emailed to e2@arawireless.org.

Comments on the Implementation of National Spectrum Strategy: Perspectives from Rural America

Effective implementation of the National Spectrum Policy is critical to modernize the U.S. spectrum policy and to make the most efficient use of this national spectrum resource in serving diverse needs in defense, scientific exploration, education, transportation, agriculture, renewable energy, as well as other public and private sectors. As we plan the implementation of the national spectrum policy in the coming 1-3 years and beyond, it is important to pay attention to the unique needs of diverse communities and sectors. In particular, ***rural America presents unique needs for spectrum policy and technology innovation, and it provides unique use cases to advance the state of the art in spectrum policy and practice.*** For instance, community- and non-profit-led rural wireless is expected to serve as a key enabler for rural broadband, if affordable spectrum access can be enabled for rural communities/ non-profits [1]. In addition, agriculture farms and rural America in general can serve as important test grounds for wireless spectrum innovation to support safe-critical wireless applications such as the use of Unmanned Aircraft Systems (UAS) in precision agriculture and telehealth [1].

Based on the above observations, it is critical that the implementation of the National Spectrum Policy keeps in mind the unique needs and opportunities provided by rural America, with a special focus on spectrum needs, use cases, policy and technology innovation, and workforce development as we explain in more detail below:

- ***Rural spectrum needs and use cases.*** Given the relatively sparse population/user-equipment density and the relatively large geographic space in rural America, lower frequency bands and the frequency bands suitable for non-terrestrial wireless networks (e.g., LEO satellite communications) will be critical to wireless connectivity in rural America. Therefore, the lower 3 GHz band (3.1 - 3.45 GHz) as well as the bands of 7.125 - 8.4 GHz, 12.2 - 13.25 GHz, and 18.1 - 18.6 GHz as mentioned in the National Spectrum Policy will be invaluable for rural America, and they can be used for rural-focused massive MIMO as well as integrated terrestrial and non-terrestrial wireless systems.

  In addition, Unmanned Aircraft Systems (UAS) are expected to be applied in diverse rural applications such as precision agriculture, infrastructure monitoring, and telemedicine, and the open space in rural America (e.g., agriculture farms) facilitates the development, testing, and early adoption of UAS in real-world settings [1]. Therefore, the UAS CNPC band of 5.03 – 5.091 GHz is of particular interest to rural America too, both as users and as participants in research and innovation.

- ***Spectrum policy and technology innovation for rural America***. Unlike large commercial carriers in urban regions, many rural wireless systems are expected to be operated by rural communities and non-profits such as farmer cooperatives. One reason why most rural community carriers have not adopted fixed wireless (and wireless in general) for rural broadband is due to the lack of access to spectrum. To facilitate the adoption of rural wireless broadband solutions, we need to remove the barrier of spectrum access by rural communities and non-profits. To this end, we need to develop new spectrum policies that are more conducive to *community- and non-profit wireless network operations* [1], and we need to develop innovative *spectrum sharing policies* between wireless carriers (e.g., between national and local community carriers) as well as between wireless communications and non-communications (e.g., radar) users.

Besides typical wireless use cases that need connectivity most of the time, rural America features unique use cases that only need spectrum access and connectivity on-demand and likely in confined geographic areas. For instance, spectrum use in crop farms tends to be seasonal, and it mainly needs spectrum access from spring to fall. In addition, even in the seasons when crop farms need spectrum access, it may only need access when certain ground and aerial vehicles need to operate in the field, thus requiring on-demand, mobile spectrum access in confined geographic space where the agriculture vehicles operate. Therefore, these spectrum use cases in crop farms pose unique requirements for *real-time, on-demand, and mobile spectrum slicing* not feasible today, and they call for both technology and policy innovations in spectrum access. In addition, many rural wireless use cases such as UAS for precision agriculture are safety-critical, thus calling for *innovations in dynamic spectrum sharing for safety-critical wireless systems*.

Given that we are still at the early stage of research and practice in dynamic spectrum sharing and that a wide range of policy and technology innovations need to be nurtured and field-tested before their adoption in practice. To this end, we need to leverage *rural-focused, real-world testbeds such as the ARA PAWR wireless living lab which provides an at-scale, real-world environment for testing novel spectrum policies and technologies [2-4]* with diverse stakeholder communities ranging from researchers to application developers, agriculture and rural users, as well as local and state government agencies.

On the technology aspect of the implementation of the National Spectrum Strategy, we need to align the implementation with other national initiatives such as those of *Open RAN*. Open RAN represents one major development in 5G-and-beyond systems, and it is poised to promote wireless network security while driving innovation, lowering costs, increasing vendor diversity and supply chain robustness, and enabling more flexible network architectures. Open RAN is of particular interest to rural America, not only because it can potentially reduce cost, but also because it reduces barrier to innovation and can enable rural-focused wireless technology development and deployment, including those on spectrum innovation. Therefore, to support collaborative efforts across Open RAN and the implementation of the National Spectrum Strategy, the *ARA PAWR testbed and the ARA O-RAN Open Testing and Integration Center (ARA OTIC) can be leveraged to support integrative research, testing, and integration activities* for innovative spectrum management strategies in the Open RAN framework.

- ***Wireless and spectrum workforce development for rural America***: Given that dynamic spectrum sharing and using advanced wireless as a key rural broadband solution are new fields of innovation and practice, rural-focused technology and policy innovation is critical, which in turn calls for *rural-focused workforce development and innovation capacity building*. To this end, the workforce development aspect of the National Spectrum Strategy implementation shall have a rural focus and engage rural stakeholders including research and education organizations (e.g., WiCI) and their partners. Specific action areas include *1) developing innovation capacity within the rural regions* so that rural-focused spectrum and wireless innovations progress in parallel with urban-focused innovations, and 2) *engaging and empowering rural-regions in spectrum and wireless innovations* such as those related to dynamic spectrum sharing, Open RAN, and rural-focused massive MIMO.

References

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