NITRD NCO Request for Public Input on development of National Spectrum Research and Development Plan

Comments of ATIS' Next G Alliance
On the
National Spectrum R&D Plan

The Alliance for Telecommunications Industry Solutions' (ATIS') Next G Alliance, an initiative to promote North American leadership in 6G, takes this opportunity to provide input in response to the Request for Information (RFI) released February 20, 2024, by the Networking and Information Technology Research and Development (NITRD) National Coordination Office (NCO). This RFI seeks input on the drafting and development of the White House Office of Science and Technology's (OSTP) National Spectrum Research and Development Plan (R&D Plan). Spectrum is the essential ingredient for the next generation network and it is critical that the R&D Plan helps to advance and accelerate spectrum availability without adding unnecessary delays.

I. Background

ATIS is a leading technology and solutions development organization that brings together the top global ICT companies to advance the industry's business priorities. ATIS' Next G Alliance brings together the private sector, academia, and government interests to drive North American leadership in 6G. Over the past three years, the Next G Alliance has brought together hundreds of subject matter experts to define 6G research drivers, technologies, use cases, and societal needs.[1] This includes extensive, ongoing efforts focused on 6G spectrum needs and radio

[1] To date, the Next G Alliance has produced more than 20 white papers aimed at driving North American 6G leadership. Available at https://www.nextgalliance.org/6g-library.

technologies to promote more efficient spectrum utilization. Additionally, the Next G Alliance Research Council brings together some of North America's top academics and industry members to identify research and development priorities needed for North American 6G leadership.

II. Discussion

Topic 1of the RFI – "Recommendations on strategies for conducting spectrum research in a manner that minimizes unnecessary duplication, ensures that all essential spectrum research areas are sufficiently explored, and achieves measurable advancements in state-of-the-art spectrum science and engineering" -- specifically asks about "methods/approaches to increase coordinated investment in R&D amongst government agencies, academia, civil society, and the private sector" and "structural and process improvements in the organization and promotion of Federal and non-Federal spectrum R&D."

ATIS' Next G Alliance recommends that investments in R&D should be coordinated not only amongst government agencies, academia, civil society, and the private sector, but also coordinated with other like-minded organizations around the world when possible. For example, the Next G Alliance worked with 6G-IA, at the behest of the U.S.-E.U. Technology and Trade Council, to provide the U.S. and E.U. governments with a joint roadmap for future collaboration opportunities to promote 6G development.[2] The paper contains a set of key strategic observations and recommendations for 6G networks and services and offers a candidate roadmap for future opportunities through E.U. and U.S. funding.[3] In terms of structural and process improvements, the NSF Directorate for Technology, Innovation and Partnerships (TIP) is a promising way to provide support for use-inspired research and the translation of research results to the market and society, however, it will require funding to deliver those benefits. To this end, we are concerned that the appropriated 2024 funding for NSF's Research and Related Activities is significantly less than both the amount requested by NSF as well as the amount that had been promised under the CHIPS and Science Act of 2022 (CHIPS Act) which created TIP.[4] Restoring full funding

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[2] ATIS Next G Alliance and 6G-IA Press Release. *ATIS and EU Smart Networks and Services Joint Undertaking Publish "Beyond 5G & 6G Roadmap" for EU-US Collaboration* https://www.atis.org/press-releases/atis-and-eu-smart-networks-and-services-joint-undertaking-publish-beyond-5g-6g-roadmap-for-eu-us-collaboration/
[3] ATIS Next G Alliance and 6G-IA. *EU-US Beyond 5G/6G Roadmap.* https://nextgalliance.org/wp-content/uploads/2024/01/EU-US-Aligned-6G-Roadmap-Joint-Paper.pdf
[4] Science. *Analysis: How NSF's budget got hammered.* March 14, 2024. https://www.science.org/content/article/analysis-how-nsf-s-budget-got-hammered

should be a top priority to ensure that NSF and TIP can achieve the important objectives of the CHIPS Act and, importantly, advance research and results to the marketplace.

With regard to RFI Topic 2 – "Recommended priority areas for spectrum research and development, as well as productive directions for advancing the state-of-the-art in those areas" -- the Next G Alliance notes that it has developed a set of Research Priorities, that include Advanced multiple-input multiple-output (MIMO) and THz/SubTHz, 6G Air Interfaces, Joint Communications and Sensing (JCAS), Spectrum Sharing and Enhanced Spectrum Access and Radio Access Technologies, the last two of which focus on various aspects of spectrum utilization and optimization for 6G Physical Layer (PHY) and Medium Access Control (MAC) designs to optimize coverage and capacity tradeoffs.[5]

The Next G Alliance Technology Working Group has developed a *6G Radio Technology Part I: Basic Radio Technologies*[6] white paper, which addresses research challenges associated with key technologies such as Waveform, Coding and Multiple Access Schemes, JCAS, Spectrum Sharing, MIMO, and Advanced Duplexing Technology, which should be priority areas for the R&D Pan.

The mobile communications industry has an established record in adopting state-of-the-art technologies, including academic research, on waveform techniques, channel coding, and multiple access techniques to improve spectrum utilization and spectrum efficiency across the past five generations of mobile technologies. This trend will continue with 6G as the industry improves the ability for the next generation to innovate by improving our ability to use spectrum that may be shared between disparate radio services.

Figure 1 illustrates the relationship between spectrum use and various forms of sharing by charting the paths of the two major regulatory regimes -- licensed and unlicensed spectrum. The Next G Alliance treats medium access control techniques, including scheduled transmissions or contention-based access such as Listen-Before-Talk (LBT) protocols as multiple-access techniques, acknowledging their role as effective sharing methodologies.

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[5] Next G Alliance. *Research Priorities – Technology.* https://www.nextgalliance.org/research-priorities/technology/

[6] Next G Alliance. *6G Radio Technology Part I: Basic Radio Technologies.* https://www.nextgalliance.org/white_papers/6g-radio-technology-part-i-basic-radio-technologies/

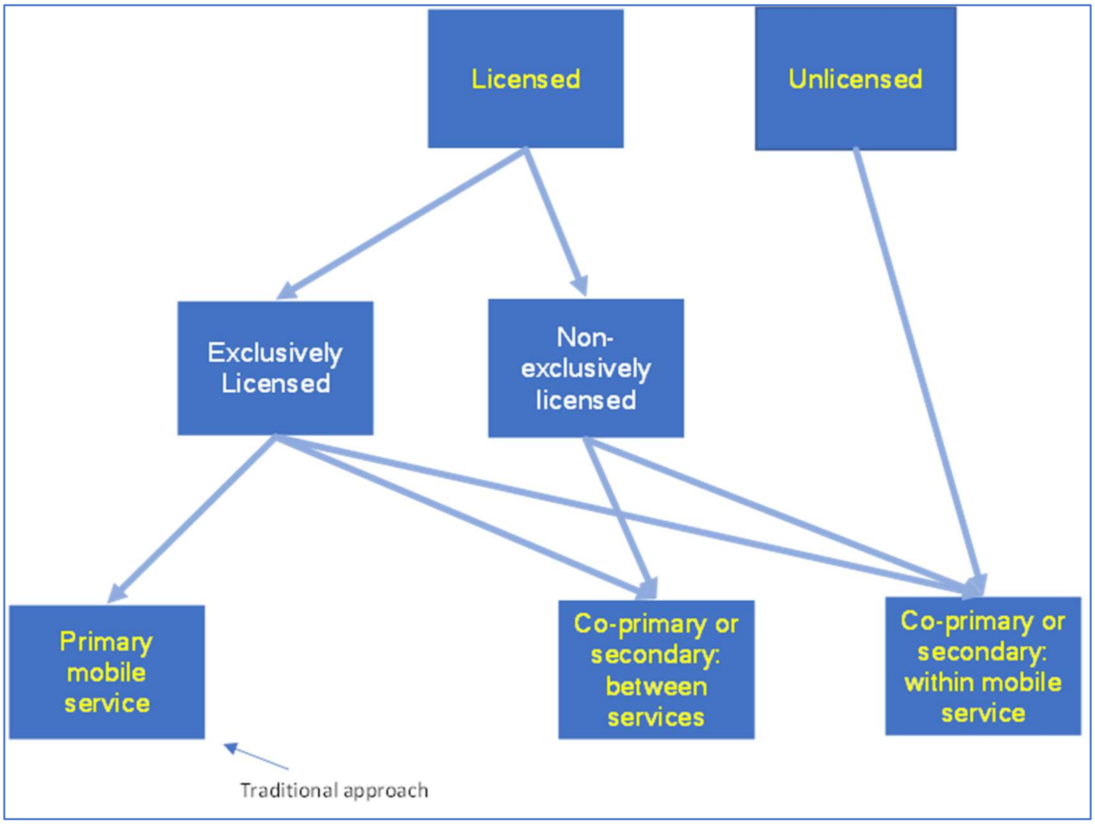

Figure 1: A tree diagram illustrating the relationship between spectrum use and various forms of sharing; the boxes with yellow text depict typical regulatory mechanisms and implementation methodologies

As the National Spectrum Strategy Implementation Plan notes, "dynamic spectrum sharing (DSS) involves the operation of independent systems close enough together (in frequency, space, or time) that dynamic access methods are required to prevent harmful interference."[7] And, as the radio coexistence environment becomes increasingly complicated from both a device and network perspective, 6G spectrum sharing native design is anticipated to accommodate wide variety of use cases.

In the context of uncoordinated spectrum sharing, 6G systems are expected to exploit high-precision spectrum shaping and advanced band-pass filter designs (similar to or better than those in 5G) to be robust toward adjacent channel interference. At the same time, there are challenges in the way legacy technologies address filter selectivity or interference resilience relative to the

[7] National Telecommunications and Information Administration, *National Spectrum Strategy Implementation Plan*, March 12, 2024, pg. 19.

current state of the art. Some incumbents are passive Radio Frequency (RF) systems, such as radio astronomy and remote sensing, which require a quiet RF environment to maintain satisfactory spectrum or system sensing and measurement performance. Passive systems are thus often sensitive even to interference from adjacent channels. Coexistence between active 6G and passive RF systems needs to be thoroughly researched.

Achieving coexistence of incumbent and new entrant services presents several challenges. To constructively share the spectrum with incumbent systems, studies must first establish the characteristics of all services that may access a frequency range that would be pertinent to the ability of the mobile network to share spectrum. Further, there must be an understanding of the improvements that can be made to any service that enhances and simplifies the ability to implement spectrum sharing between the relevant radio services. Additionally, the new entrant services may have to implement active spectrum sensing themselves or utilize a spectrum sensing capability provided by an external spectrum access system (analogous to the e.g., 6 GHz Automated Frequency Coordination (AFC) server or, Citizens Broadband Radio Service (CBRS) Spectrum Access System (SAS), or future, possibly with enhancements) to avoid harmful interference with incumbent systems. R&D priorities should include how to suppress or mitigate interference to increase Signal-to-Interference-plus-Noise Ratio (SINR); allocation of time, energy, and bandwidth resources among the sensing and communications functions; how to ensure viability of new entrant services while providing reasonable and mission-appropriate protection to primary incumbent users.

The impact on 6G networks and devices could result in the need for some operational parameters – such as frequency, bandwidth, power, beamforming, and others –to be modified on a short-term basis to adapt to new radio environments. Spatial processing techniques can be employed to minimize interference, but more research is needed to determine whether receivers can be adequately protected. New interference assessment and avoidance methods must be researched. Although individual user equipment (UE) processing capability is limited, the aggregated processing capability of a group of UEs can be substantial. Therefore, collaborative spectrum sensing and corresponding sharing mechanisms should be a priority research area, as well.

Spectrum sharing among co-licensees for commercial services could provide an opportunity to improve spectrum utilization. Research topics include improving shared access by means of network intelligence, including the moderation of medium use between shared-license holders. Machine learning could be utilized to optimize RF medium and spectrum access in a shared license network while addressing any privacy or operational security concerns that may exist. Examples include sharing among 6G co-licensees and bi-directional sharing between 6G and federal services, which would allow access to additional spectrum bands.

Unlicensed spectrum utilizes medium access protocols to prevent collisions among users and to manage interference. More research is needed to improve spectrum sensing, channel selection, and medium access procedures targeted for dense network deployments in unlicensed spectrum bands.

In addition to the aforementioned foundational technology aspects like waveform, modulation, multiple access, and channel coding, 6G systems are also expected to advance features in the areas of MIMO, millimeter wave (mmWave) spectrum, JCAS, and full duplex operation. MIMO enhancements for very large antenna arrays are, for example, expected to play a crucial role in the centimeter spectrum regime, sometimes called the upper mid-band or frequency range FR3, where they can potentially be leveraged for spectrum sharing with incumbents. In low-band spectrum, such large antenna arrays may additionally be realized as massively distributed MIMO systems and to maintain a strong position in the 6G era, North America should keep investing in cutting-edge research in these areas. This may particularly be relevant for mmWave spectrum, where North America has been at the forefront of adopting 5G NR mmWave technologies with considerable investments in mmWave spectrum. 6G research should focus on advancing and streamlining mmWave technology by making it simpler to implement, easier to deploy, easier to integrate, able to better co-exist with current and future technologies, and helping networks and UEs and other nodes have better performance. Other technologies, that may either benefit from newly available spectrum in 6G systems, such as FR3 or (sub)THz, or that may significantly increase spectrum utilization efficiency regardless of any specific band considerations, include reflective intelligent surfaces (RIS), JCAS, and full-duplex operation. From a North American technology leadership perspective, these, and many others, are key research areas whose continued advancement must be ensured. A more detailed summary is provided in NGA's 6G Technologies report[8] with a more rigorous treatment of basic 6G radio technologies in *6G Radio Technology Part I: Basic Radio Technologies.*[9] [10]

III. **Conclusion**

The National Spectrum R&D Plan is an important step toward ensuring continued U.S. leadership in critical and emerging technologies such as 6G. ATIS' Next G Alliance looks forward to working with NITRD NCO, OSTP, NSF, and other stakeholders on the development of the R&D Plan and would be happy to answer any questions or to discuss our comments in more detail. We urge the development of a bold R&D Plan that expeditiously drives increased availability and efficient usage of spectrum to meet the timelines envisioned for deployment of 6G.

Respectfully Submitted,

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[8] Next G Alliance. *6G Technologies*. https://nextgalliance.org/white_papers/6g-technologies/
[9] Next G Alliance. *6G Radio Technology Part I: Basic Radio Technologies.* https://www.nextgalliance.org/white_papers/6g-radio-technology-part-i-basic-radio-technologies/
[10] Part 2 of the *6G Radio Technology Part I: Basic Radio Technologies* paper is in preparation with an anticipated publication date in 2024.