January 2, 2024

In Response to:

Department of Commerce, National Telecommunications and Information Administration's Implementation of the National Spectrum Strategy Opportunity for Public Input

Comments by iPosi, Inc., Denver, CO

I. Summary

The National Spectrum Strategy (NSS) presents a frank assessment and thorough vision statement regarding the future of mid-band 5G/6G spectrum access. The NSS has identified 2786 MHz of government allocated spectrum for "in-depth, near term study" to determine its best and highest use for applications in and outside government. The NSS also identifies about half the bands under study for active testing within a selected set of US Government (USG) mid-band[1] allocations. The NSS asserts these particular bands were chosen presumably for readiness to be re-mobilized for dynamically shared access which can be implemented in a relatively short time. The NSS is also supported by the FCC which makes it a "trailhead" document on which to begin formulating deeper technical, IT/Data systems solutions as well as establish solid economic and policy foundations to modernize US spectrum allocation and access.

Based on existing Executive Branch authorities, the NTIA asserts a far-reaching government-as-a-whole imperative in the NSS to effectively elevate spectrum utilization among coordinated, indeed cooperative shared access. Thus, by implication the NSS actually presents two concurrent, and intertwined spectrum access use cases: 1) Inter-governmental sharing, and 2) US Government sharing with commercial or Private sector spectrum operations. We believe the NSS once transferred to a forward implementation stage then becomes a multi-layered, centrally access managed system, consistent with the NTIA's IIC[2] platform objectives to ensure highly reliable, interference-free access and through automation enables instant access to networks based on fulfilling new access for upcoming 5G/6G networks which for the first time will be

[1] "Mid-band", as used here, unless otherwise noted refers to at least a range extending from 1 to 15 GHz. The FCC has referred to this region of spectrum as the "sweet spot" due to its advantageous mix of propagation properties in and outside 5G communication applications. Mid-band crosses licensed and unlicensed allocations, radio navigation, radar, and communications fixed, mobile, maritime, and airborne services. We note there is an increasing presence of mixed service usage thus presenting greater administrative challenges to sharing.

[2] IIC: Incumbent Informed Capability, an automated platform advanced by the NTIA for collaborative sharing between government and ultimately, private industry based on matching incoming bids for access with timely, near real time fulfillment. See: https://www.ntia.gov/report/2021/ntia-report-incumbent-informing-capability-iic-time-based-spectrum-sharing

automatically able to determine accurately their electromagnetic spectrum occupancies to avoid harmful interference, increase dense sharing efficiency.

Each of these shared access cases present important technical, economic, data science/IT, and policy design implications. These should be of the same means and methods ideally to efficiently scale and remove access barriers (such as but not limited to delay, incompatible frequencies, downstream shared interference outages) that beset the prior fixed or more flexible but environmental sensing allocation regimes, which subject incumbents to interference or to uncertainty of operation even in cases where interference may only exist theoretically but impacts overall operations.

We applaud the NTIA for building consensus for the NSS within Congress and the Executive Branch, and especially the FCC. It provides all stakeholders a logical, consistent "trailhead" to serve as a vehicle to fund, plan, implement a variety of top-down and bottom-up related technologies. It fosters also important policy/economics frameworks to reach hundred-fold increase public-public shared access and, we forecast at least 1000X more public-private shared access[3].

Comments Regarding NSS's GPS Spectrum Operations and Management Presentation

iPosi, Inc. agrees whole heartedly with NSS's presentation regarding GPS/GNSS spectrum[4], in the service of its full protection, and future allocations to close the gap as well as increase the US PNT space, air, and ground PNT spectrum armamentarium.

PNT is a core, indeed vital to wireless networks to enable virtually all applications and highest performance in 5G and 6G communication networks. GPS is also valuable for gaining network node isolation (including in-path "clutter") critical across the full extent of mid-band spectrum access sharing, which when measured directly determines each node's radio-occupancy. This solution is already built-in since it adds to GPS/GNSS's gNb/eNb node synchronization timing and location, including E911. Already a cost-effective solution for mobile and IoT globally, GPS can now support indoor, in-building networks by applying deeply-assisted, cloud-based DSP to achieve greater sensitivity, thus higher performance to further secure GPS/GNSS position and timing at lower CAPEX. The same solution also increases resilience against GPS/GNSS jamming or spoofing. Upcoming LEO PNT constellations will offer further spectrum sharing capabilities and are also driven by wide ranging future business sectors in autonomous vehicle navigation thus potentially key to commercial, government and military applications.

These also self-scale. All 3GPP RAN's use GPS for coordinated time synchronization and location, both for network and connected devices intelligence, work and residential safety (E911). GPS can also be used to measure 4,5G and "BeyondG" RAN/ORAN node spectrum

[3] Compared to a traditional fixed, exclusive-use allocation regime.
[4] NSS Introduction, November 13, 2023. Paragraph 4

occupancy to fulfill greater sharing, avoid incumbent interference all within extremely low cost GPS embedded silicon, and do so deterministically.

Comments on the NSS Four Pillars

We now turn to our comments and recommendations to the NSS Four Foundational Pillars.

Pillar I: Build a Spectrum Pipeline, based on Advanced, Emerging Technologies

We interpret Pillar I to address or define these important NSS next generation implementation objectives or aims:

- Mid-band frequency scalable: The same shared access solution works across all NSS identified mid-band candidates. Potentially may include new USG mid-band candidates not previously identified that rigorously protects incumbent operations while also increase sharing without compromise to any same, or adjacent band incumbent operations.
- Operationally scalable: Levers existing centralized server/cloud architecture to securely, rapidly re-configure multi-layer (public, private sectors and military spectrum operations) access without impact or compromise to incumbent, especially military, spectrum operations. Enables a common solution for inter-layer (civilian, military, commercial) access coordination to achieve greatest scale economy.
- Compatible with any current, future RAN (4, 5, 6G) and all incumbent radar, navigation, communication operations – Not dependent on the radio, RAN-specific emission characteristics, and supports any USG-to-USG or any USG-P (Private sector) shared access use case.
- Geographically scalable, private access that is not dependent incumbent sensing – Automated access assured without reliance on portal or similar manual interventions. Avoids incumbent sensing, coastal, or interior DPA stand-off constraints seen in prior generation approaches.
- International spectrum operations compatible ("harmonized") generally. As just one example, the Department of Defense seeks to ensure its spectrum operations, especially ground based communication applications successfully operate outside the US without disrupting host nation spectrum operations. These cases require their 5/6G enterprise systems do not present or impose interference limitations in host-nation operational scenarios. International scalability also serves US economic interests by setting standards that productively increase US produced exports using common shared access solutions.
- Future-proof: Avoids imposition or constraints, re-work to present or upcoming incumbent spectrum dependent systems, including radar, navigation and non 3GPP wireless systems. Maintains integrity, stealth, mission effectiveness, defense countermeasure effectiveness in DoD and civilian agency radars or other defense spectrum-dependent systems.

- Relies on direct, continuous measurement of electrospace[5] occupancy versus sensing presence of incumbent signals to organize both efficient spectrum packing, re-use as well as avoid interference.
- Supports growing civilian and inter-agency spectrum-related operations. The Department of Transportation recently cited spectrum as a Critical Infrastructure for managing or regulating transportation modernization purposes. These operations, much of which will be powered by 5&6G fall within the NSS scope, its designated or future bands, and therefore require similar security, interference-avoidance measures as other critical agency operations.
- Proactive interference avoidance: Feasible shared access is most incumbent-protective if it avoids spectrum interference prior to incumbent signal presence to in timely fashion re-configure the shared USG or Private equipment before interference occurs. Present systems operate on the basis of first sensing, thus reacting to presence of incumbents signals which means interference is potentially happening after overlapping shared operations. This will be more intense as more access is granted to non-incumbent operations, which has serious ramifications.
- Supports transparency – A viable pipeline must show economic access performance in terms of access bids fulfilled in terms of geographic, frequency, and time utilization. This will pace all operations to operate with highest efficiency, occupying spectrum-electrospace only where its required. That fulfills lower-priced occupancy which then drives more demand and compatible spectrum utilization.

Pillar II: Supports Nation's Evolving Spectrum Needs and Planning, collaboratively. Drive process based on "best available science and data".

We interpret Pillar II as a directive to serve a variety of private commercial and governmental spectrum use cases, to test and implement advanced spectrum sharing measures through comprehensive inter-agency test plans, test-beds, and demonstration centers.

- Follow Rapid Prototype and time-sensitive development practices. Design the spectrum sharing platform following the NTIA's reasoning, its IIC and SCS spectrum access architecture, and combined management intelligence to develop DoD classified access as soon as practicable. This and other procedures may require development in a semi- to fully parallel fashion, tolerant of less than completely optimal systems to rapidly evolve the final system design to final production standards and operations.
- Tackle definition of shared access in a multi-layered fashion. Protect the more sensitive incumbent operations that logically group among other higher interference protection criteria. This need not displace more access sharing, or compromise mission effectiveness and further enhances shared access yield and density. We believe DoD and other agency terrestrial network applications will also extensively utilize the latest

[5] "Electrospace" defines, describes the spatial occupancy of EM emissions, a term first applied by R.J. Matheson, NTIA-ITS Boulder CO in 1988. Retrieved 1/1/24 at https://ieeexplore.ieee.org/document/14121/authors#authors

5G/6G, which to fulfill that purpose can host those sensitive operations compatibility with the top radar/warfighter operations layer. That enables greater access efficiency while assuring full military spectrum readiness.

- Scale the available science and data to include all mid-band applications, not necessarily limited to only the NSS designated frequency bands. Scalable access sharing can open more sharing outside as well as inside the NSS-designated bands. This increases the value, decreases the cost of IIC, SCS and occupancy-based access technologies, basically at the same time. We encourage testing and associated shared access data collection to also test increased mixed licensed/unlicensed flexible sharing across existing shared bands such as the recently opened unlicensed US 6 GHz shared band.
- Follow System Engineering best practices. Use the multi-layered approach to define compatible but relatively independent "system-of-systems" to optimize parallel testing, development, deployment of NSS shared access objectives.
- Evaluate future spectrum mid-band scenarios and establish spectrum use best practices that can guide efficient regulation and regulatory performance. Mid-band candidates that were not addressed by the NSS (in particular, and as one example the 4.4-4.9 GHz band) may still be share-able if Phase II testing outcomes present with critical certainty that option.

Pillar III: Increase Spectrum Innovation, Access and Management through Technology Development

We interpret Pillar III as a related directive to elevate new capabilities that go beyond past generation sharing methods or technology advancement, to protect a growing diversity of incumbent operations while also increasing sharing yield or density. We respectfully urge NTIA and its associated spectrum-utilizing agencies to address this Pillar through these measures:

- Spur cooperation among agencies to group or aggregate their current and upcoming spectrum needs (where they can concentrate operations to yield common interference protection criteria for instance) to build plans of record, and place those within common coordination "silos". This ensures the more demanding civilian and military spectrum operations are rationally, efficiently grouped to commonly protect.
- Consider use of the latest "outer" systems-of-systems to achieve greater shared access performance (simultaneously provide comprehensive interference protection while raising shared access yield or density). For instance, explore digital twin methods to explore limiting massive ground-based aggregate interference well in advance of impact to the physical "twin", for instance an AWACS reaching its mission altitude, thus in advance ensure fully protective radar service ranges. This is best, perhaps only achieved with proactive registration of all shared spectrum ground emission and occupancy measurements beforehand to be processed by the IIC complex for guaranteed spectrum and mission compatibility. Such would also allow the IIC platform to contour ground networks thus prevent interference to live radar or warfighter surveillance, target acquisition, or target interception phases as much in advance as possible.

- Move quickly to advance Phase II shared access pre-production testing (technology trials, aggregation effects, corner testing, compatibility criteria among other tasks) at scale.
- While AI/ML has a distinct role in dynamic sharing it is not likely to result in immediate gains or refinements are at least 5-10 years away, thus likely not essential day-one. We thus recommend AI/ML trials take place separately on parallel engineering research task track(s), in association with experienced research university able to bridge with academic AI/ML active research and that understand spectrum and government research requirements.
- Spur further economic research[6] into implementing market-efficient shared access financial exchanges that once implemented fulfill real time bids requesting access and are automatically arranged to be compatible with higher level incumbent operations, continuously or contingently occupying the automatically assigned spectrum. Flexible access rights on either the bidder or incumbent sides can then be priced to increase shared incentives which "increase productive use or social value"[7]. These will be based on incoming enterprise bids, including those deploying advanced Private 5G networks, provide a real time route to price discovery.
- Spur private sector investment partnership consistent with attaining substantial shared spectrum innovation levels that Pillar III advocates. The Government could for instance offer partner-financing vehicles as an alternative or option to its exclusive underwriting thus hasten incumbent compatible private access.
- Private sector participation expectations are real: At least one published forecast[8] presents the case for multibillion dollar economic gains based on just for one of the NSS designated bands be shared. While all such forecasts have speculative operating, financial and other assumptions and timing, these level of returns do attract private investment plus reduce risk provided the government fosters private investment incentives, timing, equity participation into the financial or contractual partnerships related to commercial sharing.

Pillar IV: Expand Spectrum Expertise and Elevate National Awareness

We interpret Pillar IV as a related directive supportive of the other Pillars, but to also ensure US leadership in spectrum, radio/communication engineering, regulatory policy, data science and IT, economics to be at the forefront of scalable spectrum access design.

- Develop new engineering, scientific research associated with greater spectrum access.
- Exploit by learning from previous research and earlier generation sharing approaches

[6] This has been explored academically as new, flexible overlay/underlay property-like rights that can be privately negotiated to incentivize new, productive access. Among the bette introductory expositions is T.W. Hazlett, former FCC Economist, who further developed flexible market based property rights in *The Political Spectrum*, p.276 ff, © 2017, Yale University Press.

[7] Excerpt quote at page 20, *Taking Stock of Spectrum Sharing*, Leibovitz, J and Milkman, R. September 2021. Retrieved at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3916386

[8] *Principles of Spectrum Sharing: Understanding the Value of Shared Spectrum*, The Brattle Group, Sept. 2023

- Develop metrics that provide transparency to further trust in new shared access systems, and to determine spectrum access efficiency to meet NSS's "unity of purpose in meeting America's spectrum needs" statement.
- Use these transparency metrics to competitively pace spectrum access to better assess how to best deliver spectrum access across increasingly diverse use cases, whether in or outdoor, consumer or the most demanding low-latency autonomous vehicle application.
- Work with standards bodies such as WinnForum[9] to further encourage and broaden stakeholder participation, inter-disciplinary spectrum management, design, policy expertise.
- Apply next generation dynamic access sharing methods, such as Occupancy Based Access Sharing to support band, emission waveform, geographically independent sharing that opens all NSS band sharing potential without current or future incumbent spectrum dependent operations.
- Ensure US shared access competency also reaches or includes newer advanced communication operations, often referred to as NTN, that operate in overlapping mid-bands from the L,S and and up to Ku/Ka Bands, and in which US based stakeholders are making large capital investments.[10]
- Underwrite formal economics research to innovate, implement spectrum access markets, exchanges following US FINTECH and exchange market leadership.

Conclusion

We compliment the NTIA for bringing forward the National Spectrum Strategy, which presents perhaps the largest, most comprehensive initiative for re-purposing government allocated spectrum -- certainly in terms of expected spectrum operations density – since the dawn of radio regulation. We close our comments to say that we stand ready to support the NTIA and its spectrum-based agencies to undertake the next stages of the four NSS Pillars. To that end, iPosi Inc. has with its research and industry partners brings an "allG" occupancy-based sharing solution that fits USG most challenging missions, from civilian to military. Now past sponsored Phase I testing, provided the sponsors are ready, we can meet the NSS implementation and timing imperatives to advance and scale testing for the initial, and possibly additional future NSS designated mid-band candidates. Perhaps in contrast to other stakeholders, we believe sharing must provide -- not marginalize -- stringent incumbent protections to secure critical military and civilian spectrum operations to encourage even greater commercial and public sector access. That ultimately serves all stakeholders' interests.

[9] WinnForum link at: https://www.wirelessinnovation.org/

[10] An exemplary reference is Amazon's April 17, 2023 Comments to the NTIA regarding NSS and Amazon's Project Kuiper investments to date.