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Request for Information on the National Spectrum Research and Development Plan

Lockheed Martin Corporation

NSF RFI Response: National Spectrum R&D Plan

LOCKHEED MARTIN CORPORATION

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1. Introduction

Lockheed Martin Corporation ("Lockheed Martin") appreciates the opportunity to submit these comments to the Networking and Information Technology Research and Development ("NITRD") National Coordination Office's ("NCO"), National Science Foundation ("NSF") Request for Information ("*RFI*"), *Request for Information on the National Spectrum Research and Development Plan*.[1] Lockheed Martin commends the NSF for working to advance coordinated, focused, and sophisticated research and development ("R&D"), which the White House *National Spectrum Strategy* ("*NSS*")[2] recognizes as paramount to improving our collective understanding of spectrum—a critical step to developing the co-existence solutions necessary for optimizing the U.S.' spectrum governance regime for the 21st Century. Lockheed Martin has been a vocal public proponent of co-existence[3] and thus looks forward to working with the NITRD NCO to develop an R&D plan which ensures that *all* spectrum users across *all* access models (*e.g.* licensed, unlicensed, experimental) may continue benefitting from our scarce and increasingly congested spectrum resources.

Lockheed Martin is a global enterprise principally engaged in research, design, development, manufacture, and integration of next-generation spectrum-utilizing technology systems, products, and services for both commercial and government customers worldwide. Examples include, but are not limited to: the nearly 800 spacecraft Lockheed Martin has built for a wide range of government and commercial missions; critical national security space capabilities; radar platforms; and myriad fixed wing and rotary-wing aircraft relied upon by governments and private sector entities globally. Further, Lockheed Martin is also looking to leverage commercial 5G technologies for the terrestrial and non-terrestrial solutions it is developing for its customers.[4]

Lockheed Martin has previously partnered with the NSF on matters of critical scientific importance, and similarly intends to work with the NSF on the nationally significant issue of spectrum R&D. Further and notably, Lockheed Martin not only develops systems, products, and services which utilize Federal spectrum allocations, but is itself a Federal Communications Commission ("FCC") licensee. As a necessity, due to its own technology research, development, testing and evaluation ("RDT&E") and sustainment activity, Lockheed Martin routinely works with the National Telecommunications and Information Administration ("NTIA") and the FCC, and other spectrum stakeholders in government, academia, and the private sector, on important issues of spectrum engineering, policy, regulation, and governance.

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[1] NSF, *Request for Information on the National Spectrum Research and Development Plan* (rel. Feb. 20, 2024)
[2] The White House, *National Spectrum Strategy* (rel. Nov. 13, 2023), https://www.ntia.gov/sites/default/files/publications/national_spectrum_strategy_final.pdf.
[3] *See e.g.*, Comments of Lockheed Martin (Docket No. NTIA-2023-0003) (Apr. 17, 2023), https://www.ntia.gov/sites/default/files/publications/lockheed_martin.pdf; Supplemental comments of Lockheed Martin (Docket No. NTIA-2023-0003) (Jun. 28, 2023), https://www.ntia.gov/sites/default/files/2023-07/lockheed_martin_written_input.pdf; and Lockheed Martin comments to NSS Implementation Plan Request for Comment (Jan. 2, 2024), https://www.ntia.gov/sites/default/files/lockheed-martin-written-input.pdf.
[4] *See, e.g.*, Lockheed Martin, Lockheed Martin and Verizon to Advance 5G Innovation for U.S. Dept. of Defense (accessed Mar. 20, 2024), https://news.lockheedmartin.com/lockheed-martin-verizon-advance-5G-innovation-us-deptartment-defense.

Lockheed Martin emphasizes the importance of a national security-first R&D approach and the need to evolve R&D as a continuum model. Further, and whereas national security-first is an overarching concept to guide R&D, insofar as the development and deployment of specific technologies, Lockheed Martin ardently believes that dynamic spectrum sharing ("DSS") technologies must be the R&D Plan's primary priority. Our Nation's spectral environment is increasingly congested, with little to no greenfield spectrum left, thereby necessitating that increased spectrum demand be met through shared spectrum use—co-existence (*i.e.*, not compression, or forced Federal relocations, etc.). The need for DSS is made all the more necessary when one considers that mission critical national security technologies, such as radar, require access to very specific spectrum bands and the relocation of which could take decades and cost hundreds of billions of dollars—if suitable alternative spectrum even exists.[5] Despite this reality, policymakers have still displayed a keen interest in forcing national security systems to compress operations or relocate. This policy reality makes the need for DSS enabling true co-existence between national security systems and commercial new entrants all the more important.

2. Strategies for Conducting Spectrum R&D

2.1 A national security-first approach

The *RFI* seeks comment on structural and process improvements in the organization and promotion of Federal and non-Federal spectrum R&D. Given our belief that spectrum co-existence must be the Plan's key objective, we recommend the adoption of a national security-first approach: the mission requirements of national security systems must serve as the bedrock for any spectrum R&D—requiring close coordination and collaboration with the Department of Defense ("DoD") and the Defense Industrial Base. The nature of these systems necessitates that commercial new entrants to bands already committed to these critical government functions conform to national security system needs, allowing DoD and other Federal users to meet the Nation's national security and other requirements. Further, national security systems often represent congressionally-approved multi-billion-dollar investments intended to remain operational for decades; it is likely less burdensome for national security technology considerations to drive development of commercial new entrant devices—which often have refresh periods on the order of months or a few years—as opposed to, for instance, requiring the Nation's ballistic missile defense system to conform to the needs of such commercial new entrant devices.

While DSS R&D considerations are discussed in-depth below, the following provides an example of the national security-first approach. Federal bands are the sole subject of *NSS* efforts to identify more spectrum for the spectrum pipeline,[6] thus (pending a major policy change)[7] the most likely spectrum reallocation scenarios are those where commercial entities gain access to

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[5] *E.g.*, with respect to the 3.1-3.45 GHz, Secretary of the Navy Del Toro testified that relocating the Navy's systems alone is "enormous…upwards of $250 billion probably". Testimony of Secretary of the Navy Carlos Del Toro before the United States Senate Committee on Armed Services (Apr. 18, 2024).

[6] *See NSS* at note 1.

[7] Lockheed Martin strongly supports expansion of the *NSS* such that commercial bands are also studied for repurposing, however recognizes such policy issues are outside the scope of this *NOI*.

bands utilized by national security systems to protect U.S. citizens and U.S. interests. Commercial devices are increasingly comprised of software defined radios with poor cyber-secure implementations that enable assembly of large quantities of interfering agents. DSS R&D must develop mechanisms to address the nefarious co-optation of such systems in order to degrade or otherwise harm DoD's incumbent capabilities within the band.

We further wish to clarify that a national security-first approach does not mean that all aspects of Federal systems' use of spectrum should remain unchanged. Rather, as discussed above, it means that the operational considerations for such systems should retain primacy over those of aspirant commercial new entrants in bands that are already committed to national security and other critical uses. For instance, in bands where new entrants seek exclusive high-power use, but where such use is incompatible with incumbent Federal systems, R&D should focus on achieving co-existence with Federal systems, as opposed to compressing Federal operations.

2.2 Leveraging existing work

As the NSF well knows, there is much disparate spectrum R&D underway across government, industry, and academia. We recommend the establishment of a mechanism through which entities can report to the NSF the nature and progress of their work such that R&D may be catalogued in order to identify both possible synergies between different groups and unnecessary duplication of efforts.

2.3 Testing and evaluation as a continuum

For spectrum R&D to remain agile, testing and evaluation must (i) evolve to provide focused and relevant information supporting decision-making continually throughout capability development and (ii) be predicated upon a sturdy foundation of in-place data and analytics. Such enhancements would allow testing and evaluation to move from a serial set of activities conducted largely and independently of systems engineering and mission engineering to a new framework focused on a continuum of activities. Test and evaluation as a continuum is being adopted by the DoD,[8] and we recommend that the NSF similarly consider its applicability for the R&D Plan.

3. Priority Areas for Spectrum R&D

3.1 In general

Excepting spectrum utilization efficiency, as discussed in the next section, Lockheed Martin is generally supportive of R&D in those areas outlined within the *RFI* by the NSF, as well as the topics associated with the enumerated priority areas.

3.2 Spectrum utilization efficiency

Lockheed Martin has elsewhere[9] and here too emphasizes that establishing a maximally shared spectral environment is a preferable objective over utilization efficiency, as efficiency is too relative a term. However, should the NSF choose to continue researching utilization efficiency, a

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[8] *See* Christopher Collins and Kenneth Senechal, "Test and Evaluation as a Continuum", ITEA Journal of Test and Evaluation Vol. 44 Iss. 1 (Mar. 2023), https://itea.org/journals/volume-44-1/test-and-evaluation-as-a-continuum/.

[9] *See* Comments of Lockheed Martin (FCC WT Docket No. 23-232) (Oct. 3, 2023), https://www.fcc.gov/ecfs/document/100493560734/1.

crucial initial step is defining “efficiency” and for whom. For example, what Lockheed Martin considers to be efficient for military radars is likely not the same as what mobile network operators consider as efficient for their networks (and vice-versa). Further, we recommend developing a methodology allowing for the incorporation of qualitative spectrum use information, as opposed to purely quantitative data, *e.g.*, the FCC has noted that “several bands may exhibit infrequent usage that are nonetheless mission critical for their intended uses…”.[10] The mission criticality of systems cannot be appropriately captured through quantitative data.

3.3 Dynamic spectrum sharing, generally

We agree with the *NSS*’ characterization of spectrum as “congested”,[11] and believe that DSS will play a critical role in expanding spectrum access for *both* Federal and non-Federal users, and also help stakeholders move past a zero-sum, winner-take-all spectrum mindset.

Regarding specific existing work, the Citizen’s Broadband Radio Service (“CBRS”) represents an initial starting point for further R&D into low-power sharing regimes capable of effectively enabling co-existence between Federal incumbents and commercial new entrants. Not only does the NTIA consider CBRS a success,[12] it is making significant progress in closing the digital divide: 70% of all active (CBRS) devices are deployed in rural census blocks.[13] Further, 45% of all (CBRS) devices are deployed in counties where spectrum is shared with DoD, highlighting low-power 5G’s ability to co-exist with national security incumbents.[14] Appropriately directed R&D funding can facilitate the development of the next generation of a CBRS-like operating environment.

3.4 Dynamic spectrum sharing for assured access for critical mission applications

An ideal DSS system for DoD co-existence offers an opportunity to both provide an economic benefit, and improve electromagnetic battle management approaches for coalition and joint communications and electronic warfare. We recommend that DSS R&D focus on developing a solution which can:

1. Provide sharing mechanisms that can cope with malicious contention, both in terms of adversarial actions (*e.g.*, spoofing and jamming), as well as additional non-collaborative interferers that native systems were not designed to address (*e.g.*, military heterogeneous networks);
2. Provision for mechanisms to handle failure modes of commercial equipment during operation, as well as improper and malicious deployments. Such mechanisms should include real-time direction finding and geolocation;

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[10] FCC, *Advancing Understanding of Non-Federal Spectrum Usage* at ¶ 22, Notice of Inquiry, WT Docket No. 23-232, FCC 23-63 (rel. Aug. 4, 2023).

[11] At 11.

[12] NTIA, The Innovative Spectrum Sharing Framework Connecting Americans Across the County (accessed Dec. 6, 2023), https://www.ntia.gov/blog/2023/innovative-spectrum-sharing-framework-connecting-americans-across-country.

[13] *Id.*

[14] *Id.*

3. Mitigate Electronic Attack (“EA”) techniques which are easier and more successful against targets operating in narrow slices of spectrum;
4. Provide mechanisms to address the co-optation of what will become a ubiquitous deployment of commercial devices designed to occupy and share bands with DoD systems. These commercial devices are increasingly comprised of software defined radios with poor cyber-secure implementations that enable assembly of large quantities of interfering agents (a scenario that would have otherwise required an adversary to overcome the challenge of covertly deploying a large number of EA assets);
5. Support graceful degradation of spectrum sharing in a way that supports mission critical users without compounding problems through “fail open” (suppress all transmission) designs;
6. Avoid revealing any aspects of military tactics, techniques, and procedures through the long-term analysis of military system reactions to system inputs. This is essential to prevent adversary adaptive systems from determining the behavior of defensive systems through machine learning techniques; and
7. Enable defense systems to use more spectrum than previously allocated during mission critical events (*e.g.*, by enabling increasingly agile DoD systems to leverage additional commercial and unlicensed spectrum during emergencies (an expansion of the first responder models for national defense scenarios)).

Co-existence between critical national security and commercial systems inherently introduces national security vulnerabilities. It is imperative that a spectrum access management system prevent commercial or secondary users from disrupting Federal spectrum usage while ensuring commercial users have ample opportunity to use their allocated spectrum (or more importantly, bandwidth). Potential vulnerabilities of such a DSS infrastructure must be fully understood and carefully mitigated to minimize impacts on national security.

When considering threats, a DSS system with the following components should be utilized:

1. United States Government (“USG”) Incumbent Users (“UIU”): USG users provided priority access to spectrum, such as Federal radiolocation systems, satellite access systems, and components of a DoD private 5G network.
2. Real-Time Spectrum Sensors (“RTSS”): Sensors installed in the field to detect USG asset spectrum usage, authorized commercial user devices, and unauthorized or failed devices. The RTSS could be an explicit device, as in CBRS, or an intrinsic capability of UIU systems.
3. Real-Time Spectrum Management (“RTSM”) system: a system that allocates spectrum to authorized users and coordinates their access in frequency, time, and geographic area. A critical aspect of real-time assessment of spectrum resource assignments, which also serves as the basis for USG situational awareness.
4. Authorized Commercial Users: commercial users such as 5G gNodeB base stations that use the spectrum under the control of RTSM.

4. Conclusion

We applaud the NSF's efforts to develop an organizing national document for spectrum R&D, which will go a long way to helping ensure that our Nation's scarce spectrum resource best serves all spectrum users across all spectrum access models. Given the criticality of national security systems, it is imperative that the R&D Plan adopt a national security-first approach, and prioritize the development of DSS technologies which would allow national security incumbents to remain in the spectrum needed to successfully perform their statutorily mandated missions. Lockheed Martin thanks the NSF for the opportunity to provide feedback to the *RFI* and looks forward to working with the NSF on this most important effort.