NTIA National Spectrum Strategy Request for Comments Response

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COMMENTS OF LOCKHEED MARTIN CORPORATION

1. Introduction

Lockheed Martin Corporation ("Lockheed Martin") appreciates the opportunity to submit these comments in response to the National Telecommunications and Information Administration's ("NTIA") Request for Comment ("*RFC*"), *Development of a National Spectrum Strategy*.[1] The United States ("U.S.") has long demonstrated leadership in spectrum governance—one of the many facets of U.S. leadership that must be balanced against one another—and it is now time to transition U.S. spectrum governance and policies into the 21st Century.

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, from GPS to satellite broadband deployment to lunar and deep space exploration;[2] critical national security space capabilities, including the Space-Based Infrared System and Next Generation Overhead Persistent Infrared missile warning systems; radar platforms such as the U.S. Army's AN/TPQ-53, U.S. Navy's SPY-7, and Missile Defense Agency's Long Range Discrimination Radar; and myriad fixed wing and rotary-wing aircraft that are relied upon by governments and private sector entities globally, such as the F-35, C-130J, F-16, UH-60 BLACK HAWK, FIREHAWK®, and S-76. Further, Lockheed Martin is also looking to leverage commercial 5G technologies for both terrestrial and non-terrestrial solutions that it is developing for its customers.[3] Finally, Lockheed Martin has a significant Foreign Military Sales ("FMS") business in support of allied nations—in fact, the Aerospace & Defense ("A&D") industry constitutes one of the top sources of U.S. exports annually, contributing significantly to U.S. technological and economic leadership. As a necessity, due to its own technology research, development, testing and evaluation ("RDT&E") and sustainment activity, Lockheed Martin routinely works with NTIA and the Federal Communications

[1] *Development of a National Spectrum Strategy Request for Comment*, Docket ID NTIA-2023-0003 (rel. Mar. 16, 2023) ("*Request for Comment*"), https://www.regulations.gov/docket/NTIA-2023-0003.

[2] This includes both non-geostationary orbit ("NGSO") small sats and mid-sats and geostationary orbit ("GEO")-sats.

[3] *See, e.g.*, Lockheed Martin, Lockheed Martin and Verizon to Advance 5G Innovation for U.S. Dept. of Defense (accessed Apr. 17, 2023), https://news.lockheedmartin.com/lockheed-martin-verizon-advance-5G-innovation-us-deptartment-defense.

Commission ("FCC"), and other spectrum stakeholders in government, academia, and the private sector, on important issues of spectrum engineering, policy, regulation, and governance.

Based on its considerable breadth of experience, Lockheed Martin understands firsthand that the National Spectrum Strategy ("NSS") must ensure sufficient spectrum access for *all* spectrum stakeholders, such as national security, public safety, communications, weather/climate, and science. If the NSS is to succeed, it must continue to move past the decades-old playbook where federal incumbents are expected to "make room" for new (commercial) entrants, or what then-NTIA Administrator David Redl referred to as a uni-directional sharing trend.[4] The NSS must recognize that, while agencies have found ways in the past to accommodate their missions in a compressed spectrum environment, "these opportunities are finite and will only become more so if the uni-directional sharing trend continues."[5]

Instead, Lockheed Martin urges NTIA to prioritize the development of co-existence approaches that effectively promote and enable the growth of U.S. national security, space, and other technologies and capabilities to retain our ability to maximize deterrent effects. At a fundamental level, co-existence approaches that constrain our ability to out-innovate others in the national security space must be avoided for the U.S. to maintain its global technology leadership.

Lockheed Martin also wishes to highlight the economic impact of the U.S. A&D industry broadly. The U.S. A&D industry proudly employs over 2.1 million employees in all 50 states and the District of Columbia, representing approximately 1.4% of the entire national employment base.[6] U.S. A&D wages are 40% higher than the national average, and in 2021 alone,[7] the U.S. A&D industry paid out more than $224 billion in compensation.[8] Between 2018-2021, the U.S. A&D industry contributed more than $1.89 trillion in gross domestic product ("GDP").[9] Lockheed Martin alone employs over 114,000 total employees, including 60,000 engineers, scientists, and information technology ("IT") professionals, and nearly one in five of whom are veterans; and has more than 16,000 suppliers across the nation, including 7,600 active small businesses.[10] Finally, the U.S. A&D industry is focused on the need to meet the national security imperative for spectrum dominance - requirements to test, train, employ, and sustain cutting-edge national security capabilities which are imperative to the Joint All Domain Operations ("JADO") concept.

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[4] Remarks of NTIA Administrator David J. Redl at the TIA Policy Forum: Federal Spectrum Policy for the 5G Era (Jun. 21, 2018).
[5] *Id*.
[6] Aerospace Industries Association ("AIA"), Industry Impact (Mar. 24, 2023) ("AIA Industry Impact"), https://www.aia-aerospace.org/industry-impact/#:~:text=%24892B%20in%20Total%20A%26D%20Industry%20Sales%20Revenue%20in%202021&text=Additionally%2C%20the%20A%26D%20industry%20generated,nominal%20GDP%20in%20the%20US
[7] 2021 represents the most recent year in which data is available.
[8] AIA Industry Impact.
[9] AIA, 2018 Facts & Figures: U.S. Aerospace & Defense, https://www.aia-aerospace.org/wp-content/uploads/2018_-Annual-Report_Web.pdf ; AIA, 2019 Facts & Figures: U.S. Aerospace & Defense, https://www.aia-aerospace.org/wp-content/uploads/2019-Facts-and-Figures.pdf ; AIA, 2020 Facts & Figures: U.S. Aerospace & Defense, https://www.aia-aerospace.org/wp-content/uploads/2020-Facts-and-Figures-U.S.-Aerospace-and-Defense.pdf ; AIA, 2021 Facts & Figures: U.S. Aerospace & Defense, https://www.aia-aerospace.org/wp-content/uploads/2021-Facts-and-Figures-U.S.-Aerospace-and-Defense.pdf ; AIA Industry Impact.
[10] Lockheed Martin, Getting to Know Lockheed Martin (accessed Mar. 24, 2023), https://www.lockheedmartinjobs.com/getting-to-know

Throughout the following, Lockheed Martin will not only provide real-world examples of the issues it raises, but also a number of potential solutions aimed at better leveraging the continued success of the U.S. A&D industry and the critical and increasing need to ensure strong and innovative national defense capabilities.

2. Requested Information Responses

2.1. Pillar I: A Spectrum Pipeline to Ensure U.S. Leadership in Spectrum-Based Technologies

2.1.1. In General

In the NSS, Lockheed Martin supports NTIA's definition of a "spectrum pipeline" as "a process for identifying spectrum bands, regardless of allocation (*i.e.*, both federal and non-federal) that should be studied for repurposing (*i.e.*, allowing new or additional uses) to meet future requirements for non-federal and federal use alike."[11] In short, this inclusive definition recognizes that federal users—and the A&D companies that support their (often statutorily mandated) missions—also require the ability to explore new opportunities for spectrum access, and such access is only practically and fairly achieved by realizing co-existence with non-federal users in non-federal and shared federal/non-federal bands.

To date, the conventional wisdom of "spectrum sharing" has often been that incumbents are not continually innovating, thus in introducing new entrants into the band, there is "no real harm done". Moreover, the current approach has led disproportionately to exclusive license arrangements where spectrum is held essentially into perpetuity with few instituted milestones to ensure that such spectrum continues to be used most effectively. While the Citizens' Broadband Radio Service ("CBRS") model is a step in the right direction, it would benefit from greater incumbent flexibility to adopt technological innovations to serve their missions; it appears as if the CBRS model's benefits currently flow more heavily in the direction of the new entrants.

The logical and necessary alternative to this one-directional regime, notwithstanding progress made via the CBRS model, is one founded on greater "co-existence", which enables federal access to non-federal bands *and* vice versa – a bi-directional regime. Congress has already recognized the importance of bi-directional co-existence, having mandated that NTIA conduct a study "to determine the best means of providing Federal entities flexible access to non-Federal spectrum on a shared basis…" in the MOBILE NOW Act.[12] Individual agencies have made clear that their spectrum requirements are continually growing and evolving; the Department of Defense ("DoD") has stated that "DoD's requirements for spectrum access continue to grow to test, train with, and employ emerging national security capabilities."[13]

Spectrum pipeline discussions today are framed almost exclusively in terms of making more spectrum available for auctions; this framing excludes the needs of other stakeholders whose technologies drive the United States economy in ways other than auction receipts, and which require other access models that enable the multitude of technologies, solutions, and platforms that enrich and ensure the safety of the American public. Accordingly, a comprehensive

[11] *Request for Comment* at 16245.
[12] Consolidated Appropriations Act of 2018, Pub. L. No. 115-141 § 610 (2018).
[13] DoD, *Electromagnetic Spectrum Superiority Strategy* at 6 (Oct. 2020) ("*DoD Spectrum Strategy*"), https://media.defense.gov/2020/Oct/29/2002525927/-1/-1/0/ELECTROMAGNETIC_SPECTRUM_SUPERIORITY_STRATEGY.PDF.

spectrum pipeline to support federal and non-federal uses must account for *all* spectrum access models, moving beyond the traditional focus on auction revenues.

A spectrum pipeline should thus account for the clear benefits of unlicensed use and other co-existence arrangements, including for federal/non-federal shared frequency allocations that leverage dynamic spectrum sensing and sharing techniques; this pipeline should also be designed to encourage the full array of access models. After all, a National Spectrum Strategy that truly accounts for the spectrum needs of the *entire nation* must ensure that spectrum policy is designed to drive toward governance models that enhance access to spectrum for all spectrum users - whether federal or non-federal, whether commercial, civil, or national security, whether licensed or unlicensed, and whether satellite, aviation, or terrestrial.

In the *RFC*, NTIA states that it "endeavors to identify at least 1,500 megahertz of spectrum for in-depth study to determine whether that spectrum can be repurposed to allow for more intensive use."[14] Lockheed Martin presumes that future use cases for this spectrum have not been predetermined; NTIA itself states that the purpose of its identification is to study whether it can be repurposed for more "intensive use" *i.e.*, no specific use case. A pipeline recognizing the importance of equitable access would ensure that this 1,500 megahertz—from current commercial, state, local and federal holdings—would be repurposed for a broad cross-section of stakeholders, as opposed to a single commercial service outcome. Lockheed Martin understands that whatever amount of spectrum may be found for repurposing, some portion of such spectrum will likely be added to the pipeline for specific commercial licensed wireless consideration. However, Lockheed Martin notes that, should the pipeline be continually mobilized for the benefit of a single economic subsector, NTIA's stated goal of "fully addressing the needs" of a large cross-section of spectrum stakeholders would be impossible to satisfy.[15]

2.1.2. The NSS Must Focus on Co-Existence, rather than Long-Term Spectrum Forecasting

The very first question posed by the *RFC* is, "What are the projected future spectrum requirements of the services or missions of concern to you in the short (less than 3 years), medium (3-6 years), and long (7-10 years) term?"[16] For decades, spectrum policymakers have been trying to predict where the market and commercial operators would take American consumers, while not generally considering the technology evolutions and mission requirements of government agencies - whether civil aviation, national security, space weather/climate, to name a few. A spectrum strategy predicated on co-existence vitiates the need for NTIA, the FCC, or other policymakers to have a crystal ball. As such, the NSS should be oriented around addressing and incentivizing spectrum co-existence capabilities to enable flexible, dynamic spectrum use, rather than encouraging stakeholders to predict where innovations and threats will arise a decade from now, which merely serves to reinforce current fixed views of spectrum "acquisition". Both the NTIA Administrator and the FCC Chairwoman have recently acknowledged the scarcity of spectrum,[17] and that greenfield spectrum "will not be as simple or easy to find."[18] We agree with those characterizations. Indeed, the proverbial low-hanging fruit is gone, and we need to avoid the detrimental effects of trying to similarly pick spectrum utilized

[14] *Request for Comment* at 16245.
[15] *Id.*
[16] *Id.*
[17] Remarks of NTIA Administrator Alan Davidson at NTIA NSS Listening Session (Mar. 30, 2023).
[18] Remarks of FCC Chairwoman Jessica Rosenworcel at Mobile World Congress 2022 (Mar. 1, 2022).

by national security and other critical federal systems, particularly with the expectation that it will be vacated or that federal use must be constrained.

For national security systems, spectrum needs are driven by mission requirements, which are themselves driven by the threat environment. So important is this notion that it is institutionalized within the DoD in the form of critical design reviews ("CDR"), which ensure that defense systems are capable of fulfilling their intended missions.[19] For example, new radar systems are expected to be developed in the 3100-3450 MHz band, allowing for effective discrimination[20] over long distances while still being "portable" enough to be deployed on naval vessels. The NSS must reflect an understanding of not only communications technology, but other stakeholder technologies, and how those technologies are used not only as stand-alone capabilities but used in full operation with other capabilities. The fundamental premise is that the threat informs the mission, which informs the spectrum need. Framing the pipeline in terms of addressing long-term spectrum needs, as opposed to developing co-existence solutions to meet those needs, will more likely result in spectrum allocation decisions that do not allow the flexibility to operate as needed for agency missions.

While regulators have a mixed record of predicting the wireless industry's spectrum needs, it is questionable whether this is the appropriate proceeding to attempt to forecast holistically the global threat environment a decade from now in terms of spectrum needs. Moreover, the U.S. must be responsive to emerging and present threats in a dynamic environment.

Focusing on co-existence will help to ensure that spectrum stakeholders—federal, state, local *and* commercial—receive access to the spectrum their missions require, regardless of when those missions become apparent.

2.1.3. Spectrum Added to the Pipeline Must be Justified

Any spectrum identified for study and potential pipeline inclusion as licensed spectrum must be justified as necessary by those seeking its study. Put differently, those spectrum stakeholders seeking to expand their access to new spectrum via the spectrum pipeline must demonstrate why that spectrum is needed, rather than using current spectrum holdings. And if intended to promote additional competition, then presumably that would define eligible participants in the licensing process. Lockheed Martin recognizes and appreciates the need to make spectrum available to *all* spectrum stakeholders and, as such, believes that the same degree of scrutiny currently placed on federal agencies' spectrum access should be applied to any other entity claiming the need for yet more spectrum for its own services, and seeking to displace incumbents. Such claims must be grounded in quantitative and qualitative analysis, and NTIA and FCC must develop a transparent process through which claims are evaluated. Accordingly, the spectrum pipeline process must

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[19] The CDR, which occurs during the engineering and manufacturing development ("EMD") phase, confirms the system design is stable and is, among other things, expected to meet system performance requirements.

The CDR provides the acquisition community with evidence that the system, down to the lowest system element level, has a reasonable expectation of satisfying the requirements of the system performance specification as derived from the Capability Development Document ("CDD") within current cost and schedule constraints.

Defense Acquisition University, Critical Design Review (accessed Apr. 6, 2023), https://aaf.dau.edu/aaf/mca/cdr/.

[20] Defined as the ability of a radar system to display separately the echoes of two targets which lie on the same bearing, but which are closely spaced in range.

have mechanisms in place to rationalize spectrum decisions and maximize *current licensed* spectrum holdings.

This principle should hold true for *all* users of spectrum; yet, historically, the U.S. spectrum governance process has often been mis-guided by the inaccurate assertion that Federal users have "too much" spectrum while commercial users have "not enough." This thesis has often relied on a lack of understanding of how particular technologies actually work in operation, as well as understanding that government agencies have independent missions and requirements, rather than just competing to provide the same service. As such, previous spectrum pipeline efforts have narrowly and consistently focused on how to force federal agencies conducting national security, weather forecasting, and other important missions for the benefit of the American public to do more with less spectrum; yet, similar efforts do not seem to have been levied to explore the repurposing of spectrum for 2nd and 3rd generation commercial wireless services for next generation wireless services, prior to any repurposing of other stakeholder spectrum.

Ironically, there has been much criticism of federal systems, claiming they are inefficient. While Lockheed Martin discusses this efficiency myth below in section 2.1.8, it is worth asking the question here: are obsolete commercial technologies, which are allowed nonetheless to operate on a licensed, exclusive use basis, "efficient" simply because they were licensed by auction? While no doubt defensible, [21] could not similar arguments be made by other uses (*e.g.*, GPS devices, aviation altimeters) chided as "inefficient"? Lockheed Martin notes that, whereas mobile devices are often refreshed on an annual (if not shorter) basis, radar systems, for instance, are designed to have multi-decade (*e.g.*, 30-year) lifespans. Lockheed Martin further notes that DoD has already indicated, that even if alternative spectrum were identifiable, it would take two decades and "hundreds of billions of dollars" for DoD radars to vacate the 3.1-3.45 GHz band. [22]

Further, pipeline decisions should ensure that identified licensed spectrum will be maximally utilized. At NTIA's March 30, 2023, NSS listening session, multiple wireless industry speakers called for large swaths of spectrum in the 7-15 GHz range to be repurposed for the mobile wireless industry on an exclusive use basis, almost as a matter of course.[23] Lockheed Martin urges NTIA to reflect on whether requiring incumbents to vacate these bands for a select subset of spectrum users constitutes intensive, or even effective, use of these bands?

2.1.4. U.S. Global Leadership is Multifaceted

The most oft-repeated rallying cry for stakeholders wishing to fill the spectrum pipeline via auction of spectrum bands with significant federal, or even national security, deployments is that the U.S.' global standing would be imperiled by failing to make more spectrum available for 5G, 6G, and NextG services. This is sometimes championed as the need to "win the race to [insert wireless technology generation here]." While these claims are typically framed in terms of a strategic or national security imperative, foreign policy, or technology leadership, such arguments are at best oversimplistic. In short, U.S. leadership is multifaceted, and there are significant implications for other facets—*e.g.*, national security, national security technology,

[21] *See, e.g.,* Alarm Industry Communications Committee Petition for Emergency Relief Due to COVID-19-Realted Delays in 3G Sunset Transition for Central Station Alarm Subscribers, GN Docket No. 21-304 (filed May 10, 2021).
[22] Remarks of DoD CIO John Sherman at NTIA Spectrum Policy Symposium Morning Session (Sep. 19, 2023) ("NTIA Listening Session").
[23] NTIA Developing a National Spectrum Strategy Listening Session (Mar. 30, 2023) ("NSS Listening Session"), https://ntia.gov/issues/national-spectrum-strategy/listening-session/march-30.

etc.—if national security spectrum is redistributed, for instance, for the exclusive use of the mobile wireless industry.[24] Advancing U.S. leadership in one area absolutely should not come at the detriment of another.[25]

Indeed, a Government Accountability Office ('GAO") study found that U.S. adversaries "are developing capabilities and strategies the could affect DoD superiority in the information environment, including the [electromagnetic spectrum];" and that, per DoD, "loss of [spectrum] superiority could result in [DoD] losing control of the battlefield."[26] GAO further noted that the DoD Chief Information Officer ("CIO"), U.S. Strategic Command ("STRATCOM"), and Joint Staff all identified increased spectrum congestion—partially as a result of Federal spectrum being sold to or newly encumbered by commercial users—as a challenge to ensuring DoD's spectrum superiority.[27] The above is succinctly summarized in the opinion piece, *Congress May Sell Out National Security for 5G—There's a Better Way*: "The last thing the Armed Forces should have to focus on right now is a potential drawback in their ability to protect our country. We face the most dangerous world in 30-plus years, with threats ranging from Russia to Iran to North Korea to China. Anything that diverts the military's attention right now ultimately endangers our national security."[28]

Lockheed Martin concurs with those stakeholders that support greater U.S. leadership within international standards setting bodies for 5G, 6G, and beyond. However, Lockheed Martin also notes the comments of wireless organizations that have flagged foreign dominance in standards bodies, and non-allied nations "working to supplant the [U.S.'] wireless leadership", to include through "trying to flood the zone in standard setting…"[29] Yet, the United States is being asked to adopt the spectrum bands standardized by those same bodies, regardless of both the source of the standards and whether any standardized bands are highly disruptive to national security capabilities. For instance, one of the 5G bands that was standardized is the S-band (lower 3 GHz). The S-band is currently home to mature, national security critical capabilities for which there is no international (or propagation) equal - here, U.S. national security capabilities are at their apex; and yet the band is the current focus of a concerted international-led effort to take from U.S. national security use. Lockheed Martin notes the following DoD conclusion: "Our adversaries have recognized DoD's reliance on [spectrum]-dependent capabilities and are seeking to exploit this vulnerability. They seek to restrict U.S. spectrum access through

[24] Members of the mobile wireless industry often call for more spectrum to be made available to them on an exclusive basis. *See, e.g.*, NSS Listening Session; CTIA, Positions: Spectrum Policy (accessed Apr. 5, 2023), https://www.ctia.org/positions/spectrum/.
[25] Lockheed Martin also notes that within U.S. spectrum leadership, leadership extends beyond just licensed use cases. For example, the U.S. has been a long-time leader in Wi-Fi technologies. Wi-Fi, which utilizes unlicensed spectrum, serves as the primary onramp to the internet for the majority of broadband connections in the U.S.
[26] GAO, *Electromagnetic Spectrum Operations: DOD Needs to Address Governance and Oversight Issues to Help Ensure Superiority*, GAO-21-64, at 37 (Dec. 2020).
[27] *Id*. at 22-23.
[28] LTG (Retired) Keith Kellogg, Congress May Sell Out National Security for 5G—There's a Better Way, The Hill (Apr. 5, 2023), https://thehill.com/opinion/national-security/3932016-congress-may-sell-out-national-security-for-5g-theres-a-better-way/. LTG Kellogg was national security advisor to Vice President Mike Pence; and his last duty position was as J-6, Director for Command, Control and Communications ("C3") for the Joint Staff.
[29] Comments of CTIA at NSS Listening Session.

international forums [(emphasis added)] while they organize, train, and equip their forces for [spectrum] advantage."[30]

Finally, spectrum pipeline proponents of exclusive-license access cite the global harmonization of wireless standards as an imperative. Lockheed Martin submits that benefits of international harmonization of both standards and spectrum are not exclusive to wireless systems. Harmonization is also essential to national security systems, aeronautical platforms, and other capabilities and systems that operate both within and outside the United States. In short, U.S. technological leadership is not the only form of leadership the U.S. must seek to preserve. Spectrum access is critical to myriad services, and singularly focusing on any individual facet of U.S. leadership only ensures that others will be adversely impacted.

2.1.5. Co-existence Must be a Pre-Requisite for Inclusion in the Pipeline

Generally, there are three phases in identifying spectrum for the spectrum pipeline: (i) pre-identification, (ii) transition planning, and (iii) reallocation. In pre-identification, a band is considered for inclusion in the pipeline, ideally including an analysis on whether co-existence can be achieved. Once spectrum has been identified for inclusion in the pipeline, the incumbent develops its transition plan, outlining to NTIA how it will either vacate the band or co-exist with the new incumbent. This part of the process relies heavily upon the Spectrum Relocation Fund ("SRF"), as is covered in-depth in section 2.2.4 below. Finally, the last step of the pipeline process is the spectrum reallocation itself, which, has historically been done via FCC auction.

Lockheed Martin acknowledges that the above construct is consistent with the trend of spectrum bands being historically identified as eligible for the spectrum pipeline, and thus for auction, without consideration of impacts to federal agencies and the national security and other missions that they perform - or other commercial wireless uses that are foreclosed by the use of auctions as the licensing method.

This construct must, however, be revisited. Co-existence must be the overriding consideration for including a band in the pipeline – if co-existence cannot be adequately achieved, the band should not be included. This is especially paramount given that FCC recently identified "ensuring co-existence among both new and existing services"[31] as a goal in its draft policy statement, *Principles for Promoting Efficient Use of Spectrum and Opportunities for New Services*.[32]

Thus, whether co-existence can be appropriately achieved in a manner not disproportionally impacting incumbent services can only reasonably be determined during the pre-identification phase of the spectrum pipeline. Co-existence cannot be validated as a *post hoc* exercise once a band is already identified; doing so strips incumbents of any ability to effectively manage their spectrum needs and presents spectrum reallocation as a *fait accompli*, as opposed to the application of good spectrum governance, which requires careful and fulsome consideration of the potential impacts of auction activity, whether designated for an exclusive-license outcome or

[30] *DoD Spectrum Strategy* at 1.
[31] *FCC Fact Sheet: Principles for Promoting Efficient Use of Spectrum and Opportunities for New Services, Fact Sheet*, ET Docket No. 23-122 (rel. Mar. 30, 2023).
[32] *Principles for Promoting Efficient Use of Spectrum and Opportunities for New Services, Draft Policy Statement*, FCC-CIRC2304-01, ET Docket Nos. 23-122, 23-137 (rel. Mar 30, 2023).

a co-existence outcome. The current practice effectively undermines the pre-identification process, as pre-identification amounts to nothing more than a rubber-stamp formality.

The process currently playing out in the National Spectrum Consortium's Partnering on Advancing Trusted and Holistic Spectrum Solutions ("PATHSS") Task Group, which is examining the feasibility of co-existence in the 3.1-3.45 GHz band, is a prime example of making a co-existence determination during the pre-identification phase. It should be noted that there is bi-partisan support for the PATHSS process, and thus, assessing co-existence during pre-identification.

Beyond determining, notionally, that co-existence is possible within a given band, sufficiently mature co-existence solutions must be developed as part of this process. The development of these solutions must not fall exclusively to the band incumbent, especially considering the view sometimes projected that the solution for a new entrant in the band in which it wishes to operate is the removal of any and all interference resulting from continued incumbent use. Sufficiently mature solutions are required as it would be contrary to the public interest to field untested solutions on bands utilized, for instance, for national security critical missions.

Research and development ("R&D") must focus on co-existence mechanisms that dually ensure the U.S.' national security posture and economic growth. Many systems rely on spectral sensing and contention mechanisms to obtain spectrum access, which can be relatively slow and inefficient. Thus, a cooperative, real-time approach with the ability to support direct collaboration is required to address these challenges. Additionally, any spectrum co-existence between federal and commercial users must address operational, security, and interference risks associated with deployment of commercial devices in a band encumbered by federal users.[33] The need for spectral sensing will not dissipate, even when employing a cooperate co-existence paradigm.

2.1.6. Current and Prior Co-Existence Initiatives

2.1.6.1. Current Spectrum Co-Existence Approaches are Insufficient

Most spectrum sharing approaches are typically band-specific, distinct, and uncoordinated because they are use-case specific. Spectrum sharing typically focuses on portions of a larger spectrum band that supports a wide range of U.S. missions (*e.g.*, CBRS). Therefore, they do not enable reliable or efficient aggregation across spectrum bands. Since many federal systems require access to fixed frequency bands to function properly because of mission requirements or design constraints, these band-specific techniques resort to avoidance to minimize interference potential. This approach diminishes the value of spectrum co-existence for commercial wireless operators because it prevents them from ensuring quality of service to their customers. A predictable service level agreement is difficult to achieve when the usage by incumbents might itself be unpredictable. For DoD specifically, DoD deploys spectrum warfare capabilities that traditional research into dynamic spectrum sharing ("DSS") and current implementations have

[33] *See, e.g.*, Congressional Research Service, *National Security Implications of Fifth Generation (5G) Mobile Technologies* (updated Mar. 14, 2023). "The Defense Innovation Board (DIB) advised DOD to consider sharing sub-6 spectrum to facilitate the build-out of 5G networks and the development of 5G technologies used in the sub-6 band. While DOD has been moving toward greater spectrum sharing, it has expressed concern that sharing presents operational, interference, and security issues for DOD users."

not thoroughly considered. MITRE's recent report on Spectrum Highways highlights the value of adopting a DSS approach compatible with both domestic and international DoD use cases.[34]

2.1.6.2. Lessons Learned from Prior Sharing Initiatives

The *RFC* asks, "Have previous efforts to facilitate sharing, whether statically or dynamically, proven successful in promoting more intensive spectrum use while protecting incumbents?"[35] As recently presented in the NTIA report on lessons learned from the 5 GHz sharing for Wi-Fi and other devices with terminal doppler weather radar ("TDWR") systems, there are numerous insights from history that should be considered when exploring co-existence with incumbent user systems.[36]

1. Opening of mid-band spectrum to commercial cellular creates a strong market reaction for increased development, sale, and proliferation of band-compatible electronics. The CBRS system is only in its infancy and yet there is already a significant catalog of certified products.[37] This proliferation creates an attack surface as discussed below in section 2.3.2.1.

2. Our inability to completely regulate the manufacture and sale of electronics presents a risk for spectrum co-existence as hastily manufactured goods that fail to meet regulatory controls impede the operation of other systems in the shared band.

3. Furthermore, improper or premature installation and modification of approved devices may be prevalent once commercial devices are released on the open market. Regulation by itself does not ensure all instances of interference (either intentional or unintentional) will be adequately mitigated.

4. Analyses assessing the risks of mutual interference and regulations on the construction, deployment, and operation of commercial radiofrequency ("RF") systems cannot ensure that all interference cases will be mitigated or even known in advance. While this was experienced during the deployment of dynamic frequency selection ("DFS") with TDWR, interference incidents associated with various garage door openers have been reported[38].

5. Permanent damage can be induced in commercial receiver systems if they are designed to operate within the same band as a high-power emitter that happens to be operating nearby. While the NTIA reports on co-existence went into depth on the spatial separation requirements between many federal radar installations using very methodical evaluation of proper closed form expressions for free space propagation, there may be unfortunate environmentally induced scenarios where RF energy is transferred farther than expected (*e.g.*, atmospheric ducting).

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[34] *See* John Stine, *Spectrum Highways: Rules of the Road for Collaborative Radio Frequency Spectrum Sharing*, MITRE (Sep. 25, 2020).
[35] *Request for Comment* at 16246.
[36] NTIA, *Lessons Learned from the Development and Deployment of 5 GHz Unlicensed National Information Infrastructure (U NII) Dynamic Frequency Selection (DFS) Devices*, Technical Report No. TR-20-544 (Dec. 1, 2019).
[37] *See* Dragoslav Stojadinovic et. al, *SC2 CIL: Evaluating the Spectrum Voxel Announcement Benefits*, 2019 IEEE International Symposium on Dynamic Spectrum Access Networks ("DySPAN") (2019).
[38] *See, e.g.*, Stewart Taggart, US Navy Closes Doors Down Under, WIRED Magazine (accessed Feb. 16, 2023), https://www.wired.com/1999/04/us-navy-closes-doors-down-under/.

Spectrum co-existence can be introduced on an incremental basis, rather like a precautionary approach, and gradually expanded into additional markets as it proves out, and adjustments are able to be made in a cost-effective way for both new entrants and incumbents with minimal impact to operations.

2.1.7. Aerospace & Defense and Spectrum

2.1.7.1. In General

The U.S. A&D industry is uniquely situated in that, while a private industry sector, its spectrum access requirements are often inexorably linked to the spectrum requirements of its customer base – the federal agencies. To conduct RDT&E and sustainment activities for systems ultimately operated by federal agencies, or foreign allies through FMS, the U.S. A&D industry must be ensured access to the same spectrum these systems will ultimately be operated on. This idea is elaborated on in section 2.2.2.4 below.

Indeed, NTIA has previously recognized that U.S. A&D industry facilities must retain access to spectrum utilized by the systems they develop pursuant to federal contracts, writing to the FCC in the context of the 3.45 GHz band: in furtherance of continuing DoD operations, NTIA has also indicated that radar manufacturing and integration facilities require access to the 3.45 GHz band "to perform experimentation and testing for radionavigation and other systems contracted for by federal agencies."[39] Further, NTIA noted, "It is critical that these facilities retain access to the spectrum for this testing and experimentation to ensure that agencies' contracting requirements can be fulfilled."[40]

The current spectrum lifecycle of a DoD system is provided below:

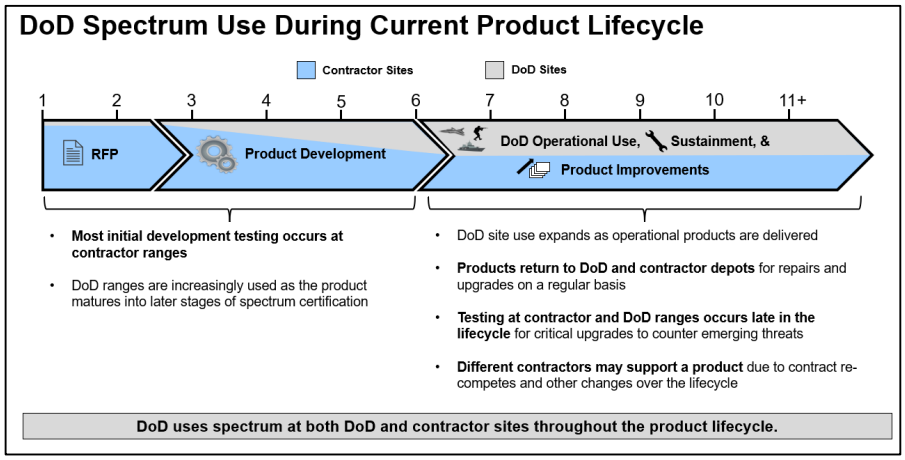

Figure 1: DoD Spectrum Use During Current Product Lifecycle

From early product development to sustainment activities such as repairs and upgrades, DoD products are extensively tested at U.S. A&D contractor sites to comply with stringent military standards required by DoD contracts (including DoD FMS contracts). While testing at DoD ranges occurs later in the product lifecycle, "factory" testing at contractor sites cannot be simply

[39] Letter from Charles Cooper, Associate Administrator, NTIA, to Ronald T. Repasi, Acting Chief, Office of Engineering & Technology, and Donald K. Stockdale, Jr., Chief, Wireless Telecommunications Bureau, FCC, WT Docket No. 19-348 (filed Sep. 8, 2022).
[40] *Id.*

relocated and duplicated elsewhere, and it occurs during the entire product lifecycle.[41] DoD product lifecycles can extend *decades* from the point of initial deployment, and even longer for legacy systems sold to U.S. allies under FMS contracts.[42] Lockheed Martin reiterates that the lifecycles of national security products are significantly longer (and more complex) than those of commercial devices.

Additionally, DoD requires contractors to compete for both developmental and sustainment contracts to promote innovation and ensure competitive pricing. Thus, as contractors have flagged before, testing may shift from one contractor site to another based on contract award, even at sites where the necessary spectrum band was not previously utilized.

Finally, Lockheed Martin reemphasizes the importance of globally harmonizing spectrum bands for national security purposes. As discussed above, the U.S. A&D industry conducts a significant amount of FMS annually—in 2022, Lockheed Martin alone reported $12.56 billion in FMS sales—and is further a net exporter of A&D products from the U.S. to U.S. allies, contributing to the U.S.' global competitive posture. In 2021 (the most recently available year), the U.S. A&D industry exported to over 205 countries maintained a positive trade balance at a value of $51.5 billion.[43] Globally harmonized bands for national security platforms, systems, and solutions, including allied interoperability, are necessary to ensure the U.S. A&D industry continues to lead globally in providing advanced technologies to the DOD and to the nation's allies.

2.1.7.2. Aerospace & Defense as an Innovator

From the earliest days of the U.S., the role of technology in shaping defense concepts and providing for the defense of the nation has been essential. The U.S. A&D industry has long represented a significant national asset in terms of innovative capability and cutting-edge technology development. In fact, in 2022 alone, Lockheed Martin invested $3.4 billion in Independent Research and Development ("IRAD"). This IRAD is informed by the customer mission and seeks to ensure that the customer's science and technology strategy addresses the key challenges that U.S. faces today and will face tomorrow.

DoD's *Technology Vision for an Era of Competition* states, "In an ever shifting and fast-moving global environment, technological advantage is not stagnant and [DoD] cannot rely on today's technology to ensure military technological dominance tomorrow;"[44] and the U.S A&D Industry is a vital partner in helping DoD retain that technological advantage.

2.1.8. Dispelling the "Efficiency" Myth

In the *RFC*, NTIA asks, "How should the Strategy assess efficient spectrum use and the potential for sharing?"[45] Similarly, critics of federal users of spectrum—or any device which uses spectrum other than for mobile wireless—often lambast non-mobile wireless devices as

[41] DoD A&D contractor sites have specialized diagnostic equipment, tools, and engineers to diagnose and address issues identified during testing. Some repairs and modifications to internal components must occur in "clean rooms" to avoid damage from foreign objects ("FOD") and using specialized tools and protective gear to prevent damage from electrostatic discharge ("ESD").
[42] The DoD has replaced the MIM-23 Hawk air defense system (put in service in the 1960s) with more advanced systems, but U.S. Allies continue to use the system. Hawks were deployed in Ukraine in 2022.
[43] AIA Industry Impact.
[44] Under Secretary of Defense for Research and Engineering ("USD(R&E)")/Chief Technology Officer Heidi Shyu, *USD(R&E) Technology Vision for an Era of Competition* (Feb. 1, 2022).
[45] *Request for Comment* at 16246.

"inefficient." As the CSMAC noted in prior reports, there is no single efficiency metric that is applicable across dissimilar uses of spectrum; but efficiency can be relevant within a similar use, so measuring efficiency among 5G, 4G and 3G networks may be relevant in spectrum policy. Sophisticated platforms, such as radar, global positioning system equipment, national security satellites, etc., are necessarily designed to meet the purpose of intended service and deployment requirements. For example, having anti-jamming capabilities, such as frequency hopping, does not mean that the periodically unoccupied frequencies for a given radar system are not "used", but are in fact in constant use as part of the random frequency hopping capability. Yet, this is often portrayed as an "inefficient use of spectrum", revealing a lack of understanding of basic radar technology, operations, and missions. Lockheed Martin notes that this often results in non-A&D stakeholders suggesting how national security radars should be designed to meet the threats.

Furthermore, systems are also generally designed to use only as much spectrum—whether transmitting or receiving—as necessary to ensure optimal performance and mission success. In this way, designs are already effectively efficient. In addition, integral to the function of these systems is a design suited to the spectral environment in which that device is required to operate, itself a function of the allocated service spectrum as well as adjacent band operations. A military radar with an intended multi-decade lifecycle is not "inefficient" because of its long life and new capabilities that emerge for the next generation radar family.

2.2. Pillar II: Long-Term Spectrum Planning

2.2.1. In General

Lockheed Martin agrees with NTIA regarding the need for a long-term planning process that allows stakeholders to work together openly and transparently in an ongoing manner.[46] However, as discussed above, Lockheed Martin believes that the focus of these efforts should be on creating incentives for all stakeholders, not just incumbents, in the identification and development of co-existence solutions and determining whether co-existence can be achieved in a specific band. Ideally, Lockheed Martin foresees a 21st century spectrum governance model where sharing by design is built into commercial and non-commercial technologies.

NTIA must incentivize early spectrum co-existence and R&D, *i.e.*, during the pre-identification phase of the pipeline so that parties are equally incentivized; spectrum stakeholders must receive an equal seat at the table.

One potentially replicable model for stakeholder dialogue is the previously mentioned PATHSS Task Group effort, where all stakeholders are provided a forum to assess whether co-existence in possible in the 3.1-3.45 GHz band. Notably, the PATHSS process includes a classified component ("PATHSS-C"), where non-national security stakeholders are afforded access to certain classified information to further the Task Group's analysis. This speaks directly to NTIA's acknowledgement of the need for transparency between stakeholders,[47] to the degree practicable.

The PATHSS activity has demonstrated the benefits, both to DoD and to external stakeholders, derived from convening a venue for the co-existence both of mission requirements and typical operational architectures. When approaching a mandate that necessitates spectrum co-existence,

[46] *Id.*
[47] *Id.*

it is common that new entrants to the band lack awareness of mission requirements that drive the design and capabilities of an incumbent's fielded systems. Activities such as PATHSS enable the facilitation of the key information that increases that awareness and should be considered an integral feature of both new entrant network designs and future incumbent relocation schemes *prior* to the initiation of auction activity.

The *RFC* also states that stakeholder dialogue will provide for a mechanism through which "evolving user requirements can be vetted."[48] Lockheed Martin notes that federal agencies are already subject to Executive Branch and Congressional oversight of program and mission needs.

Finally, the NSS will require legislative, regulatory, and policy frameworks to support its objectives. While the *RFC* does not appear to address this subject explicitly, Lockheed Martin believes this is an integral component of long-term spectrum planning, and thus discusses these frameworks below. This is further warranted given that NTIA previously examined potential implementation or governance structures for the NSS.[49]

2.2.2. Legislative, Regulatory, and Policy Frameworks to Support Co-existence

2.2.2.1. In General

The U.S.' spectrum allocation and licensing models were developed in an environment where many uses of spectrum were stove piped, whether federal and non-federal, or terrestrial and satellite, in distinct spectral bands. Many federal agencies (as well as commercial unlicensed devices and satellite system operators) have co-existed and shared spectrum with each other, accommodating multiple systems, while licensed commercial mobile wireless systems have generally enjoyed exclusive spectrum access in the U.S. The wireless industry's preference for exclusive access has been reinforced by the revenues generated through assigning spectrum licenses to wireless carriers via auctions. However, that value proposition may be in question when there is so much potential disruption and risk to critical national security systems or other valuable uses of spectrum that revenues are no longer the primary challenge in accommodating commercial wireless uses.

It is well-established in the world of modern RF spectrum system design that there are multiple modes of potential co-existence on a non-interfering basis that leverage the dimensions of spatial, temporal, and spectral separation. Further, separation can be achieved with novel digital and analog signal processing techniques. Even with these technological advances, achievability is ultimately hindered by fundamental physical limits on how much information can be conveyed in a fixed amount of spectrum. Thus, we have reached our current dilemma.

Over the last two decades, the spectrum environment has changed significantly. Spectrum demand has increased exponentially to support burgeoning modern federal, state, and local missions as well as next generation commercial wireless technology needs. These needs have resulted in congestion that require focus on creating breakthroughs in technologies and reforming spectrum policy and governance model to reflect 21st century realities.

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[48] *Id.*

[49] CSMAC, *Working Group 1: Governance: Final Report* at 1 (Jul. 30, 2020) ("*CSMAC Final Report*"), https://ntia.gov/sites/default/files/publications/csmac_sc1_report_july_2020_r1_0.pdf.

2.2.2.2. Creating the Spectrum Resource Agency

The CSMAC has previously made recommendations related to implementation structures and governance models for an NSS. The CSMAC'S Working Group 1 (Governance) ("WG1") was given the following mandate:

> "What should be the United States' implementation structure or governance model for the National Spectrum Strategy? Consider whether the U.S. spectrum management approach is optimized for the implementation of a 21st century national spectrum strategy and, if not, whether there is value in establishing a new approach or structure to accomplish this. If there is value in a new approach or structure, what are its characteristics? (Recommendations are due in 3–4 months.) If the Commerce Spectrum Management Advisory Committee (CSMAC) concludes that there is utility in revising the U.S. spectrum management approach, consider what structural changes, new entities, roles, responsibilities, and legislation would be required to implement. (Recommendations are due in 6–9 months.)"[50]

Pursuant to this mandate, WG1, comprised of a broad cross-section of spectrum stakeholders, developed a list of options for NTIA to consider. NTIA should consider the options set forth by the CSMAC, and in particular the value of the Administration establishing a spectrum resource agency ("SRA"). What follows is the CSMAC's outline of the option for the SRA:[51]

The SRA presents a streamlined version of a consolidated spectrum agency, with an emphasis on top-level spectrum governance and policy decisions and would not include all associated downstream activities that arise from allocation decisions. The SRA's mission would be limited to:

- Planning and allocation
- International policy, including treaty negotiation and border coordination
- Research and development
- Forecasting

The SRA is envisioned as an independent Executive Branch agency and would be led by a single Administrator who would serve a term longer than the president - ideally between five (5) and seven (7) years. As discussed previously, independent federal agencies are those that exist outside of agencies that are managed by Cabinet secretaries. While managed by the Executive Branch (*e.g.*, subject to Office of Personnel Management, Government Accountability Office), the leadership of the agency is independent of the president by virtue of statutory limitations on the ability of the president to dismiss its leadership and the length of the administrator's term.

Spectrum assignment mechanisms (including auctions) and non-federal licensing (including transfers of control, public safety issues, federal assignments, equipment authorization, and enforcement) would remain in the FCC's domain for licensed and unlicensed device manufacturers; federal assignment holders would remain in the NTIA's domain.

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[50] *CSMAC Final Report* at 1.
[51] *Id.* at 11-14.

The SRA would be obligated to establish and advance a single set of national spectrum policy priorities - both domestic and international. Additionally, the future spectrum co-existence policy environment would be enhanced by a single independent agency with responsibility for all affected stakeholders. This structure would enhance the credibility of policy solutions and enable the creation of a more balanced and accepted output. As will be discussed below, this carries more weight if the SRA is located within the Executive Branch.

For the functions that the SRA performs, the FCC and NTIA would receive the decisions of the SRA (*e.g.*, Table of Allocations decisions) or receive the facts that the SRA has found (*e.g.*, forecasting). For spectrum planning and allocation, the FCC and NTIA would be required to receive the SRA's work as settled policy and implement their processes in accordance with the SRA's decision; however, they would be free to participate in its development and suggest further improvements to it as desired. As a helpful analogy, the FCC and NTIA would become "constituents" of the SRA.[52]

The following examples should help illustrate the relationship:

- A decision by the SRA to allocate (or, conversely, not to allocate) a band to terrestrial mobile would have to be followed by the FCC and (if applicable) NTIA.
- A decision by the SRA to allow federal fixed microwave users to share a band also used by commercial fixed microwave users would need to be implemented by both the FCC and NTIA.
- The FCC would continue to manage all licensing methods and decisions on licensing approaches for commercial users, including spectrum auctions as an assignment method, but the eligibility of a spectrum band for commercial use would be determined by the SRA's allocation responsibilities.

By creating the SRA, even if that agency is formed of components of NTIA and the FCC, there are some issues that arise due to the separation of policy decisions from policy execution. An example of this would be the R&D function of the SRA – particularly the case of developing new and more innovative co-existence mechanisms.

Such an agency could facilitate co-existence among federal, state, and local governments and commercial systems, acting as a trusted independent mediator for resolving any disputes that might arise. The SRA can also promote and encourage innovation, in collaboration with private (*e.g.*, academic, and commercial) entities, but focused on the breadth of spectrum sharing challenges, and not stove-piped by stakeholder community.

2.2.2.3. Regulatory Incentives

Regulatory incentives are a key element to establishing an equitable co-existence environment - the pace of technology development is increasing, in particular with the deployment of massive internet-of-things ("IoT") systems in a 5G commercial and government ecosystem.

This situation presents opportunities for spectrum policymakers to create incentives for federal and non-federal users to share spectrum bands for which allocations currently strictly limit access to users of a single regulatory classification. Such incentives should encourage the

[52] As an additional benefit, the State Department would be obligated to advance the priorities established by the SRA, as opposed to today's structure, where it sometimes must reconcile differing views of the FCC and NTIA.

development of innovative co-existence mechanisms and techniques, while maintaining protections for incumbent users. One such opportunity for a technological solution to co-existence could be the result of the FCC exploring how "co-existence by design" could be accomplished by updating current equipment certification rules to encourage spectrum co-existence capabilities built into future radios and systems to the degree practicable.

2.2.2.4. Protections for DoD Contractor Facilities

As directed by the MOBILE NOW Act,[53] NTIA evaluated the feasibility of allowing commercial wireless services shared address to the 3100-3550 MHz band, under the assumption of no changes to incumbent operations, "except for possibly limiting some use of airborne radar systems over the continental United States."[54] NTIA worked with DoD to evaluate conditions needed to enable commercial services to operate in the 3450-3550 MHz band without causing impact to incumbents.

Following this assessment, the 2020 America's Mid-Band Initiative Team ("AMBIT") report ("Report") set an objective to make 100 megahertz of contiguous spectrum available within the 3400-3500 MHz band, in part, by revising DoD operations. Notably, while the AMBIT report did include protections from commercial operations in the 3400-3550 MHz band for DoD ranges and *de facto* (by way of proximity) protections for DoD contractor facilities adjacent to such ranges, contractor facilities not adjacent to DoD ranges were never discussed in the Report, and thus received no such protection from commercial operations.

These contractor facilities support national security critical RDT&E and sustainment, and CDR activities throughout the lifetime of military systems, just as those adjacent to DoD ranges do, and thus must be included in any future spectrum co-existence or protection framework. Such considerations are absolutely critical to increasing spectrum access while preserving DoD's missions; and is consistent with prior DoD and NTIA practice, as emphasized in NTIA's letter to the FCC in the CBRS proceeding: "There is also a need to protect a limited number of facilities used by DoD and its contractors [emphasis added] for the development and testing of shipborne radar systems in the 3.5 GHz Band."[55]

Further highlighting the importance of contractor facilities, in issuing its June 16, 2021, Special Temporary Authority ("STA") to Lockheed Martin,[56] the FCC found warranted Lockheed Martin's assertion that without issuing an STA to allow Lockheed Martin to continue conducting radar RDT&E and sustainment activities in the 3.45-3.525 GHz band, the "public interest would be seriously prejudiced by the extraordinary risk of disrupting a critical national security supply chain and U.S. technological leadership in the national security sector."[57]

DoD contractor facilities also represent massive fixed capital investment. Relocation of ongoing RDT&E and sustainment work to federal test ranges is not a tenable solution, imposing significant potential risks, delays, and costs to current and future contracts, not to mention impact

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[53] Consolidated Appropriations Act of 2018 § 605.
[54] NTIA, *Feasibility of Commercial Wireless Services Sharing with Federal Operations in the 3100-3500 MHz Band* at 1 (Jul. 2020), https://www.ntia.doc.gov/files/ntia/publications/ntia_3100-3550_mhz_mobile_now_report_to_congress.pdf.
[55] Letter from Paige R. Atkins, NTIA, to Julius P. Knapp, FCC/OET at 6 (Mar. 24, 2015).
[56] *Lockheed Martin Request for Part 90 Special Temporary Authority to Operate Two Radiolocation Service Sites in the 3.45 GHz Band*, ULS File No. 0009581172, Order, DA 21-693 (rel. Jun. 16, 2021).
[57] Lockheed Martin Request for Special Temporary Authority at 1-2, ULS File No. 0009581172 (filed Jun. 9, 2021).

on workforce. Furthermore, federal test ranges have limited capacity to expand use to accommodate additional tests that might be displaced from DoD contractor sites that have already been significantly expanded to accommodate demanding test schedules, and do not have the specialized test facilities required for the development of leading-edge technologies. In addition, federal test ranges do not have the unique personnel skills required for ongoing program operations. For these reasons, operations at DoD contractor facilities should be included in any future spectrum co-existence solutions.

2.2.3. For Heavily Encumbered Bands, NTIA Should Consider Delegating Limited Spectrum Management (or Co-Existence) Responsibilities to the Relevant Agencies.

For bands with significant federal encumbrance, NTIA should consider delegating, at least in part, the management of the band, to include co-existence, to the relevant agency or agencies.

Consider, for instance, bands encumbered by national security systems. Beyond DoD, what federal entity: has an intimate understanding of how the electromagnetic spectrum is challenged by peer and near peer adversaries;[58] the dynamics of great power competition; the unified treatment of spectrum management activities as electromagnetic spectrum operations ("EMSO"); DoD's plan for maintaining military overmatch against its adversaries; the specific operating requirements of national security systems and the missions which they support; the roles of the Military Services, DoD CIO's office, Joint Staff, and unified combatant commands ("CCMD"), etc., all play in DoD's spectrum operations; or even has access to the national security sensitive information upon which the answers to many of these questions are predicated?

The electromagnetic operational enviornment is a maneuver space, a battlespace, a place where competition and warfare, as well as commerce and other non-military activities, are conducted. Spectrum is not a separate domain of military operations, because it is inseparable from the domains established in the joint doctrine.[59]

Further, 21st century spectrum governance may require a different approach by federal spectrum regulators given the capabilities required to enable DoD operations in a truly shared environment. NTIA's own Incumbent Informing Capability ("IIC"), which is mentioned in the *RFC*,[60] is still in the nascent stages of development. According to the NTIA FY 2024 budget as presented to Congress, "Funding in FY 2024 would enable NTIA to stand up an IIC Project Management Office ("PMO") to oversee the development of an incumbent informing system…. This initial investment of $14 million and 6 positions *for the first year of a five year program* [(emphasis added)] provides for formal project initiation through the development of acquisition plans and documentation needed for project governance, planning and coordination of spectrum policy changes needed to expand spectrum access, and information technology planning for future spectrum-sharing automation."[61] In short, the IIC is still years away from being ready to facilitate co-existence between critical national security critical and commercial spectrum users.

There is already some precedence to borrow from for a future governance model. For example, the Aeronautical Advisory Group ("AAG") and Military Advisory Group ("MAG") are areas

[58] *DoD Spectrum Strategy* at I.
[59] *Id* at 3.
[60] *Request for Comment* at 16247.
[61] NTIA, FY 2024 Budget as Presented to Congress at NTIA-26 (Mar. 2023), https://www.commerce.gov/sites/default/files/2023-03/NTIA-FY2024-Congressional-Budget-Submission.pdf.

where the NTIA has delegated spectrum management authority on a band-by-band or capability basis. The AAG is chaired by the Federal Aviation Administration ("FAA") and is responsible for "engineering frequency assignments and determining whether or not applications for frequency assignment action in [bands listed in the NTIA Redbook] of primary concern to the aeronautical mobile and aeronautical radionavigation services should be approved by NTIA."[62] The MAG is chaired by the Air Force and provides "guidance and procedures for the management of [bands listed in the NTIA Redbook] which are of primary concern to the military departments."[63] Here, deference is correctly provided to the relevant SMEs, such that they are permitted to manage their spectrum operations. Next-generation spectrum co-existence may require consideration of delegation of authority for different models and stakeholder groups.

2.2.4. The Spectrum Relocation Fund

Created in 2014,[64] the SRF provides a centralized and streamlined funding mechanism through which federal agencies can recover costs associated with their relocating radiocommunications systems, or co-existence in reallocated spectrum. For DoD especially, the SRF is vital; for the 1755-1780 MHz band alone, the U.S. Navy estimates that moving to a new band will take more than a decade and cost over $16 billion.[65] The SRF is currently funded by the spectrum auctions for the given band that would require federal incumbents to either relocate or co-exist with the auction winners.

To date, the SRF has been interpreted in ways that limit its ability to be used to meet its intended goal of incentivizing federal agencies to identify spectrum that it could release or share if allowed to modify operations. Lockheed Martin understands that agencies are being informed that the SRF is not able to fund whole system upgrades, but rather just replacement of technology. This not only disincentivizes the level of effort necessary for co-existence, but also deprives the American public of the advanced capabilities available to the agencies that serve them, by forcing agencies to replace technology that was state-of-the-art at the time of acquisition, with technology that is likely a generation or two behind.

Section 928(g)(2) of the Communications Act currently provides for transfers from the SRF to eligible federal agencies for pre-auction research and development, engineering studies, economic analyses, activities with respect to systems, or other planning activities. Overall, these activities are intended to improve the effectiveness of spectrum use for the purpose of making available qualifying frequencies not yet identified for auction, but assigned to federal entities for reallocation, and for subsequent licensing utilizing the auction provisions of the Communications Act.

Lockheed Martin supports statutory changes to the SRF with the aim of preserving agencies' ability to conduct their missions, while incentivizing spectrum sharing where feasible – in both federal and non-federal bands. Such changes could include: 1) after the completion of a transition plan, allowing excess funds to remain in the SRF for R&D activities; 2) providing agencies with the ability to retain transition funds for a current or future transition plan; 3)

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[62] NTIA, *Manual of Regulations and Procedures for Federal Radio Frequency Management* at 1-8 (rev. Jan. 2022) ("Redbook").
[63] *Id.*
[64] Commercial Spectrum Enhancement Act, H.R. 5419, 108th Cong., Title II.
[65] NTIA, Transition Plans and Transition Data for the 1755-1780 MHz Band (Sep. 30, 2020), https://www.ntia.gov/other-publication/2020/transition-plans-and-transition-data-1755-1780-mhz-band.

allowing contractors access to SRF funds for pre-decisional R&D; 4) clarifying that SRF monies may be used for the acquisition of state-of-the-art replacement systems; and 5) requiring that any denial for SRF funding by the Technical Panel be reported to Congress, along with the justification.

These changes would leverage the SRF as a means of increasing co-existence among federal and non-federal systems. Furthermore, amendments to the SRF permitting for the use of funds to support planning and pre-production activities would enable technology developers to ensure the most current spectrum sharing techniques are incorporated in the next generation of platform designs and deployment plans. SRF reform in this context would facilitate cost and capabilities trade studies to inform system architecture options, to include how spectrum co-existence techniques could be built into system designs.

2.2.5. Band Identification

The RFC asks, "are there any specific spectrum bands or ranges to be looked at that have high potential for expanding and optimizing access? Which, if any, of these spectrum bands or ranges should be prioritized for study and potential repurposing? Conversely, are there any bands or ranges that would not be appropriate for access expansion?"[66]

While modern RF systems can generally support dynamic spectrum assignments, mission and system design constraints often restrict the usable bands. Moreover, even when the assumption is made that new systems should be agile, many existing federal systems cannot foreseeably be made more agile due to physical constraints of particular platforms, or the operational impact to pull deployed systems out of service for optional updates. As a result, the impact of any spectrum reallocation and co-existence with commercial systems must be carefully assessed prior to policy and regulatory decisions, in order to ensure that *incumbent and planned* federal systems meet their critical performance requirements.

As propagation characteristics vary greatly between bands, spectrum is not readily interchangeable for either the mission or the systems. Propagation is so impactful on performance of RF systems that band selection is often a primary consideration in the design of a system to meet performance requirements. For example, long range air surveillance radars operate within the L- and S-bands with array sizes and power levels required to meet stringent surveillance timelines with manageable propagation loss. These systems cannot be arbitrarily reallocated to other frequency bands without significant development, expense, and potential mission requirement shifts - and certainly not with appropriate SRF support.

Similarly, since the rate at which data can be transmitted is related to the frequency due to a combination of Shannon capacity limits and antenna fractional bandwidth limitations, data throughput potential generally increases for higher band signals. The mobile industry has primarily targeted spectrum used by satellite and radar systems and flight testing for repurposing for mobile broadband exclusive use—due to the attractiveness of wide contiguous regulatory blocks of spectrum—and much of this is exclusive federal spectrum. Therefore, the mid-band (1-6 GHz) region is attractive for commercial wireless and Wi-Fi because it offers relatively long transmission distances with minimal environment absorption and relatively high throughput.

[66] *Request for Comment* at 16247.

These characteristics are also the reason why the mid-band frequencies have been selected for many of the nation's military defense systems.

To date, despite CBRS deployment in the C-band, there has been little real progress on developing full spectrum co-existence capabilities, to enable in-band or adjacent band spectrum compatibility between commercial wireless and national security mission requirements. The identification of any future spectrum bands that could be eligible for spectrum co-existence must be accompanied by a thorough inventory of incumbent uses in any given band, including consideration of projected uses of the spectrum both for sustainment and the design and deployment of the next generations of currently fielded systems. Absent such an assessment, the ability to meet emerging threats would be hindered significantly; technical and engineering analysis must be conducted to determine the feasibility of a spectrum band co-existence regime with both existing and emerging threats, as well as existing and planned new national security capabilities.

Lockheed Martin notes that there are often multiple standardized bands that enable mobile network operators ("MNO") to provide their services; this is in stark contrast, for example, to radar missions. This is the case in the 3.1-3.45 GHz band, despite the fact that this band is the only spectrum band in which many current radar systems are able to operate and perform their critical mission as designed - a result of billions of dollars of investment and operational deployments. While the current U.S. spectrum governance regime operates as if there are no other 5G bands, or that specific licensed entities do not have other spectrum holdings, it is, ironically, the federal systems which *do not* have access to alternate bands on which to readily operate.

Should federal spectrum, such as radar-designated S-band spectrum, be adversely impacted, there is significant risk of both disrupting a critical national security supply chain and U.S. technological leadership in the national security sector. At the same time, preserving the S-band for federal radar missions would in no way undermine nationwide 5G rollout; the currently targeted S-band would at best most as a supplement to the existing inventory that the MNOs already hold. Moreover, with the right regulatory policies in place, the MNOs could potentially repurpose their old 2G, 3G spectrum holdings to relieve their own pressures for more spectrum to support next generation services.

2.2.6. On Auctions

The *RFC* asks, considering spectrum authorization broadly what approaches may optimize the effectiveness of U.S. spectrum allocations?[67] Historically, the spectrum conversation in America has generally been dominated by one access model - auctions. Auctions have been a successful method of licensing spectrum to the mobile wireless operators, primarily for stove-piped exclusive access – but it is a licensing method, not an allocation policy tool. Yet, prospective auction revenues are often rolled out as a justification for repurposing spectrum before a decision has been made as to whether the band can be repurposed (or shared), and if so, whether exclusive licensed spectrum is the best use of such repurposed spectrum.

[67] *Id.*

Revenue generation is not, in and of itself, a hallmark of good spectrum governance. Initial auction authority to the FCC directed the FCC not to take revenues into account[68] – which should be a guiding principle for a 21st century spectrum governance model focused on intensive use and co-existence.

Lockheed Martin believes that, under § 309(j) of the Communications Act of 1394, the FCC has broad discretion in how and when to use auctions. This authority and that of the NTIA should be leveraged to use models that incentivize the development of co-existence solutions, not ones that can only favor a subset of spectrum stakeholders.

Further, for future spectrum auctions of encumbered bands, FCC and NTIA should consider whether to require that potential new entrants have *proven* technologies to facilitate co-existence in the band. Lockheed Martin believes that this would incentivize collaboration between stakeholders, as it makes co-existence technologies a discriminator in auctions and in obtaining scarce spectrum resources. Currently, co-existence technologies are sometimes developed after an auction has been conducted, creating friction between incumbents and new entrants, and may create unintentionally uneven playing field.

2.3. Pillar III: Unprecedented Spectrum Access and Management Through Technology Development

2.3.1. In General

As NTIA well knows, there are a wide range of approaches for both licensed and unlicensed spectrum access, including a myriad of spectrum co-existence solutions that are band specific depending on existing, new, and modified systems in the band and which occur on a time, geographic, and frequency basis between/among like and dissimilar services and between/among all combinations of federal and non-federal users, both with and without the use of third-party databases and coordinators.

With respect to "unprecedented spectrum access," Lockheed Martin emphasizes the need for equitable spectrum access via a technology and business model neutral approach. Unprecedented spectrum access must not be operationalized as unprecedented spectrum access, for a select subset of spectrum stakeholders to the detriment of all others.

2.3.2. Dynamic Spectrum Management

The *RFC* asks, "what other technologies and methodologies are currently being, or should be researched and pursued that innovate real-time dynamic spectrum sharing…?"[69]

[68] Omnibus Budget Reconciliation Act of 1993, Pub. L. No. 103-66, 107 Stat. 312, § 3003(b)(6) (1993). "…shall not consider the expected revenues from the use of a particular block of spectrum to the Federal Government as a primary criterion in establishing regulatory policy or in marking a decision regarding the assignment of licenses or permits."

[69] *Request for Comment* at 16247.

The predominant spectrum management process used today is based on static rather than dynamic assignments, though many modern wireless protocol standards employ elements of dynamic spectrum access ("DSA") within their fixed spectrum allocations: DSA is already in use within 3G, 4G, and 5G systems.[70] Modern wireless technologies have evolved towards DSA within homogeneous deployments (*i.e.*, employing DSA within adjacent cells of the same type and/or operated by the same provider). DSA is a challenging approach for heterogeneous systems, requiring additional specialized techniques to permit DSS between systems not explicitly designed to do so. DSA and DSS raise numerous technical, regulatory, process, and operational issues regarding equipment spectrum certification and the assignment of spectrum to these systems for field testing, training, and operational use.

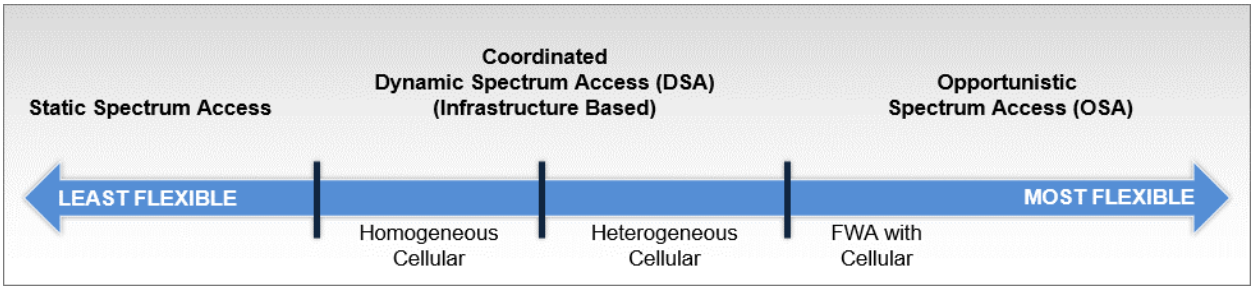

Figure 2: Spectrum Access Taxonomy

Opportunistic spectrum access ("OSA") is a distributed DSS enabling approach. OSA protocols and algorithms embody the concept of opportunistic use of unoccupied spectrum ("spectrum holes") with the basic tenet, "cause no harm." In this philosophy, a spectrum broker does not exist. These algorithms can be used to determine the best times at which to utilize available spectrum in a non-disruptive manner, but either require all users to adhere to the same wireless protocols or require secondary users to respect and cede access to primary users. Overall, DSS incorporates all aspects of operational and technical requirements of cognitive radios, interactions in cognitive networks, military radios and network technology, operational implementation, and the environmental challenges and issues.[71]

While modern RF systems can support dynamic spectrum assignments, mission and system design constraints often restrict the usable bands. Moreover, new DoD systems cannot necessarily be agile because of physical constraints. Thus, the impact of spectrum reallocation and co-existence with commercial systems must be carefully assessed to ensure that incumbent defense systems meet their critical performance requirements.

In addition, propagation characteristics differ greatly between bands creating variability in performance across the RF spectrum. Propagation is so impactful on performance of RF systems that band selection is often a primary consideration in the design of a system to meet performance requirements. For example, long range air surveillance radars operate within the L- (1-2 GHz) and S-bands (2-4 GHz), permitting reasonable array sizes and achievable power aperture products that meet stringent surveillance timelines with manageable propagation loss. These systems cannot be reallocated to other frequency bands without significant development or

[70] Lockheed Martin notes that the Commercial Mobile Radio Service also already utilizes components of DSA.
[71] *See* Pitor Gajewski and Marek Suchanski, *Dynamic Spectrum Management for Military Wireless Networks* (Sep. 1, 2010).

expense. Some legacy DoD systems may not be adaptable to support dynamic spectrum approaches.

Already, significant research has been written on the topics of DSA, DSS, real-time spectrum management ("RTSM"), and interference effects induced between communications and radiolocation systems.[72] This collection of various research efforts generated the following key conclusions:

1. Guaranteeing a completely interference free environment in all co-existence scenarios is difficult, challenged by ineffective regulations, faulty deployments, inadequate mitigation designs, flawed or failed construction, and/or co-opted operation.[73]

2. Interference is difficult to conclusively mitigate in bands where systems operate that do not account for co-existence. For example, the recent assessment by the Radio Technical Commission for Aeronautics ("RTCA") on the operational impacts of 5G operations in the 3.7-4.2 GHz range utilized by aircraft radar altimeters found a large array of feasible scenarios such as loss of situational awareness, controlled flight into terrain, and many other operational impacts ranging from major to catastrophic.[74] As this example highlights, any interference to DoD critical systems during a national security emergency requires a real-time method of promptly locating and removing such interference.

3. Incumbent military systems must have a method of securely communicating spectrum requirements without revealing sensitive mission parameters. This need presents a challenge under the constraints of single band resource planning.

The Defense Advanced Research Projects Agency ("DARPA") and other federal research agencies also completed multiple programs that focused on spectrum co-existence between DoD and commercial systems, including the Shared Spectrum Access for Radar and Communications ("SSPARC") program in which Lockheed Martin was a participant.

The more recent DARPA Spectrum Collaboration Challenge ("SC2") events competition revealed the value of full band DSS, enabled by collaborative intelligent radio networks. If a secure and effective real-time backchannel (such as SC2's CIRN interaction language) exists for collaboration, the spectrum efficiency of all parties can be greatly increased.[75] Promisingly, SC2 primarily focused on spectral and temporal agility while modern radar systems support orthogonal agility in spectral, temporal, spatial, coding, and polarization dimensions.

An ideal DSS system for DoD co-existence offers an opportunity to not only provide an economic benefit, but also improve Electro-Magnetic ("EM") battle management approaches for coalition and Joint communications and Electronic Warfare ("EW"). Such a system must:

1. Provide sharing mechanisms that can cope with malicious contention, both in terms of adversarial actions such as spoofing and jamming, as well as additional non-collaborative

[72] Andra Voicu, Ljiljana Simic, and Marina Petrova, *Survey of Spectrum Sharing for Inter-Technology Coexistance*, 2 IEEE Communications Surveys & Tutorials 2 (2019).
[73] *Supra* note 36.
[74] RTCA, *Assessment of C-Band Mobile Telecommunications Interference Impact on Low Range Radar Altimeter Operations* (2020).
[75] Alex Chiriyath, Bryan Paul, and Daniel Bliss, *Radar-Communications Convergence: Coexistence, Cooperation and Co-Design*, 3 IEEE Transactions on Cognitive Communications and Networking 1 (Mar. 2017).

interferers that the 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;

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 capability is essential to prevent adversary adaptive systems from determining the behavior of our defensive systems through machine learning techniques; and

7. Enable defense systems to use more of the spectrum than previously allocated during mission critical events (*e.g.*, by enabling increasingly agile DoD systems to leverage additional spectrum bands of commercial and unlicensed spectrum during emergencies (an expansion of the first responder models for national defense scenarios)).

2.3.2.1. Security Threats to a DSS System

Spectrum co-existence between critical national defense and commercial systems inherently introduces national security vulnerabilities. It is imperative to have a spectrum access management system that prevents commercial or secondary users from disrupting USG usage of the spectrum while ensuring commercial users have ample opportunity to use the spectrum (or more importantly, bandwidth) that they have licensed. Potential vulnerabilities of such a DSS infrastructure must be fully understood and carefully mitigated to minimize impact on national security.

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

1. USG Incumbent Users ("UIU"): USG users who have priority access to the 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 spectrum usage by USG assets, 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 an RTSM is a real-time assessment of spectrum resource assignments, which also serves as the basis for USG situational awareness.
4. Authorized Commercial Users ("ACU"): commercial users such as 5G gNodeB base stations that use the spectrum under the control of RTSM.

2.3.3. Enabling a Real Time Spectrum Management System

Once proven technically and commercially viable, to meet both DoD mission and commercial wireless operational requirements, RTSM likely needs to enable policy and regulatory changes within the existing statutory frameworks of the FCC and NTIA, including enhanced cooperation given the split jurisdiction of spectrum management in the U.S. In addition to investing in the technical and operational development of RTSM, Lockheed Martin recommends that part of that investment be focused on the regulatory components necessary to support it most effectively.

The RTSM approach is to ensure that both the DoD and the commercial operators have the functional equivalence of exclusive bandwidth through constant dynamic assignment of the bandwidth within a broader set of shared spectrum allocations. Thus, the regulatory cooperation across FCC and NTIA will be critical in terms of implementation of shared spectrum allocations, assignment/license conditions for access to such shared spectrum allocations, enforcement schemes. Specifically, Lockheed Martin anticipates that RTSM would require NTIA/FCC changes to the Table of Allocations through rulemakings, service rules conditions developed, and in the long term, FCC regulatory proceedings to consider how to permit RTSM-based access by federal agencies to commercial wireless spectrum.

RTSM operation should have no privacy implications as the dynamic assignment of available spectrum requires no commercial operator location operations or such information to be shared with the RTSM database. RTSM development would be predicated on 5G characteristics and network requirements (and be upgradeable for next generation wireless networks), requiring deep collaboration with the wireless carriers and OEMs. Given the lack of U.S. manufacturers of network infrastructure and the likely need for cleared technical personnel in the commercial wireless carriers, rules and processes governing technical data sharing regulations and processes should need review in this context. This is not unique to RTSM but is required going forward with any efficient spectrum sharing regimes.

An RTSM database would likely be best administered by the NTIA to address security concerns and interface with the FCC and its licensed commercial wireless industry. An RTSM database management function will need to be funded, and NTIA (or any other database manager) would need to recover the costs of administration, including human resources, and costs of technology upgrades for the systems as appropriate. NTIA does not have any statutory authority to collect fees for such a database from federal entities, let alone from commercial entities, directly or through the FCC. Other federal agencies have the requisite statutory authority to recover fees for "services" from non-federal entities, such as State Department for passport and visa functions.

It should be important for the commercial wireless community and other policy stakeholders to have confidence in both the concept and practicality of RTSM. Otherwise, RTSM would face the

challenge of regulatory policy intransigence to move from exclusive commercial wireless licenses in a fixed bandwidth to RTSM-based sharing with a minimum bandwidth (*e.g.*, 100 megahertz), due to a comfort level with the status quo. Yet, the long-term benefits in avoiding disruption to taxpayer funded national security infrastructure, coupled with the proof of concept, would likely offset the short-term lower auction revenue. RTSM could enable the U.S. to advance a spectrum co-existence solution that allows U.S. leadership in both 5G and defense technologies globally.

There would need to be significant regulatory review of spectrum regulations to remove any embedded barriers that could hinder the implementation of RTSM. Both the CSMAC and FCC's Technical Advisory Committee could be tasked to undertake such reviews, as appropriate.

3. Conclusion

Sufficient access to spectrum is critical to a wide range of stakeholders, from both the economy and national security perspective. Spectrum supports not only the functions of civil society as well as the needs of American consumers, but also federal, state, and local government operations and missions. A successful NSS will be a blueprint for global leadership in civil and national security technologies.

Further, the scarcity of spectrum today necessitates that the development and fielding of co-existence solutions is of paramount importance to the National Spectrum Strategy. Without these solutions, adding further spectrum to the pipeline will only exacerbate existing tensions between band incumbents and those seeking new access to the band. Co-existence solutions are particularly important in bands currently encumbered by critical national security systems, which are not readily relocatable and are purpose built to use a specific band based upon mission requirements and global harmonization.

Lockheed Martin thanks NTIA again for hosting two NSS listening sessions, in which Lockheed Martin participated, and for the opportunity to comment on the development of the National Spectrum Strategy and looks forward to working with NTIA on this most important issue for the Nation.