NTIA Implementation of the National Spectrum Strategy
Response to Notice of Opportunity for Public Input

LOCKHEED MARTIN CORPORATION

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PREPARED BY:
Lockheed Martin Corporation
2121 Crystal Drive
Suite 100
Arlington, VA 22202

For additional information:

Jennifer A. Warren
Vice President, Regulatory Affairs & Public Policy
Jennifer.Warren@lmco.com
571-435-7991

Ryan N. Terry
Director, Regulatory Strategy, Licensing & Policy

Andrew D. Farquharson
Regulatory and Public Policy Analyst

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1. Introduction

Lockheed Martin Corporation ("Lockheed Martin") appreciates the opportunity to submit this whitepaper in response to the National Telecommunications and Information Administration's ("NTIA") Notice of Opportunity for Public Input ("*Notice of Opportunity*"), *Implementation of the National Spectrum Strategy*.[1] Lockheed Martin has been an active contributor into NTIA's development process of the National Spectrum Strategy ("*NSS*"), having participated in both NTIA listening sessions,[2] submitted initial[3] and supplemental comments to the NSS Request for Comment ("*NSS RFC*"),[4] met with NTIA staff to further discuss its comments;[5] Lockheed Martin also attended the White House's release event of the *NSS*. Lockheed Martin has constantly emphasized that the U.S. spectrum governance regime and its underlying policies must be brought into the 21st Century – to enable a transition to the new spectrum environment, away from (i) the less viable approach of exclusive spectrum stovepipes for new allocations, and toward (ii) more expansive access models that support spectrum needs of new technologies, whether to advance Federal or non-Federal capabilities.

Technology innovation is generated from many industry sectors of the U.S. economy, to include aviation, space, defense, and transport in addition to telecom. This fact is evidenced by the broad array of participants in the comprehensive *NSS* feedback cycle. Such innovation also crucially enables and fuels U.S. technology leadership in a wide array of economic sectors. The implementation of the *NSS* should thus in turn seek to advance broad U.S. technology leadership by ensuring that spectrum access considerations go beyond the wireless sector, or any sub-sector.

For its part in the U.S. innovation ecosystem, Lockheed Martin is a global enterprise engaged in research, design, development, manufacture, and integration of advanced technologies, systems, products, and services; which are spectrum-dependent; for both government and commercial 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;[6] 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

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[1] NTIA, *Implementation of the National Spectrum Strategy*, Notice of Opportunity for Public Input (rel. Nov. 29, 2023), https://www.ntia.gov/sites/default/files/publications/ntia-nss-implementation-public-notice.pdf.

[2] Remarks of Lockheed Martin Vice President for Regulatory Affairs & Public Policy Jennifer Warren at Yates Auditorium NTIA NSS Listening Session (Mar. 30, 2023), https://www.ntia.gov/issues/national-spectrum-strategy/stakeholder-engagement/listening-sessions/march-30; Remarks of Lockheed Martin Director for Regulatory Strategy, Licensing & Policy Ryan Terry at University of Notre Dame NTIA NSS Listening Session (Apr. 11, 2023), https://www.ntia.gov/other-publication/2023/national-spectrum-strategy-listening-session-april-11.

[3] Comments of Lockheed Martin, Docket No. 230308-0068 (filed Apr. 17, 2023).

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

[5] *See* Lockheed Martin Summary of National Spectrum Strategy Meeting (May 22, 2023), https://www.ntia.gov/sites/default/files/2023-05/lockheed_martin_corporation_nss_meeting.pdf.

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

- 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.

These platforms and packages, whether operating on the ground, at sea, in the air, or in space, rely upon spectrum for connectivity; they are prime examples of next-generation technology systems and capabilities, advancing goals for secure, connected, high-tech platforms to share information across every domain. Technology innovation in this realm helps the U.S. leverage connected data from all potential sources, shrinking threat deterrence decision-making to seconds, rather than minutes. Likewise, Lockheed Martin has for decades been developing and delivering advanced autonomous systems to meet its customers' most demanding missions. Current research and development in uncrewed technologies is enabling systems to operate longer and succeed in harsh and dangerous conditions. Within these systems are communications elements that leverage artificial intelligence and advanced computing to help operators make more informed decisions. Further, Lockheed Martin is itself also working to leverage commercial 5G technologies into both terrestrial and non-terrestrial solutions that it is developing.[7]

The aerospace and defense ("A&D") industry broadly constitutes one of the top sources of U.S. exports annually,[8] contributing significantly to U.S. technological and economic leadership. Furthermore, the Defense Industrial Base ("DIB") is an important source of advanced technologies, reflected by the export control regime applicable for most A&D technologies, capabilities, and systems and technologies to appreciate how advanced they are considered globally.

Finally, Lockheed Martin's technology research, development, testing and evaluation ("RDT&E") and sustainment activity relies upon its and other sectors' ability to attract, train, and grow the current and next-generation spectrum workforce. It has taken several different initiatives to cultivate the availability of already skilled workers and to train incoming entrants into this workforce, to facilitate a key pillar of the *NSS*.

In sum, Lockheed Martin routinely works with NTIA and the Federal Communications Commission ("FCC"), and other spectrum stakeholders in government, academia, and the private sector, on important issues of spectrum engineering, policy, regulation, and governance. For a *NSS* to succeed – which Lockheed Martin believes is necessary – its implementation must move past the decades-old playbook where U.S. Government ("USG") 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.[9] A successful *NSS* will need to recognize that, while agencies have found ways in the past to accommodate their missions in a compressed

[7] *See, e.g.*, Lockheed Martin, Lockheed Martin and Verizon to Advance 5G Innovation for U.S. Dept. of Defense (accessed Dec. 4, 2023), https://news.lockheedmartin.com/lockheed-martin-verizon-advance-5G-innovation-us-deptartment-defense.

[8] *See* Aerospace Industries Association, Industry Impact: 2023 (accessed Dec. 14, 2023), https://www.aia-aerospace.org/industry-impact/.

[9] Remarks of NTIA Administrator David J. Redl at the TIA Policy Forum: Federal Spectrum Policy for the 5G Era (Jun. 21, 2018).

spectrum environment, "these opportunities are finite and will only become more so if the uni-directional sharing trend continues."[10]

Accordingly, and as in its initial comments to the *NSS RFC*,[11] Lockheed Martin urges NTIA to prioritize the development of coexistence approaches that effectively promote and enable the growth of U.S. national security, space, and other technologies and capabilities to retain our ability to innovate technologies that maximize deterrent effects. At a fundamental level, coexistence approaches that constrain the U.S.' ability to out-innovate in the national security environment must be discarded, in favor of the U.S.' ability to maintain its national security technology leadership – a leadership that extends beyond commercial mobile wireless services. An opportunity for U.S. technology leadership is in the development of true coexistence capabilities. Lockheed Martin offers several recommendations for consideration by NTIA on how the NSS implementation plan may achieve these important objectives.

2. National Spectrum Strategy Implementation

2.1 In General

2.1.1 "Coexistence" and "Sharing"

2.1.1.1 Implementation Recommendation: Coexistence and sharing must be clear objectives, distinct from outdated "relocation" approach.

Lockheed Martin applauds the emphasis in the *NSS* on sharing and co-existence, though notes these terms remain undefined and require greater characterization. Lockheed Martin is aware of certain instances where "sharing" and "coexistence" have, in other fora, been muddled. For example, Lockheed Martin is aware of some suggestions that DoD "share" the 3.1-3.45 GHz by "vacating" the 3.3-3.45 GHz in order to auction it for full-power mobile use. Despite this rebranding effort, it is immediately clear that this is a proposal to relocate, or compress, radar operations. Lockheed Martin therefore recommends that NTIA define the terms it is using in its forthcoming implementation plan to ensure that all stakeholders and NTIA are effectively communicating.

2.2 Pillar One: A Spectrum Pipeline to Ensure U.S. Leadership in Spectrum-Based Technologies

2.2.1 Strategic Objective 1.1: Ensure sufficient spectrum access to support Federal agency missions now and into the future

2.2.1.1 Implementation Recommendation: The spectrum pipeline should adhere to the NSS RFC's definition, to include examining non-Federal spectrum for reallocation.

In the *NSS RFC*, NTIA defined "spectrum pipeline" as "a process for identifying spectrum bands, regardless of allocation (*i.e.*, *both Federal and non-Federal*) [emphasis added] that should be studied for repurposing (*i.e.*, allowing new or additional uses) to meet future requirements for non-Federal and Federal use alike."[12] It correctly recognizes that Federal spectrum users, too, have evolving spectrum needs; however, it was therefore surprising, and a seeming disconnect, that the *NSS* "will not examine bands that were previously made available

[10] *Id*.
[11] Comments of Lockheed Martin at 2.
[12] *NSS RFC* at Fed. Reg. 16245.

for non-Federal use by the FCC…"[13] in its effort to create new sharing opportunities. As the terms "spectrum pipeline" and "sharing" are noticeably absent from Pillar Two and the related strategic objectives, it is wholly unclear whether the *NSS*' implementation is to focus perpetually on the "traditional" repurposing of Federal bands exclusively. Further, the *NSS* never rescopes itself such that the exploration of sharing opportunities would explicitly apply to both Federal and non-Federal bands at any future point – in either Pillar One or Two.

The *NSS*' implementation must recognize that technology innovation occurs, and needs to be able to continue to occur, in the A&D industry. Our spectrum demands include innovating effectively to meet the requirements set forth in the 2022 National Security Strategy.[14] As NTIA OSM staff has seen through its spectrum work in partnership with Federal agencies, modern national security systems have wider bandwidth needs than older systems. Therefore, next-generation defense capabilities can often require access to greater swaths of spectrum. The spectrum pipeline cannot and should not focus, therefore, on exclusively reallocating Federal spectrum – this would not further the above strategic objective. Having sufficient spectrum access is driven by the need to ensure that Federal agencies can adopt more sophisticated technology capabilities to meet their evolving mission requirements.

2.2.1.2 Implementation Recommendation: The NSS must be implemented equitably for Federal and non-Federal users.

The *NSS* must be implemented with equal emphasis on sufficient access for both Federal and non-Federal users of spectrum. While Strategic Objective 1.1 dedicates a full two paragraphs of text to considerations as to how Federal agencies must identify requirements to justify additional spectrum access,[15] Strategic Objective 1.2 (*Ensure spectrum resources are available to support private sector innovation now and into the future*) does not make a single reference to implementing a similar vetting process for expanding non-Federal access to new or additional spectrum bands. Indeed, the current U.S. spectrum governance regime appears to place even more scrutiny on agency claims regarding the need for continued access to their *existing* spectrum allocations than on non-Federal entities making assertions as to their need for *new* spectrum allocations, let alone in national security bands. This disparity is contrary to national spectrum priorities; in short, any process established to assess spectrum access needs must be equitably applied to the one or the other other category of Federal and non-Federal users. An example of an equitable application within the above-mentioned criteria for Federal spectrum would result in at least two criteria being useful in consideration of non-Federal spectrum demands: (i) assessing spectrum resources allocated to support a particular agency's current and future spectrum-dependent operations, and (ii) the potential for improved efficiency and mission effectiveness through new technology developments and coexistence techniques.

With respect to (i), the NTIA and FCC should assess whether spectrum resources currently allocated to non-Federal users are better suited to support non-Federal operations than Federal bands. For instance, the NTIA and FCC should assess whether non-Federal bands housing obsolete commercial technologies could more readily be used to facilitate 5G and 6G deployments, as opposed to bands currently supporting critical national security missions that

[13] The White House, *NSS* at 3 n.1 (rel. Nov. 13, 2023), https://www.ntia.gov/sites/default/files/publications/national_spectrum_strategy_final.pdf.
[14] The White House, National Security Strategy (rel. Oct. 12, 2022).
[15] *NSS* at 4.

would take decades and cost "more than $250 billion" to relocate[16] – 5G technologies are relatively "agnostic to the frequency bands that it uses,"[17] being able to be deployed in any of the several bands identified by 3GPP as technically feasible.

On (ii), expanding spectrum access into new bands should focus on coexistence, as opposed to requiring Federal incumbents to compress or shift their operating bands (which may not even be possible). Despite already developing *sixth* (6G) generation mobile wireless technology, wireless manufacturers do not yet appear to be designing systems for operational coexistence with other users, even though the industry continues to target for 5G/6G standardization the frequency bands identified for national security uses here and in other allied nations. The current spectrum governance model does not seem to incentivize such design goals, but rather reinforces assumptions that NTIA and FCC will simply continue to require Federal incumbents to "make room." Unless both Federal *and* non-Federal users are both incentivized to prioritize coexistence, Federal policymakers will continue to face pressure to force USG systems to cease operating as designed to meet their defined national security missions, in favor of high power, mobile wireless systems.

Further, the *NSS'* implementation should not solely burden Federal agencies with the obligation to modify their operations in order to accommodate access for non-Federal entrants into a band. Using the 3.1-3.45 GHz, for example, DoD (and the DIB's) operations should not be singled out for modification; the commercial mobile wireless industry must also be required to undertake operational modifications to achieve coexistence. Put differently, investment in coexistence technologies, such as dynamic spectrum sharing, should be required by all parties – and especially by proponents of reallocations.

2.2.2 Strategic Objective 1.2: Ensure spectrum resources are available to support private sector innovation now and into the future.

2.2.2.1 Implementation Recommendation: Any future protections provided to Federal facilities must also be provided for supporting contractor facilities.

The *NSS* cites the 3450-3550 MHz as one example of how Federal users have contributed to efforts to increase spectrum efficiency and effectiveness and improve access to spectrum resources for both Federal and non-Federal users.[18] Reallocation of the 3450-3550 MHz highlights an important consideration that cannot again be overlooked during spectrum planning decision-making: ensuring private sector entities that are the manufacturing supply chain for the Federal systems, platforms, and capabilities (such as the DIB) are afforded the same protections as the Federal users themselves.

In the context of 3450-3550 MHz, the USG rightly protected the DoD operational capabilities through the establishment of Cooperative Planning Areas ("CPA") and Periodic Use Areas ("PUA"). However, the need to extend those protections to DoD contractor facilities responsible for a significant portion of the RDT&E and sustainment activities for DoD systems was not fully understood in the hasty development of the CPA/PUA scheme. The role of these

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[16] *See e.g.*, Jason Sherman, "DoD's prized mid-band spectrum to be protected from 'carte blanche' auction, lawmaker says", Inside Defense (Sep. 15, 2023). https://insidedefense.com/share/219076.
[17] S.P. Kochhar, "Bridging the spectrum gap: The crucial role of mid-bands in 5G & beyond", ET Telecom (Nov. 29, 2023), https://telecom.economictimes.indiatimes.com/blog/bridging-the-spectrum-gap-the-crucial-role-of-mid-bands-in-5g-beyond/105589825.
[18] *NSS* at 5.

contractor facilities is so significant that NTIA asserted this view in a written communication to the FCC regarding continued contractor operations in the band.[19] The FCC agreed the public interest would be seriously prejudiced by the extraordinary risk of disrupting a critical national security supply chain of AN/TPQ-53 radars and U.S. technological leadership in the national security sector.[20]

Furthermore, DoD contractor facilities represent massive fixed-capital investment and cannot easily or realistically be relocated to CPAs or PUAs. Federal test ranges have limited to no schedule capacity to accommodate additional contractor RDT&E activities that would be displaced from DoD contractor sites that have been significantly expanded to accommodate demanding test schedules, and do not have the specialized test facilities required for the development of leading-edge technologies. Additionally, contractor test facilities, such as Syracuse, NY, have highly skilled personnel, unique to support program operations.

Accordingly, Federal contractor facilities must be afforded the same protections as the Federal agencies they support. Otherwise, Strategic Objective 1.2 would fail to ensure the availability of spectrum resources for the DIB – a national security-critical sector of the economy.

2.2.2.2 Implementation Recommendation: No restudy of the 3.1-3.45 GHz.

The *NSS* notes that "additional studies" of the 3.1-3.45 GHz "will explore dynamic spectrum sharing and other opportunities for private-sector access in the band, while ensuring DoD and other Federal mission capabilities are preserved, with any necessary changes."[21] Some have interpreted this statement as meaning that there will be a restudy of the 3.1-3.45 GHz. For example, CTIA has interpreted the *NSS* as directing a "re-study [of] all options for future full-power commercial access to the lower 3 GHz band."[22]

NTIA was a participant, and ultimate co-leader, in the Partnering to Advance Trusted and Holistic Spectrum Solutions ("PATHSS") Task Group, and, thus, is fully aware that the DoD has recently completed its Emerging Mid-Band Radar Spectrum Sharing ("EMBRSS") report. This statutorily-mandated, nearly two-year-long study, importantly included wireless and radar OEMs, a range of wireless providers, academia, and government participants; it culminated in a reported 1,200 page study, submitted to the Secretary of Commerce. The PATHSS stakeholder review of the the draft EMBRSS report clearly answered the question on sharing between full-power 5G services and DoD systems in the 3.1-3.45 GHz band. Lockheed Martin looks forward to the public release of the unclassified summary of the report's findings, so as to allow a greater

[19] Letter of Charles Cooper, Associate Administrator, NTIA, to Ronald Repasi, Acting Chief, Office of Engineering and Technology and Joel Taubenblatt, Acting Chief, Wireless Telecommunications Bureau, FCC (Feb. 19, 2021) ("There are several radar manufacturing and integration facilities which require access to the 3450-3550 MHz band to perform experimentation and testing for radionavigation and other systems contracted for by federal agencies… It is critical that these facilities retain access to the spectrum for this testing and experimentation so federal agencies' contracting requirements will be fulfilled.").

[20] FCC, *Lockheed Martin Request for Part 90 Special Temporary Authority to Operate Two Radiolocation Service Sites in the 3.45 GHz Band* at ¶¶ 15-20, ULS File No. 0009581172 Order (rel. Jun. 16, 2021).

[21] *NSS* at 6.

[22] CTIA President & CEO Meredith Attwell Baker, CTIA Statement on White House National Spectrum Strategy (Nov. 13, 2023), https://www.ctia.org/news/ctia-statement-on-white-house-national-spectrum-strategy.

focus on where there may be some long-term sharing potential with a CBRS-like, or lower-power, licensed wireless use framework.

Most recently, at the World Radiocommunication Conference 2023 ("WRC-23"), the global community took the decision not to include the 3.1-3.3 GHz band in future bands for study for 5G/6G (*or*, International Mobile Telecommunications ("IMT"), *i.e.*, mobile wireless) at WRC-27. Lockheed Martin believes that this decision reflects that the 3.1-3.45 GHz band is too important to give up on, from the perspective of national security capabilities. These are further discussed below.

2.2.2.3 Implementation Recommendation: The EMBRSS report must be the basis for any action opening the 3.1-3.45 GHz to non-Federal use.

To ensure an efficient and timely approach to any further coexistence analysis in the 3.1-3.45 GHz band, NTIA should use the recommendations of the EMBRSS report as a starting point. As NTIA knows, the PATHSS Task Group spent nearly two years on the EMBRSS study, to include direct input from a breadth of non-Federal participants. Ignoring the EMBRSS study and selecting a new starting point would result in the unnecessary expenditure of additional Federal and non-Federal scarce resources, in addition to undermining the legitimacy of (i) the statutorily-mandated EMBRSS report, (ii) Pillar Two's desire to "facilitate robust and regular dialogue and interchanges of data, building trust and transparency among all stakeholders,"[23] and (iii) the U.S.' spectrum governance institutions and processes more generally. Lockheed Martin expects that the public release of an unclassified summary would help to reduce the burdensome information asymmetry that presently exists.

2.2.2.4 Implementation Recommendation: DoD must retain primary status across the 3.1-3.45 GHz band.

Lockheed Martin remains deeply concerned that the *NSS* is setting the stage for the NTIA to deprioritize radar systems in this band, by removing or changing its primary allocation status across the 3.1-3.45 GHz band. The inclusion of language referencing "other opportunities for private-sector access in the band" and "with any necessary changes" leaves open such a possibility,[24] and, more directly, the NTIA Administrator testified similarly, stating that additional studies would explore whether DoD's radar systems could be relocated.[25] Such a loss of spectrum would seriously place at risk current and planned S-band radar capabilities and solutions; furthermore, myriad authoritative public statements have been made regarding the criticality of the 3.1-3.45 GHz for DoD and the U.S.' national security.[26]

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[23] *NSS* at 9.
[24] *NSS* at 6.
[25] *Supra* note 22.
[26] *See e.g.*, Remarks of Sen. Mike Rounds at Senate Armed Services Committee nomination hearing (Sep. 14, 2023), https://www.navy.mil/Press-Office/Testimony/display-testimony/Article/3526404/senate-armed-services-committee-holds-nomination-hearing/; Testimony of Secretary of Defense Lloyd Austin at Senate Armed Services Committee budget hearing (Mar. 28, 2023), https://www.armed-services.senate.gov/hearings/to-receive-testimony-on-the-department-of-defense-budget-request-for-fiscal-year-2024-and-the-future-years-defense-program; Testimony of Chairman of the Joint Chiefs of Staff General Mark Milley at Senate Armed Services Committee budget hearing (Mar. 28, 2023); Testimony of DoD Chief Information Officer John Sherman at House Armed Services Committee Subcommittee on Cyber, Innovative Technologies and Information Systems hearing (Mar. 9, 2023), https://democrats-armedservices.house.gov/_cache/files/3/e/3e79fc77-4361-4d4a-9d42-

As one of several U.S. S-band radar manufacturers, Lockheed Martin highlights that the 3.1-3.45 GHz band was not arbitrarily chosen as the band in which DoD would operate systems for detecting intercontinental ballistic missiles with multiple warheads, decoys, and jammers traveling at 15,000 MPH, maneuvering hypersonics at +7,500 MPH, or dozens of other threats – in fact, its characteristics make it uniquely suited for these missions. The band is also particularly critical to national security operations given its ability to permit radar systems to pinpoint threats at very long distances with great accuracy in any weather conditions – essential especially to maritime operations. The fact that this band has been one of several national security bands targeted by foreign-led international industry standards groups should be taken into account when disrupting national security operations, particularly given expressed concerns by wireless organizations over the very same foreign leadership.[27]

Further, any outcome which displaces radars from the band would also appear at odds with the President's memo on the *NSS*,[28] which directs that a pipeline "support commercial innovation and *agencies' needs* [emphasis added] now and into the future."[29] The DoD has made it overwhelmingly clear that it needs to retain access to the band for today and its future capabilities.[30]

2.2.2.5 Implementation Recommendation: NTIA should focus on exploring a low-power sharing regime in the lower 3 GHz.

Lockheed Martin was an active participant in the development of the EMBRSS report, and thus believes based on the analyses it has both conducted and reviewed from other sources that, under certain circumstances, Federal and non-Federal coexistence within the lower 3 GHz *may* be possible with *low-power* 5G/NextG systems; such an outcome will clearly require future investment by the commercial mobile wireless industry. One such model, the Citizens' Broadband Radio Service ("CBRS"), is already operational in the 3.5 GHz band (3550-3700 MHz). The CBRS model is an important example of an initial framework that was designed to foster spectrum coexistence. Discussions with various stakeholders suggest that it would benefit from greater incumbent flexibility to adopt technological innovations to serve their missions, as the CBRS model's benefits currently flow more heavily in the direction of the new mobile

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4b609d53efca/552FBCFA3E308A583E86767F33AED773.sherman-testimony.pdf; Testimony of Assistant Secretary of Defense for Space Policy Dr. John Plumb at House Armed Services Strategic Forces Subcommittee hearing (Mar. 8, 2023), https://armedservices.house.gov/hearings/strategic-forces-subcommittee-hearing-fy24-strategic-forces-posture; Testimony of United States Northern Command and North American Aerospace Defense Command Commander General Glen VanHerck (Mar. 23, 2023), https://www.armed-services.senate.gov/hearings/to-receive-testimony-on-the-posture-of-united-states-northern-command-and-united-states-southern-command-in-review-of-the-defense-authorization-request-for-fiscal-year-2024-and-the-future-years-defense-program; and Testimony of Chief of Naval Operations Admiral Lisa Franchetti at Senate Armed Services Committee nomination hearing (Sep. 14, 2023).

[27] *E*.g., Comments of CTIA at Yates Auditorium NTIA NSS Listening Session; CTIA, White Paper Response: Next-Generation Electromagnetic Spectrum Strategic Roadmap RFI (Feb. 17, 2023), https://api.ctia.org/wp-content/uploads/2023/02/230217-CTIA-White-Paper-on-DoD-Strategic-Spectrum-Roadmap-RFI.pdf.

[28] Memorandum on Modernizing United States Spectrum Policy and Establishing a National Spectrum Strategy (Nov. 13, 2023), https://www.whitehouse.gov/briefing-room/presidential-actions/2023/11/13/memorandum-on-modernizing-united-states-spectrum-policy-and-establishing-a-national-spectrum-strategy/.

[29] *Id*. at Sec. 3(a).

[30] *Supra* note 27.

wireless entrants. There is ample opportunity for all parties to benefit from the evolution of the current CBRS model into the next generation of a spectrum coexistence framework.[31]

Lockheed Martin is not alone in its support of the further exploration of a next generation CBRS-like coexistence model; there exists a diverse ecosystem of companies, nonprofits, and industry groups supportive of this arrangement for sharing.[32] Not only does NTIA consider CBRS a success,[33] low-power sharing is making significant progress in closing the digital divide: 70% of all active (CBRS) devices are deployed in rural census blocks;[34] and the CBRS networks of the City of Las Vegas,[35] the New York Public Library,[36] and the Fresno Unified School District[37] are further helping to close the digital divide in heavily populated metropolitan regions – regions serviced by commercial mobile wireless carriers. Further, 45% of all CBRS devices are deployed in counties where spectrum is shared with DoD,[38] highlighting low-power 5G's ability to coexist with DoD. Notably, the aforementioned counties have a total aggregate population of over 232 million,[39] representing a significant portion of the U.S. public.

Lockheed Martin does note, however, this implementation recommendation must still be viewed through the lens of Sec. 90008(b)(2) of the Infrastructure Investment and Jobs Act ("IIJA"), which is explicit in that frequencies within the 3.1-3.45 GHz band can only be identified for sharing subject to determination by the Secretary of Defense that sharing such frequencies would not impact the primary mission of military users. Unless and until the Secretary of Defense has made this determination, no sharing regime, low-power or otherwise, should go forward in the 3.1-3.45 GHz band.

2.2.2.6 Implementation Recommendation: NTIA should conduct thorough study of the 7/8 GHz band for potential impacts on Federal users.

Lockheed Martin notes that the *NSS* also identifies the 7125-8400 MHz band and rightly identifies that "a variety of mission-critical Federal operations in this band" exist, which "…will make it challenging to repurpose portions of the band while protecting incumbent users from

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[31] On December 19, the Commerce Department's Spectrum Management Advisory Committee (CSMAC) adopted a final report in response to questions from NTIA on the implementation and future of a CBRS framework in other bands. *See* Commerce Spectrum Management Advisory Committee Report of Subcommittee on CBRS (rel. Dec. 19, 2023). The report recommended that there be the creation of "a process with all federal, commercial, NTIA, and FCC stakeholders to drive timely improvements to rules, operational settings, and standards as applicable. This process could inform the soon-to-be-created Interagency Spectrum Advisory Council as mentioned in NTIA's National Spectrum Strategy" (at 18).

[32] *E.g.*, the Spectrum Future coalition, https://spectrumfuture.com/.

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

[34] *Id.*

[35] OnGo Alliance, How Las Vegas Used CBRS to Bridge the Digital Divide (Sep. 16, 2021), https://ongoalliance.org/how-las-vegas-used-cbrs-to-bridge-the-digital-divide/.

[36] Comments of Philip Neufeld, Executive Office, Information Technology, Fresno Unified School District at New America Future of Private Networks event (Oct. 31, 2023), https://www.newamerica.org/oti/events/the-future-of-private-networks/.

[37] Comments of Garfield Swaby, Vice President of Information Technology, New York Public Library at New America Future of Private Networks event (Oct. 31, 2023).

[38] *Supra* note 33.

[39] *Id.*

harmful interference."[40] In addition to concerns about potential disruption to Federal uses of the band stemming from any domestic decision, allied nations expressed significant concerns at WRC-23 about the frequency range even being included in the few bands for study for IMT under a WRC-27 agenda item, noting wireless uses had extremely little potential for success in gaining spectrum access in this band. These concerns reinforce the need to assess potential impacts of the U.S. de-harmonizing existing internationally-harmonized uses of spectrum by the U.S. and its allied partners.

Lockheed Martin thus urges NTIA to implement a comprehensive coexistence study and technical feasibility assessment process, co-led by relevant Federal stakeholders, *in advance of* any decision to introduce mobile wireless use, whether on a licensed or unlicensed basis as the *NSS* identifies as being possible; in particular, Lockheed Martin also urges the NTIA to draw from the lessons learned from the narrow assessment process applied to the 3.1-3.45 GHz band (coupled with resultant challenges in the 3.45-3.55 GHz band).

2.3 Pillar Two: Collaborative Long-Term Planning to Support the Nation's Evolving Spectrum Needs

2.3.1 Strategic Objective 2.1: Establish a persistent strategic planning process guided by the best available data and science.

2.3.1.1 Implementation Recommendation: The spectrum planning process should follow an IIJA-type process for any band with a Federal primary use.

Any Federal bands identified for study and possible inclusion in the spectrum pipeline, both for Pillar One and Two, should follow a process similar to the IIJA's Sec. 90008 for the 3.1-3.45 GHz band. Lockheed Martin strongly believes the IIJA process is successful, given the: (i) strong Government, industry, and academic participation in developing the EMBRSS report; (ii) ability to provide certain classified information to commercial participants via PATHSS-C (the classified component of PATHSS); and (iii) thoroughness of the report (as last seen by PATHSS' non-Federal participants). Further, as the process has actually been utilized, it could likely be replicated with minimal new effort – there is no need to reinvent the wheel.

There have been some claims that Sec. 90008 process was a deviation from U.S. spectrum policy. Lockheed Martin disagrees. When Congress passed and the President signed into law the IIJA, Sec. 90008 became *part of U.S. spectrum* policy, not a deviation from it. Furthermore, Lockheed Martin understands that modernization of spectrum governance will require adjustments from all stakeholders used to the *status quo*, but it also recognizes that the *status quo* is not likely an adequate or viable approach in a spectrum environment where the precedent of exclusive stovepipes is needing to be reconsidered, due primarily to the spectrum demands signals from the traditional mobile wireless industry.

Moreover, there exists a wide array of non-Federal stakeholders who adhere to the Sec. 90008 process and the opportunity here presented to reimagine a modernized domestic spectrum governance policy – for example, the U.S. leaning in on new spectrum access models, such as low-power, licensed mobile networks, with the potential capability of true coexistence with Federal incumbents, on a band-by-band basis.[41] Sec. 90008 represents the very type of 21st

[40] *NSS* at 6.
[41] *See e.g., supra* note 32.

Century spectrum governance reform needed in the U.S., one that prioritizes coexistence and is backed by science and data.

Further, any study of a Federally-encumbered band should create incentives for co-existence, by focusing first on opportunities for coexistence – as opposed to simply defaulting to relocation (or "compression"). The technical work must be done, to determine whether co-existence or any other spectrum access model has a negative impact on the agency's concept of operations ("CONOPS"). Even as Sec. 90008 was narrowly tailored to address the role of DoD, it is recommended that the study process initiated under a Sec. 90008-like regime be expanded in scope such that a required study process be co-led by the primarily impacted Federal agency and NTIA, and that it include all of the relevant industry stakeholders. In addition, similar to Sec. 90008, the head of the primary impacted federal agency should be required to certify that such action would not adversely impact the agency's mission.

An IIJA-type process, with co-lead status, would best ensure that the technical and CONOPS expertise of the primary impacted agency is both fully incorporated into the study process and into the eventual outcome of the studies that result from the effort. While the FCC and NTIA work to regulate domestic spectrum effectively, the operating federal agencies work to ensure that their critical missions are enabled by the necessary spectrum bands and bandwidth for operations; concurrently, the A&D prime contractors build new capabilities in those spectrum bands to meet requirements and potentially support other demands from around the world, and in that process bring their own set of technical knowledge. In short, DoD possesses the expertise as to its mission needs and use cases. These unique knowledge attributes can be extended to NASA, NOAA, and beyond – and must be relied upon.

2.3.1.2 Implementation Recommendation: The spectrum planning process must also consider both economic and national security impacts of de-harmonization of spectrum.

Spectrum decisions impact more than just arrangements for spectrum use; they may also have unintended, and unwelcome, impacts on operations with and by international partners and allies, as well as foreign military sales. Accordingly, it is recommended that any decisions stemming from the *NSS* take appropriate stock of and recognize possible global impacts of de-harmonizing otherwise harmonized national security related bands – to U.S. partners and allies – as well as the economic impact on U.S. exports. As NTIA experienced at WRC-23, national security and other critical systems have been designed to depend on the availability of internationally-harmonized spectrum bands and coordinated capabilities. Lockheed Martin recognizes that NTIA is not likely the primary Executive Branch agency responsible for identifying which existing treaties and other bilateral/multi-lateral agreements should be taken into consideration concerning these operations; thus, it recommends that NTIA expand its international considerations to such factors.

At WRC-23, U.S. partners and allies expressed serious concerns regarding the U.S. proposal to study 5G/6G (or IMT) in the 3.1-3.3 GHz band, as well as the 7/8 GHz and 15 GHz bands (the latter two were ultimately included in the future WRC-27 agenda item). And while U.S. allies publicly expressed serious concerns about these globally harmonized, and coordinated, national security bands being proposed for study, the U.S. remained silent. It is unclear how the U.S. Government plans to reconcile these considerations through the *NSS*, but Lockheed Martin urges the U.S. to do so, particularly if the targeting of national security bands for 5G/6G standards continues.

2.3.2 Strategic Objective 2.2: Develop and document an evidence-based national spectrum decision-making methodology.

2.3.2.1 Implementation Recommendation: Any value-based framework must be grounded in pragmatism and validated data.

As the *NSS* intends to "develop models that use a value-based framework to assess the potential impacts of spectrum reallocation options,"[42] Lockheed Martin strongly recommends that any such framework validate the proposed inputs that NTIA will rely upon to inform that framework. Put differently, it is not enough for *NSS* implementation to be grounded in data – the data must be realistic and from relevant and validated sources.

Non-Federal entities are often highly optimistic on the value proposition to U.S. key policy objectives, such as bridging the digital divide and providing rural connectivity when seeking additional spectrum. Yet, it appears financial grant programs and alternative funding mechanisms make the difference, more than additional spectrum allocations:[43]

> The next generation of mobile technology is presented to consumers and regulators alike with slick branding and chart after chart of sharp, upward slopes. 5G, for example, was projected to create some four million jobs, add more than $1.5 trillion to US Gross Domestic Product (GDP), close the digital divide, and unlock a sci-fi future of smart cities, autonomous vehicles, and ill-defined "killer apps."

The broader FTI assessment reinforces that, when calculating the "societal value"[44] of spectrum, the inputs must be appropriately scrutinized.

Further, data as presented may not always tell the full story. For instance, the *NSS* states that, "[a]ccording to one estimate, data traffic on macro cellular networks is expected to increase by over 250 percent in the next 5 years, and over 500 percent in the next 10 years."[45] What this statistic does not, however, reveal is that industry data also show that video streaming, largely from social media sites, constitutes the majority of all global mobile network traffic – a figure of 71% in 2022 that is expected to reach 80% by 2028.[46] Further, when combined, social networking and video streaming are forecasted to constitute 87% of all global mobile network traffic in the next 5 years.[47] This breakdown of the global data should be relevant to policymakers when faced with making decisions on demands for reallocation and exclusive access to spectrum supporting national security operations.

Spectrum allocations are not easily reversable, and our Nation's scarce spectrum resources must be allocated based on validated and complete data – whether classified or commercial.

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[42] *NSS* at 11.
[43] FTI, Next Generation Dreams (Oct. 25, 2023), https://freedomtechnologiesinc.com/next-generation-dreams/.
[44] *Supra* note 42.
[45] *NSS* at 4.
[46] Ericsson, Video Traffic Update (accessed Dec. 5, 2023), https://www.ericsson.com/en/reports-and-papers/mobility-report/dataforecasts/traffic-by-application.
[47] *Id.*

2.4 Pillar Three: Unprecedented Spectrum Innovation, Access, and Management through Technology Development

2.4.1 Strategic Objective 3.1: Improve spectrum efficiency and bolster coexistence by facilitating investments in new and emerging technologies.

2.4.1.1 Implementation Recommendation: Dynamic spectrum sharing capabilities should serve as a discriminator when making spectrum allocation decisions.

2.4.1.1.1 In General

In light of the congestion of today's spectrum environment and the *NSS*' recognition of the importance of dynamic spectrum sharing ("DSS") – which Lockheed Martin applauds – Lockheed Martin encourages NTIA to explore serious incentives for commercial investment in DSS.

For example, if the NTIA and FCC were to agree to reallocate spectrum encumbered by the DoD via auction, they should adopt bidding rules that requires bidders to deploy proven DSS solutions capable of detecting use of the band by DoD and Federal contractors supporting DoD and ensuring commercial operations do not constrain those operations; this could be done either as a qualification criteria for bidding or within a clearly defined post-auction timeframe. Such an approach would incentivize non-Federal entities to invest and deploy DSS technologies.

2.4.1.1.2 DSS and DoD

An ideal DSS system for DoD coexistence offers an opportunity to not only provide economic benefits, 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 interferers that native systems were not designed to address (*e.g.*, military heterogeneous networks);
2. Provision for mechanisms to handle failure modes of commercial equipment during operation, as well as improper and malicious deployments. Such mechanisms should include real-time direction finding and geolocation;
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)).

Spectrum coexistence between critical national defense and commercial systems inherently introduces national security vulnerabilities. It is imperative that spectrum access management systems prevent commercial or secondary users from disrupting USG operations in the spectrum while ensuring commercial users have the opportunity to use their licensed spectrum (or more importantly, bandwidth). Potential vulnerabilities of such a DSS infrastructure must be fully understood and carefully mitigated to minimize impacts to national security.

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

2.4.1.1.3 RTSM

Once proven technically and commercially viable, to meet both DoD mission and commercial wireless operational requirements, Real-Time Spectrum Management 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, the regulatory components necessary to support it most effectively must also be considered.

The RTSM approach ensures that both the DoD and non-Federal operators have the functional equivalence of exclusive bandwidth through constant dynamic assignment of the bandwidth within a broader set of shared spectrum allocations. Thus, regulatory cooperation

across FCC and NTIA will be critical in terms of implementation of shared spectrum allocations, license conditions for access to such shared spectrum allocations, and enforcement schemes. Specifically, Lockheed Martin anticipates that RTSM would require 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 should be reviewed 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 the commercial mobile 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 the Department of State 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 MHz), 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 short-term lower auction revenues. RTSM could enable the U.S. to advance a spectrum coexistence solution that allows U.S. leadership in both 5G and defense technologies globally.

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

2.4.2 Strategic Objective 3.2: Commit to improving collective understanding of the electromagnetic spectrum through coordinated, focused, and sophisticated research and development.

2.4.2.1 Implementation Recommendation: General recommendations

Lockheed Martin recommends that the research and development ("R&D") plan explore both passive and active approaches to dynamic spectrum utilization, and be aligned to specific

use cases. This would allow for the holistic exploration of dynamic spectrum solutions while ensuring that R&D is grounded in real-world uses. Further, and with respect to artificial intelligence/machine learning and advanced radar technologies, xApp development focused on dynamic spectrum allocations predicated upon sensor data input should also be explored.

2.4.3 Strategic Objective 3.3: Pursue spectrum policies that maximize flexible use of spectrum, accommodate new and innovative technologies, and identify opportunities to expand spectrum access.

2.4.3.1 Implementation Recommendation: Changes to the Spectrum Relocation Fund

Lockheed Martin is encouraged by the *NSS'* recognition that spectrum policy must "respect current spectrum users, ensuring incumbents are protected from harmful interference and avoiding risks to national security, public safety, scientific research, or commercial operations," and further, the potential enabling role of the Spectrum Relocation Fund ("SRF").[48]

Created in 2004, the SRF provides a centralized and relatively streamlined funding mechanism through which Federal agencies can recover costs associated with relocation of their radiocommunications systems, or coexistence in reallocated spectrum. For DoD especially, the SRF is vital; for the 1755-1780 MHz band alone, the U.S. Navy estimates that relocation will take more than a decade and cost over $16 billion.[49] The SRF is currently funded by the spectrum auctions for the given band that would require Federal incumbents to either relocate or coexist with the auction winners – creating an unfortunate dependence on spectrum auctions for funding, which the *NSS* should explore how to break.

To date, the SRF has been interpreted in ways limiting its ability 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 system upgrades, but rather just replacement of technology. This not only disincentivizes the level of effort necessary for coexistence, 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 behind.

Section 928(g)(2) of the Communications Act currently provides for transfers from the SRF to eligible Federal agencies for pre-auction R&D, 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.

The USG should seek 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 in specific bands; (2) providing agencies with the ability to retain transition funds for a current or future transition

[48] *NSS* at 17.
[49] 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.

plan; (3) allowing agencies to fund contractors via 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 coexistence among Federal and non-Federal systems. Furthermore, amendments to the SRF permitting 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 coexistence techniques could be built into system designs.

2.5 Pillar Four: Expanded Expertise and Elevated National Awareness

2.5.1 Strategic Objective 4.1: Attract, train, and grow the current and next-generation spectrum workforce.

2.5.1.1 Implementation Recommendation: The USG should consider how to leverage the National Space Council's Workforce Initiative.

The *NSS* is correct in stating that "modernizing the spectrum workforce and preparing for the future is essential to foster innovation and to keep up with technological advancements, meet the growing demand for spectrum access, navigate our complex policy landscape, and maintain the Nation's continued economic growth." The *NSS* could seek to leverage the National Space Council's ("NSpC") Workforce Initiative for the National Spectrum Workforce Plan. The Interagency Roadmap to Support Space-Related STEM Education and Workforce[50] provides a solid basis for such an effort.

Under the NSpC Workforce Initiative, Lockheed Martin has worked with the State of Florida's Space Florida and industry peers to inform the state's Master Credential List and establish a "Space Academy" menu of training opportunities for educational partners and students. These concepts could similarly be incorporated into the *NSS*' Workforce Plan. Working to inform the Master Credential List would help to raise the visibility of critically-needed skillsets within the U.S. spectrum workforce, and a "Spectrum Academy" would improve ease of access to the necessary related training opportunities.

There are additionally a number of concepts Lockheed Martin has implemented for the NSpC Workforce Initiative with applicability here:

> **Engage Talent Earlier:** High school career and technical education ("CTE") programs would ensure that high school students are equipped with skills the spectrum ecosystem could use right now.

[50] Office of Science and Technology Policy, Interagency Roadmap to Support Space-Related STEM Education and Workforce (Sep. 2022), https://www.whitehouse.gov/wp-content/uploads/2022/09/09-2022-Interagency-Roadmap-to-Support-Space-Related-STEM-Education-and-Workforce.pdf.

Inform CTE Curricula: Industry should eliminate the guesswork by working with education providers to inform CTE curricula, ensuring that curricula match with industry needs.

Raise Awareness of Opportunities: Most students likely have no idea how many paths to careers in the spectrum ecosystem there are – many assume unless they're an engineer, there's no place for them.

Identify New Instructors and Leaders: The NSS should promote the identification of the next generation of spectrum leaders, in all relevant fields: engineering, technicians, policymaking, etc.

Pathways for Advancement: Workforce retention and the talent pool (new hires and professional applicants) could be increased through demonstrated pathways for career advancement and growth.

2.5.1.2 Implementation Recommendation: Upskilling

Upskilling is critical to ensuring that existing spectrum workforce participants stay abreast of the latest developments within their respective fields and remain competitive relative to workforce new entrants for whom new technologies and techniques were likely part of their education and training.

Lockheed Martin has experienced great success in its own 5G upskilling accelerator program, which has allowed Lockheed Martin to place accelerator graduates on 5G.MIL™ projects to make an immediate difference. On average, participants doubled their skill level through the accelerator with participant feedback showing the following outcomes: learning was a worthwhile investment (88% of respondents), they learned new knowledge and/or skills (86%), they would recommend the program to a colleague (76%), training improved the quality of product delivery (63%), and training improved productivity and efficiency (54%).

2.5.2 Strategic Objective 4.2: Improve policymaker's understanding of spectrum considerations.

2.5.2.1 Implementation Recommendation: There should be particular focus on Federal agencies' use of spectrum.

Increasing policymakers' understanding of spectrum is vital to ensuring that spectrum governance decisions are reflective of the current landscape. A cornerstone of this effort must be educating policymakers on the critical role spectrum plays in Federal agencies' authorized operations.

In addition to enabling wireless communications, policymakers provide leadership to ensure that the U.S. retains and expands technology leadership globally across an array of economic sectors driven by spectrum-dependent innovations in defense, aviation, space, and transportation. It is also critical to understand the full breadth of U.S. manufacturing sector support of Federal agency missions, as well as the agencies' operations and activities themselves which serve us all. Better educating policymakers on the spectrum-dependent nature of many of these Federal uses will help ensure that policymakers are fully informed on both the current and future economic and mission value of the agencies's systems and capabilities.

3. Conclusion

Sufficient access to spectrum is critical to enabling technology innovations across a wide range of stakeholders, both Federal and non-Federal. Spectrum supports not only the functions of civil society as well as the needs of American consumers, but also critical Federal, state, and local government operations and missions upon which our society depends – provided by myriad actors across numerous economic sectors. For the *NSS*' implementation to be successful, the domestic and international spectrum needs of government agencies and their missions must have consideration parity with those of commercial users, and *all of the relevant* economic sectors – telecom, aviation, space, defense, transport, and others – should be recognized as spectrum stakeholders and must be treated equitably. Lockheed Martin believes the recommendations contained in this submission can help advance this essential principle.

Lockheed Martin again thanks NTIA for the opportunity to provide inputs for the implementation of the *NSS*, and looks forward to working with NTIA and other stakeholders on optimizing the U.S. spectrum governance regime for the 21st Century.