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COMMENTS OF AT&T, INC. ON THE IMPLEMENTATION OF THE NATIONAL SPECTRUM STRATEGY

INTRODUCTION

AT&T welcomes this opportunity to provide further comments on the National Telecommunications and Information Administration's (NTIA's) efforts to implement a National Spectrum Strategy (NSS). The NSS document describes four "pillars" for US spectrum policy: (1) a spectrum pipeline to ensure US leadership in advanced and emerging technologies, (2) long term planning; (3) technology development to spur innovation in spectrum access and management; and (4) raising awareness and developing expertise in spectrum technologies. The NSS document goes on to identify three "strategic objectives" within each pillar and identifies scores of discrete tasks and actions that must be accomplished to implement the strategy and deliver its intended benefits to the American people. The Implementation Plan ("Plan") must first establish priorities, goals, and deadlines, including the overarching goal of making available—in the next three to four years—significant amounts of contiguous spectrum for full-power licensed use. To reach this goal the Plan should lay out who will do what and when in a manner that is both feasible and sufficient. We offer these comments on how to approach selected actions that we think will most contribute to successfully achieving the overall objectives of the NSS.

I. GENERAL COMMENTS ON THE NSS AND IMPLEMENTATION PLAN

The NSS includes positive proposals that should result in more collaboration and coordination among federal agencies that rely on spectrum resources, the NTIA, as the agency that assigns federal spectrum rights, and the FCC, the independent agency that allocates spectrum for commercial and non-federal government users. The NSS then includes a series of principles and steps, including further testing, with the objective of making more spectrum available for commercial use. As it implements the NSS, it is essential that NTIA, together with the White House and the FCC, apply the principles outlined in the NSS to adopt concrete spectrum policies that ensure the U.S. achieves the objectives of the NSS. In the sections that follow, AT&T offers more granular recommendations on ways to implement the strategy within the first three pillars. Generally, however, the Plan should swiftly move the nation beyond principles and studies to yield concrete, actionable spectrum policies, including making available at least 1,500 MHz of spectrum for full-power licensed use in large contiguous blocks. The development of the Implementation Plan should proceed with the following purposes:

- **Filling the "Spectrum Pipeline" by setting specific goals, priorities, and deadlines.** A study is not a spectrum strategy, nor is it a pipeline. The evidence NTIA has gathered in this effort should enable it to prioritize each competing request, assessing its importance to the national interest, including the timing of when additional licensed spectrum must be made available to avoid losing U.S. global leadership. While identifying spectrum for study is important, NTIA must define what constitutes tangible success. Failure to set concrete objectives would likely result in only more studies or compromised outcomes that follow the path of least resistance, yielding spectrum policy recommendations that fail to maintain U.S. leadership in critical areas like broadband infrastructure.

  For instance, while opportunistic, interruptible spectrum uses under low power and unlicensed-like sharing regimes might avoid tough choices, they will not serve the national imperative to make more spectrum available for full-power, wide area network use. Instead, the failure to take on significant but surmountable hurdles will result in indefinite delay in making spectrum resources available, while studies and testbeds grind along inconclusively, and the Nation falls further behind global competitors. The NSS should determine and prioritize the nation's strategic spectrum use objectives—i.e. national security, mobile broadband network infrastructure, satellite. The NSS should also identify how much spectrum is needed to meet these national strategic objectives, the nature of the spectrum needed (propagation, contiguity, license characteristics, etc.), and set deadlines for deploying these spectrum resources to accomplish each objective. The success of any studies or testbeds should be measured by whether the needed spectrum resources are identified, allocated and assigned in keeping with these objectives. It is indisputable that the critical need today, and in the future, is for contiguous blocks of full-power licensed spectrum. As such, NTIA's primary goal through the NSS should be to identify a minimum of 1,500 MHz of full-power licensed spectrum for auction.

- **Evaluating current allocations, uses, and demand to set these targets**. One should not confuse demand for allocation with demand for spectrum use. Hundreds of millions of Americans use spectrum resources every day to access mobile broadband, GPS, and Wi-Fi. Demand among "would be" satellite service providers for cost-free spectrum assignments may be increasing, but demand for resources needed to offer such services is not the same things as demand by consumers for these services. Similarly, there is spectrum demand from the automobile industry for self-driving cars, but it remains to be seen how demand for such spectrum-based services will develop. Meanwhile, mobile broadband networks are America's most widely used form of broadband and demand for spectrum resources on this infrastructure continues to skyrocket even as the industry innovates to increase the efficiency of its spectrum use.

  The strategic importance of U.S. leadership in mobile broadband network platforms is not in dispute, nor is the need for "network grade"[1] spectrum allocations. It is clear that new, full-power, licensed spectrum to accommodate this explosive demand and innovation for 5G, 6G, and beyond is needed in the short term. By contrast, the U.S. is awash in unlicensed and near unlicensed spectrum, such as CBRS. There is plenty of such spectrum to support innovation and no looming supply shortage. Without concrete priorities, goals, and deadlines, however, there is a real danger that the studies will result only in more coals to Newcastle—i.e. more unlicensed or lightly licensed spectrum allocations that fail to satisfy National priorities.

- **Prioritizing national security and mobile broadband infrastructure ahead of edge spectrum uses like Wi-Fi and private networks.** Maintaining U.S. leadership in mobile broadband network platforms will bolster national security, enhance economic competitiveness, and drive the innovation in other forms of spectrum-based technologies. The NSS should address these critical objectives and identify concrete measures—reallocations, changes to the Spectrum Relocation Fund (SRF), timelines for spectrum assignments—to accomplish them. While new spectrum uses in areas like commercial satellite and driverless cars should be considered, they should not be accommodated at the cost of ceding U.S. leadership in defense technologies or mobile broadband infrastructure leadership. There is a critical need for the United States to maintain leadership in mobile broadband network technology and deployment. This is the engine of innovation in the wireless ecosystem, the most widely used yet most strained form of broadband, used daily by hundreds of millions of Americans.

- **Incorporating market incentives**. Auctions help to ensure that commercial spectrum goes to its highest and best use. Competition drives innovation. Explosive consumer demand has led to more efficient spectrum use through advancements in air interfaces, compression, antenna technologies, densification, massive MIMO, etc. These benefits all flow, in large part, from incenting auction investment through spectrum licensing rules, which in turn drives behaviors designed to earn a return. Auctions of flexible use, full-powered, licensed spectrum will also generate revenues that, through an improved SRF, would help fund advancements in defense technologies, allowing our armed forces to upgrade and innovate to develop new systems capable of coexisting with advanced commercial networks globally, rather than just moving old systems onto new frequencies.

- **Considering "sharing" broadly and critically to ensure sharing meets National needs and makes efficient use of spectrum**. The NSS puts significant focus on dynamic spectrum sharing, though it does not proffer a definition, or even functional description. We provide one below in our discussion of implementing Pillar Three. We note here that sharing can be accomplished through dividing frequencies, geography, time slots, power or some combination of the above. Mobile broadband networks continuously employ all these methods dynamically (and efficiently) to assign spectrum resources to hundreds of millions of users each day. Examining whether a Spectrum Access System

[1] AT&T, Comments to NTIA Request for Comments, p. 2, April 17, 2023, available at https://www.ntia.gov/sites/default/files/publications/at_t_0.pdf.

(SAS), Incumbent Informing Capabilities (IIC), Automated Frequency Coordination (AFC) system, or similar approach can contribute to facilitating sharing is a worthwhile effort, but the Implementation Plan must not ignore the tried-and-true sharing models that allow for full-power spectrum use. Also, critically, it must not overlook the commercial and economic incentives essential to drive investment in the underlying infrastructure that puts spectrum to work effectively and efficiently. A sharing model that "works" technically but lacks commercial viability is no sharing model at all. Instead, it is a recipe for waste of an essential resource. Moreover, the form sharing may take to enhance spectrum utilization in one band or for some uses might differ from the form it takes for another purpose. The U.S. should seek to harness market incentives to drive innovations in sharing, as in the case of MNOs. Lastly, it is worth noting that "dynamic sharing" is a tool that might be useful to implement some aspects of a spectrum strategy. It is not a strategy in and of itself.

- **Acknowledging that the nation's demand for advanced mobile broadband spectrum cannot wait.** Test beds should be conducted in bands that are not as critical to the immediate need, such as millimeter wave bands, to allow experimentation to proceed without causing the U.S. to fall behind.

We now provide specific recommendations for implementing pillars One, Two, and Three.

II. IMPLEMENTING PILLAR ONE: SPECTRUM PIPELINE

The NSS properly states that "[t]o continue our Nation's economic growth, to maintain and improve our global competitiveness, and to support critical public services and missions, we must make spectrum available for innovative new uses and to meet growing demand."[2] The NSS then identifies 2,786 MHz across five disparate bands for "in-depth, near-term study to determine suitability for potential repurposing to address the nation's ever-evolving needs."[3] However, the NSS makes no commitment to determining that any of this spectrum—or, for that matter, any other conceivable spectrum—will be repurposed.[4] Absent such a commitment to repurposing and, more importantly, meeting that commitment through the Implementation Plan, the NSS will fail to promote those national interests of economic growth, global competitiveness, and delivery of critical public services. The Implementation Plan should therefore take the logical next step and establish a measure of effectiveness for the Plan of identifying 1,500 MHz of mid-band spectrum to be made available to auction for full-power commercial licensed

[2] National Spectrum Strategy, p. 3.

[3] National Spectrum Strategy, p. 3.

[4] National Spectrum Strategy, p. 7: "Because the spectrum is congested—and as "greenfield" spectrum becomes harder to find—U.S. policy (and stakeholders) must recognize that "studying" a band for potential repurposing to enable more efficient use does not prejudge the outcome of the study (i.e., that all, part, or none of the band ultimately will be repurposed as a result of the study.)"

use.[5] Of non-federal uses, this category of use has the clearest and most significant demand that has not been satisfactorily met by recent spectrum policy actions and is also where the U.S. is in the worst position relative to its peers, thereby risking the U.S.'s competitive status globally.

A. Prioritize and Conduct with Urgency the Studies of the Lower 3GHz and 7-8 GHz band in the Next 18-24 months.

Two of the five studies the NSS describes are relevant to the need for 1,500 MHz of mid-band spectrum: 3.1-3.45 GHz and 7.125-8.4 GHz. We provide more detailed recommendations on the execution of each of these studies below. While the other three bands identified for studies each have some degree of importance, those bands will not meet the nation's most significant need for licensed mid-band spectrum. Accordingly, NTIA's efforts in prioritizing its finite resources over the next 18-24 months of the Implementation Plan should be focused on these two mid-band studies.[6] Crucial to the success of both studies in achieving the objectives of the NSS is that they must be studies of "how" and not "whether" to make the bands available for full-power, commercial licensed use.

1. 3.1-3.45 GHz Band

In performing the study of the 3.1-3.45 GHz band NTIA, with the support of the Department of Defense (DoD), should:

- Build off the data collected by DoD from both DoD system operators and the private sector and used in DoD's EMBRSS analysis. This will greatly expedite the study as it takes considerable time to collect system performance data from across the many varied DoD users in this band.
- Examine sharing options that were excluded from or underdeveloped in DoD's EMBRSS analysis. These sharing options include but should not be limited to: segmentation of the band for differential sharing regimes in the 3.3-3.45 GHz (which falls within 3GPP's Band n78) and 3.1-3.3 GHz portions of the band;[7] assessments of the impact of already planned and possible relocation of selected

[5] Further discussion of measures of effectiveness for the Implementation Plan is provided below in the context of Pillar Three.

[6] In parallel, the U.S. will need to be in preparation for WRC-27 where one of these bands are set for study in Agenda Item 1.7 (AI 1.7)—the 7.125-8.4 GHz band. AI 1.7 also includes the study of the 4.4-4.8 GHz band in Regions 1 and 3. While not in the Americas, the U.S. should consider adding this band to the Implementation Plan's study efforts in order to allow for harmonized use of the band should that be the direction that is taken globally in four from now.

[7] In view of the demonstrated near term need for full-power, licensed, contiguous mid-band spectrum to maintain U.S. leadership in mobile broadband network technologies and to avoid supply shortages, the portion of the band that falls within 3GPP Band 78 (3.3-3.45 GHz) should not be included in any national test bed efforts in a way that

incumbent systems—particularly those in the 3.3-3.45 GHz portion of the band; and more robust modeling and analysis of EMBRSS's COA 3—Digital Cancellation of 5G.

- Take ownership of and improve the modeling of the hypothetical commercial 5G network used to conduct the electromagnetic compatibility analysis against federal systems. This effort should incorporate PATHSS members' recommendations and learnings from ongoing technical discussions and field trials in both the 3.1-3.45 and 3.45-3.55 GHz bands. This model should be calibrated against the real-world performance of mobile network operators' live 5G networks and employ a network footprint informed by network operators' deployments and realistic projections of deployments in this band.

Procedurally, NTIA and DoD should extend and continue the PATHSS Task Group (and the PATHSS-C sub-group) as one broad forum for engagement across government and all pertinent industries. This novel entity was helpful in fostering discussions and exchanging information in a secure and trusted environment in ways that had not been done before and can continue to contribute to the NSS's study of the 3.1-3.45 GHz band. However, to most effectively and rapidly advance the study, NTIA should also initiate smaller fora in parallel to PATHSS for focused technical exchanges to guide NTIA's refinement of the electromagnetic compatibility analysis. These smaller fora should allow for protected exchanges and discussions of proprietary data between NTIA and the relevant participants (e.g., under appropriate Non-Disclosure Agreements). NTIA should then gain support from the broader PATHSS membership *prior to*, or at least through iterations of, analysis intended to serve as the basis for decision-making.

2. 7.125-8.400 GHz Band

Assuming the status of other mid-band spectrum allocations remains unchanged, the 7.125-8.4 GHz band provides the last, best option for sufficient contiguous bandwidth in the mid-band range to meet the needs of licensed 5G and future G services—the foundation of the wireless ecosystem. Consideration of making any portion of this band available for unlicensed or low power uses will eliminate the possibility of the U.S. (for at least the next decade) closing the gap in licensed spectrum allocations and would be a detriment to the long term economic and national security of the nation.

The study of this band should proceed in parallel with that of the 3.1-3.45 GHz band and can likely leverage many of the same processes and participants. For example, the PATHSS Task Group (and

might result in delays in reallocation. There are established modes of sharing that could be used to facilitate rapid reallocation of this spectrum to avoid ceding U.S. leadership in mobile broadband.

PATHSS-C) could support this study as a second work item, with Federal incumbents providing information in this trusted information environment on their in-band systems and missions and non-Federal users providing information on their understandings of differences in use and prospective deployment of this band relative to the 3 GHz band for licensed services.

3. Other Mid-Band Frequencies Not Identified in the NSS

The U.S.'s allocation of the entirety of the 6 GHz band—1,200 MHz of highly-valued spectrum—to unlicensed use removed the only large, contiguous portion of mid-band spectrum that is not used by the DoD from consideration for licensed commercial mobile use. Regardless of whether adding the entire 1,200 MHz of 6 GHz to the surfeit of unlicensed spectrum already available in the U.S. was a choice that had merit at the time, it is clear in hindsight that failing to auction off at least a portion of the band for mobile broadband network deployments was a missed opportunity, and one that will have negative ramifications for the U.S. A potential complement to conducting the study of the 7,125-8,400 MHz band, given the significant complications of DoD incumbent uses in that band, would be to revisit the FCC's 6 GHz allocation decision. Given the outcomes of the World Radio Conference 23 (with 6 GHz identified for mobile use in all regions and where "countries representing 60% of the world's population actively sought inclusion in the identification of this band for licensed mobile[,]"[8]) and the lack of DoD incumbents in the band, the 6 GHz band could provide a significant amount of spectrum more quickly with no impacts to DoD than can a study of the 7,125-8,400 MHz band.

Furthermore, as a result of other decisions made at WRC-23, the 4.4-4.8 GHz band (adjacent to the 4.8-4.94 GHz band studied at WRC-23) will be studied for possible identification to International Mobile Telecommunications (IMT) at WRC-27 in Region 1 and Region 3. While the Agenda Item excludes the Americas (Region 2), it would be beneficial if the Plan also included this band to provide additional opportunities for large blocks of contiguous spectrum to be identified and studied, allowing for international harmonization.

[8] GSMA, "WRC-23 main results at a glance," (https://www.gsma.com/spectrum/wrc-series/, last accessed January 1, 2024).

4. Other Studies

The three other studies the NSS identifies have varying degrees of significance to the overall spectrum challenges and policy decisions facing the nation. The Implementation Plan should lay out how each will proceed but the two mid-band studies discussed above should have priority in the Implementation Plan. Should resource or time limitations come to bear on the execution of the studies, the remaining studies could be pursued as a second tranche outside the primary Implementation Plan window of the next 18-24 months.

B. Formalizing Best Practices for Conducting Technical, Scientific, Mission, and Economic Analyses in Support of Spectrum Management Decisions

NTIA identified a need in the NSS to formalize best practices for conducting analyses across four domains (technical, scientific, mission, and economic) to inform future studies and ensure the highest quality, reliability, and believability of such studies.[9] We concur that this is a valuable element of the NSS, especially since it calls for multiple studies to be conducted simultaneously. Accordingly, NTIA should rapidly collect and apply lessons learned from prior studies to inform development of best practices across each of the four categories identified. Critically, the establishment of best practices, and standards for assessing studies and their recommendations, should be completed and published *prior to* completion of the five studies identified in Strategic Objective 1.2, such that those studies may be evaluated by the public against the terms of those best practices. Lessons learned collected from the conduct of those five studies should then be applied to a refinement of best practices for analyses going forward.

We also concur that studies should be peer-reviewed and published. Depending on the construct of the study and degree of participation of non-U.S. government entities in the execution of the study (e.g. through leveraging the PATHSS Task Group or other codified multi-stakeholder organizations), study reports should include comments and concurrence or non-concurrence from participating non-U.S. government entities to further support ultimate peer review.

[9] National Spectrum Strategy, p. 7.

There are several interrelated best practices that should be common across all four domains of analysis, with specific applications in each domain: openness and transparency, intellectual rigor, and consistency. Openness and transparency will facilitate public understanding of both the terms of the analysis and its conclusions and best support subsequent peer review. Intellectual rigor will enable the studies to stand up to scrutiny (including peer review) and have the credibility necessary to support decision making. And consistency will allow for valid comparisons between studies. The table below illustrates the applicability of these attributes across study types:

		Study Types		
		Technical/Scientific	*Mission*	*Economic*
Best Practices	Openness & Transparency	Using generally or publicly available analytical/modeling tools and datasets or clearly defining and describing any proprietary data sets.	Minimizing classification and obfuscation of federal systems and assignments, within the bounds of protecting national security.	Using generally or publicly available economic datasets and metrics and demonstrating methodologies.
	Intellectual Rigor	Validating technical assumptions &/or calibrating study models against real-world data. Stating confidence intervals in analysis and under what conditions the analytical results could differ.	Clearly defining and consistently delineating federal mission *types* such as operational, training, maintenance and calibration, and research development test & evaluation (RDT&E).	Defining econometric values to model and optimize and objectively assessing the relative economic value to the nation of differing spectrum uses.
	Consistency	Using the same fundamental models of commercial services (e.g., a commercial licensed 5G network) across different studies versus developing *de novo* models for each study.	Applying a common risk analysis framework for the missions—to include risk mitigation steps federal users could pursue for mission assurance if federal exclusive spectrum is repurposed or shared.	Maintaining the same economic criteria for analysis and optimization across differing studies of comparable spectrum uses.

C. Implementing Leading Program Management Practices to Plan and Monitor the Success of Spectrum Repurposing Objectives

Strategic Objective 1.3 is to "[m]aintain the spectrum pipeline by applying principles and leading program management practices to identify additional bands for study."[10] First principles of program

[10] National Spectrum Strategy, p. 7.

management suggest that there must be a program objective towards which the program is being managed and that such an objective must be significant enough to warrant applying program management techniques. However, as the NSS currently stands, there is no pipeline to maintain—and thus no significant program objective towards which to manage—because there is no commitment to repurposing any spectrum. As we proposed above, the Implementation Plan should redress this by establishing a program objective of identifying 1,500 MHz of spectrum for repurposing to full-power, commercial mobile licensed service by a specified date. This would provide a substantive program objective against which the success or failure can be measured. Otherwise, a spectrum pipeline program oriented to delivering studies but not spectrum will mean the program may succeed while the NSS fails. Lastly, global activities must be considered in the process of maintaining the spectrum pipeline, including formulating effective U.S. positions on Agenda Items to be decided at WRC-27.[11]

III. IMPLEMENTING PILLAR TWO: COLLABORATIVE LONG-TERM PLANNING

A. Develop an Architecture for a New Collaborative Framework

The collaborative framework should strive to be as transparent as possible with respect to spectrum under consideration for allocation or assignment for federal uses, allowing commercial and non-federal spectrum users to participate to the extent possible. Similarly, federal agencies that utilize spectrum assigned by the FCC or share spectrum with other users authorized by the FCC should, in connection with the fourth pillar, increase their expertise, awareness and, through NTIA, their participation. This would help prevent situations like the recent concerns raised by the aviation industry regarding the inability of their radio altimeter receivers to reject signals outside the altimeters bands. The situation came to a head after the C-band auction and the time needed to remediate it resulted in significant delays in deploying robust 5G services to millions of Americans.

B. An Evidence-Based National Spectrum Decision-making Methodology

[11] See the discussion in Section III.A.3 above of the 6 and upper 4 GHz bands.

The NSS's discussion of Strategic Objective 2.2 notes that the "societal value of the spectrum will be calculated based on a quantifiable estimation of the direct and indirect benefits of the different uses of spectrum to the Nation."[12] We concur that a sound spectrum strategy should aim to ensure efficient use of scarce spectral resources to advance social welfare. As such, economic analyses of the impact of existing allocations and new, proposed options—whether federal or non-federal—should be a core component of the Implementation Plan. Such economic analyses should take into consideration both existing allocations and the impact of marginal increases in spectrum availability to any use cases. Additionally, such economic analyses should include examinations of opportunity costs. Such economic analyses would have guided the CBRS experiment, for example, to a different band, where the potential value of such a sharing regime—which has yet to be proven and has clearly fallen far short of its proponents' promises—could have been explored without sacrificing 150 MHz of prime, contiguous mid-band spectrum that would have been ideal for 5G broadband network deployment (and likely would have added tens of billions to the U.S. treasury, including the SRF). As part of the 3.1-3.45 GHz study, NTIA and the FCC should consider whether to relocate the CBRS experiment to a portion of this band and auction the 3.55-3.7 GHz band as high-power, licensed spectrum, using auction proceeds to fund the relocation and or upgrade of the U.S. Navy's mid-20th century radar systems that still operate in the band today.

C. Employ New or Modified Validated Co-existence Models Developed through Best Practices and Real-World Measurements as Appropriate

For electromagnetic compatibility studies that seek to assess compatibility between federal use and non-federal use (whether commercially licensed, unlicensed, or other spectrum allocations), there should be singular, validated, and appropriately calibrated models of the non-federal use for each band under analysis. These models should be owned and operated by NTIA but developed in collaboration with the relevant non-federal spectrum users. All federal users should provide the relevant technical inputs on federal systems for NTIA to incorporate into the modeling and use in the execution of compatibility analysis.

[12] National Spectrum Strategy, p. 11.

IV. IMPLEMENTING PILLAR THREE: SPECTRUM INNOVATION, ACCESS, AND MANAGEMENT THROUGH TECHNOLOGY DEVELOPMENT

A. Moonshot Effort to Advance Research, Investment Incentives, and Set Forth Measurable Goals for Advancing the State of Technology for Spectrum Access and National Testbed for Dynamic Spectrum Sharing

The most notable tasks identified within Pillar Three, and the two with the most aggressive timeline of 12-18 months, are the whole-of-nation "moonshot" effort to advance spectrum access technology "with an emphasis on dynamic forms of sharing" and the related establishment of a national dynamic spectrum sharing testbed.[13] As a threshold matter, a common and widely accepted set of minimum characteristics of what constitutes 'dynamic spectrum sharing' (or access) must be developed if there is to be any path to success in advancing research in those spectrum access technologies that would justify the necessary investment. "Dynamic Spectrum Sharing" is a term used in many different contexts with very different meanings.[14]

We recommend that the Implementation Plan use the following operational definition of dynamic spectrum sharing: *a sharing mechanism that allows for spectrum access to the same frequency band by two dissimilar spectrum users that varies in near-real time across one or more other dimensions of spectrum use: geography, frequency, time, or power*.[15] The terms geography, frequency, and time are self-explanatory while power, generically, is often suggested as a radio frequency transmission attribute with significant relevance to sharing. However, we posit that it is specifically "received power at a given location and time" that is the actual variable of potential interest to dynamic spectrum sharing. For

[13] National Spectrum Strategy, p. 13.

[14] For example, "Dynamic spectrum sharing (DSS)" is a specific term formally defined in 3GPP technical specification 21.917 for the mechanism to enable a single network operator to allow LTE and 5G New Radio (NR) waveforms to share the same carrier (channel). DSS has allowed network operators to deploy 5G NR in spectrum already in use by 4G LTE prior to re-farming the 4G LTE spectrum or receiving access to new spectrum allocations. We assume that the National Spectrum Strategy is *not* referring to this definition of dynamic spectrum sharing but highlight it to underscore the need for explicitly defined and broadly accepted terms in the context of the Strategy and Implementation Plan.

[15] The caveat included in this definition of *dissimilar* spectrum users is important because modern wireless communications technologies have been designed to efficiently share finite spectrum resources amongst large numbers of *similar* users of the communications services, largely though sophisticated scheduling and/or sensing (i.e., contention-based) protocols.

example, both geographic and frequency separation of radio frequency (RF) transmission and reception (by two different spectrum users) are simple ways of reducing the received power at a given location and time to below the interference threshold of the receiving RF system. Similarly, while altering a transmitter's normal transmission power is another means of reducing received power at a given location, so too are more sophisticated and dynamic approaches enabled by 5G Radio Access Networks, like null steering, beam muting, and physical resource block blanking—all while the network as a whole operates at full power. Thus, the examination of dynamic spectrum sharing approaches in the Implementation Plan, "moonshot" efforts, and testbed should take a broad view of the full range of mechanisms that can achieve the necessary received power at a given location and time.

The common objective of any sharing mechanism, including dynamic means, is to provide for mutually acceptable coexistence between users such that those sharing the spectrum have sufficient predictability and reliability in when, where, and how they can utilize the spectrum to meet their service requirements. It is only with this predictability and reliability of usage that there will be an incentive for investment in infrastructure and the broader ecosystem of devices and services. Thus, the Implementation Plan should set as a "moonshot" research objective discovering ways of sharing spectrum that at a minimum provide commercially viable predictability and reliability of dynamic spectrum access.

In addition to testing the technical aspects of spectrum sharing, the Implementation Plan should consider the appropriate set of incentives to ensure that spectrum sharing mechanisms drive the allocation of shared spectrum rights to their most highly valued uses. Spectrum sharing models that do not incorporate such incentives will fail to maximize social welfare. To drive shared spectrum rights to the most highly valued uses, users of shared spectrum not obtained through auction must internalize the opportunity costs of their use. The Implementation Plan should consider a variety of approaches to this problem, including but not limited to: making shared rights alienable in a secondary market; establishment of spectrum-usage fees; the use of Harberger taxes.

The NSS provides little insight into the nature of the national dynamic sharing testbed, particularly given the lack of specificity on what constitutes dynamic spectrum sharing, and thus what

could or should be tested in the testbed. And, while band agnosticism, technological neutrality, and extensible sharing solutions may be worthy intermediate objectives of research and engineering efforts,[16] they must not come at the cost of failing to keep the NSS's ultimate objective in mind—prompt repurposing spectrum for greatest efficiency in service of the nation's interests. That is, sharing approaches that are band-specific and/or reliant on particular technologies but that can best serve to make more spectrum available for more efficient use should neither be excluded from the testbed nor from consideration for adoption when repurposing a band.

The NSS did not specify the frequencies for which the testbed would be developed—a critically important decision. To the extent the testbed could support one or more of the studies and hasten the repurposing of spectrum for commercial use—particularly through collection of data that can validate the studies' analyses and demonstrate to incumbents the viability of the sharing approaches—use of one or more of the NSS studies mid-band bands in the testbed may be appropriate. If, however, inclusion of a band in the testbed will likely delay its identification for repurposing due to the nearly inevitable complications and delays in developing, operating, and generating substantive results from the testbed, then non-priority bands should be initially used in the testbed.[17]

B. Engaging with Agencies to Provide Enterprise Capabilities for Modeling Electromagnetic Compatibility

As spectrum regulating entities, NTIA and the FCC should do more than just engage with other agencies to offer or provide enterprise modeling capabilities for electromagnetic compatibility analysis with non-federal use of spectrum.[18] Those other agencies must be required to use the relevant enterprise modeling capabilities developed and validated by NTIA (and, when appropriate, the FCC). Other agencies have no expertise in modeling or analysis of non-federal spectrum use and have their own organizational

[16] National Spectrum Strategy, p. 16.

[17] As noted above, we recommend against including at least the 3.3-3.45 GHz band in any test bed study as the need for full-power, licensed mid band spectrum for advance mobile network deployments should be too high and immediate a priority to risk delaying the reallocation of this spectrum. We think 37-37.6 GHz would be ideal for the test bed, or, to the extent that mid-band is to be considered for this purpose, 3.1-3.3 GHz.

[18] National Spectrum Strategy, p. 15.

biases and incentives that can, intentionally or not, cause their analysis to unnecessarily deviate from reality. Also, having a proliferation of models of commercial systems or networks across differing agencies, or multiple models within individual agencies, is duplicative, wasteful, and could lead to inconsistent results.

C. Assess Analytical and Statistical Modeling of Electromagnetic Interference and Propagation Used to Perform Data-Driven, Risk-Informed Spectrum Sharing Compatibility and Coexistence Analyses

The NSS's task for the collaborative framework to "assess analytical and statistical modeling of EM interference and propagation (particularly for mid-band and millimeter wave spectrum) used to perform data-driven, risk-informed spectrum sharing compatibility and coexistence analyses"[19] is an important one. A lack of consistent and agreed upon approaches to EM propagation and interference modeling has plagued analysis of the entirety of the 3 GHz band with distinct effects across EMBRSS/PATHSS (3.1-3.45 GHz), AMBIT (3.45-3.55 GHz), CBRS (3.55-3.7 GHz), and C-Band (3.7-3.98 GHz) sharing, coordination, and coexistence analyses. The result has been delayed or slowed deployment, wasted spectrum, and failures to deliver potential benefits to the nation in a timely manner. The Implementation Plan should (1) identify the relevant public and private sector stakeholders to participate in this assessment and (2) establish a near-term deadline for specified deliverables for this assessment process such that the recommended modeling approaches can be employed in the conduct of the five studies supporting Strategic Objective 1.2.

D. Consider Legislative Changes to the Spectrum Relocation Fund

The NSS notes that a "national spectrum policy that maximizes flexible use of spectrum... could include considering legislative changes to the SRF to make payments for costs associated with general spectrum coexistence and compatibility research and development by Federal entities across all spectrum access models."[20] This would be a productive change in policy. Another needed change to the SRF

[19] National Spectrum Strategy, p. 16.

[20] National Spectrum Strategy, p. 17.

authorization would be enabling federal incumbents to use SRF money to *improve* their spectrum dependent systems' overall system capabilities when modifying or replacing them to accommodate spectrum repurposing (whether through relocation or sharing-enablement). Currently, the SRF limits the use of money to only paying for the changes necessary to enable the spectrum repurposing. The Implementation Plan should provide Congress with the appropriate proposed statutory language to accomplish both these changes, for Congress's incorporation into pending spectrum legislation.

E. Jointly Oversee Periodic Assessments of U.S. Spectrum Policy to Determine if it Fosters Technology Development, Incentivizes Implementation of New Technologies, and Maximizes Benefits for all Americans.

In the discussion of Strategic Objective 3.3, the NSS states that NTIA and the FCC will "jointly oversee a periodic, targeted assessment of U.S. spectrum policy..."[21] The Implementation Plan should establish the periodicity of this assessment and clearly define the criteria by which the success of U.S. spectrum policy in delivering technology development, incentivization for implementation of new technologies, and the "benefits for all Americans" are to be measured. The weighting of these factors should distinctly be on the "benefits to all Americans" over other policy objectives and the development and adoption of technology for technology's sake or the sake of a particular business sector. It should include both service performance-oriented measures (e.g., coverage and capacity relative to demand) and economic measures. Crucially, this assessment must evaluate both federal and non-federal spectrum use and establish criteria for adequately comparing the relative societal and economic values between the two. Establishing these criteria now in the Implementation Plan will create consistent benchmarks future spectrum policymakers can use in the periodic assessments—and against which they can be held accountable.

CONCLUSIONS

AT&T recognizes that maintaining U.S. leadership in the deployment of the world's most advanced and capable mobile broadband networks cannot be the only objective of U.S. spectrum strategy,

[21] "The U.S. spectrum-regulating agencies," National Spectrum Strategy, p. 17.

but it should be among the top three, along with national security and satellite leadership. This is because nothing does more to spawn investment in national broadband infrastructure and innovations in the wireless ecosystem than competition among the world's most advanced wide-area mobile broadband platforms. This innovation occurs within America's broadband networks, and at the edge, with new Wi-Fi capabilities, private networks, and new applications. Moreover, hundreds of millions of Americans rely on spectrum resources every day on these wireless networks, which are the networks Americans choose most often and, in many cases, exclusively for broadband services.

AT&T encourages NTIA, as it implements the NSS, to apply its principles to develop concrete spectrum policies. Studies, testbeds, and sharing regimes are good tools to use to identify and implement a strategy, but they are not strategic objectives themselves. We recommend that NTIA start the implementation by setting priorities, goals, and deadlines designed to address America's strategic needs. Identify the highest priority needs by importance and timing. Fill the pipeline with a minimum of 1,500 MHz of licensed full-power spectrum. Adopt a timeline for its availability. This will ensure that the U.S. maintains its position as the global leader. We look forward to continuing to work with the NTIA on this critical journey.

Respectfully submitted,

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