

## Commerce Spectrum Management Advisory Committee

### Working Group 1: Governance: Final Report

July 30, 2020

#### Introduction

The mandate of Commerce Spectrum Management Advisory (CSMAC) Working Group 1 (WG1) is as follows:

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

In addressing this question, WG1 first had to determine how to order its agenda. The group began with a level-setting review of the statutory authorities of the Federal Communications Commission (FCC) and the National Telecommunications and Information Association (NTIA), including references to any relevant writing on problems in spectrum management. WG1 then reimagined a variety of new approaches to spectrum management at a conceptual level. That exercise enabled the group to quickly assess how these new approaches might be better than the existing framework. From that exercise, the group concluded:

There is general agreement among WG1 members that the United States' current approach for managing the use of spectrum is no longer effectively serving the needs of the entire stakeholder community and would benefit from reform. Moreover, with the increased use of spectrum by all stakeholders, we agree that issues around allocations, spectrum-sharing and band adjacencies will need to be handled with both speed and skill to ensure that the US is making the most of its critical national resources.

Accordingly, we have developed multiple options that reflect WG1's best thinking on the range of possible implementation structures or spectrum management governance models that could offer improvement. These are contained below. Our goal in providing these options is to provide a basis for examination of the best spectrum management governance model to meet the goals of the still-to-be-released National Spectrum Strategy.

We were unable to locate extensive literature or research on reforming U.S. spectrum management. The issue of spectrum governance in the United States, therefore, is largely an issue of first-hand experience from the membership. Accordingly, WG1 felt it was necessary to explore a range of possible options on governance for U.S. spectrum management—from minor to significant changes that would improve upon the current spectrum management process. This review of ideas should provide NTIA and others with the ability to build on our work. The CSMAC WG1 has not endorsed these options or any single option.

As an initial matter, WG1 agreed that spectrum management is a much broader topic than broadband spectrum. Many uses of the spectrum, both in communications and non-communications, would need to be considered. A broad range of devices—from cell phones to weather and communications satellites to GPS to radar to garage door openers to public safety networks to classified defense systems—utilize the spectrum resource.

As used in this report, the term “governance” at a minimum includes regulatory control over the U.S. Table of Allocations, which identifies broad categories of uses based on bands of spectrum, and changes to that Table. As a result, governance also considers the International Radio Regulations, which encompasses the International Table of Allocations, maintained by the International Telecommunication Union – Radiocommunication Sector (ITU-R). “Governance” also includes a regulatory or policy decision to allow one type of radio frequency service to share spectrum with a different service or to protect or displace an existing service. Finally, the term includes resolution of adjacent and co-channel interference issues associated with allocation changes.

We also looked briefly at the history of spectrum management in the United States and any lessons we could learn from other countries spectrum management approach. As noted above, there was no comprehensive history of our spectrum governance system, although there are source documents from which a history could be examined and synthesized.

With regard to international examples, we found very few, if any examples, of countries who currently or in the past split spectrum management between government and non-government uses. Overwhelmingly, spectrum is managed through a single entity either at a Ministry or regulator level. When spectrum is managed at the Ministry level, licensing, the development of technical rules and enforcement may be handled by a separate regulatory body.

WG1 also desires to call attention to what we did *not* do. While we looked at spectrum management governance at a high level, because of our lack of expertise, we did not consider the federal civil service rules or union rules, legal or administrative issues transitioning from the current system to a new one, or the operational requirements of a new agency (or an expanded agency), such as overhead cost and management. Accordingly, we do not provide specific budget estimates or address legal or administrative requirements. We also did not attempt to list specific concerns that we (or others in the spectrum community) believe are an issue with the current system that could be corrected or mitigated with a new or revised system. While a specific “what’s broken” discussion would have been an interesting one, WG1 decided that it would be most helpful to focus on proposing alternative governance ideas. Also, in the absence of a National Spectrum Strategy to work from, we were unable to filter, evaluate, or align the policy options to it.

Finally, because the members of WG1 serve on the CSMAC in a personal capacity, these views do not necessarily reflect the views of the organizations in which WG1’s members work.

## **Working Methods**

The Working Methods for WG1 included:

- Holding over 20 meetings
- Reviewing key parts of the existing statutes and regulations to ensure a common understanding of the current environment
- Examining international spectrum management regimes to ascertain lessons learned

- Soliciting contributions from members on governance ideas to develop a reasonable array of available governance model options for consideration
- Inviting a distinguished guest speaker, Peter Tenhula (NTIA), on Interdepartment Radio Advisory Committee (IRAC) operations
- Researching the history of the present structure thanks to Dale Hatfield and University of Colorado law students
- Deciding on “operational rules” for this phase of the investigation
  - In the absence of a final National Spectrum Strategy, we put our best ideas forward for improving spectrum governance
- Preparing a draft report for review and input

## DISCUSSION

The Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America’s Future asserts the following:<sup>1</sup>

*It is the policy of the United States to use radiofrequency spectrum (spectrum) as efficiently and effectively as possible to help meet our economic, national security, science, safety, and other Federal mission goals now and in the future. To best achieve this policy, the Nation requires a balanced, forward-looking, flexible, and sustainable approach to spectrum management.*

In the absence of a final National Spectrum Strategy, CSMAC WG1 developed a range of options to improve spectrum governance for our nation. Not everyone agrees with each idea. Indeed, some of them may have drawbacks that make the option unworkable. But given the dearth of writing on this topic, WG1 decided to simply produce our best thinking on all of these options and allow readers to draw their own conclusions. In addition, there may be beneficial aspects of these ideas that we did not articulate, and there may be drawbacks that we failed to flag. This was unintentional and only occurred because of the limited time we had to engage with this subject.

### Existing Spectrum Governance Framework

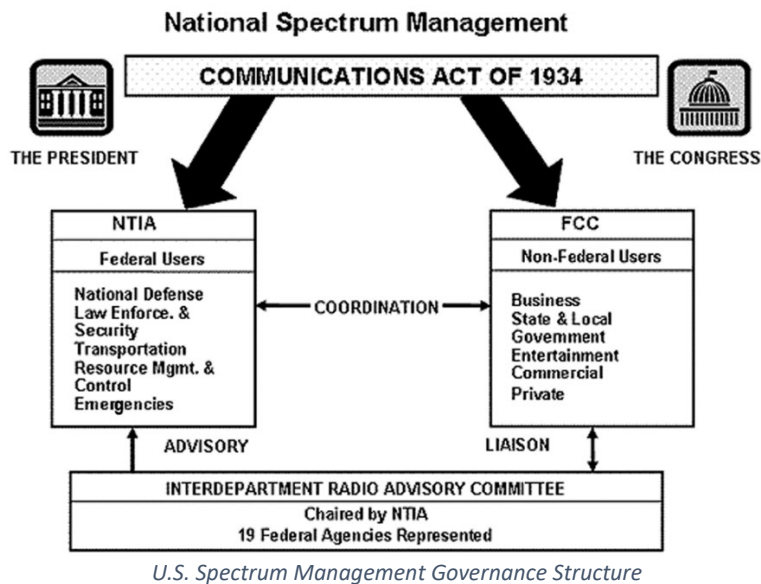
The U.S. operates under a dual spectrum management structure established by the Communications Act of 1934.<sup>2</sup> NTIA has regulatory authority over the Federal Government’s use of spectrum, and the FCC has regulatory authority over non-federal use of spectrum. The Communications Act authorizes NTIA and the FCC to develop classes of radio service, allocate frequency bands to these services, and authorize

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<sup>1</sup> White House, “Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America’s Future,” 25 October 2018. [Online]. Available: <https://www.whitehouse.gov/presidential-actions/presidential-memorandum-developing-sustainable-spectrum-strategy-americas-future/>. [Accessed 29 March 2020].

<sup>2</sup> Communications Act of 1934, 47 U.S.C. § 151.

frequency use. The national spectrum management governance structure is illustrated in the following figure.<sup>3</sup> In addition, the U.S. Table of Allocations is part of the FCC’s rules.



There are no statutory federal or non-federal bands. All such federal, non-federal, and shared band allocations result from agreements between NTIA and the FCC. A Memorandum of Understanding (MOU) between NTIA and the FCC was signed in 2003 (and is currently in effect) to increase coordination between the agencies and promote efficient use of spectrum in the public interest.<sup>4</sup>

Additionally, the U.S. Department of State is responsible for international aspects of spectrum management and leads U.S. participation in the ITU-R.<sup>5</sup> The ITU is a specialized agency of the United Nations (UN), and the ITU-R allocates spectrum use under international law. The ITU’s World Radiocommunication Conference (WRC) reviews and revises the ITU Radio Regulations, an international treaty governing the use of radio frequency spectrum, every 3 to 4 years.

### Governance Challenges and Opportunities

The current spectrum management regime is over 100 years old. During its existence, significant technological advancements—some of them unforeseeable—have emerged, such as wireless and satellite services. 5G, Internet of Things, space, unmanned aerial systems, autonomous ground vehicles, and telemedicine applications—all of these increase pressure for more spectrum to be reallocated from government to non-federal users and for sharing to be enabled among services and users. However, spectrum is also critical for meeting important federal agency missions. While there is increasing demand

<sup>3</sup> NTIA, “Who Regulates the Spectrum.” [Online]. Available: <https://www.ntia.doc.gov/book-page/who-regulates-spectrum>. [Accessed 29 March 2020].

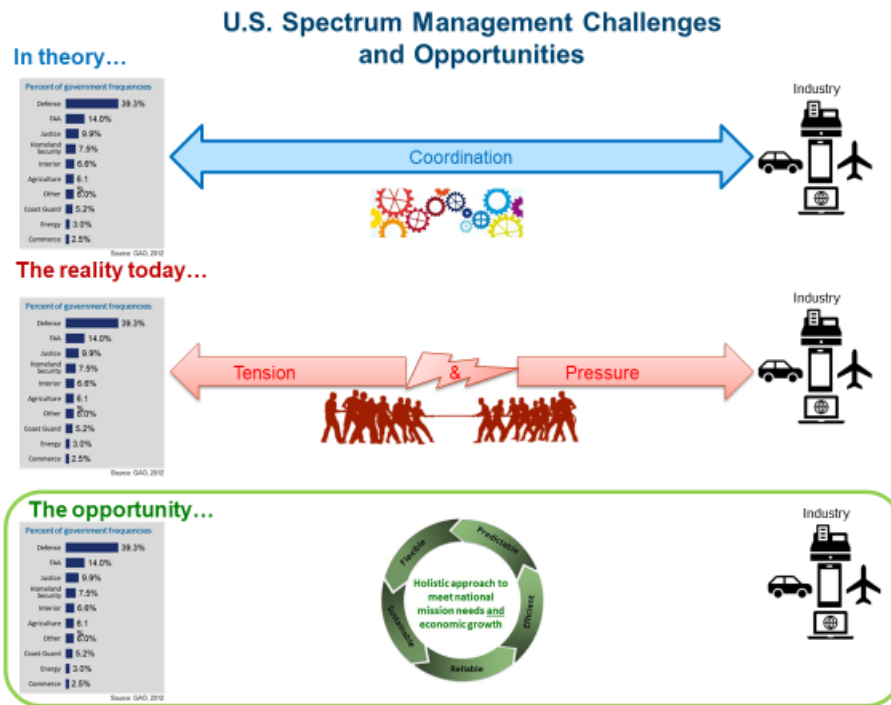
<sup>4</sup> “Memorandum of Understanding between the Federal Communications Commission and the National Telecommunications and Information Administration.” [Online]. Available: <https://docs.fcc.gov/public/attachments/DOC-230835A2.pdf>. [Accessed 29 March 2020].

<sup>5</sup> NTIA, “International Telecommunication Union Radiocommunication Sector (ITU-R).” [Online]. <https://www.ntia.doc.gov/legacy/osmhome/international/ITUR.html>. [Accessed 29 March 2020].

U.S. Department of Commerce, “Spectrum Policy for the 21<sup>st</sup> Century,” March 2008. [Online]. [https://www.ntia.doc.gov/files/ntia/publications/international\\_spectrum\\_policy\\_improvements\\_report3-13-08\\_final.pdf](https://www.ntia.doc.gov/files/ntia/publications/international_spectrum_policy_improvements_report3-13-08_final.pdf). [Accessed 29 March 2020].

for radio frequency spectrum among numerous government and commercial users, its supply as a practical resource is finite. The use of spectrum must be balanced to include both non-federal and federal agency mission needs and the manufacturing industries and their supply chains that support all needs.

Given this technical and economic paradigm shift, there is an opportunity to update our current system to remove artificial limitations, manage spectrum more holistically, and optimize the use of this precious national resource. A more efficient, effective, flexible, and sustainable spectrum access approach will help alleviate the growing demand to meet the needs of a 21<sup>st</sup> century national spectrum strategy. The following figure depicts the general challenges and opportunities in spectrum management today.



*U.S. Spectrum Management Challenges and Opportunities*

CSMAC WG1 has identified opportunities to align governance, economics, and policy to improve spectrum management for the nation as a whole.

### Options for Spectrum Governance Reform

We developed the following options for the consideration of NTIA. They are roughly grouped into the following categories: (1) Ideas that would stand up a new agency that would unify spectrum management decision-making within the U.S. Government; (2) repurposing either of the existing agencies to have broader jurisdiction over spectrum governance; and (3) additional ideas that could be attached to other reforms or stand on their own. For each proposal, we have assigned a letter (e.g., Option A) that is solely intended to help us easily differentiate between the options. The letter selected conveys no meaning or preference by WG1. We have also provided matrices that WG1 prepared as part of our work in Appendix B.

## Table of Options

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### I. Proposals to Stand Up a New Agency

#### A. Full-Service Spectrum Agency

Because there are two entities—the FCC and NTIA—involved in U.S. spectrum governance, opportunities exist for conflict, delayed decision-making while the entities work out these conflicts, and overlapping responsibilities. Full integration of the agencies into one body would allow for the creation of a decision-making chain within the new entity that could resolve policy matters within a single institution. This would ensure that spectrum management decisions are effectively executed, whether the downstream workflow involves solving for the development of a sharing mechanism, resolution of an adjacent channel issue, spectrum auctions, licensing or assignments, equipment approval, or enforcement. Therefore, a single “Full-Service Spectrum Agency” option represents a spectrum governance solution that presents the most comprehensive approach to reform.

Under this approach, the FCC and NTIA would transfer spectrum and related functions to a new entity and continue with non-spectrum-related functions only.<sup>6</sup> Examples of administrative components that would move include portions of: the FCC Wireless Bureau; the FCC’s Office of Engineering and Technology, including lab functions related to wireless equipment certification; FCC International Bureau; FCC Office of Economics and Analytics; FCC Enforcement and Public Safety Bureaus; NTIA’s Office of Spectrum Management and portions of its International Office; IRAC; and likely some ITS lab functions yet to be determined.

Under this approach, there would be a single spectrum management regulatory body within the U.S. Government. While in other options, WG1 provided specific proposals around whether the new entity would exist as an independent agency reporting to Congress (similar

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<sup>6</sup> There are non-spectrum functions that currently represent a significant portion of the FCC’s and NTIA’s workload. The goal of reducing decisional “friction” by having multiple agencies, as well as reducing the potential for redundancy, can be minimized by moving all spectrum related functions to the new entity. This means that for commercial communications entities that utilize a mix of spectrum and non-spectrum inputs, those entities will now face two regulatory bodies for different purposes. The impact of this issue would benefit from further examination.

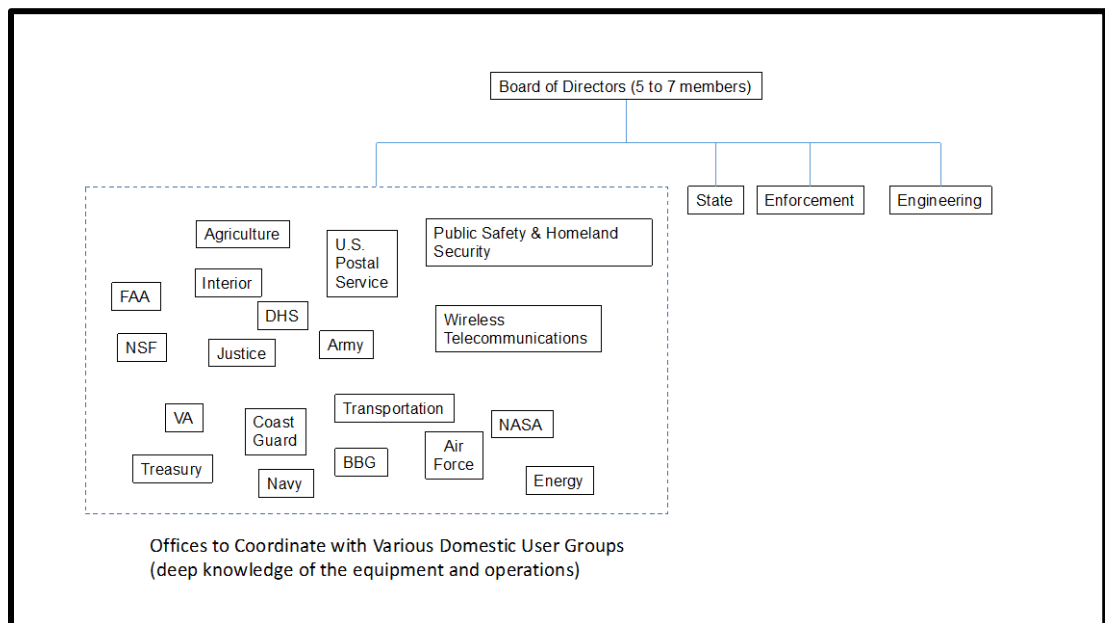
to the FCC) or as an agency reporting to the executive branch, for this option, we are simply noting that where the entity would fit within the U.S. Government's structure is an open issue for future resolution.

This option involves consolidating all of the following spectrum management functions:

- Planning and allocation
- International coordination and cooperation
- Assignment and licensing
- Monitoring and enforcement
- Standards specification and equipment type approval
- Research and development
- Forecasting

Decisions would be made by a board of directors. Pursuant to whatever statutory authority is used to stand up the Full-Service Spectrum Agency, its board would be required to comprise individuals with domain expertise and engineers with radio frequency and electrical engineering credentials.

Spectrum coordination offices would be established within the new agency that would support different user groups, and those offices would also be required to have domain knowledge of the user community and how spectrum is utilized and integrated into user operations. This would instill in the new agency a deep understanding of the systems and missions of federal and non-federal users. An office to coordinate with the U.S. State Department would also need to be part of the new agency. The following figure represents a conceptual view of the new agency with respect to its spectrum-related functions.



The entity would be responsible for the Table of Allocations, frequency licensing or assignments, regulations, databases of relevant information (e.g., publicly available licensing records), sharing regulations, and more. In-house or third-party research and development into propagation models, interference modeling, and sharing mechanisms would also be managed by the Full-Service Spectrum Agency.<sup>7</sup> By combining all of the spectrum-relevant functions into one entity, this option would best address decisional dependencies, where knowledge of one issue is important to the resolution of another. The following is an example of how one function—spectrum planning and allocation—affects other functions within the new agency.

Function	Dependencies
Planning and Allocation	N/A
International Coordination and Cooperation	Consider global standardization and international border issues to develop new spectrum-sharing methods.
Assignment and Licensing	Build on and extend existing assignment databases to support new spectrum-sharing methods.  Need detailed knowledge of current legacy systems and deployment to plan reallocations and to develop spectrum-sharing methods.
Monitoring and Enforcement	Need to develop monitoring and enforcement methods in the design of new spectrum-sharing methods.
Standards Specification and Equipment Type Approval	Need to develop standards and equipment type approval methods when developing new spectrum-sharing methods.
Research and Development	Research and development is required to develop new spectrum-sharing methods.
Forecasting	Forecasting future spectrum use is critical to the reallocation process.

Within **Appendix B** of this report are tables illustrating some of the dependencies that may exist and that would be addressed by having a single entity instead of multiple agencies coordinating. We will not repeat these charts for the other options but, instead, will try to show if other options have the potential to create interagency coordination issues, friction, or delays because the decision-making knowledge is in another agency.

The concerns and open issues that need further examination include the following: (1) By introducing a change in federal decision-making over spectrum and associated activities, such as licensing and equipment authorization, what is the period of uncertainty and disruption that would reasonably be expected before the new entity was effectively stood-up and operating with timely decision-making capacity? (2) Are there collateral issues (e.g., retention of personnel, private sector impacts, negative impacts to government spectrum planning, or others) with this proposed change, and how could they be mitigated? (3) A significant input (i.e., spectrum) to the nation’s GDP and defense systems is effectively in the hands of one agency, making it all the more critical that the new agency be able to initiate its new remit while having the confidence and trust of key stakeholders and projecting domain expertise. Because this option has not definitively been declared to be an FCC-like “independent agency” or an independent agency within the executive branch, we

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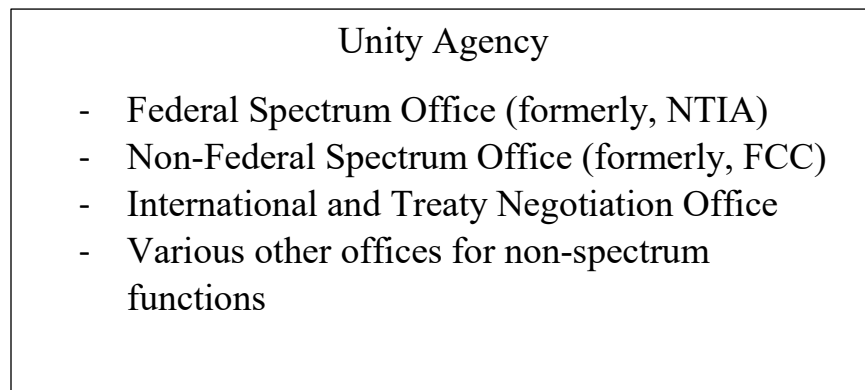
<sup>7</sup> More on this is discussed in the following section on research and development.



do not identify further issues here that would likely need to be examined if the entity were within the executive branch, nor do we examine potential issues if the Full-Service Spectrum Agency were an independent agency reporting to Congress.

## **B. Unity Agency**

This option moves one step further than the Full-Service Spectrum Agency option by folding the entire NTIA and FCC into a new Unity Agency. This would include both spectrum and non-spectrum functions. To borrow an analogy from private sector merger and acquisition parlance, functions within NTIA and the FCC would become subsidiaries of the Unity Agency and would be characterized as “offices” of that new agency.



The new Unity Agency would exist as an independent federal agency under the executive branch analogous to the Environmental Protection Agency. Independent federal agencies are those that exist outside of agencies managed by Cabinet secretaries. While managed by the executive branch (e.g., subject to the Office of Personnel Management and Government Accountability Office), the leadership of the agency is independent of the president by virtue of statutory limitations on the ability of the president to dismiss its leadership. Independent agency leadership posts can also be held for a term that exceeds the 4-year term for the president.

The Unity Agency approach would eliminate the need for FCC commissioners as decision-makers on spectrum and non-spectrum matters. The decision-making function would revert to a single administrator with the component parts of the Unity Agency reporting to the administrator.

This unified approach would allow consolidation of similar functions that the agencies perform. Like the Full-Service Spectrum Agency approach, the Unity Agency merges into one entity all of the following functions related to the use of radio spectrum:

- Planning and allocation
- International policy, including treaty negotiation and border coordination
- Assignment and licensing
- Monitoring and enforcement
- Standards specification and equipment type approval
- Research and development

- Forecasting

In addition, the subject matter dependencies identified as part of the Full-Service Spectrum Agency (Option A) would all apply to this option as well.

An important aspect of the approach is that the Unity Agency would have the requisite expertise, authority, responsibility, and accountability to determine the best use of spectrum and to execute the policy decisions it makes.

The Unity Agency would balance the needs of diverse spectrum stakeholders to promote economic growth and ensure mission requirements are met—a win-win solution. By leveraging more detailed and robust data across industry and government, prioritization schemes, dynamic spectrum access, sophisticated data analytics and modeling, trusted stakeholder collaboration, and objectivity, the Unity Agency would be empowered to achieve the best overall results for the nation.

The Unity Agency would be charged with balancing spectrum needs among federal and non-federal government missions and commercial needs. This is particularly important given the growing demand for radio spectrum by commercial and governmental users. This proposed approach would include band assessments and data analysis; identification of repurposing, reallocation, coexistence, and sharing opportunities; interference analysis, enforcement, and automation capabilities; and feasibility assessments of forward-leaning approaches. It would facilitate joint business cases, shared risks, and opportunities to enable greater spectrum utilization—a potential game-changer that both improves the utility of radio spectrum and increases its value to the nation as a whole.

The Unity Agency approach provides a logical locus for U.S. government global policy leadership because all of the expertise (particularly spectrum and spectrum system expertise) is housed in one agency. The Unity Agency would therefore act as the subject matter expert for the State Department on international treaty matters and would operate as the lead federal agency for spectrum and telecommunications matters.

Moreover, it may be possible for consolidation to eliminate redundant functions. For example, both agencies currently have a role in international treaty development for radio spectrum, and those functions could be combined.<sup>8</sup> Consolidation removes a layer of bureaucracy by allowing stakeholders to interact with one entity that fully controls the policymaking apparatus.

The list of concerns that need further examination include: (1) By introducing a profound change in federal decision-making, what is the period of uncertainty and disruption that would reasonably be expected before the new entity was effectively stood up and operating with timely decision-making capacity? (2) Are there collateral issues (e.g., retention of personnel, private sector impacts, negative impacts to government spectrum planning, or others) with this proposed change, and how could they be mitigated? (3) A significant input (i.e., spectrum) to the nation's GDP and defense systems is effectively in the hands of one agency and, ultimately, one administrator, making it all the more critical that the new entity/administrator be able to initiate its new remit while having the confidence and trust of

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<sup>8</sup> While there is no agreement about whether consolidation could produce cost savings, there is a view that there may be some efficiencies that would lead to reduced costs and timelines. This issue requires further review.

key stakeholders and projecting domain expertise. (4) What are the key FCC functions that help protect constitutional freedoms and that benefit from being separated from control by the Office of the President (e.g., broadcast ownership and content enforcement decisions), and is there a way to insulate these functions from potential interference?

A legal issue that also requires further study is whether the Unity Agency approach is consistent with World Telecommunications Organization (WTO) treaty commitments. That treaty requires the establishment of an independent regulator, which has at least one meaning (possibly two). The first meaning is a regulator independent from an operator (which is not implicated in this proposal). However, the term “independent” has also been used as a framework for urging countries to separate their regulator from a ministry or, in U.S. parlance, cabinet office. A new federal approach that combines all telecommunications and spectrum functions in the Unity Agency may raise issues of how the U.S. has interpreted WTO treaty obligations.

While the Unity Agency would necessarily be stood up by a Congressional action and answer to Congress on fulfilling its statutory obligations and any programmatic assignments made by Congress, special attention would need to be given to auction authority and whether placing auction authority in the hands of an independent executive branch agency would raise any novel issues that would need to be addressed.

On its face, the proposal is also “over-inclusive” of the assignment given to the CSMAC, in that it goes well beyond “spectrum governance.” However, there may be other synergies that make this option interesting to consider, such as combining the FCC’s remit to study competition for broadband and NTIA’s broadband activities, including mapping. If there are other activities that would benefit from combination, that would make a more compelling case for a Unity Agency.

### **C. Spectrum Resource Agency**

The Spectrum Resource Agency (SRA) proposal differs from the prior two options in that it presents a streamlined version of a consolidated spectrum agency with an emphasis on top-level spectrum governance and policy decisions. Unlike either of the prior options, the SRA would not include all associated downstream activities that arise from an allocation decision. Its mission would be limited to the following:

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

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

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

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

For the functions that the SRA performs, the FCC and NTIA would receive the decisions of the SRA (e.g., Table of Allocations decisions) or receive the facts that the SRA has found (e.g., forecasting). For spectrum planning and allocation, the FCC and NTIA would be required to receive the SRA’s work as settled policy and implement their processes in accordance with the SRA’s decision; however, they would be free to participate in its development and suggest further improvements to it as desired. As a helpful analogy, the FCC and NTIA would become “constituents” of the SRA.<sup>9</sup>

The following examples should help illustrate the relationship:

- A decision by the SRA to allocate (or, conversely, not to allocate) a band to terrestrial mobile would have to be followed by the FCC and (if applicable) NTIA.
- A decision by the SRA to allow federal fixed microwave users to share a band also used by commercial fixed microwave users would need to be implemented by both the FCC and NTIA.
- WRC treaty obligations would be considered only by the SRA, although the constituent agencies could request a change, participate in the discussion, and—if the SRA’s final decision did not meet their needs—continue to request further consideration of change.
- The FCC would continue to manage all licensing methods and decisions on licensing approaches for commercial users, including spectrum auctions as an assignment method, but the eligibility of a spectrum band for commercial use would be determined by the SRA’s allocation responsibilities.

Like the Unitary Agency approach, the SRA approach provides a logical locus for Federal Government global policy leadership because the key policymaking expertise is housed in one agency. The SRA would act as the subject matter expert for the State Department on international treaty matters and would operate as the lead federal agency for spectrum

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<sup>9</sup> One additional benefit is that the State Department would be obligated to advance the priorities established by the SRA, as opposed to today’s structure, where it sometimes must reconcile differing views of the FCC and NTIA.

matters.<sup>10</sup> It could also play the lead role in coordinating cross-border issues affecting spectrum use, depending on whether the expertise remained within the state or was consolidated within the SRA.

The SRA would not eliminate the FCC or its commission-led decision-making process for functions remaining at the FCC, nor would it eliminate the NTIA decision-making process for functions remaining at NTIA. The functions transferring to the SRA would report to a single administrator.

For the FCC, functions that would transfer include the portions of the International Bureau, Wireless Bureau, Public Safety and Homeland Security Bureau, Mass Media Bureau, and Office of Engineering and Technology. For NTIA, functions that would transfer include portions of the Office of Spectrum Management, some IRAC functions, and the International division. Stated differently, Part 2 of the Code of Federal Regulations, Title 47, would be the responsibility of the SRA.

By creating a spectrum resource agency, even if that agency is formed of components of NTIA and the FCC, there are some issues that arise because of the separation of policy decisions from policy execution. An example of this would be the research and development function of the SRA—particularly the case of developing new and more innovative sharing mechanisms.

Many spectrum observers believe that spectrum demands will require disparate systems to increasingly share spectrum. In its research and development role, the SRA would have its own engineering resources and budget to continue to develop ways that sharing could successfully occur as well as be more effective in leveraging the whole of government and industries for that research. The SRA could decide on the feasibility of sharing and how that sharing could be achieved to meet national priorities. The SRA would then hand this off to the FCC or NTIA for the implementation of its decision. From that point forward, the SRA would only need to engage if there were concerns that the implementing agency or agencies were not faithfully executing its decision. To be clear, the SRA would evaluate the feasibility of sharing and declare a particular mode of sharing, such as a database. It would be up to the agencies to execute that decision with all of the necessary details and development. This method, while seemingly complicating the sharing process, could facilitate sharing among federal, state, and local governments and commercial systems. This is because the SRA would act as an independent mediator for resolving any disputes that might arise.

With respect to its broader research and development agenda, the SRA can promote and encourage innovation, not only by working in-house but also by inviting private or other governmental entities to contribute. The SRA should maintain an innovation agenda and workstream. With respect to sharing mechanisms, the SRA should be guided by the feasibility of the proposed solution.

A different issue with dependencies arises from the role that the FCC and NTIA play with administration of interference resolution. While the SRA should not become a compliance

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<sup>10</sup> Independent of any option is whether a State Department role is still needed for the WRC treaty process, given that the State Department is not involved in the International Civil Aviation Organization (ICAO), the WTO, and other expert bodies.

or enforcement agency (as in the case of FCC) or mediate specific issues (as in the case of NTIA or its IRAC), there should be some formal feedback mechanism from those agencies to the SRA so that the SRA can be informed if subsequent issues arise (e.g., with a sharing mechanism, adjacent channel, or intermodulation problem).

In addition, there is a possibility for the SRA to backstop certain specific agency compliance efforts if an SRA decision is being violated.<sup>11</sup>

Another set of issues requires further discussion: Whether the SRA would benefit from a non-decisional interagency advisory committee that could include the FCC and NTIA, how to stand up the transferred functions of the IRAC, and whether the agency would benefit from a CSMAC and/or Technical Advisory Committee (TAC).

## II. Proposals to Repurpose and Expand the Jurisdiction of an Existing Agency

### A. “New” FCC

Under the New FCC option, the New FCC would take over all spectrum management responsibilities for the Federal Government and manage the overall spectrum policy. It would assume sole responsibility for both federal and non-federal spectrum in the following areas:

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

All other responsibilities that the FCC and NTIA have today would remain in place.

With sole responsibility for managing the U.S. Table of Allocations, the New FCC would have to accept responsibility for—and accountability to—all stakeholders; non-federal; and federal, state, and local governments. This expanded portfolio would provide the New FCC with spectrum planning and allocation duties to address the needs of both the governmental and commercial systems that the FCC currently oversees. The New FCC would also identify, study, and recommend bands for government-commercial sharing, as well as the sharing of bands within the governmental sectors and within the commercial sectors. The New FCC would also be responsible for initially identifying and recommending a solution for adjacent channel issues. These responsibilities are consistent with the basic mission of the FCC: To

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<sup>11</sup> Rogue transmissions, pirate radio, and other malicious behaviors would ordinarily be in the province of FCC enforcement. One open issue that bears further examination is that automated sharing systems might be able to contribute to the identification of malicious incidents in the future. There are business model and cost issues with this approach that would need to be thoroughly evaluated at the beginning of a sharing design discussion.

make available adequate facilities at reasonable charges, foster national defense, and safeguard lives and property.<sup>12</sup>

The FCC would retain its functions with respect to commercial uses for technical rules, service rules, licensing, competition policy, equipment authorization, and enforcement.

There are significant changes to existing FCC operations that must be considered under this proposal. This proposal would require the FCC to add knowledge of federal systems, which would necessarily require a significantly increased capability for managing national security information, a topic that will be further discussed below. Some of the policy functions that are now assigned to the IRAC would have to be performed under the aegis of the New FCC or, at minimum, directly inform the New FCC decision-making, but specific federal assignments and coordination between federal and non-federal entities on license- or assignment-specific matters could remain with the existing IRAC at NTIA.

With respect to international policy, such as treaty negotiation and border coordination, the New FCC would be the subject matter expert within the Federal Government and would lead the development of U.S. positions and international advocacy.<sup>13</sup>

New responsibilities would also include those that the New FCC would undertake in research and development and forecasting. These are further highlighted in Option E. Forecasting of federal spectrum management needs would in some substantial part need to be conducted under a national security umbrella and not in the open.

Having one agency develop a unified, top-level spectrum management approach would improve the coordination and understanding of the United States' overall plan for its spectrum resources and help develop the plan for spectrum resources going forward. The FCC today manages spectrum policy across a very wide range of stakeholders and technologies, which requires a deep understanding of the technical issues around potential interference. The New FCC is a possibility because it has established administrative processes that are largely open and transparent.

The New FCC could also protect items that are the subject of national security from public scrutiny, but its capacity to handle various levels of classified information would need to be upgraded. Additional staff and internal reorganization of some type would likely be required to protect national security information. At the decision-making level, there is currently an "FCC Defense Commissioner," who is the primary commissioner on homeland security matters. Consideration may be given to expanding this role or establishing in law a role for the designated commissioner (or commissioners) to act on behalf of the executive branch, particularly in matters of national security.

The FCC also has significant experience in developing and administering advanced sharing mechanisms, such as TV white spaces and the Citizens Broadband Radio Service (CBRS)

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<sup>12</sup> 47 USC Section 151 states: "interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States, without discrimination on the basis of race, color, religion, national origin, or sex, a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, for the purpose of promoting safety of life and property through the use of wire and radio communications."

<sup>13</sup> An open issue is whether the involvement of the State Department continues to be needed on these matters.

SAS mechanisms (while recognizing the important contribution of NTIA and its Boulder lab to the CBRS effort). That work could and should continue in cooperation with NTIA and the private sector. But with its expanded jurisdiction, the New FCC would have improved visibility and control when considering sharing mechanisms. With the New FCC as the decision-maker regarding allocations, its decision that a specific federal band would support sharing would carry more weight and ensure that the focus of that decision would reside within its jurisdiction. It would need to continue to cooperate with NTIA at an operational level to advance implementation.

In addition to these issues of national security, other issues with this proposal need to be resolved.

First, while the FCC commissioners routinely resolve competing demands for spectrum and decide important policies around sharing, the responsibility of ensuring that evolving federal requirements can be met would be a significant addition to the FCC portfolio. Therefore, it is highly likely that further development of this proposal would need additional resources, budget, and reorganization for the New FCC.

Second, as the commissioners tend to come from generalist backgrounds (as opposed to engineering backgrounds), new or enhanced capabilities or organizational structures within the Commission may need to be implemented to better support decision-making, particularly regarding the national security issues already discussed.<sup>14</sup> In addition, amendments to the FCC's statutory mission to ensure that new capabilities or structures properly capture its expanded jurisdiction should be considered.

Third, further thought would need to be given on whether to retain the IRAC within NTIA or replicate its policy-making function at the New FCC. If the IRAC remained within NTIA, it might be possible to create new operational rules for what decisions or recommendations the IRAC would make and how and to whom those would be reported.

Fourth, and potentially most importantly, the FCC is an independent agency reporting to Congress and is not housed in the executive branch. It is unclear whether, under the constitutional concept of separation of powers, an independent agency answerable to Congress could or should control the access that Executive Branch agencies have to radio spectrum even if they are statutorily charged with this function. This issue requires careful examination at a legal and policy level, including consideration of mechanisms that could ensure Executive Branch needs are being met. For example, NTIA could be required to stand up a role of "Spectrum Inspector General" for federal agencies to investigate and report on whether the New FCC is fulfilling its responsibilities to federal stakeholders.

Finally, if implemented, this approach would raise uncertainty on the part of federal stakeholders that critical decisions might not be made in a timely way during or immediately after the transition or that they might not get access to spectrum resources critical to their missions during the transition. Transitional mechanisms might be considered to ensure that decision-making could continue until the New FCC became fully staffed and prepared to take on its new responsibilities.

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<sup>14</sup> Recognizing that the FCC's Public Safety and Homeland Security Bureau already has some of these functions.



## B. New NTIA

Under the New NTIA option, the New NTIA would take over all spectrum management responsibilities for the non-federal sector and Federal Government. Its mission would expand to include sole responsibility for both federal and non-federal spectrum in the following areas:

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

All other responsibilities that the FCC and NTIA have today would remain in place, including existing spectrum assignment methods, which, in the case of the FCC, includes spectrum auctions.

Under this option, the New NTIA would expand its authority, taking on exclusive spectrum planning and allocation duties to address the needs of both the federal governmental systems NTIA is already familiar with and the non-federal systems that the FCC oversees. These responsibilities are consistent with the basic mission of the Commerce Department: To generate economic growth. The New NTIA would also identify, study, and recommend bands for government-commercial sharing and for sharing within the governmental and commercial sectors. The New NTIA would also be responsible for initially identifying and recommending solutions for adjacent channel issues. In addition, the New NTIA would retain all of its existing functions.

The New NTIA is a logical choice for a unified approach to spectrum management. For example, NTIA already has significant experience with government spectrum allocations and system requirements and the government systems that utilize them. In addition, NTIA and the Department of Commerce are often exposed to new technologies. NTIA is also a neutral agency within the executive branch that has extensive experience resolving intramural issues on the government side. It also has public safety responsibilities and technical experience with spectrum-sharing and adjacent band interference through the ITS Lab in Boulder.

Regarding international policy such as treaty negotiation and border coordination, the New NTIA would be the subject matter expert within the Federal Government and would lead the development of U.S. positions and international advocacy.<sup>15</sup>

Spectrum forecasts, research and development of sharing systems, radio propagation, and other engineering studies would be handled by the New NTIA. The spectrum forecasts give all stakeholders a common window into how the demand for radio systems is changing. The New NTIA would be responsible for further research and development of sharing systems, which it could do itself or through funding awarded to third parties. Purely commercial-to-commercial sharing systems could be developed privately and would be handled by the FCC, but the New NTIA would handle this issue for mixed or federal government systems.

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<sup>15</sup> An open issue is whether the involvement of the State Department continues to be needed on these matters.

Because of NTIA's increase in responsibility, the status of NTIA would be raised in the Department of Commerce. Given an enlarged set of duties, the job of managing spectrum governance for the entire Table of Allocations might need to be at a more senior level. For example, the leadership might need to be upgraded to the undersecretary level. Whatever the structure, the day-to-day responsibilities of the chief executive would likely be significantly tilted in the direction of spectrum policy. This might lead to increasing the number of senior executive staff who could effectively manage other issues in NTIA's portfolio unrelated to spectrum.

In addition, given the large number of wireless stakeholders that the New NTIA would have, there would likely be a need for a more transparent rulemaking administrative process than what currently exists for NTIA that would still honor its national security requirements. FCC stakeholders have grown used to a highly transparent decision-making apparatus and a routine way of interacting with staff. As much of this culture as possible would need to be imported into the New NTIA.

If implemented, this approach would raise uncertainty on the part of federal and commercial stakeholders that critical decisions might not be made in a timely way during or immediately after the transition or that they might not get access to spectrum resources critical to their missions during the transition. Transitional mechanisms might be considered to ensure that decision-making could continue until the New NTIA became fully staffed and ready to take on its new responsibilities.

Issues requiring further exploration include the following:

- Additional staffing, budget, and reorganization of NTIA's structure to accommodate the new demands placed on the agency.
- Amendments to NTIA's statutory mission to ensure that these properly capture the need to address changes in commercial systems due to technology and consumer demand.

### III. Proposals That Could Attach to Other Options or Stand on Their Own

#### A. Research and Development Option

The current spectrum governance framework fails to address several important questions that profoundly impact our ability to get the most from spectrum. If we are considering changing our spectrum governance processes, it is important that these issues be addressed as part of the transformation. For that reason, we have included a new Research and Development (R&D) function for each of the options presented in the following list. But this function could also be a standalone reform, even if spectrum policy governance is not addressed.

- **Gathering data about consumer demand or other relevant parameters about demand growth.** Today, agencies rely on privately produced data and have no access to a dataset of their own. This is incredibly important with respect to leading spectrum systems to help assess how spectrum allocations will need to change. To be clear, this

function should not necessarily be limited to commercial systems, such as 5G or Wi-Fi, but should also include relevant federal systems. As the deliberations of our colleagues in Working Group 2 have shown, there are serious questions about the authority of the government to collect usage data from licensees that may need to be addressed, in addition to the cost of doing so.

- **Gathering data about evolving technologies and how they will utilize spectrum.** One driver of spectrum utilization is how technology is evolving from a bandwidth and capability perspective. By tracking developments in technology (standards-based or proprietary), regulators can better understand and—more importantly—predict spectrum requirements.
- **Advancing the understanding of radio propagation through refinement in modeling.** While there is some work that is variously performed at NTIA’s Boulder lab or at the National Institute of Standards and Technology (NIST), there is no centralized mechanism to decide what problems are important to help regulators address the interference claims that inevitably arise when systems are asked to share spectrum. This agenda should also include further investigation of adjacent channel effects and intermodulation effects, which are equally important as regulators place diverse systems closer together. The mission of this function should be broad enough to permit further investigation into the harm claim threshold theory and the role of receiver performance.
- **Advancing understanding and development of sharing mechanisms, particularly automated sharing mechanisms.** This should include work on proofs of concept and prototypes. While the private sector will continue to have an important role in the development of sharing mechanisms, the Federal Government needs its own capability to develop solutions and test private sector ideas.

This R&D function could variously be stood up as a group within an agency, administering an internal and external R&D work program, or the function could be privately sourced to an entity required by contract to execute on an R&D agenda provided by government.<sup>16</sup> The main differences from the status quo are: (1) Coordinated focus on spectrum engineering problems and demand study around key spectrum systems that most impact regulatory decision-making, (2) enhanced funding for R&D, and (3) a mechanism to address medium- (3–5 years) and long-term (5–10 years) issues involving our use of radio spectrum (today, these issues are often ignored at the expense of short-term R&D needs).

The benefit of the R&D function is having a dedicated organization work on complex technical study issues. The work of this group could also be guided by an advisory board, and unless it involves a classified system, its work should be publicly available to enhance accountability.

The function would operate similarly to a Defense Advanced Research Projects Agency (DARPA) or National Science Foundation (NSF) program management style of setting a

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<sup>16</sup> A close analogy is the Department of Transportation’s Research Office, led by an assistant secretary. <https://www.transportation.gov/administrations/research-and-technology>

research agenda that is refreshed every couple of years. Public participation in the creation of a research agenda should be mandated, and the R&D function should consult broadly with its stakeholders. This R&D agenda is different than the work today being performed at Boulder,<sup>17</sup> NIST<sup>18</sup>, and other agencies (such as the National Science Foundation and National Academies of Science) in that the agenda is specifically to advance integrated and improved federal management of the Table of Allocations. As such, the function is strongly tied to a regulatory agenda—it does not exist for purely academic exploration of spectrum issues. Moreover, while there is some coordination of R&D today performed by the White House Office of Science and Technology, that coordination function does not uniformly tie R&D to advancing our use of radio spectrum. This new function could do so, acting as both a filter to determine topics where additional investigation is needed and as a driver to focus research efforts to the extent that it can fund these efforts. However, it would not control the research agendas of these other organizations.

As proposed, the R&D function would not be involved with day-to-day activities of NTIA, the FCC, or any other agency (should a new agency be created). This proposal would also not change the agencies' relationships with their labs, which would continue to do the work that they do today. The only difference would be a possible funded research effort that either the FCC or NTIA Boulder lab might wish to undertake on top of existing duties.

Under the existing regime with two agencies, the agencies would ideally have a process to agree to a common set of tasks that would benefit both regardless of where the R&D entity or contractor reported. This could be agreed to as part of the interagency MOU. A possible way to help promote beneficial activities across the two agencies would be to utilize a federal advisory committee to help direct the R&D agenda. The advisory committee would need to be given a charge to recommend that resources be committed to benefit both federal and non-federal stakeholders. Finally, this function would be required to report on its activities and results annually (excluding national security matters). Factual findings could be released on specific matters to inform the agencies based on a common inquiry. However, the agencies could adjust the findings based on record evidence.

Other activities would also be important to ensure no duplication of effort:

- The R&D function could sign an MOU with the National Spectrum Coalition to coordinate or collaborate on R&D; per the MOU, the National Security Council (NSC) could host conferences or workshops on topics of interest.
- The R&D function could enter into a consulting agreement with the NSC.

In addition, personnel would likely attend standards meetings, track standards development for more important spectrum systems, and routinely engage with the vendor community. In addition to engineering, academic disciplines related to forecasting would need to round out

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<sup>17</sup> From time to time, Boulder has performed work in this area at the request of NTIA (e.g., unlicensed use of portions of the 5 GHz band or CBRS). But there is no single function in government addressing the agenda-setting question: What problems does the regulatory community face in administering the Table of Allocations, and what information or solutions do we need to solve them? Also, there is no entity rigorously capturing demand data.

<sup>18</sup> NIST has performed propagation studies, but, again, this is without reference to the broader *regulatory* agenda and the near-term challenges confronting regulators.

personnel assigned to this function. It would appear reasonable to cap the full-time equivalent workforce at 50 persons together with a reasonable research budget.

If the current agency structure is maintained, it would be best to develop a set of R&D questions that have broad applicability to both agencies. For example, the R&D agenda in this eventuality should be added to the MOU. If the function is implemented as a new department within NTIA or the FCC, there would likely need to be legislation to acknowledge the new structure and provide its budget. Moreover, the largest issue with this proposal appears to be budgetary.

## **B. MOU Revision**

This option would improve the existing MOU on spectrum coordination between the FCC and NTIA, including process and timing. Under this option, the agencies would retain their current organization and responsibilities, but the process for review and coordination on spectrum issues would be addressed. However, the process the agencies use to coordinate on spectrum actions, including licensing and use of spectrum, would be improved with set timeframes for action and coordination.

The existing MOU between NTIA and the FCC prescribes that the chairman and assistant secretary will meet at least biannually to conduct joint spectrum planning on the following issues:

- The extent to which licenses for spectrum use can be issued pursuant to section 309(j) to increase federal revenues
- Future spectrum requirements for public and private uses
- The spectrum allocation actions necessary to accommodate those uses
- The actions necessary to promote the efficient use of the spectrum, including spectrum management techniques to promote increased shared use of the spectrum that does not cause harmful interference as a means of increasing commercial access

The proposal would enhance the MOU by:

- 1) Updating the MOU between NTIA and the FCC and incorporating more formal spectrum planning activities that could be more clearly quantified (the MOU was last revised in 2003).
- 2) Regularly updating the MOU (recommended every two years).
- 3) Establishing a process and timeframe for non-routine items (outside of the 15-day period for routine items).
- 4) Including the following revised MOU:
  - a) Review timeframe for non-standard FCC items, including specific timeframes for meetings to resolve related issues and an agreed escalation process all the way up to the FCC chairman and the head of NTIA. Also, such a procedure should consider (as appropriate) participation by other agencies who have an interest.

- b) The FCC and NTIA will provide Congress with an annual report on their joint spectrum planning activities and future spectrum requirements.
- c) Include estimated future spectrum requirements for federal and non-federal uses, the spectrum allocation actions necessary to accommodate those uses, and any actions taken to promote the efficient use of spectrum.
- d) Highlight in the report any outstanding areas where consensus cannot be found.
- e) Evaluate and identify the possible implementation of technologies that enhance spectrum utilization and efficiencies. Utilize the Spectrum Sharing Innovation Test-Bed for collaborative testing of such technologies.
- f) Formalize the development of a national spectrum strategy that provides guidelines for spectrum management decision-making between the two agencies (e.g., how issues will be raised and how conflicts will be resolved).
- g) The FCC and NTIA will hold a joint workshop annually to discuss spectrum research and coordination activities and explore novel spectrum-sharing and management techniques and approaches.
- h) The FCC and NTIA will agree to develop a common set of metrics to predict potential harmful interference.
- i) The FCC and NTIA will create and co-chair the Federal Advisory Committee on Spectrum Planning and Usage, comprising both federal and non-federal stakeholders, to develop collaboration and planning strategies between federal and non-federal spectrum users and licensees.

Finally, we note that this may also be a good transition mechanism to a longer-term solution and does not require legislation.

### **C. Periodic Review of Spectrum Governance Models**

We should establish a review process to periodically assess and maintain the effectiveness of spectrum governance in the U.S. A reasonable period for review would be every 3–5 years by an agency such as the General Accounting Office. This review would be released publicly.

### **D. Miscellaneous Options**

There are several actions that can improve spectrum governance, regardless of the framework:

- Increasing detailees from each agency (FCC and NTIA) to cross pollinate the agencies, improving communications and understanding of the process.
- Housing the FCC and NTIA in the same office complex so that they can communicate more easily.

- Internal FCC and NTIA reorganization as a step toward another reform outlined earlier. It may make sense to put all spectrum responsibilities in each agency into one bureau or office so that they can be easily reorganized within the final structure.

## **Conclusion**

WG1 has concluded its work on its mission, with this report, on whether there is utility in revising the U.S. spectrum management approach, and to consider what structural changes, new entities, roles, responsibilities, and legislation would be required to implement.

## **Appendix A: WG1 Members**

- Co-chairs: Jennifer A. Manner/Mary L. Brown
- Andrew Roy
- Audrey Allison
- Bryan Tramont
- Carl Povelites
- Carolyn Kahn
- Chris Weasler
- Claude Aiken
- Dale Hatfield
- Jeff Cohen
- Mariam Sorond
- Mark Crosby
- Mark Gibson
- Mark Lewellen
- Mark McHenry
- Mark Racek
- Michael Calabrese
- Robert Weller
- Steve Sharkey
- Thomas Dombrowsky
- Wayne Phoel
- Jennifer Warren
- NTIA Liaison: Chris Mattingly



## Appendix B

### Full-Service Spectrum Agency

The following tables show what each spectrum management function needs from the other functions to succeed. As shown, there is significant interdependence among all of the functions.

• *Table 1. Planning and Allocation Function Dependencies on Other Spectrum Management Functions*

<b>Function</b>	<b>Dependencies</b>
Planning and Allocation	N/A
International Coordination and Cooperation	Need to consider global standardization and international border issues to develop new spectrum-sharing methods.
Assignment and Licensing	Need to build on and extend existing assignment databases to support new spectrum-sharing methods. Need detailed knowledge of current legacy systems and deployment to plan reallocations and to develop spectrum-sharing methods.
Monitoring and Enforcement	Need to develop monitoring and enforcement methods in the design of new spectrum-sharing methods.
Standards Specification and Equipment Type Approval	Need to develop standards and equipment type approval methods when developing new spectrum-sharing methods.
Research and Development	Research and development is required to develop new spectrum-sharing methods.
Forecasting	Forecasting future spectrum use is critical to the reallocation process.

• *Table 2. International Coordination and Cooperation Function Dependencies on Other Spectrum Management Functions*

<b>Function</b>	<b>Dependencies</b>
Planning and Allocation	Need to include the United States' plans for future spectrum needs and future spectrum-sharing approaches for international coordination.
International Coordination and Cooperation	N/A
Assignment and Licensing	Need knowledge of legacy US border spectrum assignments to resolve border issues.
Monitoring and Enforcement	
Standards Specification and Equipment Type Approval	Need to develop worldwide standards and approval approaches.
Research and Development	
Forecasting	Need to include the United States' plans for future spectrum needs for international coordination.

- *Table 3. Assignment and Licensing Function Dependencies on Other Spectrum Management Functions*

<b>Function</b>	<b>Dependencies</b>
Planning and Allocation	Need to build on and extend existing assignment databases to support new spectrum-sharing methods. Need detailed knowledge of current legacy systems and deployment to plan reallocations and to develop spectrum-sharing methods.
International Coordination and Cooperation	
Assignment and Licensing	N/A
Monitoring and Enforcement	
Standards Specification and Equipment Type Approval	
Research and Development	Need to provide detailed knowledge of legacy spectrum users and equipment to make R&D relevant.
Forecasting	

- *Table 4. Monitoring and Enforcement Function Dependencies on Other Spectrum Management Functions*

<b>Function</b>	<b>Dependencies</b>
Planning and Allocation	
International Coordination and Cooperation	
Assignment and Licensing	
Monitoring and Enforcement	N/A
Standards Specification and Equipment Type Approval	
Research and Development	Need to coordinate with R&D efforts to enable practical spectrum-sharing approaches.
Forecasting	

- *Table 5. Standards Specification and Equipment Type Approval Function Dependencies on Other Spectrum Management Functions*

<b>Function</b>	<b>Dependencies</b>
Planning and Allocation	Need to coordinate with planning and allocation efforts to enable practical spectrum-sharing approaches.
International Coordination and Cooperation	Need to develop worldwide standards and approval approaches.
Assignment and Licensing	
Monitoring and Enforcement	
Standards Specification and Equipment Type Approval	N/A
Research and Development	Need to coordinate with R&D efforts to enable practical solutions.
Forecasting	

- *Table 6. Research and Development Function Dependencies on Other Spectrum Management Functions*

<b>Function</b>	<b>Dependencies</b>
Planning and Allocation	Need requirements and scenarios to base R&D on.
International Coordination and Cooperation	
Assignment and Licensing	Need detailed knowledge of legacy spectrum users and equipment to make R&D relevant.
Monitoring and Enforcement	Need requirements and scenarios to base R&D on.
Standards Specification and Equipment Type Approval	Need to develop technologies that can be practically approved for operation. Need requirements and scenarios to base R&D on.
Research and Development	N/A
Forecasting	

- *Table 7. Forecasting Function Dependencies on Other Spectrum Management Functions*

<b>Function</b>	<b>Dependencies</b>
Planning and Allocation	Need information about planned spectrum uses.
International Coordination and Cooperation	Need to understand worldwide trends in equipment and applications to create forecasts.
Assignment and Licensing	Need detailed knowledge for current users to provide spectrum use baselines.
Monitoring and Enforcement	
Standards Specification and Equipment Type Approval	
Research and Development	Need to understand how new spectrum-sharing R&D approaches would impact spectrum usage.
Forecasting	N/A