Spectrum Management for Economic Growth and National Security

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Spectrum Management for Economic Growth and National Security

Introduction

*Spectrum is an essential engine for economic strength, driving U.S. leadership domestically and worldwide. It also provides our armed forces the ability to dominate the battlefield in the event of conflict. Continued collaboration between industry and DoD is the key to enabling both our economy and our armed forces to make optimal use of this scarce resource.*—Maj. Gen. Robert E. Wheeler (USAF Ret.), former Deputy Chief Information Officer for Command, Control, Communications and Computers and Information Infrastructure Capabilities, U.S. Department of Defense

Demand for applications and services that rely on the electromagnetic spectrum has grown exponentially. Mobile smart devices, capable of audio and video streaming, are expected to generate 23 times more traffic by 2020. Adding to the challenge, machine-to-machine (M2M) connected devices, including the expanding Internet of Things (IoT), will account for more than 25 percent of all connections by 2020.¹

Accommodating this growth will require large swaths of spectrum. In 2010, the Obama administration issued a presidential memorandum directing the National Telecommunication and Information Administration (NTIA) to free up 500 MHz of spectrum for wireless broadband by 2020.² This economically critical goal presents a significant challenge to spectrum-allocation policies, which maintain a delicate balance between a diverse set of users.

Spectrum not only enables commercial wireless communication and mobile broadband service vital to the U.S. economy, it is also fundamental to federal services and national security. The Department of Defense (DoD), in particular, relies on the electromagnetic spectrum for mission-critical capabilities, such as air and ground force communication, electromagnetic warfare, munitions guidance, and unmanned aerial system control. Spectrum helps to drive our global market leadership and the unmatched capabilities of our armed forces.

The process of balancing spectrum allocation between federal and commercial users is complicated. Commercial providers seek spectrum in order to maintain service and deliver new, more-efficient services to consumers, including government. DoD and other federal entities seek spectrum in order to execute mission-critical functions. Spectrum demands for both commerce and defense will continue to grow.

Economic and national security gains from spectrum policy are not mutually exclusive. The present process is based on Federal Communications Commission (FCC) spectrum auctions and the Spectrum Relocation Fund (SRF) to make more spectrum available for commercial use. A portion of the auction proceeds funds federal relocation efforts. This model has proven successful. In 2015, the Advanced Wireless Services (AWS)-3 auction produced billions of dollars from wireless providers that went directly to federal agencies. Confronted with the exponential growth in digital devices and sensors, we should continue the strategy of spectrum auctions, while also identifying ways in which the current approach can be expanded and accelerated.

Current restraints on SRF funding for federal research and development must be adjusted to allow federal users to be more efficient and flexible in their spectrum use. Combined with greater federal adoption of commercial off-the-shelf technologies, and opening of spectrum "beachfront property" for commercial use, this can maintain federal mission assurance while satisfying the universal need for more spectrum.

The Auction Process

The FCC allocates spectrum through auctions. First, the FCC identifies the spectrum bands it will open for wireless provider use. The NTIA then directs federal incumbents in the band to study their relocation capability and write transition plans. Federal agencies identify alternative spectrum that suits their needs and write SRF expense requests for system redeployment. Federal incumbents will vacate the spectrum to be auctioned, whether through wholesale mission relocation or temporary or permanent sharing arrangements. As seen in past auctions such as AWS-3, this has allowed federal users to upgrade or replace older systems with newer technologies, something they were often unable to do without the funding provided by auctions.3

If commercial incumbents operate in the band, the FCC must buy the spectrum of interest from them. These incumbents are usually over-the-air TV providers whose licenses are largely unused. The FCC offers progressively lower bids in a reserve auction to broadcast TV providers, until the requisite amount of spectrum is obtained. Wireless providers then engage in a forward auction to buy available spectrum.4 The Office of Management and Budget

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OMB then authorizes funds transfers from the SRF to federal agencies to cover their relocation expenses.\(^5\)

This system is a remarkable improvement from historical allocation procedures. In 1993, for instance, the NTIA was directed to reassign 200 MHz of federal spectrum to commercial use. While the 1999 Strom Thurmond Act mandated direct reimbursement of federal users from the commercial providers to occupy the spectrum, federal users had no real protections under the arrangement, and were not compensated under the Act’s rules.\(^6\)

The National Defense Authorization Acts (NDAA) for fiscal years 1998 through 2000 gave federal users authority to seek reimbursement for relocation costs, and assured DoD that alternative bands of comparable technical suitability would be provided. This leveled the playing field—federal users could be compensated while commercial providers could gain access to new spectrum for their businesses.

Commercial users are granted access to spectrum frequency bands through three mechanisms: the wholesale relocation or clearing of incumbent users to another band; sharing schemes based on geography, timing, and other technical requirements between new and incumbent users; or a combination of relocation and sharing.\(^7\) The success of this approach is best exemplified in the recent AWS auction, in the 1755–1780 MHz band.

Effective Cooperation

The repurposing of the 1755 MHz band is an example of effective cooperation to maximize spectrum efficiency. DoD and other federal agencies depended on this portion of the band for a multitude of functions: military tactical radio relay; air combat training systems; spacecraft tracking, telemetry, and command (TT&C); law enforcement video surveillance and robotics; terrestrial aircraft telemetry; missile flight testing; and unmanned aerial systems control. Figure 1 shows the missions assigned to the spectrum band.\(^8\)

NTIA concluded in March 2012 that it was possible to relocate most federal missions in the band, and vacate it for wireless broadband use.\(^9\) Some systems would remain indefinitely, including satellite TT&C for emergency procedures, testing and training for electronic warfare (EW), and software-defined radios. Defense users of the spectrum band developed

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\(^5\) National Telecommunications & Information Administration, "AWS-3 Transition," https://www.ntia.doc.gov/category/aws-3-transition.


\(^8\) All data presented here extracted from National Telecommunications & Information Administration, "1755–1850 MHz," October 6, 2014, https://www.ntia.doc.gov/files/ntia/publications/compendium/1755.00-1850.00_01DEC15.pdf.

transition plans detailing temporary sharing arrangement, and identified destination spectrum and cost estimates. For all systems requiring continued use of the 1755–1850 MHz band, DoD required “a clear procedure ensuring priority access to this spectrum.” The NTIA’s study paved the way for the FCC’s license auction in 2015.

Figure 1. Percentage of Frequency Assignments in the 1755–1850 MHz Band, by Mission

The subsequent auction produced over $41 billion. The Spectrum Act dictated how this money would be spent. First, FCC auction costs would be paid. Next, auction revenues were used for the Spectrum Relocation Fund to reimburse relocation or sharing costs incurred by agencies vacating the auctioned spectrum. This totaled $5.03 billion. After paying relocation expenses, the Spectrum Act required that auction revenues go into the Public Safety Trust Fund to support the First Responder Network Authority (FirstNet), a high-speed, interoperable, nationwide wireless broadband network for emergency and public safety communications, and other public safety programs. Finally, more than $20 billion went directly to the Treasury Department for deficit reduction.

The military’s capabilities and systems are greatly improved as a direct result of proceeds of the last two auctions of spectrum reallocated for commercial use. We need more opportunities that benefit American consumers and American fighting men and women.—Maj. General Robert E. Wheeler (USAF Ret.), former Deputy Chief Information Officer for Command, Control, Communications and Computers and Information Infrastructure Capabilities, U.S. Department of Defense

Enabling Proactive Federal and Defense Investment

The explosion in demand for spectrum requires a more comprehensive approach to reallocation. Federal and national security missions must be protected. Risk-averse federal and defense users should be afforded more agility in identifying and deploying new
technologies to improve and relocate their operations. The best way to do this is to expand the SRF’s provisions for research and development.

The 2012 Spectrum Act codified a process whereby license auction proceeds are directed to the SRF, to fund research and relocation into new bands, and to test the feasibility of sharing bands with commercial users. The 2015 Spectrum Pipeline Act went one step further. Under this Act, federal entities can recover funds used to improve spectrum-use efficiency in bands not yet identified for auction. A federal entity can submit a research plan for review by an NTIA Technical Panel composed of three technical experts.\(^\text{10}\) The panel’s decision is based on the probability of federal relocation as a result of the project, possibility to auction off vacated spectrum no later than eight years after the project, and the expected increase in value of the spectrum band in the subsequent auction.\(^\text{11}\)

This is a step in the right direction. However, increasing demands for spectrum call for more change in SRF administration to allow federal agencies more flexibility in research and development. Efficiency will become more important as both the volume and types of data exchanged over wireless spectrum increase. SRF funding procedures should be altered to allow for research and development into spectrum efficiency with fewer restraints. This could also lead to an auctions process where larger spectrum blocks are allocated, and exclusion zones are more effectively roped off, satisfying carriers and federal agencies.

Fostering Next-Generation Technology and Infrastructure Development

FCC auctions have been helpful for improving efficiency by relocating incumbent users. However, incremental improvements to spectrum-dependent technologies have greatly increased transmission speeds, straining available spectrum resources. For instance, 4G LTE transmits at a data rate 16 times greater than 3G. As commercial providers transition to 5G technologies, however, growth in wireless traffic will outpace the ability of new-generation networks to support the traffic. This will create a technology backlog, and vastly exacerbate the spectrum-management problem.

That said, there are more proactive approaches to satisfy growing demand in the commercial sector while not jeopardizing the ability of DoD and other agencies to conduct key missions. The 2015 Spectrum Pipeline Act made FCC auction revenue directly available to federal research and development efforts for improving spectrum use and efficiency. This made the job of federal users much easier, but spectrum users still face a challenging landscape to meet rising demand. In the near term, the most pressing strain on networks will continue to

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\(^{\text{10}}\) One expert each is appointed by the director of OMB, the assistant secretary of commerce for communications and information, and the chairman of the FCC. Legal Information Institute, “47 U.S. Code § 923—Identification of reallocable frequencies,” Cornell University Law School, https://www.law.cornell.edu/uscode/text/47/923.

be confined to specific geographic locations, and often limited to "rush" periods of high-density usage.

Greater use of shared spectrum is one solution, although there are challenges. For example, the FCC wants to open up the 3.5 GHz band for mobile broadband under an experimental spectrum-sharing regime. The Navy presently uses this band for coastal and offshore radar systems. To ease concerns that commercial services in the band would interfere with Navy operations, the FCC announced that an experimental spectrum-sharing arrangement would be tested in the band. The arrangement is based on the "Spectrum Access System" (SAS), a sensing-based access-management technology undergoing global trials, and will feature three tiers of priority, with top-tier incumbents completely protected from interference from commercial or general use.12

Sharing arrangements—geographic, temporal, or otherwise—have long been proposed as solutions to help meet rising demand. While SAS and other new technologies have the potential to improve quality of service, they do not completely eliminate risk for federal users. Also, sharing arrangements are still subject to restrictions or limitations on use that can make it difficult for commercial providers to use some bands.13 Sharing solutions can be first steps on the path to long-term improvements in spectrum efficiency.

Another way to ease strain on federal missions is to open up more spectrum "beachfront property" for technology development and future commercial use. Through the Spectrum Frontiers initiative, the FCC identified high-band millimeter waves to be made available for the development of 5G. In July 2016, the FCC opened up nearly 11 GHz of spectrum in the high-frequency bands between 28 GHz and 71 GHz (specifically, licensed bands at 27.5–28.35, 37–38.6, and 38.6–40 GHz, and a wide unlicensed band at 64–71 GHz).14 Critically, in doing so, the FCC did not impose technology or use requirements, allowing commercial operators more freedom to develop for this space.15 With the right technology, this unclaimed spectrum could be used to offset commercial usage in high-value-generating urban areas.

While the prospect of unclaimed spectrum sounds promising, use of these frequencies is not without challenges. Millimeter waves above 24 GHz decay quickly as they travel, and do not easily penetrate obstacles. New technologies will be needed to support their deployment including intelligent small cells, advanced antenna technology, and flexible networking

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software. Other challenges in deploying these new technologies generally involve improvements to network efficiency to support IoT and next-generation devices, and updating physical infrastructure. Moving into unclaimed spectrum bands will require large infrastructure investments on the part of commercial providers, but this approach balances the economic gain of increased spectrum availability with federal and defense mission assurance.

Partnerships for Spectrum-Allocation Technology

In 2012, the Presidential Committee of Advisors on Science and Technology recommended that a Spectrum Sharing Partnership Steering Committee of industry executives, in collaboration with NTIA and FCC, manage a national shift away from rigid licensing arrangements and toward full spectrum sharing. Specifically, the committee recommended a target of identifying 1,000 MHz of underutilized federal spectrum in which to deploy spectrum-sharing technologies.

The proposal was controversial, but technological progress may allow it to be implemented. The National Advanced Spectrum and Communications Test Network, a CAC-DoD joint research arrangement, brings together technical and policy communities from federal and commercial entities to develop new spectrum-management technology at minimum risk to both parties.

Similarly, the Defense Advanced Research Project Agency’s (DARPA) newest Grand Challenge is designed to develop “smart” systems that collaboratively adapt to today’s congested spectrum environment, using advanced software-defined radio for spectrum efficiency. The goal of the three-year program is to develop machine-learning systems that can be implanted into radios to autonomously optimize spectrum usage. This long-awaited technology could eventually enable a wholesale departure from fixed spectrum-allocation policies and allow more effective broadband sharing. DARPA encouraged companies, universities, and independent competitors to take part in the challenge. Proposals and technologies that come out of partnerships like these will shape the future of spectrum management. To spur this development, DARPA, NTIA, and academic centers of excellence should all be provided more federal resources to drive a coordinated research agenda.

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17 Ibid.
Next Steps

The current spectrum-allocation model is a successful one, but federal users will require more flexibility to pursue research and development as data streams become increasingly crowded. First and foremost, this necessitates adjustments to the SRF. Agencies are already able to draw from the fund upfront to cover research and development, but these requests are governed by a lengthy review process based on future auction value add. More freedom to improve spectrum use efficiency would allow DoD users to more quickly integrate and streamline missions. This would vacate more spectrum, and decrease the strain on commercial users to satisfy demand.

Once DoD is assured greater agility in studying and deploying spectrum-efficient technologies, further measures can be pursued to evolve current spectrum-management procedures. Simultaneous development of engineering-based proposals, like Spectrum Access System technology, and opening up of spectrum “beachfront property” for future licensing will help to ensure that DoD’s missions can be continued in presently occupied spectrum while allowing commercial providers to expand their services.

Bolstered public/private partnerships, through DARPA, NTIA and academic centers of excellence, would help advance the development of intelligent spectrum-management technology. Federal and defense users will then be able to identify suitable areas in which to adopt off-the-shelf commercial technologies for certain communications and missions. As these changes take hold, the auction process itself can shift its focus toward increased sharing, and a national-level planning body can develop long-term spectrum-management policies that both benefit commercial users and preserve critical Department of Defense and federal functions.

The spectrum-allocation dilemma is a longstanding one, but it is not without solutions. Successful models for federal-commercial information sharing, cooperation, and collaboration already exist. These models will, however, have to be matured to match growing commercial demand for spectrum in the coming years. The following are three recommendations for maintaining national security-preserving spectrum-allocation policies well into the future.

1. Modernize SRF administration for more agile deployment of new technologies. Improving accessibility to SRF funds is the most critical change necessary for DoD to begin preserving mission-critical functions today. Stricter operational requirements and drawn-out technology development life cycles afford DoD far less flexibility than commercial users in deploying, maintaining, and improving spectrum-usage technologies. The R&D funding provisions of the SRF must be opened up for increased use. For instance, using these funds, DoD can improve spectral efficiency by investing in the next generation of systems that use white space. The FCC has already taken steps to approve the use of white-space devices that take advantage of unused broadband spectrum to improve the quality of commercial services in certain geographic areas. Investing in technologies that can more easily identify and access underused bands in the unlicensed space, or allowing DoD and commercial providers
to move into the higher-frequency bands above 24 GHz without fear of interruption, should be research priorities. A modernized SRF could allow DoD to explore these and other new technologies.

2. **Continue to develop potential sharing programs between industry and government.** Some approaches to sharing could benefit national security and the economy. In particular, fast band-switching technology would allow commercial providers to take advantage of fringe spectrum to offload heavy traffic, while preserving DoD humanitarian/disaster relief operations. This would eliminate the need for time-intensive international band coordination, and would assuage fears of signals being jammed in a combat scenario. The FCC has helped improve both DoD and commercial spectrum use efficiency in some respects, and can continue to do so by facilitating more band-sharing schemes between federal and commercial entities.

Recognizing the limits of these arrangements is important. Sharing should be encouraged to the degree that it does not force DoD and commercial providers to pursue solutions that impose undue costs and tradeoffs to federal and commercial users, especially where alternative arrangements have the potential to create mutual benefits.

3. **Enable public-private partnerships for spectrum R&D and management.** R&D institutions such as DARPA, NTIA, and universities should develop harmonized research agendas and be afforded more resources to pursue technology-driven solutions. To be effective, engineering-based solutions should be informed by a national-level spectrum usage planning process to sustainably manage spectrum in the long term. This process could build on the work of the National Spectrum Consortium, involving both industry and federal entities, to lay out a roadmap for spectrum usage, and research and development, over the next 10 to 20 years.

**Conclusion**

The high level of engagement that preceded the auction of the 1710–1850 MHz band demonstrates that successful collaboration and cooperation can create mutual gains. Success, however, cannot be taken for granted. Inaction will not meet rising demand, and will come at the cost of innovation and competitiveness.

Investing in research and development for technical solutions that take advantage of unused and underused bands should continue to be a priority. But new technology alone is not a silver bullet. Reforming the FCC auction process to prioritize sharing and limit federal relocation would improve the management of existing resources in the near term. Legislative changes that would introduce greater flexibility in the transfer and use of licenses should also be explored. Spectrum is an essential part of the technologies, applications, and services that make up the information age, and managing this resource is vital to both continued economic growth and national defense missions. Only through sustained engagement can federal and commercial entities find a balance to continue leading in spectrum-dependent capabilities for the future.
About the Author

James A. Lewis is a senior vice president at CSIS, where he writes on technology, security, and innovation. Before joining CSIS, he worked at the Departments of State and Commerce as a Foreign Service officer and as a member of the Senior Executive Service. His government experience includes work on a range of politico-military and Asian security issues, as a negotiator on conventional arms transfers and advanced military technology, and in developing policies for satellites, encryption, and the Internet. Lewis led the U.S. delegation to the Wassenaar Arrangement Experts Group on advanced civil and military technologies and was the rapporteur for the 2010, 2013, and 2015 UN Group of Government Experts on Information Security. He was also assigned to U.S. Southern Command for Operation Just Cause and to U.S. Central Command for Operation Desert Shield. He received his Ph.D. from the University of Chicago.

Lewis is an internationally recognized expert on cybersecurity. Lewis is the U.S. lead for a long-running Track II Dialogue on cybersecurity with the China Institutes of Contemporary International Relations. He has authored numerous publications on the relationship between technology, innovation, and national power. Other reports written by Lewis examine the role of space in national security. His current research examines international security and governance in cyberspace, the relationship between innovation and technology, the future of warfare, and the effect of the Internet on politics. He has served as a member of the Commerce Department’s Spectrum Management Advisory Committee and the State Department’s Advisory Committee on International Communications and Information Policy, and as a member and chair of the Advisory Committee on Commercial Remote Sensing. Lewis is frequently quoted in the press and has testified numerous times before Congress.
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