# Evolving Economic and Policy Mechanisms to Support Spectrum Sharing

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***Abstract*—Technological progress in electromagnetic spectrum sharing must be coupled with innovation in economic and policy mechanisms. This discussion paper considers the current and future role of economic and policy mechanisms needed to support spectrum sharing. It highlights the influence of economic and policy in spectrum repurposing. Continuous regulatory reform could be an important advancement to support greater spectrum sharing. Economic innovation is also needed to increase the fungibility, or exchangeability, of spectrum access. Coupling technological, economic, and policy innovation will enable the United States to more efficiently and effectively accommodate increased demand for spectrum.**

***Keywords—electromagnetic, spectrum, economic, policy, repurposing, sharing***

## I. Introduction

The pervasiveness of electromagnetic spectrum sharing depends on bridging the gap between technology and economic and policy innovation [1]. While technical advancements are underway and in development to enable spectrum sharing—such as carrier aggregation, self-optimizing networks, real-time databases, sensing, and waveform co-design—economic and policy innovation is needed to make evolved and expedited spectrum sharing a systematic reality.

Economic and policy mechanisms influence stakeholder decisions. The ability to use spectrum more efficiently and effectively via sharing depends on the integration of technology, economic factors, and policy innovation. This conceptual paper first highlights current economic and policy mechanisms and then provides considerations for policy and economic innovation.

## II. Current Economic and Policy Mechanisms

The White House and Congress have been repurposing spectrum from federal agency use to commercial wireless services for decades. This activity has been stipulated via executive and legislative measures. Some examples of these measures include the Commercial Spectrum Enhancement Act (CSEA) [2], Middle Class Tax Relief and Job Creation Act [3], Spectrum Pipeline Act [4], Making Opportunities for Broadband Investment and Limiting Excessive and Needless Obstacles to Wireless Act of 2017 (MOBILE NOW) [5], Infrastructure Investment and Jobs Act [6], and international Radio Regulations [7].

The CSEA in 2004 established the Spectrum Relocation Fund (SRF), which is administered by the Office of Management and Budget (OMB) in consultation with the National Telecommunications and Information Administration (NTIA). The SRF provides a mechanism, funded from auction proceeds, for federal agencies to be reimbursed for some of their costs to repurpose spectrum from federal agency to commercial use; remaining funds are deposited in a general fund of the Treasury. Since its initial establishment, multiple legislative acts have evolved the SRF. The Middle Class Tax Relief and Job Creation Act of 2012 expanded eligible costs to include relocation or sharing costs; pre-auction costs; costs of research, engineering studies, and economic analyses; costs to modify or replace equipment; and engineering costs. The Spectrum Pipeline Act of 2015 further extended eligible costs to include research, development, and planning activities that increase the probability of relocation or sharing, increase expected net auction proceeds, or other activities to improve spectrum efficiency and effectiveness in order to increase spectrum reallocation and/or sharing.

Beyond establishing the SRF, legislative acts have explicitly mandated spectrum repurposing. The Spectrum Pipeline Act of 2015 required the Secretary of Commerce to identify 30 MHz of federal spectrum for repurposing or sharing by 2022 for auction by 2024 [4]. MOBILE NOW required NTIA and the Federal Communications Commission (FCC) to repurpose 255 MHz of spectrum for mobile broadband by December 31, 2020 [5]. The Infrastructure Investment and Jobs Act of 2021 made available pre-auction funding for the Department of Defense (DoD) to study the 3.1 to 3.45 GHz band for potential repurposing [6].

At the international level, spectrum is governed by the Radio Regulations, the international treaty governing the allocation and use of radio frequency spectrum and satellite orbital locations. The Radio Regulations are reviewed and revised, if necessary, during the World Radiocommunication Conference (WRC), which is held every three to four years by the International Telecommunication Union, the United Nations specialized agency for information and communication technologies. The agenda for each WRC is preliminarily established during the preceding WRC, typically following national and regional preparations and support. International harmonization provides important benefits, including facilitating global usage, driving economies of scale, and minimizing border issues.

## III. Spectrum Repurposing

Since Congress authorized FCC spectrum auctions in 1993, over 100 auctions have been conducted, generating $230 billion to the Treasury [8]. Noteworthy is the recent auction of spectrum in the C-band, specifically 3.7 to 3.98 GHz, which yielded over $90 billion. The C-band spectrum auction was the highest-grossing spectrum auction ever and may have also been the highest-revenue-generating auction of any kind ever [9].

According to NTIA, through "a combination of reallocation, license modifications, new leasing authority, and greater regulatory flexibility," the government has made more than 1,130 MHz of licensed mid-band spectrum ready for U.S. industry to deploy for 5G services, and an additional 15,215 MHz of unlicensed spectrum is being made available for next-generation Wi-Fi and related technologies [10] [11]. As a result of spectrum repurposing, industry benefits from cheaper and more ubiquitous data [12].

However, continuous repurposing of spectrum from government to commercial users is unsustainable. Spectrum is critical to federal agency missions, which our nation requires for national security, science, safety, and other federal mission goals now and in the future [13]. Decisions to allow spectrum sharing in suitable bands offer a more sustainable approach that enables increased efficiency and flexibility of the use of spectrum to better accommodate increased demand [14]. Further, the international spectrum regulatory process is lengthy and can take a decade to implement change.

## IV. Continuous Regulatroy Improvement

Continuous regulatory reform could be an important advancement to support a more sustainable approach that includes greater spectrum sharing. As introduced by Rebecca Dorch and Michael Cotton in the International Symposium on Advanced Radio Technologies (ISART) 2022's call for proposals, a continuous regulatory improvement model could be an iterative process that is more responsive to change [15].

The concept of continuous regulatory improvement would provide greater agility in the policy domain. Agile approaches are used in other contexts, including software development, acquisition, systems engineering, testing, collaboration, project management, and organizational transformation. Its benefits include faster timelines, increased quality and performance, improved efficiency, and reduced risk. Continuous process improvement can be used for planning, initial small-scale implementation, analysis of results, identification of gaps, and refinement to address challenges and close gaps [16].

An iterative spectrum policy process should start with initial decisions known not to cause adverse impacts, followed by more detailed engineering analysis, policy pilots, tests, and experimentation to inform subsequent and more refined or targeted policy decisions. Initial policy could be followed by improved iterations of the policy.

A more agile approach to spectrum policymaking should leverage engineering data and spectrum information technology (IT) modernization [17] to be more responsive to technological change. This could be implemented using current processes that are accelerated by use of data and modernized IT infrastructure. The foundation for an accelerated process must be established. This requires the secure collection and maintenance of robust data, development and acceptance of standardized analysis methods, efficient and effective coordination processes and procedures, and development and implementation of modernized IT infrastructure. Many of these efforts are currently underway. As robust data is increasingly collected, analysis guidelines accepted and standardized, and IT infrastructure modernized and integrated, timelines for spectrum policy decision-making based on science and engineering should accelerate without adversely impacting safety or risk.

## V. Considerations for Economic Innovation

Continuous regulatory improvement must be supported by economics. For spectrum sharing to be viable on a more widespread basis, a sustainable economic model is needed to negotiate "spectrum use that does not depend upon 'one-and-done' auctions that have the effect of depleting a finite resource [11]."

Stakeholders must continually balance many tradeoffs, including technical and operational requirements, resource needs, costs, benefits, risks, and schedule. Each stakeholder weighs these considerations from its own perspective. Decisions should be economically viable both at the micro (e.g., organization) and macro (e.g., national) levels.

Economic reform is needed in the spectrum domain to increase the fungibility, or exchangeability, of spectrum access and provide greater support to spectrum sharing. This could be realized via several different mechanisms.

The Spectrum Relocation Fund could be reformed in several different ways. First, its scope could be expanded to more completely reimburse federal agency costs of spectrum reallocation and/or sharing. This would reduce negative impacts of spectrum reallocation and/or sharing by providing reimbursement for cost differences to maintain comparable capability. SRF reimbursements could be extended to include:

- Increased operating and support costs attributable to the repurposing
- Pre-auction costs prior to a band being identified for reallocation and/or sharing
- Greater standards development costs
- Subsidization of equipment replacement, including out of service time, required by users
- Increased costs of obtaining commercial infrastructure and/or services
- Increased costs associated with reallocation and/or sharing on a non-exclusive basis
- Costs to manage federal agency sharing of spectrum and systems with non-federal users
- Holistic, data-driven, cross-stakeholder spectrum data analysis and forward-leaning solutions (technical, policy, and economic) to increase spectrum efficiency, flexibility, and spectrum access

Additionally, excess SRF funds could be applied toward innovation and research and development to modernize

spectrum access. Upgrades could include more advanced technologies, such as transmitters and receivers.

Beyond cost reimbursement and modernization, the SRF could be further reformed to provide an incentive. It could be used to incentivize more efficient and fungible spectrum access by providing a means to monetize federal agency spectrum decisions by designating a percentage of auction proceeds and/or spectrum leasing revenue to federal agencies to motivate greater spectrum efficiency. Another option is to broaden the SRF to include cost reimbursement for increased capability and/or increased spectrum efficiency of systems that support greater reallocation and/or sharing. Policymakers could also leverage spectrum auction proceeds to a greater extent by enabling reinvestment opportunities to help meet U.S. telecommunications goals [9]. Reforming the SRF may require statutory changes.

Beyond reimbursement, economic reform could also support flexible spectrum use to a greater extent and the "untapped potential" of mechanisms such as secondary use and leasing [18]. Secondary use and leasing of spectrum could be implemented on a voluntary basis with stakeholder concurrence to enable shorter-term transactions that reduce risk. For the lessor, shorter-term transactions provide the opportunity for an additional revenue stream, which can offset a portion of the auction fees. For the lessee, it can provide an option for shorter-term spectrum access at a lower cost, which could in turn increase the spectrum access market beyond traditional private sector spectrum license holders to hyperscalers and others. This could help widen the number and diversity of participants acquiring spectrum access rights.

We must build on and couple work being done in pioneering the new approaches with a much more flexible, post-auction economic and regulatory model for spectrum management, to allow the growing universe of spectrum users and uses to cohabit the spectral terrain far more effectively. If we succeed, this will generate enormous benefit to all stakeholders, spurring American economic and technological growth and protecting U.S. national security.

## VI. Discussion

The electromagnetic spectrum is a congested environment. Economic and policy mechanisms, along with technology advancements, are key to increasing its utilization via more flexible use and sharing. Spectrum rights hold value. To repurpose spectrum, incumbents must be either required or incentivized to relinquish their rights. Economic incentives for mobile network operators include revenue generation and cost reduction. For federal agencies, incentives include cost reimbursement, risk reduction, and increased capabilities. Policy mechanisms include executive orders and Congressional mandates.

Technological progress in spectrum sharing must be coupled with innovation in economic and policy mechanisms. This coupling will enable the United States to more efficiently and effectively accommodate increased demand for spectrum.

To evolve economic and policy mechanisms to support spectrum sharing, policymakers could consider reform to (a) accelerate the international and U.S. spectrum regulatory processes by implementing more agile policy development supported by IT spectrum modernization, and (b) increase the fungibility of spectrum access by more fully reimbursing costs of repurposing spectrum and supporting secondary use and leasing to increase flexibility and increase spectrum utilization.

A more agile economic and policy model will bridge the otherwise deal-breaker gap between technical innovation and the economic and policy mechanisms required to support it. Agile economic and policy reform is needed to move with the speed of technology advances, particularly in areas of emerging capabilities, to enable a predictable and efficient market for industry. Economic and policy mechanisms that foster a strategically coordinated whole-of-nation approach—bringing together industry, government, and academia and other non-profit organizations—to achieve shared national objectives is key to optimizing spectrum sharing solutions. The model can also be proposed as a framework for other whole-of-nation problems beyond the spectrum domain.

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