



April 17, 2023

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NTIA–2023–0003. Development of a National Spectrum Strategy (NSS)

Dear Ms. Weiner:

Thank you for inviting academic contribution to the development of NTIA’s National Spectrum Strategy (NSS). Spectrum is likely the single most important issue in telecommunications policy and has enormous fiscal and economic implications. Moreover, the merit of market-based allocation of spectrum via competitive auction at the Federal Communications Commission (FCC) has been recognized with a recent economics Nobel prize and may be the most important policy innovation. I am an American researcher based in one of the world’s leading engineering universities and share my knowledge for the benefit of the proceeding and my fellow Americans. Please note that these comments reflect my own research and should not be construed as the position of Aalborg University.

This commentary makes the following points summarized below.

Academic Background.....	1
NTIA Leadership Is Greatly Needed and Appreciated In the Proceeding	2
Market-Based Allocation Should Be The National Spectrum Strategy	3
The US Military Can Still Be the Best in the World With Market-Based Spectrum Allocation.....	4
The US Lack of Licensed, Exclusive Use Spectrum Is A National Security Risk.....	5
Benefits of Market-Based Spectrum Allocation Will Work for Federal Spectrum	8

Academic Background

I have enjoyed affiliation with Denmark’s Aalborg University since 2012 where I earned my PhD and continue my research today.¹ Our university department hosts doctoral students from around the world who wish to make multidisciplinary and international comparisons of telecom policy. As a multidisciplinary program we marry engineering inquiries with analysis from social science, examining the preconditions and effects of digital transformation. Aalborg University is ranked by U.S. News and World Report as 8th in the world for its overall engineering program² In addition to my department of Communication, Media and Information Technologies, our research and educational domains include Antennas, Propagation and Millimeter-wave Systems; Automation and Control; Connectivity:

¹ “Profile for Roslyn Mae Layton,” Aalborg University’s Research Portal, accessed April 11, 2023, <https://vbn.aau.dk/en/persons/roslyn-mae-layton>

² “Ranking of AAU,” accessed April 11, 2023, <https://www.en.aau.dk/research/ranking/>.



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Wireless Communication Networks; and Signal and Information Processing. We use “problem-based learning” to examine, teach, and learn about complex, real world problems. Spectrum management is a textbook example of a complex real-world problem for its engineering and political requirements. Our department has produced some 500 publications on research in 5G and spectrum.³

My research at Aalborg University has supported through the country’s industrial PhD program, more than 50 years strong.⁴ Our industrial partner is Strand Consult, an independent company developing strategic research on critical topics in mobile telecommunications. Its recent report in a series details the percentage of Huawei and ZTE equipment in 103 European mobile operators’ 5G networks.⁵ This report is used by European governments to identify problem areas for rip and replace efforts. Strand Consult founded China Tech Threat to bring attention the larger issue of technological threats from firms owned and affiliated with the Chinese government.⁶ The organization is now led by Retired Major General James “Spider” Marks.⁷

These comments reflect my own views informed by international research on regulatory design, spectrum management, 5G, and related topics.

NTIA Leadership Is Greatly Needed and Appreciated In the Proceeding

As American citizen and policy scholar, I am encouraged by the leadership of NTIA in this hearing. NTIA recognizes the importance of spectrum to Americans, the national economy, US global leadership, and international competition, and it wants to work collaboratively with the FCC. NTIA observes in the proceeding,

“Access to more spectrum, in short, will help the United States continue to lead the world in advanced technology and enhance our national and economic security. Spectrum access, however, must be managed responsibly and efficiently. NTIA jointly manages the nation’s spectrum resources with the Federal Communications Commission endeavors to identify at least 1,500 megahertz of spectrum for in-depth study to determine whether that spectrum can be repurposed to allow more intensive use.”

While it should be applauded for conducting this public process, NTIA should be realistic about how best to maximize value and outcome of federal spectrum to Americans. Indeed in 1922, the Interdepartmental Radio Advisory Commission (IRAC) had a similar benevolent outlook to steward the airwaves for Americans’ benefit. One hundred years hence, we can see that governance of federal spectrum has not evolved. Already in 1962, Ronald Coase detailed that IRAC was falling short of its mission established some 40 years before.⁸

³ Listing of publications on 5G and spectrum from CMI Aalborg University Denmark. <https://vbn.aau.dk/da/publications/?search=5g+spectrum&pageSize=25&showAdvanced=false&allConcepts=true&inferConcepts=true&searchBy=PartOfNameOrTitle>. Accessed April 17, 2023

⁴ Danish Innovation Fund. <https://innovationsfonden.dk/en/p/grand-solutions>. Accessed April 17, 2023

⁵ “The Market for 5G RAN in Europe: Share of Chinese and Non-Chinese Vendors in 31 European Countries,” December 14, 2022, <https://strandconsult.dk/the-market-for-5g-ran-in-europe-share-of-chinese-and-non-chinese-vendors-in-31-european-countries/>.

⁶ “About Us,” China Tech Threat, accessed April 13, 2023, <https://chinatechthreat.com/about-us/>.

⁷ <https://chinatechthreat.com/welcome-spider-marks/>

⁸ Coase, R. H. “The Interdepartment Radio Advisory Committee.” *The Journal of Law & Economics*, vol. 5, 1962, pp. 17–47. *JSTOR*, www.jstor.org/stable/725004. Accessed 16 July 2020.



Rather than endure another century of federal spectrum stasis, the Department of Commerce's NTIA should promote a policy which delivers value for Americans: pricing, if not privatizing, federal spectrum.

Market-Based Allocation Should Be The National Spectrum Strategy

Pricing offers the most effective tool to allocate scarce resources. Indeed the innovation of auctions and spectrum pricing has been recognized with the 2020 Nobel Prize in Economics,⁹ but many Nobel economists have earlier observed the value of pricing the radio spectrum, including but not limited to Milgrom/Wilson (2020); Hart/Holstrom (2016), Tirole (2014), Mirrlees/Vickrey) 1996), Coase (1991), and Stigler (1982).

Pricing and privatizing federal spectrum are not new ideas. Privatizing federal spectrum was proposed in 1996 by the Reason Foundation which suggested a steering committee of the FCC, NTIA, the Office of Management and Budget, and the Treasury which would set oversee the privatization of federal spectrum over 10 years.¹⁰ This would entail phasing out existing government allocations and the introduction of the auction of federal frequencies. Such an auction would allow the government to maintain a spectrum registry. Such a privatization was estimated to bring \$100 billion-300 billion in 1996 dollars and would be dwarfed by long term benefits from new jobs, products, and services. Notably such a transition, if conducted today, could bring trillions of dollars to the US Treasury, to say nothing of similar positive economic and social benefits.

Under such a scenario, all who want to get spectrum could do so on the market, the same as any other input (eg land, labor, capital). Spectrum is no different than other assets and has the added benefit of being renewable. Notably there should be no further profligate giveaways of unlicensed spectrum. The folly of the FCC's giveaway of the 6 GHz band for unlicensed is detailed in a separate paper.¹¹

Attached to this comment is my testimony for a hearing in the Senate Commerce Committee on the State of US Spectrum Policy. It details the rationale for such a federal spectrum privatization.¹² A few points are worth noting as to why spectrum is used more efficiently when it is allocated through a competitive process.

1. Federal users, which get resources for free and which have few incentives or requirements for efficiency, transparency, or accountability, are not ideal spectrum stewards. We can see how private actors which acquire spectrum licenses via competitive auction make increasingly efficient use of the spectrum.

⁹ "Some mobile operators may find it difficult to understand why the Nobel Prize in Economics was awarded for innovation in spectrum auctions." Strand Consult. <https://strandconsult.dk/some-mobile-operators-may-find-it-difficult-to-understand-why-the-nobel-prize-in-economics-was-awarded-for-innovation-in-spectrum-auctions/> October 19, 2020

¹⁰ David Colton. "Spectrum Privatization: Removing the Barriers to Telecommunications Competition." Reason Foundation, July 1, 1996. <https://reason.org/policy-study/spectrum-privatization/>

¹¹ Layton, R., & Witkowski, D. (2021). 5G Versus Wi-Fi: Challenges for Economic, Spectrum, and Security Policy. *Journal of Information Policy*, 11(1), 523-561. <https://doi.org/10.5325/jinfopoli.11.2021.0523>

¹² "U.S. Senate Commerce Committee Subcommittee on Communications, Technology, Innovation and the Internet. July 23, 2020. Testimony of Roslyn Layton, PhD on the State of U.S. Spectrum Policy" (US Senate, July 23, 2020), <https://www.commerce.senate.gov/services/files/663FEEF0-983A-46F3-8EF8-73A7DEA61D01>.



2. The many uses, needs, technologies, and applications of wireless spectrums can never be fully known by regulators. Regulators can never get the necessary and sufficient information to manage effectively. Just as we understand the limits of the planned economy, the returns of a planned spectrum economy will always be inferior to a competitive market.
3. Transition to a market-base allocation regime would provide greater transparency, accountability, and revenue to the US Treasury. Other resources in the economy are allocated by competitive process. Spectrum should be no different.
4. NTIA could explore the Broadband Incentive Auction¹³ (which yielded some \$20 billion) as a model for agencies to relinquish spectrum, among other financial rewards and incentives.

Indeed if NTIA pursued a spectrum privatization, the proposed pillars would not be needed. For example, there would be no need to make a pipeline, as all spectrum would be available to license or through secondary markets. With privatization, there is no need for long-term planning, an area to which government actors are inherently poor. Politics always changes priorities, and as the record shows, the governance of federal spectrum has changed little in a century. Finally, dynamic spectrum management technologies are already afoot without NTIA needing to micromanage them.

The single most valuable act NTIA can do is to make pricing of scarce radio frequencies the National Spectrum Strategy. Federal actors already procure their assets from the economy; spectrum should be no different.

The US Military Can Still Be the Best in the World With Market-Based Spectrum Allocation

The Department of Defense makes annual reports to Congress about global threats and how it plans to address them. Overwhelmingly, military operations are predicated on addressing conflicts in foreign theatres; that is, it is not envisioned that the US military would engage in combat in the United States. As such, other than for training and essential tracking, satellite, and surveillance, the US military does not need spectrum for operations within the United States. Indeed the US military would ostensibly deploy its wartime wireless applications abroad, in international airspace, over the seas, and in outer space. Indeed, if there was a military conflict within the US, the Pentagon could immediately commandeer the frequencies needed from license holders through wartime authority. Indeed license holders would likely volunteer the frequencies in such a situation. In the meantime, the spectrum could be working for Americans rather than sitting little used.

Simply put, a smart National Spectrum Policy would focus on maximizing the value of spectrum to its highest use today for as long as possible. To date, DoD sits on vast swaths of spectrum which have been underused for decades when they could have been used in multiple ways by millions of Americans for commerce, health, education, and other social benefit services.

¹³ Federal Communications Commission. Incentive Auctions. <https://www.fcc.gov/about-fcc/fcc-initiatives/incentive-auctions> Accessed April 17, 2023.



The US Lack of Licensed, Exclusive Use Spectrum Is A National Security Risk

Spectrum strategy has geopolitical implications. Not only does China influence global organizations where spectrum decisions are made such as the International Telecommunication Union and various technical standards organizations, it commands and controls its spectrum policy in a way to align military and industrial interests to promote its national champions in space/satellite technologies, network equipment, wireless devices, software platforms, and emerging technologies such as smart cities solutions, artificial intelligence, and quantum computing. Sometimes US policy appears to pit federal and commercial interests against each other, rather than adopt the market-based approach which would put the US on the best technological footing versus China.

There is a significant and threatening gap between the US and China on mid-band spectrum. Mid-band frequencies, also called the Goldilocks band, are prized for their technological capabilities to send large amounts of data over long distances. China, and even Canada, are on track to have some 500 MHz of mid-band spectrum deployed (and Japan with 1000 MHz), whereas the US has a scant 350 MHz.

The People's Republic of China (PRC) presents the most consequential and systemic challenge to U.S. national security and a free and open international system. This is the conclusion of multiple annual reports from the Pentagon to Congress on China Military Power and the annual National Defense Strategy.¹⁴ The reports describe the People's Liberation Army playing a key role in statecraft with "Civil Military Fusion" to achieve the long-term goal of "the great rejuvenation of the Chinese nation" by 2049." Central to China's strategy are concepts of information warfare and electronic warfare, which entail the control of data and information across communication channels like cyberspace and the electromagnetic spectrum, both to protect its own networks and to deny enemy its use of the same.

China's electronic warfare (EW) strategy emphasizes suppressing, degrading, disrupting and/or deceiving enemy electronic equipment through the continuum of conflict. Early targets in a conflict would include the adversary's radio, radar, infrared, microwave, optical and any related informational system. Notably the People's Liberation Army invests significantly to conduct jamming and anti-jamming of communications networks and global positioning systems. While the US has strategies for these domains, China has the advantage on spectrum allocation. A Government Accountability Office (GAO) report¹⁵ "ELECTROMAGNETIC SPECTRUM OPERATIONS: DOD Needs to Address Governance and Oversight Issues to Help Ensure Superiority" raised these issues two years ago with the Pentagon largely concurring with GAO's assessment. A NATO commander observes that adversaries are "rejuvenating obsolete, spectrum-dependent systems, such as low-frequency radar, with upgraded hardware."¹⁶

Naturally the US should not emulate China's authoritarianism. However China's spectrum policy appears rational, technologically sound, and value-maximizing. The Chinese government deserves credit for allocating the right radio spectrum frequencies to its best technological use in the case of 5G. Simply put, if you want to do 5G, you need mid-band spectrum in the 2.6-6 GHz range, the frequencies which maximize data transmission across distance. This is nothing more than physics and

¹⁴ "National Defense Strategy," U.S. Department of Defense, accessed April 13, 2023, <https://www.defense.gov/National-Defense-Strategy/>.

¹⁵ "ELECTROMAGNETIC SPECTRUM OPERATIONS, DOD Needs to Address Governance and Oversight Issues to Help Ensure Superiority" (GAO, December 2020), <https://www.gao.gov/assets/720/711155.pdf>.

¹⁶ "Electronic Warfare – The Forgotten Discipline - Joint Air Power Competence Centre," December 2, 2018, <https://www.japcc.org/articles/electronic-warfare-the-forgotten-discipline/>.



technocratic management, but US policymakers fail on this front. The following table illustrates this definitively.

Table of Frequencies allocated for 5G, China vs. USA

China	USA		Suggested for USA
	1700-2100 MHz	<p>LOW Coverage layer for rural areas. Represents re-farming of 2G-4G spectrum for 5G. Performance depends on proximity to tower.</p>	
	1900 MHz		
	850 MHz		
	600 MHz		
	2.5 GHz		
2.515 - 2.675 GHz	China Mobile		3.1-3.45 GHz
	3.45 - 3.55 GHz	<p>MID. Sweet spot for 5G to maximize data transmission over distance.</p>	
3.4 - 3.5 GHz	China Telecom		
3.5 - 3.6 GHz	China Unicom		
	3.7 GHz		
4.8 - 4.9 GHz	China Mobile		4.4-4.94 GHz
			7.125-8.5 GHz
24.75 - 27.5 GHz	Pipeline	<p>HIGH Ideal for cities with mmWave propagation.</p>	
	28 GHz		
37 - 40 GHz	Pipeline		
	39 GHz		
40 - 42.5 GHz	Pipeline		



To put the numbers into perspective, consider that the federal government sits on 70 percent of the so-called spectrum “beachfront”, some 2500 MHz, used primarily for radar and radio navigation. The government’s holdings amount to more than four times what America’s five major wireless carriers (T-Mobile, AT&T, Verizon, Dish, and US Cellular) have in mid-band frequencies for 5G. The US is in an existential battle with China for 5G and is trying to do it on scraps of mid-band spectrum.

5G is the quickest way to equalize the digital divide between urban and rural America, providing the same, if not, superior connectivity than wireline networks. While there is a promise of some more mid-band spectrum in the future, the allocation process for these frequencies, which by rights should be have been a quick, speedy private transaction, was seized by political actors protecting incumbent firms.¹⁷

In any event, if there was a market-based process to allocate federal spectrum, there would be no need to quibble about the 3.7 to 4.2 MHz, as private actors would have the opportunity to buy, sell, lease, trade, or share the most valuable swath of the airwaves. Simply put, the federal spectrum holders are insulated to the pain caused by the spectrum imbalance. Policymakers have made a choice to prioritize certain federal (notably military) applications above civilian wants and needs. This is not to say military applications are unimportant, but it is a valid policy research question of whether all 2500 MHz is best deployed for radar and radio navigation when some measure of this spectrum could have enabled over 100 million US students to participate in distance learning during the pandemic.

While no country’s spectrum policy is perfect, the US has driven important successes over the last century. The US has been the driving force behind the FCC reforms to liberalize the allocation of commercial spectrum, which has become a model for countries around the world. Reforms include a liberalized allocation process for commercial spectrum, flexible use, competitive bidding to make rights assignments more efficient, and tools and processes to make spectrum use more efficient whether repacking spectrum (a result of the broadcast incentive auction, for example). As a result of these and other efforts, the FCC has improved the access, availability, and efficiency of commercial spectrum, without which America’s wireless economy would not be possible. Over 90 commercial spectrum auctions in the US have delivered over \$116 billion to the US Treasury.¹⁸ Wireless spectrum enables the trillion-dollar wireless economy. We now accept the premise that spectrum is a finite resource for which prices and markets can improve their allocation.

If such reforms have improved the outcomes for commercial spectrum, it stands to reason that similar improvements could be driven for federal spectrum. At the very least this would include improving access and availability for federal users, but more largely, better outcomes for the American people.

Leading telecom economist and former FCC chief economist Thomas Hazlett observes, “The FCC had no idea that mobile would become a mass market (not a luxury niche), that handsets would become pocket (not car) phones, that texting and data (not just voice) would become standard, or that digital was superior to the analog standard it mandated. And that was after vast input from scientists, management consultants, broadcasters, Motorola, and AT&T.”¹⁹ Spectrum markets had to be liberalized before innovation and adoption took hold.

¹⁷ “A Government 5G Coup.” *Wall Street Journal*. Editorial Board. November 19, 2019. <https://www.wsj.com/articles/a-government-5g-coup-11574208133>

¹⁸ “REMARKS OF FCC CHAIRMAN AJIT PAI AT THE INFORMATION TECHNOLOGY AND INNOVATION FOUNDATION.” February 6, 2020 <https://docs.fcc.gov/public/attachments/DOC-362334A1.pdf>

¹⁹ “Commentary: The Best Way for the FCC to Enable a 5G Future,” *Reuters*, January 17, 2018, <https://www.reuters.com/article/us-hazlett-5g-commentary-idUSKBN1F6253>.



To facilitate the buying, selling, and leasing of spectrum, the FCC operates a Universal Licensing System (ULS). The greatly increased use of the ULS by the public is indicative of the growth in the demand for spectrum. The FCC reports some remarkable statistics from the ULS platform, for example the thousands of licenses holders (including individuals), the many uses of spectrum, and the number of licenses issued annually (more than 150,000 per year for almost a decade).²⁰ The FCC has responded to exploding demand for commercial spectrum by modernizing the ULS over a multi-year upgrade. A similar software system could add value and transparency to the use of federal spectrum.

Benefits of Market-Based Spectrum Allocation Will Work for Federal Spectrum

Ronald Coase laid the theoretical foundations for market-based regimes and challenged the prevailing regulatory wisdom of administrative allocation of radio frequencies. His 1959 article *Federal Communications Commission*²¹ exposed the fallacy of administrative allocation which justified restricting spectrum use to limit interference. Coase showed that the same function can be performed more efficiently through a “price system.” In his day, Coase’s proposals were mocked by policymakers. The first auction for spectrum rights was delayed until 1994.²²

Today, however, spectrum auctions are practiced around the world and are considered *de rigueur* for telecom regulators and spectrum authorities. Coase is not alive today, but his Nobel prize and the legacy of his work (including the fact that he remains the most cited among Nobel prize winners, in law, and in economics²³) attest that he was correct on pricing and radio spectrum. Hazlett, Porter and Smith argue that Coase’s work on radio spectrum is on par of that of Adam Smith’s *Wealth of Nations* for its bringing “disruptive clarities to system dynamics.”²⁴

They note that Coase dispensed with then-prevailing notions from economist Arthur Pigou on externality and spillover, showing that central planning was not costless. Moreover, Coase demonstrated the destructive fallacy of assigning rights by government fiat, noting that how the airwaves were used and who used them were not one in the same.²⁵ The existence of secondary markets proves that the creation of rights and its assignment are separable.²⁶ Additional ironies and inequalities are that the federal government is primary holder of spectrum rights, but is not the primary user. This suggests that additional optimization is possible.

NTIA should endeavor to do more with the NSS than merely extend the last century of static federal spectrum governance. NTIA should make a strategy which delivers economic and financial results for the American people. A proper NNS is to enable market-based allocation of federal spectrum. The US military can also thrive under such a regime, as it would benefit financially from auction incentives to make spectrum available.

²⁰ “FCC Licenses at a Glance.” Accessed July 21, 2020. <http://reboot.fcc.gov/license-view/>

²¹ Coase, R. H. “The Federal Communications Commission.” *The Journal of Law & Economics*, vol. 2, 1959, pp. 1–40. *JSTOR*, www.jstor.org/stable/724927. Accessed 9 July 2020.

²² Coase, R. H. “Comment on Thomas W. Hazlett: Assigning Property Rights to Radio Spectrum Users: Why Did Fcc License Auctions Take 67 Years?” *The Journal of Law & Economics*, vol. 41, no. S2, 1998, pp. 577–580. *JSTOR*, www.jstor.org/stable/10.1086/467403. Accessed 16 July 2020.

²³ Landes, William M., and Sonia Lahr-Pastor. “Measuring Coase’s Influence.” *The Journal of Law & Economics*, vol. 54, no. 4, 2011, pp. S383–S401. *JSTOR*, www.jstor.org/stable/10.1086/666478. Accessed 21 July 2020.

²⁴ Thomas Hazlett, David Porter, and Vernon Smith, “Radio Spectrum and the Disruptive Clarity of Ronald Coase,” *Journal of Law and Economics* 54 (November 1, 2011), <https://doi.org/10.1086/662992>.

²⁵ *Ibid*

²⁶ *Ibid*



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Thank you for NTIA's leadership with his important hearing. Please do not hesitate to contact me for questions.

Respectfully submitted,

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Attachments

[Testimony](#) to the US Senate Commerce Committee on the State of U.S. Spectrum Policy (Jul. 23, 2020)

Collected articles by Roslyn Layton in the popular press on spectrum policy, 5G and auctions