AALBORG UNIVERSITY
DENMARK

April 17, 2023

Ms. Stephanie Wiener
Acting Chief Counsel
National Telecommunications and Information Administration (NTIA)
Herbert C. Hoover Building
U.S. Department of Commerce
1401 Constitution Avenue, N.W.
Washington, D.C. 20230

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

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 program[2] 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/.

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 rational 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 Auction[13] (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 at 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) report[15] "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	**LOW** Coverage layer for rural areas. Represents refarming of 2G-4G spectrum for 5G. Performance depends on proximity to tower.	
		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		
3.4 - 3.5 GHz	China Telecom		**MID.** Sweet spot for 5G to maximize data transmission over distance.	
3.5 - 3.6 GHz	China Unicom			
		3.7 GHz		4.4-4.94 GHz
4.8 - 4.9 GHz	China Mobile			
				7.125-8.5 GHz
24.75 - 27.5 GHz	Pipeline			
		28 GHz	**HIGH** Ideal for cities with mmWave propagation.	
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 riguer* 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 economics[23]) 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

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

Respectfully submitted,

Roslyn Layton, PhD
Visiting Researcher
Center for Communication, Media and Information Technologies
Aalborg University Copenhagen
A.C. Meyers Vænge 15
DK - 2450 København SV
Denmark
roslyn@layton.dk

Date: April 17, 2023

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

AALBORG UNIVERSITY
DENMARK

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

Thank you, Senator Thune, Ranking Member Schatz, and members of the committee. It is an honor and a privilege to testify on the State of U.S. Spectrum Policy. This issue which is arguably the most important in telecom policy. I hope to highlight some key findings from the academic field of spectrum management and policy and preliminary policy recommendations to improve the outcomes for the American people. I am an American and have enjoyed affiliation with Denmark's Aalborg University since 2012 where I earned my PhD and continue my research.[1] Our university hosts doctoral students from around the world who wish to make multidisciplinary and international comparisons of telecom policy. Our university is ranked by U.S. News and World Report as 4th in the world for its overall engineering program and 2nd for Electrical and Electronic Engineering.[2] 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: 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 both for its engineering and political requirements. My comments reflect my own views.

Aalborg University has been strengthened with public-private partnerships for innovation and the frameworks of the country's industrial PhD program, soon celebrating its 50th year. My participation has been enabled by Strand Consult where I serve as Senior Vice President. Strand Consult is an independent company developing strategic research on critical topics in mobile telecommunications. Its most recent report details the percentage of Huawei and ZTE equipment in 103 European mobile operators' 4G networks.[3] 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.[4] While it is not the precise theme of this hearing, spectrum management has geopolitical implications. Not only does China influence global organizations where spectrum decisions are made such at 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 will put the US on the best technological footing to challenge China both economically and militarily.

The gap between the US and China on mid-band spectrum has been noted. Mid-band frequencies, also called the Goldilocks band, are prized for their technological capabilities to send large amount 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. As such, *S. 1986, SPECTRUM NOW Act* sponsored by Chairman Wicker, Ranking Member Schatz, and Senators Moran and Udall has critical importance. Using the Spectrum Relocation Fund, this bill would support federal entities operating on mid-band spectrum to

[1] "Profile for Roslyn Mae Layton," Aalborg University's Research Portal, accessed July 17, 2020, https://vbn.aau.dk/en/persons/roslyn-mae-layton
[2] "Top Electrical and Electronic Engineering Schools in the World - US News Education," accessed July 17, 2020, https://www.usnews.com/education/best-global-universities/electrical-electronic-engineering.
[3] "Understanding the Market for 4G RAN in Europe: Share of Chinese and Non-Chinese Vendors in 102 Mobile Networks." Strand Consult. July 2020 http://www.strandreports.com/sw8772.asp
[44] "Our Mission." https://chinatechthreat.com/about-us/#Our-Mission Accessed July 21, 2020

study the feasibility of increasing spectrum efficiency and relocating federally held spectrum or sharing it with commercial users to facilitate the deployment of 5G.[5]

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 it 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.[6]

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 enable over 100 million school children 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. This Committee 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) or dynamic sharing such as in the 3.5 GHz Citizens Broadband Radio Service proceeding. As a result of these and other efforts, the FCC has improved the access, availability, and efficiency of commercial spectrum, without which our wireless economy would not be possible. Over 90 commercial spectrum auctions in the US have delivered over $116 billion to the US Treasury.[7] 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. Presently federal spectrum is managed the National Telecommunications and Information Administration (NTIA) and more specifically, the Interdepartment Radio Advisory Committee (IRAC), which was founded in 1922. While commercial spectrum allocation has been reformed, the management of federal spectrum is essentially unchanged for almost 100 years. It is timely and appropriate to review it.

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

[5] "Supplementing the Pipeline for Efficient Control of The Resources for Users Making New Opportunities for Wireless Act." S. 1986, SPECTRUM NOW Act, 116th Congress. https://www.congress.gov/bill/116th-congress/senate-bill/1968/text

[6] "A Government 5G Coup." *Wall Street Journal.* Editorial Board. November 19, 2019. https://www.wsj.com/articles/a-government-5g-coup-11574208133

[7] "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

standard it mandated. And that was after vast input from scientists, management consultants, broadcasters, Motorola, and AT&T."[8] Spectrum markets had to be liberalized before innovation and adoption took hold.

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).[9] The FCC has responded to exploding demand for commercial spectrum by modernizing the ULS over a multi-year upgrade.

This Commerce Committee has already taken important steps to bring the IT system for America's federal users spectrum up to speed. While some have observed that having a single system for both federal and commercial spectrum, there are some important differences in the law and policy which creates some challenges to run an integrated system. For example, some federal uses may be classified for national security reasons and not suitable for commercial viewing. On the other hand, there are additional levels of data (e.g. precise location of infrastructure towers), which are collected for the federal system but are not collected for commercial spectrum (perhaps for competitive reasons).

In any event, there need not be a single system but make a systemic improvement in spectrum management. Indeed, there is much that federal users can learn from the FCC's ULS system. I applaud Chairman Wicker and Senators Cantwell, Inhofe, and Reed for introducing ***S. 3717, the Spectrum IT Modernization Act*** which requires NTIA and other federal agencies to outline a plan for modernizing the information technology infrastructure used for the management of federal spectrum, to define the parameters of interoperability, and for the Department of Defense to report on their challenges of management and utilization.[10]

Following the Federal Radio Act, it took US policymakers 67 years to try the market-based spectrum allocation for commercial spectrum which is now considered standard.[11] We should be rushing to bring these benefits of market based allocation to federal spectrum holdings.

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*[12] 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.[13]

Today, however, spectrum auctions are practiced around the world and are considered *de riguer* 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 economics[14]) attest

---

[8] "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.
[9] "FCC Licenses at a Glance." Accessed July 21, 2020. http://reboot.fcc.gov/license-view/
[10] S. 3717, the Spectrum IT Modernization Act. 116th Congress. https://www.congress.gov/bill/116th-congress/senate-bill/3717/text
[11] 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.
[12] 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.
[13] 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.
[14] 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.

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."[15] 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.[16] The existence of secondary markets proves that the creation of rights and its assignment are separable.[17] An additional irony and inequality is that the federal government is primary holder of spectrum rights, but is not the primary user. This suggests that additional optimization is possible.

Coase discussed the IRAC at length in his 1962 article.[18] This testimony highlights some of his observations which are still highly relevant.

The "First Best" realization of Coase's recommendation is to liberalize the underlying resource—privatizing the spectrum itself--not just the use and licensing regime. This would entail sunsetting administrative allocation, also called command and control. A 1996 policy proposal suggested that the sale of federal spectrum holdings could generate as much as $300 billion (almost half a trillion in today's dollars) to pay down the national debt and transition the administrative allocation regime to privatization within a decade.[19]

Indeed, a common law property rights regime for spectrum had already emerged before the Federal Radio Act of 1927. I review this briefly, but as it is outside today's scope, I will describe "Second Best" options, notably spectrum fees. I provide additional suggestions for transparency, accountability, and IRAC reforms.

In recent years Congress has had success to reform Executive Branch agencies, most recently with the Foreign Investment Risk Review Modernization Act of 2018 (FIRRMA) for the Committee on Foreign Investment in the US. (CFIUS). This reform was achieved within a single session of Congress and was overwhelmingly bipartisan. It represents one of the most significant Congressional efforts to improve national security by requiring that CFIUS screen foreign investment for cybersecurity and privacy implications. Already it resulted in the halting, if not reversal, of foreign acquisitions of MoneyGram, PatientsLikeMe, Grindr, and StayNTouch because of concerns that that Americans' personal data would fall into the hands of the Chinese government. Importantly, FIRRMA requires greater accountability of CFIUS to Congress, as it was observed that Congress' concerns about security threats had been discounted by the Executive Branch in the past in an effort to effect quick transactions.[20] It is entirely appropriate that Congress and the Commerce Committee assert greater authority over federal spectrum, which after all, is what the Constitution prescribes.

Common law property rights for spectrum

Spectrum markets were already working before the creation of the 1927 Federal Radio Act. The government created a solution that the market didn't need, but it did serve to cement federal power over the radio spectrum and protect politically favored incumbents. Up to that time, hundreds of radio stations flourished under free market, common law tenets, and a secondary market emerged with transferring rights with equipment. Parties met annually under the auspices of the Department of Commerce to make trades.

---

[15] 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.
[16] Ibid
[17] Ibid
[18] 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.
[19] David Colton. "Spectrum Privatization: Removing the Barriers to Telecommunications Competition." Reason Foundation, July 1, 1996. https://reason.org/policy-study/spectrum-privatization/
[20] Roslyn Layton and Robert Pittenger, "CFIUS' Growing Power to Protect American Security from China Tech Threats: Examining TikTok and Lenovo" (China Tech Threat, June 26, 2020), https://chinatechthreat.com/wp-content/uploads/2020/06/CFIUS-Paper-062420_.pdf.

Hazlett details this little-known spectrum history in a recent article, showing that a common law property rights regime was well-established before the implementation of the Act.[21] Hazlett challenges the conventional view that policymakers of the day didn't have information of how a spectrum rights market could work and therefore opted for administrative allocation. Hazlett shows that Senator Clarence Dill (D-WA) and the bill's supporters knew exactly what they were doing. Moreover, Hazlett uses market data from the 1920s to demonstrate how the National Association of Broadcasters (NAB) and Radio Corporation of America (RCA) benefitted from the new regime, which limited competitive entry into the market, secured licenses to existing broadcasters, and ensured a stream of revenue for established manufacturers of radio receivers. Indeed, Hazlett observers how the term "public interest" was coined by private actors to protect their market position.

The U.S. Department of Commerce had powers granted under the 1912 Radio Act to "minimize interference." It used a common law method to recognize first-in-time emission rights and to protect against encroachment. Stations that strayed from their registered frequencies were disciplined with the Department of Commerce's police powers. Commerce convened an annual conference where emergent players organized. Hazlett describes,

> Commerce had designated an AM radio band, collaborating with radio manufacturers and broadcast stations in annual Radio Conferences that were convened by the Commerce Department from 1922 through 1925 (Benjamin 1998). Entrants that requested new rights were assigned vacant AM channels. Where none were available, applicants were told to strike a time-sharing agreement with an existing licensee or to buy a station, in which case the transmission rights would be transferred (with the broadcasting facility) to the new owner. The chief sponsor of the 1927 Radio Act, Sen. Clarence C. Dill (D-WA), explained that the legal institution employed by Commerce was well known as "property by right of user," "squatter sovereignty," or "adverse possession" (Dill 1938, p. 78). Under this regime, over 500 radio stations were broadcasting—which created a new mass media market—with substantial investments of private capital. In early 1926, a trade union in Chicago, intent on launching radio station WCFL, had the option to buy the broadcasting rights of three different local stations, including that of WHT, which was asking $285 000 (Godfried 1997, p. 33). In September 1926, AT&T sold its New York City radio station, WEAF, for $1 million to the Radio Corporation of America (RCA), of which $800,000 was for the value of spectrum rights (Barnouw 1966, pp. 185–186)."[22]

Data from the period shows that the common law regime worked such that consumers purchased radios (which amounted to $1000 in today's money) at a brisk pace. However, to create the needed "chaos" in the airwaves which would support the bill, then Commerce Secretary Herbert Hoover cancelled the annual conference and stopped enforcing rights. The subsequent interference "chaos" that ensued was seized by the press and policymakers as justification for the new law.

Hazlett notes that 1927 Act was decidedly against property rights. The statute states that while it will consider the "use" of spectrum, its purpose is to "pre-empt the assertion of private property rights in radio spectrum." The law further prescribes that "No station or license shall be granted... until the applicant therefore shall have signed a waiver of any claim to the use of any particular frequency or wave length or of the ether as against the regulatory power of the United States because of the previous use of the same, whether by license or

[21] Thomas W. Hazlett, 2020. "The 1927 Radio Act as Pre-emption of Common Law Property Rights," Review of Industrial Organization, Springer; The Industrial Organization Society, vol. 56(1), pages 17-35, February. https://ideas.repec.org/s/kap/revind.html

[22] "Two major interests sought a new regime that would grant regulators greater discretion: On the one hand, successful commercial stations sought to limit competitive entry. In the 1925 formation of the National Association of Broadcasters—a trade group that represented incumbent broadcasting stations—the industry created a novel standard for rights assignment. "An interesting fact," wrote Senator Dill, is that the broadcasters themselves suggested the inclusion of the words "public interest" in the law as a basis for granting licenses" (Dill 1938, p. 89). On the other hand, policy makers—such as Hoover, Dill, and other members of Congress—desired to assert political authority over what they recognized as an influential new medium of public opinion. License awards were said to be mandated as a consequence of nature, and licensing authority was then leveraged to include administrative oversight of speech and the press; this skirted constitutional limits that were binding elsewhere (Hazlett 1998)."

otherwise." The 1927 Radio Act did not "stumble" into administrative allocation of frequencies but sought a regime change. The prospect of property rights in frequencies was not a foreign concept. Indeed, a system of priority-in-use rights for radio broadcasts was in play since the first radio station, KDKA, in Pittsburgh in 1920.

The Act launched the regime of administrative licensing or command and control spectrum management. The government served as the clearing house for spectrum, its proffered benefit being the control of interference by exclusivity to protect the licensee's signals. To get a license, the applicant would participate in a "beauty contest" to show why its service did a better job to realize the "public interest" than another. There was no fee based on an estimated value of the spectrum. Such a model emphasizes the political rewards of spectrum assignment which accrue to the licensing body and the licensee. Moreover, it incentivizes the application to overpromise to win the application but underdeliver once received.

Naturally, command and control offers some marginal economic benefits (some use of the spectrum is better than none at all), but it is not optimal. Some countries have attempted to rectify perceived political bias through spectrum lottery, but this also fails to reflect the economic contest by competing actors for a scarce resource. The command and control regime was further legitimized by the 1943 Supreme Court decision *NBC v. FCC* asserting that there is not enough spectrum for everyone and that there is a finite natural limit of radio stations that can operate without interference.

Hazlett offers further history and analysis *The Political Spectrum: The Tumultuous Liberation of Wireless Technology, from Herbert Hoover to the Smartphone*.[23] He documents systematic deterrence of new technology by bureaucracy. He blames not the regulators themselves, individuals who want new technologies, but the "administrative apparatus" and "regulatory gridlock" to access unused spectrum, requiring potential licensee to file an application, detail the business plan, and demonstrate the technology before it is ever tried. Moreover, the applicant must prove that the technology will serve the "public interest, convenience, and necessity." Incumbents can nix technologies they believe to be threatening. It can take a decade or more to bring a new technology to market. Most innovators fail, and many pass away unrecognized, bankrupted, and demoralized.

Problems with Administrative Allocation

Coase critiqued IRAC for what he termed "governmental administrative machinery", the "complex process of bargaining and accommodation," and the "widespread feeling of dissatisfaction with the way the present arrangements are working."[24] He noted that IRAC allocates too much spectrum to government departments and too little to private users. Coase took issue with IRAC's policy of "first come, first served," calling it a system in which "those who are first granted the use of a radio frequency are not easily displaced by a newcomer" (p. 37). Coase noted that IRAC's assignments are rarely disturbed. "What this implies is that radio frequencies are used by Government departments for purposes which have a relatively low value as compared with what are the same frequencies would be worth if they could be made available to a private user," says Coase. By contrast,

[23] Thomas W. Hazlett, 2020. "The 1927 Radio Act as Pre-emption of Common Law Property Rights," Review of Industrial Organization, Springer; https://ideas.repec.org/s/kap/revind.html. The Industrial Organization Society, vol. 56(1), pages 17-35, February.

[24] Coase quotes Dr. Irvin Stewart of served in leadership functions for the FCC and IRAC: "It is a body composed of users. The situation is one in which naturally there is a desire to accommodate the wishes of the users who participate. There is nobody sitting in the position of arbiter. There is nobody who can ask too many hard questions. There is nobody who has an overriding task of requiring that the necessity for a particular new assignment be established in light of all the assignments that have been made in the past. . . . It is natural for each Government department to emphasize the importance of its role; and there isn't inherent in the situation any necessary motivation to conserve frequencies in order that they might be available for only-Government use. In many cases in the assignment of frequencies, security considerations must be taken into account, and that means that justifications for the assignments cannot be made a matter of record. And then when you have no public record, you have another fertile ground for suspicion" (Hearings on Spectrum Allocation p. 33-34).

we can see that since the FCC adopted market-based reforms, assignments are frequently changing as license holders trade up for better uses.

Coase ascribed the challenge for IRAC in part to the downsides of central planning, observing,

> The experience in the United States with the administrative structure which has been devised to handle the allocation of radio frequencies illustrates very vividly one of the dilemmas of planning. The attempt to control everything from the center is liable to lead to paralysis. The delegation of control leads to inconsistency of action. If central control is instituted, the necessity of referring all questions to the center involves expense in compiling and transmitting information and delay before decisions can be made. Nor are the decisions necessarily better when they are made. The remoteness of the center from the areas affected by the decision may lead to a failure to understand the significance of the issues under consideration. . . The division of control of the allocation of radio frequencies between the FCC and IRAC has no doubt led to misuse of radio frequencies. It may well have resulted in too great an allocation of radio frequencies in total for the use of Government departments. But there is every reason to suppose that an attempt to avoid such misallocation by extending the powers of the FCC to cover Government stations or by establishing a new Board to supervise the allocation of frequencies to Government departments (using procedures similar to those of the FCC) or by setting up a single super Board to control the allocation of all frequencies in the United States, would impose additional expense and delay and would bring about new misallocation. It is no doubt desirable to realize the inefficiencies inherent in the present system. (p. 39)

It is interesting to note that there have been multiple attempts to improve allocation of government spectrum, even an idea from the 1930s that the FCC would allocate the government frequencies. “But this move was resisted by the Government departments, particularly the military departments, and the final result of success reorganization was to place the FCC, if anything, in a subordinate rather than dominant position,” notes Coase (p. 38). Moreover, in the realpolitik of spectrum among federal agencies, there are political payoffs which never appear on the balance sheet. Spectrum can be a valuable token when budgets and other assets are limited. As such keeping some spectrum issues unresolved allows them to used for later trades.

The Case for Spectrum Fees

Coase thought that private and government users should pay for spectrum. He described the simplicity and superiority of a pricing system over administration allocation, how it eliminates waste and misuse, and how it would deliver better outcomes in the national interest. He described, quite plainly in 1962, that the demand for the scarce resource of spectrum exceeds supply:

> In the case of radio frequencies, as the price that is charged at the present time is, of course, zero, it is hardly surprising that we find a situation in which there is an excess of demand over supply and there is need for some governmental administrative machinery to decide who among the many claimants shall be granted this valuable resource. Those in positions of authority who deal with the problems of allocating the radio spectrum act as if they were unaware that the rest of the American economic system largely works on different principles. (p. 42)

Coase then described why a pricing system is superior to administrative allocation, noting that,

> . . . resources are obtained by those who will pay the most for them. Since the amount which a user will pay for a resource reflects the value of that resource in whatever employment he is contemplating using it, the pricing system tends to result in that allocation of a resource between its various uses which maximizes the value of production. If a price had to be paid for radio frequencies, government departments would not use them unless they felt that, by spending their money in this way, it would serve the purposes of the department better than by spending that money in any other way. And if the price was made sufficiently high so as to bring the demand for radio frequencies into equality with the supply, this would both eliminate the need for an administrative allocation and ensure radio frequencies were used for those governmental purposes which justified the greatest monetary sacrifice (p. 41).

Coase understood the economics of information and observed that government users

> would be naturally reluctant to disclose information which might result in their having to relinquish any radio frequencies. It is one of the advantages of the pricing system that, for its efficient working, the only person who needs to know about how any given user would use radio frequencies is the user himself. He has to decide how much it is worth his while to offer for a certain radio frequency: whether he obtains it depends on what others are willing to offer. (p. 43) . . .The absence of a market price (which measure the value of a frequency to another user in another use) means that a user has little idea of when he is using a frequency "wastefully" and no financial inducement to find out. Obviously, a frequency should not be used for a particular purpose if it prevents the accomplishment of some other purpose of greater value or if the same purpose could be achieved by the use of another resource which would mean a smaller fall in the value of production than the use of the frequency. It is clear that such wasteful use must be very common with the existing system. Any user with the existing system will not willingly surrender frequencies that he has been allocated so long as their use (or potential use) has a value greater than zero and this even though there may be others to whom the frequency has higher value (p 45).

Coase described that a pricing system for spectrum would benefit the military and the nation. "The introduction of a market would tend to bring the interest of the military departments and the national interest into a closer conformity," he wrote (p.44) Coase noted that spectrum usage fees could be made available for short or long terms and that this did not preclude the addition of other regulation.

Accessing fees on government agencies is logical and rational. Just as agencies procure resources from the market (labor, building rental, electricity), they should also pay for spectrum. A fee regime can be implemented without requiring the government to divest its spectrum ownership. Though it still requires some administration, it is an improvement because it brings pricing discipline. Spectrum regulator Ofcom in the United Kingdom implemented a fee regime in 2007.[25] The goal was to nudge agencies to return their lightly used spectrum. While the agencies ended up requesting the funds to purchase the frequencies outright, the regime brings greater attention and accountability to resource management and forces the agencies to acknowledge the value of spectrum.

Some might resist a fee regime for spectrum on the ground that the US military has been rendered less effective by the bureaucratic "accountability police".[26] However it is not logical nor rational that the military (or any federal agency) acquire all of its inputs (land, labor, weapons etc.) through a market process, but not a problem. The bureaucratization of the military is a separate problem, but it is no excuse to a continue the command and control regime that diminishes the effectiveness of spectrum policy and discourages the military from being a responsible spectrum user.

IRAC and Reform

Conflict within and between NTIA/IRAC and FCC is not new. Over the decades there have been a series of political struggles. This will likely continue as long as spectrum is allocated by administrators, not the market. Policymakers should not invest hope that there is some magical institutional design that can resolve the conflicts. It is natural and predictable that incumbent industrial and government interests will use institutions to maintain the status quo and protect their position, which appears to be the case with the proposals under development by

[25]Ofcom. "Modifications to Spectrum Pricing." January 10, 2007. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/287994/UK_Spectrum_Strategy_FINAL.pdf
[26] Christian Browse. *The Kill Chain: Defending America in the Future of High-Tech Warfare. Hachette Books*, 2020.

Commerce Spectrum Management Advisory Committee *(*CSMAC) for "new" versions of NTIA, FCC, or a unified spectrum authority.[27]

Indeed, leaders have been aware of the consequences of the IRAC policy choice. Reflecting on his role leading the organization, E.M. Webster described IRAC in 1945 noting,

> The IRAC is unique among government agencies in that it came into being, not as the result of action by either the executive or legislative branches of the government, but spontaneously through a demand of the interested government agencies. . . These people represent their respective agencies whenever frequencies are involved, but it should be emphasized that, while each is acting to some extent as an individual, he is primarily the medium of policy expression for his organization.[28]

This statement dispels the view that IRAC acts collectively on behalf of the American people. Rather it is designed to further the interest of vested federal agencies. Today's members include the Air Force, Army, Navy, Coast Guard, Broadcasting Board of Governors, Federal Aviation Administration; the Postal Service, the National Science Foundation, the National Aeronautics and Space Administration, and the Departments of Commerce, Energy, Homeland Security, Interior, Justice, State, Transportation, Treasury, and Veterans Affairs. The FCC is only a liaison. Observers include the Department of Defense, the Food and Drug Administration, and the National Security Agency.

Webster recounts the debate on the need for trials on vacuum tubes versus arc transmitters and how the government would dispose of obsolete radio equipment from World War II (lest it continued to be used and cause interference.) He observed how the agency spent significant time regulating small pieces of spectrum, which in retrospect was a waste of time as new technology from the private sector made government choices obsolete. He recognized that federal spectrum holders needed to be more tolerant of interference and that receivers needed to be improved.

Webster observed that the conduct of war is not for the military alone. Many actors which need to use the spectrum when the nation is at war, especially domestic and international broadcasters. He noted that the government's use of spectrum must by necessity be constrained. If the use of spectrum is limited for government during war, it must certainly be limited during times of peace, and it must be shared for communications, aviation, navigation, public safety, forestry, channels for allies, and so on. He noted how during wartime that government users had to shuffle and relinquish rights and accept higher levels of interference. Given limited frequencies, priority use was established. This is an important lesson for today's pandemic. Households and business are economizing during a financial crisis. There is no reason why the Department of Defense should not examine how to make better use of its $800 billion budget. Indeed, pricing could help NTIA and IRAC make better decisions and reduce internal conflict among competing agencies.

Webster described IRAC's decision guidelines as the protocols of priority use, freedom from harmful interference, and precedence. He described detailed decision making at the agency which requires it to assess many factors when making spectrum allocation including

a. Rule of law as defined by agreements and records, Executive Orders, IRAC minutes and records, international and interagency agreements;

[27] "Report on the Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America's Future: Governance" (CSMAC Working Group 1, April 22, 2020), https://www.ntia.gov/files/ntia/publications/csmac_sc1_presentation_april_22_2020.pdf.
[28] E. M. Webster, "The Interdepartment Radio Advisory Committee," in *Proceedings of the IRE*, vol. 33, no. 8, pp. 495-499, Aug. 1945, doi: 10.1109/JRPROC.1945.230506.

b. National interest, where in consideration is given to relative need for the frequency in question and to the degree of utilization by the agencies involved;
c. Necessity for using radio, taking into consideration the availability of other means of communication;
d. Expansion. Here, in the interest of planned and orderly utilization of the radio spectrum, the Committee recognizes the desirability of providing for normal expansion of a service where it is shown by the applicant that expansion will occur, and where its trend and magnitude can be estimated;
e. Geographical priority, which, as applied to mobile stations, is construed to extend only to the geographical area specified at the time the frequency was assigned; as applied to a fixed station, it extends only to the geographic allocation of the points of communication designated in the authorization;
f. Dates of assignment and first use, where other considerations are substantially equal, establish the priority as between stations unless by the terms of an agreement it is specifically provided otherwise. To the end that there be most efficient utilization of the radio spectrum, acceptance of a radio-frequency assignment imposes definite obligations on the assignee with respect both to equipment and to use. Some of these are specified in treaties and laws.

Additionally, the organization was obligated to

a. To use the best and most selective radio apparatus the state of the art and service operating requirements permit;
b. To use frequencies economically by avoiding unnecessary emissions and conducting operations on a minimum number of frequencies;
c. To share frequencies between agencies as a recognized and necessary expedient for the fullest utilization of the radio spectrum.

These requirements are interesting in light of today's interagency conflicts. For one, the pricing mechanism would eliminate much of the "administrative machinery" Coase described, but also, it is not evident that federal agencies even follow IRAC's rules. For example, the former Under Secretary of Defense for Research and Engineering Michael D. Griffin in the Department of Defense noted that the military's GPS receivers will not fulfil military grade expectations until 2035.[29] Government agencies have made technological choices which are not emissions-efficient, and rather than using a "minimum" number of frequencies, they claim to need more than they have, even challenging private rights' holders. Moreover, the notion that agencies need to share the scarce spectrum resources is belied by government behavior which challenges new uses.

While Congress has vested authority in NTIA and IRAC, there could be an issue in the violation of the nondelegation doctrine in that Congress has devolved too much power and function to the Executive Branch on an issue which it is constitutionally bound to exercise itself.[30] Spectrum is at the heart of interstate commerce, which is clearly an Article I responsibility, and one of critical importance to the people of the United States.

Aside from public choice and rule of law questions about IRAC, its governance today consists of some 20 federal agencies whereas the "public" (purportedly consumers) is represented only by the FCC, which does not enjoy the same standing or power as the other agencies. IRAC's proceedings are not fully public, and it appears to be subject only to limited Congressional oversight and judicial review. As such, most spectrum remains under legacy rules and is unavailable to satisfy the highest-valued demands of consumers.

[29] "Department of Defense Spectrum Policy and the Impact of the Federal Communications Commission's Ligado Decision on National Security," Armed Services, May 6, 2020, https://www.armed-services.senate.gov/hearings/20-05-06-department-of-defense-spectrum-policy-and-the-impact-of-the-federal-communications-commissions-ligado-decision-on-national-security.
[30] Kelley, William K. "Justice Scalia, the nondelegation doctrine, and constitutional argument." *Notre Dame L. Rev.* 92 (2016): 2107.

It is not even clear that NTIA and IRAC are fulfilling their duty to inform the White House of their activities. The requirement to develop a Sustainable Spectrum Strategy is one of many requests from the President which has not been delivered, or at least not made public.[31]

Congress should consider the introduction of a pricing system for federal users which reflects the market value of the spectrum. Failing this, Congress should consider reforms so that the American people are duly represented in IRAC, or at least to bring more accountability to its decisions. The recommendations in the subsequent section begin to address these issues. Simply put, having more spectrum in use by private actors makes our country richer, increases gross domestic product, and provides valuable services to consumers and producers.

Second Best Options

Transparency of spectrum use

Senator Mike Lee's (R-UT) proposed the Government Spectrum Valuation Act which would task NTIA, the Office of Management and Budget, and the FCC to estimate the value of relative spectrum for licensed or unlicensed and report what is assigned and allocated to each agency.[32] Coase explained why government users will resist such an effort, and unsurprisingly, this common-sense bill has not moved forward. However, such a study need not be stymied by lack of legislative support. The National Science Foundation (NSF), for example, could conduct the study, though without access to NTIA's underlying information, NSF would only be able to provide estimates.

Market actors could help bring transparency to opaque government spectrum usage. The FCC has approved seven Spectrum Access System (SAS) administrators for the 3.5 GHz band.[33] One or more of these administrators could create a public dashboard of frequencies to show how little federal spectrum is used. This promises to show the opportunity cost of leaving spectrum fallow when so many actors are willing to use it more efficiently and pay for the right to do so. Some 350 firms have signed up to participate in the forthcoming 3.5 GHz auction in which the FCC offers three payment tiers to access 70 MHz of valuable but little used federal spectrum.[34] Given the plethora of firms willing to pay significantly for spectrum access, the FCC should consider implementing a similar tiered framework for the 6 GHz band, which otherwise is a giveaway to America's richest software companies during a time of national financial crisis.

Report Cards

The Congressional Budget Office could play a role not only to estimate the opportunity cost of little used federal spectrum but could issue report cards on agencies for their efficiency of spectrum use. Spectrum stewardship could be included as part of the review criteria for appropriations and authorizations. Reports cards need not be developed by government actors. Private and academic actors could contribute on this instrument.

Examination of interference studies

Recent spectrum conflicts offer a valuable policy research opportunity to test the purported claims of interference. Many agencies have portended Y2K-like disaster scenarios from FCC decisions on commercial spectrum.[35] As some time has elapsed since these proceedings and services have been deployed, it is valuable to

[31] "Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America's Future," The White House, October 25, 2018, https://www.whitehouse.gov/presidential-actions/presidential-memorandum-developing-sustainable-spectrum-strategy-americas-future/.
[32] "Sen. Lee Introduces Government Spectrum Valuation Act," Mike Lee, May 23, 2019, https://www.lee.senate.gov/public/index.cfm/2019/5/sen-lee-introduces-government-spectrum-valuation-act.
[33] "3.5 GHz SAS Conditional Approval Public Notice," Federal Communications Commission, December 21, 2016, https://www.fcc.gov/document/35-ghz-sas-conditional-approval-public-notice.
[34] Mike Dano, "The Full List: Here Are the Actual Bidders in the CBRS Auction," Light Reading, June 19, 2020, https://www.lightreading.com/5g/the-full-list-here-are-the-actual-bidders-in-the-cbrs-auction/d/d-id/761602.
[35] Roslyn Layton, "GPS Interference Fears Are Today's Y2K, Says Former UK Spectrum Director," Forbes, May 8, 2020, https://www.forbes.com/sites/roslynlayton/2020/05/08/gps-interference-fears-are-todays-y2k-says-former-uk-spectrum-director/.

see whether the predictions proved true, were mitigated as the FCC described, or never occurred. This is also a legitimate area of study for the FCC's Office of Economics and Analytics and NTIA's Institute for Telecommunications Sciences.

Spectrum policy choices have economic and national security consequences. While market reforms have helped correct misguided historical choices for spectrum decisions, many features of command and control administrative allocation remain. Today, many stakeholders are unsatisfied. Nearly every industry and federal agency would like more spectrum but can't get it. Inefficient use is encouraged; new technologies are deterred; and Americans are denied new jobs and services in the wireless domain.

The most cited academic literature and experience shows the value of market-based allocations of spectrum. The first best policy choice for consumers is to privatize the spectrum itself and sunset administrative allocation. However, the second-best policy choice, the introduction of a market-based pricing system, has been introduced within a framework in which regulators still make the categorical allocations, albeit with more flexible uses.

The template for federal spectrum allocation is essentially unchanged for a century. Bringing pricing discipline to federal users would be a quantum leap from the status quo and would improve outcomes for federal users and Americans in general. It could be implemented without having to dismantle existing agencies.

With the SPECTRUM Now Act and the Spectrum IT Modernization Act, this Committee is taking important steps to bring federal spectrum allocation into the 21st century and building on proven success of improved management and efficiency of commercial spectrum. A feasibility study of increasing federal spectrum efficiency and relocating federally held spectrum and/or sharing it with commercial users to facilitate the deployment of 5G is much needed. Similarly, modernizing the IT infrastructure for federal spectrum can also help to bring transparency and improved decision-making.

Thank you for the opportunity to testify today. I look forward to your questions.

Sincerely,

Roslyn Layton, PhD
Visiting Researcher
Communication, Media and Information Technologies
Technical Faculty of IT and Design
Department of Electronic Systems
Aalborg University
A.C. Meyers Vænge 15
Frederiksborgkaj 12, 3rd Floor
Copenhagen SV, Denmark 2450

The Pentagon's $45 Billion 140 MHz Spectrum Blindspot

19 December 2022

https://www.forbes.com/sites/roslynlayton/2022/12/19/the-pentagons-45-billion-140-mhz-spectrum-blindspot/?sh=a41574d35fe5

Unveiled last month by China Electronics Technology Group Corporation (CETC), the SLC-18 high-power, low-frequency P-band (216-450 MHz) satellite-hunting radar is reported to detect and track low-orbiting satellites and functions around the clock in all weather conditions. Observers dubbed it the "Anti-Starlink" system.

The People's Republic of China (PRC) is 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. 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 PLA invest 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) report "ELECTROMAGNETIC SPECTRUM OPERATIONS: DOD Needs to Address Governance and Oversight Issues to Help Ensure Superiority" raised these issue 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."

China crushes the US on 5G spectrum strategy

While we can fault the Chinese government for its authoritarian ways, it 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 basic physics and 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	**LOW** Coverage layer for rural areas. Represents refarming of 2G-4G spectrum for 5G. Performance depends on proximity to tower.	
		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		
3.4 - 3.5 GHz	China Telecom		**MID.** Sweet spot for 5G to maximize data transmission over distance.	
3.5 - 3.6 GHz	China Unicom			
		3.7 GHz		4.4-4.94 GHz
4.8 - 4.9 GHz	China Mobile			
				7.125-8.5 GHz
24.75 - 27.5 GHz	Pipeline			
		28 GHz		
37 - 40 GHz	Pipeline		**HIGH** Ideal for cities with mmWave propagation.	
		39 GHz		
40 - 42.5 GHz	Pipeline			

China crushes the USA on the critical strategy for 5G spectrum.

The Bipartisan Win-Win Of Building The Spectrum Pipeline

27 October 2022

https://www.forbes.com/sites/roslynlayton/2022/10/27/the-bipartisan-win-win-of-building-the-spectrum-pipeline/

Republicans and Democrats in the final election sprint compete on their policy differences. One area where there is widespread bipartisan agreement is identifying new bands of spectrum suitable for commercial use. For years, the United States has set the global standard in spectrum auctions, which has led to innovation that benefits consumers, boosted the mobile wireless economy, and delivered much-needed revenue for the Treasury. The recent auction for 3.7-3.98 GHz earned a record breaking $90 billion. A healthy balance of licensed and unlicensed spectrum is essential to achieve social, economic, and geopolitical outcomes, including but not limited to closing the digital divide, enabling the competitive edge for enterprise with next generation technologies, and achieving climate goals through 5G energy management and efficiency applications. But it does need to be a balance. Unfortunately, recent actions have upset this balance. We must be diligent and ensure a pipeline of licensed spectrum.

To date, U.S. mobile wireless prowess in 2G-4G has been achieved largely through low-band spectrum (300-3 GHz), less than one-third of the total frequencies in the band. Mobile wireless actors have successively and successfully "re-farmed" the frequencies for greater efficiency. However wireless technologies have evolved so that they can take advantage of the properties of higher spectrum bands, enabling greater throughput across distance. Moreover, consumer and enterprise use of mobile wireless technology have exploded with the number of subscriptions exceeding population and the emergence of the Titanium Economy, new industries with the advent of 5G and its capability for automation, robotics, AI, and quantum computing.

Nevertheless, the U.S. underutilizes the proven facility of market-based spectrum auctions. Remarkably only a scant 270 MHz is available for commercial licensed mobile wireless service today in the mid-band, the sweet spot for 5G. A recent report from Accenture reveals that seven times (1,910 MHz) this amount is available for unlicensed and a whopping 12 times (3,300 MHz) for federal use. Analysts expect most U.S. wireless subscriptions to be 5G in less than five years—provided the spectrum can be wrested from the federal government agencies, particularly the Department of Defense.

While most other nations prioritize 5G with sizable chunks of mid-band spectrum (the frequencies of 1-6 GHz in the radio spectrum, a section noted for its ability to enable high throughput across distance) the U.S. government dominates these frequencies in the 50 states and has been reluctant to rationalize its holdings, with some exception. Americans' ability to lead 5G and successive generations of wireless technology will depend largely on the reallocation of federal spectrum, part of a lagging modernization of American government and defense.

A recent decision from the Federal Communications Commission (FCC) reveals what's at stake in our nation's spectrum management policy. In the 6 GHz band, the FCC allocated 1,200 MHz to unlicensed spectrum. Unlicensed spectrum is important and has a role to play, but in the 6 GHz decision, the FCC caved to the interests of the unlicensed community. The decision amounts to yet

another free ride to Big Tech which has the most cash of any wireless actor to pay for the use of public resources.

Other nations have not been so cavalier with the 6 GHz band. The United Kingdom's Ofcom opted not to designate the upper portion of the band for unlicensed, and Chile reversed an earlier decision on all unlicensed to ensure that the upper portion could be used for 5G. In China, regulators opted to make the entire 6 GHz band available for 5G use. A study by Kalvin Bahia and Pau Castells of the 6 GHz policy in 24 countries found that 500 MHz in the lower 6 GHz was sufficient for Wi-Fi, with no additional social benefits for the whole band being unlicensed.

Globally, regulators consider the spectrum tradeoffs between licensed mobile for 5G versus unlicensed use for Wi-Fi 6, a critical question of market entry via an orderly, transparent competitive auction or the spectrum commons free-for-all. In the former, mobile wireless service providers pay for the right to use the public's resources; in the latter, the largest Wi-Fi content providers and device makers tend to dominate the frequencies. One study suggests that 5G is 4.5 times more valuable to the U.S. economy than Wi-Fi, owing to superior spectral efficiency and security. The key bands of spectrum listed below will help the U.S. regain a healthy balance of licensed and unlicensed spectrum.

3.1-3.45 GHz

Considered a bone thrown from the vast federal horde back to the public, 100 MHz of beachfront spectrum at 3.45GHz to 3.55GHz was auctioned and garnered some $22.5 billion from 23 bidders last year. Adjacent to this sliver is 350 MHz at 3.1-3.45 GHz, promising a nice patch of contiguous spectrum enabling greater spectral efficiency, less need of antennas, and reduced environmental impact. These contiguous patches are a boon for device makers, particularly when they are harmonized globally, and indeed 70 nations have already prioritized this patch already for 5G. The Infrastructure Investment and Jobs Act notes the value of the band for commercial uses and a NTIA report described the feasibility of sharing this band with current uses of U.S. military radar operations.

4.4-4.94 GHz

The 4.4-4.94 GHz is yet another band already designated in many countries for 5G, but in the U.S. is occupied by a range of federal users. With 5G, the frequencies could enable broadcasting, autonomous vehicles, and other uses.

7.125-8.4 GHz

Another 400 MHz could be enabled from federal use in 7.125-8.4 GHz. These frequencies are ideally suited to providing wireless broadband in cities. Beyond the obvious benefits of greater competition, this band is ideally suited for smart city applications, campuses, and office parks.

Building the spectrum pipeline should be a top priority for Congress. A spectrum pipeline would equalize the spectrum dedicated for 5G and Wi-Fi, and it would balance the frequencies used by the American people and enterprise versus that of the government. While a daunting task to transition frequencies form the government to the people, CTIA's Nick Ludlum remains positive: "There's a lot of bipartisan support for wireless and we're confident we can work together to secure a pipeline

of licensed, commercial spectrum that will enable America to continue to lead the world in wireless."

Congress must prioritize the building of a pipeline of licensed spectrum. America's global leadership and competitive edge are at stake.

Spectrum Auctions Have Raised $230 Billion; The FCC's Authority To Conduct Them Will Lapse Soon If Congress Doesn't Act.

29 April 2022

https://www.forbes.com/sites/roslynlayton/2022/04/29/spectrum-auctions-have-raised-230-billion-the-fccs-authority-to-conduct-them-will-lapse-soon-if-congress-doesnt-act/?sh=3e37157a908e

In 1993, Congress established the world's first spectrum auction authority, empowering the Federal Communications Commission (FCC) to conduct bidding for radio frequency licenses. The innovation has exceeded expectations, earning Nobel prize recognition in 2020 and bringing $230 billion in revenue to the Treasury. The FCC has conducted over 100 auctions with the recent C-band earning more than a record $90 billion. These monies have been used for taxpayer relief, the FirstNet public safety communications network, and funding to the Department of Defense and other agencies.

Policymakers should be on top of the spectrum auction cash cow, maximizing the opportunities for market-based allocation and earning revenue for public coffers. After July's 2.5 GHz auction, the spectrum pipeline is empty. Credit is due to FCC Commissioner Brendan Carr for raising the issue last year and Senators Wicker and Thune for asking FCC Chair Rosenworcel for its plan.

Spectrum auctions are a wild success; why are they not prioritized?

Not everyone is on the same page. Many policymakers think that Big Tech companies should get access to scarce spectrum resources for free. The 6 GHz proceeding was a giant giveaway to Big Tech; which had it been auctioned, could have raised at least $20 billion.

The rollout of licensed wireless services is disruptive to some established players in the broadband industry. If people can get their home broadband through the air, there is not a need to bring a wire through the ground to the office or house. The growth of fixed wireless access to more than 7 million broadband subscribers attests to this shift.

More largely, the Executive Branch under both parties has failed miserably to lead on spectrum strategy to optimize allocation for federal and commercial uses. The management of federal spectrum has changed little in a century with two-thirds of America's airwaves held by agencies, many of which resist efforts for spectrum transparency and greater efficiency. Failing the needed Presidential leadership, Rosenworcel has taken the lead to rebuild a cooperative relationship between FCC and NTIA, the two agencies tasked with managing our nation's spectrum resources.

What needs to be done

Congress must act quickly to reauthorize the FCC's authority before it lapses on September 30, 2022; a short-term (12-18 month) extension should be enough time to build the spectrum pipeline, ensure the auction authority for the coming decade, and engage spectrum stakeholders.

Importantly the FCC's authority needs to be clarified and protected from other federal agencies which attempt to hijack FCC auction and related spectrum activities. There are a litany of embarrassing incidents, including the recent, unseemly action by the Federal Aviation Administration (FAA) to demand that mobile operators delay the rollout of 5G indefinitely (even to ground planes) because of no standardized altimeters. The US failure made it a laughingstock compared to the likes of Japan, France, Norway, and some 50 other countries which rolled out 5G without drama.

The US needs leadership in both Congress and the Executive to modernize spectrum policy to reflect the needs of the US as one of the world's leading wireless economies, which brings in hundreds of billions of dollars annually, millions of jobs, and connectivity to nearly every area of life. While the US has leadership in this domain, other countries – notably Japan and China – allocate more spectrum for commercial wireless services. If we take the so-called global competition seriously, it's time for a spectrum policy meet this ambition.

It's Time For The U.S. To Let 5G In The C-Band Take Off

14 January 2022

https://www.forbes.com/sites/roslynlayton/2022/01/14/its-time-for-the-us-to-let-5g-in-the-c-band-take-off/?sh=603a2e9f2289

The U.S., which prides itself on technological innovation, hit a roadblock with the rollout of 5G in the C-band last fall. The Federal Communications Commission (FCC) published the rules for 5G transmission in the 3.7 GHz to 3.98 GHz band (also known as C-band) in March 2021, which included a 220 MHz guard band around aviation operations (twice the industry's requested amount) as well as phased rollout for additional testing. At the 11th hour, the Federal Aviation Administration (FAA) made a public cry, claiming that altimeters are vulnerable to 5G transmissions. This became a national embarrassment, dragging on for the last few months. More than 40 nations have rolled out 5G wireless technology in the C-band across 175 networks with zero reported problems to aviation. Fortunately 5G operators Verizon and AT&T architected a technical solution which enables mitigation around airports and now plan to go live on January 19. As a policy matter, it's valuable to review why the FAA, which knew about the rollout of 5G for years, waited so long to act and failed to use empirical tests appropriately.

FAA: Self-asserted supremacy

The FAA asserts, "The U.S. airspace is the most complex in the world… Aviation in the U.S. is the safest in the world. That's because we rely on data to mitigate risk.." However, the FAA's data did not consist of actual aviation tests performed at airports with 5G base stations as was done in Japan, Norway, France, and other countries. Instead the FAA hired an organization to create a predictive model of the worst-case scenarios of 5G transmissions at high power levels with obsolete altimeters. While such a model could be helpful to supplement real-world tests, the FAA based its decision on a laboratory model and refused to make the underlying data available to independent

researchers for review. Richard Bennett, co-inventor of Wi-Fi, called the FAA's model a hazard analysis, not a risk assessment.

France: Cooperation to ensure aviation safety and speedy 5G rollout

While the FAA sat on its hands for more than a year, France's National Frequency Agency (ANFR), upon publication of the aforementioned model in October 2020, acted immediately. It worked cooperatively with the French Civil Aviation Authority (DGAC) to ensure timely 5G deployment with sufficient safety controls. It appears what has taken U.S. actors months, the French resolved in weeks. Gilles Brégant, CEO of ANFR explained in an email:

"Enabling coexistence of multiple wireless service is indeed a key target for spectrum agencies like ANFR. The French baseline was to enable 5G deployment in C-band as initially planned, allowing only slight limitations in the vicinity of major airports. The idea was to provide time to perform throughout real-life testing to understand if a problem could actually appear.

"After few weeks of consultations with all parties involved (including the operators, the vendors and Airbus) temporary measures were taken, including some buffer zones around airports and the downtilt obligation over the entire territories. In February 2021, these measures were relaxed to limit buffer zones to CATIII (low visibility) airports and to limit the downtilt obligation to these buffer zones and to some heliports."

In recent years conflict and rancor has characterized relationships between the FAA, FCC, and National Telecommunications Information Administration (NTIA). In France, however, the sister agencies are aligned. Brégant observed, ANFR pays attention to both safety of aviation and the development of 5G. "We had the responsibility with the civil aviation (DGAC) and the regulator (Arcep) to develop proportionate solutions to address both objectives . . . 5G and radio altimeters are the same all around the world and the solution will need to be global," he said.

Testing is straightforward

It is interesting that in advanced, so-called data-driven societies, outcomes can be so different. David Hall, Go-To-Market Director, Semiconductor & Electronics at NI (formerly National Instruments), which makes interference testing equipment among other products and service observes:

"The FAA vs FCC dispute is a great example of how assumptions can severely shape our views of whether an engineering solution is viable or not. We might live in a data driven world, but the assumptions you make regarding how much power a transmitter will emit or how well a receiver can reject power in adjacent bands has severe implications on whether you conclude two systems can co-exist or not.

"In the case of most base stations operating in the C-band spectrum, emissions farther than 100 GHz from the band of operation are practically non-existent. Assuming the FCC's initial analysis of the C-band spectrum was correct (and let's face it, they've been doing this type of analysis for decades), a 6-month trial is unlikely to surface examples of interference. Thus, in parallel with documenting any actual interference, an important step is to conduct more thorough lab testing of legacy radio altimeters.

"The FAA claims that this type of testing has been done already. The FCC claims that the conditions in the FAA's study didn't represent a typical 5G signal. It's hard to know who's right, but with strict regulations on how powerful a 5G signal is allowed to be, doing a realistic test is actually straightforward. Perhaps the most important step moving forward is to agree on a third-party referee to oversee the testing process and methodology."

This is about a payout, not safety.

Few things are more important than aviation safety, and Americans rely on the FAA to delivery this good. However, it is not evident that 5G was ever a problem; indeed the FAA itself noted no evidence of harmful interference from 5G transmission. While the FAA's statutory mandate is to ensure the safe and efficient use of the airspace for civil, military, and other purposes, the 5G experience suggests that altimeter stakeholders have been prized above the American people who rely on next generation broadband for health, work, education, and safety. As altimeter makers do not invest in their own equipment standards modernization process like the mobile industry does with the Third Generation Partnership (3GPP), it appears they (and pilot and aircraft makers) have lobbied the FAA to create the appearance of a safety crisis to force the mobile industry to pay for upgrades they should have been doing all along.

5G isn't the first technology that the FAA has slowed, if not blocked. Consider the innovations which could improve our lives which are not allowed because they upset incumbent stakeholders: supersonic flight, air taxis, passenger drones, and electric aircraft. Left to its own devices, the FAA would ground 5G forever. Fortunately 5G providers have crafted a solution so Americans can enjoy flight and 5G in the C-band.

UK Spectrum Expert: The FAA Fails To Justify 5G Delays

9 November 2021

https://www.forbes.com/sites/roslynlayton/2021/11/09/uk-spectrum-expert-the-faa-fails-to-justify-5g-delays/?sh=686ce292734d

AT&T and Verizon recently announced they would delay the launch of 5G in the C-band for one month because the Federal Aviation Administration (FAA) needs more time to understand the interference impacts on altimeters installed in planes. Meanwhile 5G has been ongoing in other spectrum bands in the US since 2019 and in some 175 networks in more than 50 countries globally without any interference with aviation. The economic costs of the delay are significant. Economists estimate that 400 MHz of C-band for 5G would deliver $274 billion in economic development and 1.3 million new jobs over 6 years.

To understand why the US is stumbling while other nations aren't, I caught up with UK spectrum expert and former Ofcom regulator Dr. William Webb who observed the pattern of Y2K style spectrum techno-panics each time a new wireless technology is launched.

Mobile providers in the U.S. have agreed to a 30-day pause on C-Band deployments to give regulators time to work out their concerns. Is this delay necessary?

The mobile wireless industry has already made a huge concession to aviation. The spectrum allocated for aeronautical use starts at 4.2GHz. This means that the 5G band could run from around 3.4GHz up to 4.2GHz – 800MHz of bandwidth which is likely to be needed within five years if current growth rates in mobile consumption continue. But the FCC has decided to only allocate spectrum up to 4.0GHz to mobile, leaving a 200MHz band allocated to satellite (whose weak signals will not cause interference), to provide extra protection to aviation. If there had not been interference, then a plan could have been put in place to move satellite completely out of the band and allocate it all to mobile. As a result, only 75% of the potential 5G spectrum in this mid-band will be available – and in practice even less because of other restrictions across the band.

You observe that the FCC offered as an overgenerous guard band, apparently twice what the aviation industry recommended. If that's the case, why is the FAA concerned about interference with altimeters?

There is no doubt that long standing aviation industry failures are to blame for the month delay and much more importantly the 200MHz of sub-optimally used spectrum. Aeronautical altimeters have been designed and built with insufficient filtering to protect them from signals in adjacent bands. This has not been an issue to date because prior to 5G these bands have been used for applications that result in low-power signals. But this is no excuse – these altimeters should have been designed from the start to have sufficient protection. And this is not an isolated problem, recent issues with potential interference into GPS receivers have exactly the same cause – insufficient filtering in the receiver.

What should be done in the short term to resolve the immediate issue of turning on 5G in the C-band and in the long-term to prevent this type of blockade from happening again every time a new radio-communications technology is introduced?

Firstly, since the fault lies with the aviation industry, they should move with more urgency to implement a program to redesign and then replace altimeters. To delay 5G while this is underway is neither fair nor needed. 5G is used in these bands around the world, and no issues have been reported. The situations where interference might arise are extremely unusual and even were they to occur would rarely lead to safety issues. Of course, we must do all we can to avoid accidents, but there must be a sensible assessment of risk.

What about the longer term – how can we avoid others building receivers with insufficient filtering or other similar defects, especially those who can then play the "too big to fail" card, such as GPS users or the aeronautical industry?

Just as banks need to be regulated to have sufficient capital, the FCC and FAA must work together to craft appropriate airline regulations to ensure adequately designed receivers. It would be relatively simple for a regulator such as the FCC to publish a minimum performance specification. Whether there is an appropriate legal framework to enforce this is less clear. For less critical users, licenses specified in terms of the interference they are allowed to cause, pioneered in the UK some years ago although not widely adopted, provide a clear signal as to future potential interference. This gives those license holders who deploy poor receivers no excuse to complain should interference occur.

In our last discussion, you observed how regulators are excessively risk averse. U.S. policymakers resisted spectrum auctions for 35 years. It seems like the FAA would like to stave off 5G forever; it has no incentives or obligation for 5G progress.

Regulators and other non-commercial organizations are excessively risk-averse. The reasons are obvious – there's little upside for an FAA employee to take a risk, however small, but plenty of downside should that risk crystallise. Of course, there are notable and praiseworthy exceptions to this, but they are just that – exceptions. Where the commercial world comes into conflict with the non-commercial then two different cultures clash. Because the non-commercial world is the rule-maker it tends to win out. Changing culture is very hard, but processes can be put in place that result in an optimal balance between risk and reward, such that individuals do not have to make subjective decisions.

The way to address this risk-aversion is to allow the license conditions to be modified in the light of actual evidence. As the service is deployed, its real impact, as opposed to its modeled impact, can be studied. When it is clear that more interference could be tolerated, then guard bands can be reduced, and power levels increased.

Today's inadequate receivers in too-big-to-fail applications coupled with risk-aversion are costing us all significantly by delaying or curtailing innovative new digital services that can transform our lives.

5G Spectrum Is 4.5x More Valuable To Economy Than 'Free' Wi-Fi

11 October 2021

https://www.forbes.com/sites/roslynlayton/2021/10/11/5g-spectrum-is-45x-more-valuable-to-economy-than-free-wi-fi/?sh=38ff2abb760b

Despite the pandemic, the Federal Communications Commission (FCC) advanced major spectrum policy and auctions last year. The C-band auction was a record breaker in US history; 50 entities bid for spectrum licenses totaling $94 billion in gross proceeds. This high figure reflects some important policy innovations including purchase of spectrum without expiration dates, flexible use of the bands, and secondary markets. The 2020 Nobel Prize for economics awarded FCC auction designers. Despite continued successes of commercial spectrum auctions in which market actors pay for the right to use the public's resources, policymakers persist in giving away valuable resources to Big Tech through antiquated "beauty contests."

5G vs. Wi-Fi

My paper co-authored David Witkowski and published in the Penn State University Press Journal of information Policy examined two FCC proceedings in 2020, the auction of 280 megahertz (MHz) in the C-band for licensed 5G use versus the 1200 MHz allocated for unlicensed in the 6 GHz band. A spectrum license confers the right to transmit to a specific party, e.g. mobile operator, whereas unlicensed spectrum can be used by anyone provided adherence to FCC interference limits. Wi-Fi business models are predicated on free, unlicensed spectrum.

The C-band auction drove $94 billion in gross proceeds, with net proceeds of $81 billion deposited to the US Treasury. 5G licensed mid-band spectrum is projected to deliver $191.8 billion to the US economy over 7 years. Wi-Fi revenues over unlicensed spectrum over 6 years are projected to bring $153.76 billion. When adjusted on an annual per MHz basis, 5G spectrum is $0.59 and Wi-Fi, $0.13. Over the period, 5G spectrum provides 4.5 times more economic value per MHz than Wi-Fi.

Despite the pandemic, the Federal Communications Commission (FCC) advanced major spectrum policy and auctions last year. The C-band auction was a record breaker in US history; 50 entities bid for spectrum licenses totaling $94 billion in gross proceeds. This high figure reflects some important policy innovations including purchase of spectrum without expiration dates, flexible use of the bands, and secondary markets. The 2020 Nobel Prize for economics awarded FCC auction designers. Despite continued successes of commercial spectrum auctions in which market actors pay for the right to use the public's resources, policymakers persist in giving away valuable resources to Big Tech through antiquated "beauty contests."

5G vs. Wi-Fi

My paper co-authored David Witkowski and published in the Penn State University Press Journal of information Policy examined two FCC proceedings in 2020, the auction of 280 megahertz (MHz) in the C-band for licensed 5G use versus the 1200 MHz allocated for unlicensed in the 6 GHz band. A spectrum license confers the right to transmit to a specific party, e.g. mobile operator, whereas unlicensed spectrum can be used by anyone provided adherence to FCC interference limits. Wi-Fi business models are predicated on free, unlicensed spectrum.

The C-band auction drove $94 billion in gross proceeds, with net proceeds of $81 billion deposited to the US Treasury. 5G licensed mid-band spectrum is projected to deliver $191.8 billion to the US economy over 7 years. Wi-Fi revenues over unlicensed spectrum over 6 years are projected to bring $153.76 billion. When adjusted on an annual per MHz basis, 5G spectrum is $0.59 and Wi-Fi, $0.13. Over the period, 5G spectrum provides 4.5 times more economic value per MHz than Wi-Fi.

Despite the pandemic, the Federal Communications Commission (FCC) advanced major spectrum policy and auctions last year. The C-band auction was a record breaker in US history; 50 entities bid for spectrum licenses totaling $94 billion in gross proceeds. This high figure reflects some important policy innovations including purchase of spectrum without expiration dates, flexible use of the bands, and secondary markets. The 2020 Nobel Prize for economics awarded FCC auction designers. Despite continued successes of commercial spectrum auctions in which market actors pay for the right to use the public's resources, policymakers persist in giving away valuable resources to Big Tech through antiquated "beauty contests."

5G vs. Wi-Fi

My paper co-authored David Witkowski and published in the Penn State University Press Journal of information Policy examined two FCC proceedings in 2020, the auction of 280 megahertz (MHz) in the C-band for licensed 5G use versus the 1200 MHz allocated for unlicensed in the 6 GHz band. A spectrum license confers the right to transmit to a specific party, e.g. mobile operator, whereas unlicensed spectrum can be used by anyone provided adherence to FCC interference limits. Wi-Fi business models are predicated on free, unlicensed spectrum.

The C-band auction drove $94 billion in gross proceeds, with net proceeds of $81 billion deposited to the US Treasury. 5G licensed mid-band spectrum is projected to deliver $191.8 billion to the US economy over 7 years. Wi-Fi revenues over unlicensed spectrum over 6 years are projected to bring $153.76 billion. When adjusted on an annual per MHz basis, 5G spectrum is $0.59 and Wi-Fi, $0.13. Over the period, 5G spectrum provides 4.5 times more economic value per MHz than Wi-Fi.

Despite the pandemic, the Federal Communications Commission (FCC) advanced major spectrum policy and auctions last year. The C-band auction was a record breaker in US history; 50 entities bid for spectrum licenses totaling $94 billion in gross proceeds. This high figure reflects some important policy innovations including purchase of spectrum without expiration dates, flexible use of the bands, and secondary markets. The 2020 Nobel Prize for economics awarded FCC auction designers. Despite continued successes of commercial spectrum auctions in which market actors pay for the right to use the public's resources, policymakers persist in giving away valuable resources to Big Tech through antiquated "beauty contests."

5G vs. Wi-Fi

My paper co-authored David Witkowski and published in the Penn State University Press Journal of information Policy examined two FCC proceedings in 2020, the auction of 280 megahertz (MHz) in the C-band for licensed 5G use versus the 1200 MHz allocated for unlicensed in the 6 GHz band. A spectrum license confers the right to transmit to a specific party, e.g. mobile operator, whereas unlicensed spectrum can be used by anyone provided adherence to FCC interference limits. Wi-Fi business models are predicated on free, unlicensed spectrum.

The C-band auction drove $94 billion in gross proceeds, with net proceeds of $81 billion deposited to the US Treasury. 5G licensed mid-band spectrum is projected to deliver $191.8 billion to the US economy over 7 years. Wi-Fi revenues over unlicensed spectrum over 6 years are projected to bring $153.76 billion. When adjusted on an annual per MHz basis, 5G spectrum is $0.59 and Wi-Fi, $0.13. Over the period, 5G spectrum provides 4.5 times more economic value per MHz than Wi-Fi.

Institutional entrepreneurship

In the whole scheme of things, the spectrum available for licensed, commercial use is small. The federal government sits on some two-thirds of all frequencies through a non-public governance model which hasn't changed a century.

By law, the standard to judge FCC decisions is the "public interest". It is confounding then how the FCC can put enormous efforts into auctions of 100 MHz and then giveaway 1200 MHz. The paper suggest that it is not the public interest guiding the FCC's spectrum decisions but institutional entrepreneurs in the form of a trade associations. University of Surrey Tazeeb Rajwani calls trade associations "informal regulators" through their standard setting in norms of behavior as well as defining the boundaries of an industry through membership and acting as "the voice of an industry" by unifying disparate companies around a single message. Advocacy by the Wi-Fi Alliance, which represents 800 global companies, was critical to securing the 6 GHz spectrum. The organization claims that their members' future success requires free, unlicensed access to the entire 6 GHz band, and that they will need an additional 1500 MHz by 2023.

If spectrum is critical to the Wi-Fi industry, it follows that the Wi-Fi industry should pay for it. It is not logical that spectrum is exempt from payment when businesses must purchase every other input (land, labor, capital) from the market. Wi-Fi Alliance members like Google, Microsoft, and Amazon are sophisticated spectrum users with their own network strategies and significant cash. They could purchase spectrum to ensure delivery of their services or form a spectrum consortium. Spectrum should not be a "windfall", especially when it's scarce and large commercial interests expect to monetize it. Policymakers are intent on regulating Big Tech; the first step should be to stop giving them free spectrum.

National Security Experts Support FCC 5G Spectrum Plan Voted Today

28 February 2020

https://www.forbes.com/sites/roslynlayton/2020/02/28/national-security-experts-support-fcc-5g-spectrum-plan-voted-today/?sh=5ab8c58f4be6

National security and defense, the protection of the nation state, its citizens, economy, and institutions, is an essential duty of government. Safeguarding the nation state includes a range of activities to prevent, deter, and mitigate attacks by adversarial foreign nations, as well as strengthening the nation's security and defense through economic and technological development. Securing the spectrum resources to enable America's increasingly wireless digital economy and society is now a key policy issue. The Federal Communications Commission (FCC) voted today on an important spectrum item with national security implications.

America's global prowess comes in part from information communications technologies, notably the 4G/LTE mobile wireless ecosystem. While the U.S. emerged as the global winner in 4G, adding hundreds of billions of dollars in gross domestic product and millions of new jobs, 5G dominance is up for grabs. The move to 5G, or the fifth-generation of mobile wireless technology, will drive innovation in artificial intelligence, augmented reality, robotics, and quantum computing. China has many advantages over the U.S. in the race to 5G, including the deployment of mid-band spectrum, which is particularly well suited for 5G technology and service development.

It is no secret that China, whose government, military, and industry are suffused into a single entity under the Chinese Communist Party, wants to supplant the U.S. in global digital dominance, and 5G is a key battle front. China has already deployed 200 megahertz of mid-band spectrum and is in the process of deploying another 500 megahertz. Since 2015, it has outspent the U.S. by roughly $24 billion in wireless infrastructure and plans to spend $400 billion on 5G investments. It has also built about 12 times more 5G base stations than the U.S. and has invested some $75 billion in Huawei, its largest telecommunications company, to corner the 5G market and undercut international competitors across 170 countries.

National security and defense, the protection of the nation state, its citizens, economy, and institutions, is an essential duty of government. Safeguarding the nation state includes a range of activities to prevent, deter, and mitigate attacks by adversarial foreign nations, as well as strengthening the nation's security and defense through economic and technological development. Securing the spectrum resources to enable America's increasingly wireless digital economy and

society is now a key policy issue. The Federal Communications Commission (FCC) voted today on an important spectrum item with national security implications.

America's global prowess comes in part from information communications technologies, notably the 4G/LTE mobile wireless ecosystem. While the U.S. emerged as the global winner in 4G, adding hundreds of billions of dollars in gross domestic product and millions of new jobs, 5G dominance is up for grabs. The move to 5G, or the fifth-generation of mobile wireless technology, will drive innovation in artificial intelligence, augmented reality, robotics, and quantum computing. China has many advantages over the U.S. in the race to 5G, including the deployment of mid-band spectrum, which is particularly well suited for 5G technology and service development.

It is no secret that China, whose government, military, and industry are suffused into a single entity under the Chinese Communist Party, wants to supplant the U.S. in global digital dominance, and 5G is a key battle front. China has already deployed 200 megahertz of mid-band spectrum and is in the process of deploying another 500 megahertz. Since 2015, it has outspent the U.S. by roughly $24 billion in wireless infrastructure and plans to spend $400 billion on 5G investments. It has also built about 12 times more 5G base stations than the U.S. and has invested some $75 billion in Huawei, its largest telecommunications company, to corner the 5G market and undercut international competitors across 170 countries.

National security and defense, the protection of the nation state, its citizens, economy, and institutions, is an essential duty of government. Safeguarding the nation state includes a range of activities to prevent, deter, and mitigate attacks by adversarial foreign nations, as well as strengthening the nation's security and defense through economic and technological development. Securing the spectrum resources to enable America's increasingly wireless digital economy and society is now a key policy issue. The Federal Communications Commission (FCC) voted today on an important spectrum item with national security implications.

America's global prowess comes in part from information communications technologies, notably the 4G/LTE mobile wireless ecosystem. While the U.S. emerged as the global winner in 4G, adding hundreds of billions of dollars in gross domestic product and millions of new jobs, 5G dominance is up for grabs. The move to 5G, or the fifth-generation of mobile wireless technology, will drive innovation in artificial intelligence, augmented reality, robotics, and quantum computing. China has many advantages over the U.S. in the race to 5G, including the deployment of mid-band spectrum, which is particularly well suited for 5G technology and service development.

It is no secret that China, whose government, military, and industry are suffused into a single entity under the Chinese Communist Party, wants to supplant the U.S. in global digital dominance, and 5G is a key battle front. China has already deployed 200 megahertz of mid-band spectrum and is in the process of deploying another 500 megahertz. Since 2015, it has outspent the U.S. by roughly $24 billion in wireless infrastructure and plans to spend $400 billion on 5G investments. It has also built about 12 times more 5G base stations than the U.S. and has invested some $75 billion in Huawei, its largest telecommunications company, to corner the 5G market and undercut international competitors across 170 countries.

Leading national security experts support Chairman Pai's plan to quickly auction the C-band spectrum before the end of the year. Mike Rogers, former Chairman of the House Permanent Select Committee on Intelligence, commissioned the 2012 report which recommended that the U.S. stop

doing business with Huawei and ZTE. Rogers, now serving as Chairman of 5G Action Now, a group formed to establish the U.S. as the worldwide leader in 5G, supports the Chairman's auction plan and benefits of 5G, including economic growth in rural America, technological expansion and improved national security. Joining Rogers on a letter to Pai are Heritage Foundation Visiting Fellow Steve Bucci, former Deputy National Security Advisor for the Trump Transition Team Andy Keiser, and former Director of Homeland Security Tom Ridge, noting, "The first country to deploy 5G will control the global communications network and have a national security edge on the rest of the world… Chairman Pai's proposal prioritizes speed in an effort to deploy the next generation of wireless technology before China." While moving forward quickly with the C-band auction is an important and vital step to securing America's national security and leadership in the 5G age, there is still more work to do.

C-Band Spectrum Is Not The Beachfront; It's Affordable Housing.

12 January 2021

https://www.forbes.com/sites/roslynlayton/2021/01/12/c-band-spectrum-is-not-the-beachfront-its-affordable-housing/?sh=5283bb523ff4

One bit of bright news in the new year is the C-Band auction. On its opening day December 8, bids for the 280 MHz of the 3.7-3.98 GHz band reached $2 billion; now they surpass $80 billion. Some call this section of radio spectrum "the beachfront", as if only the wealthy, exclusive set could occupy it. A more proper term is "affordable housing" for no other broadband technology can bring high quality connectivity to the every American more economically. Indeed, multiple bids from 57 companies to serve every part of America reflect an expectation of progress, growth, and innovation for the future. Unlike over-hyped tech IPOs, investing in mobile networks requires real world installation of infrastructure on the ground, service delivery to hundreds of millions of people, and a quality of experience that keeps customers subscribing month after month.

Mobile cellular wireless technologies maximize broadband equity

5G technology will achieve through *innovation* what broadband advocates have long sought through *regulation*: a high quality, high speed broadband connection to everyone everywhere. Provided the right spectrum, 5G can enable a high speed, high throughput connection through the air in all directions. This is technologically and economically superior to a wire in the ground which only can deliver data in two directions.

European renters vs. American home-owners

European spectrum licenses are offered for short terms of 15 years, forcing operators to be renters. US operators, on the other hand, which can buy spectrum licenses for a near unlimited term with the option to sell, behave like home-owners. They make long-term investments, build nationwide networks, and upgrade technology to improve their quality and value. There is no one operator that serves all of Europe, but the US has three 5G nationwide networks underway, with 5G networks from Dish and US Cellular in the making. This is the difference of owners' vs. renters' economics. Just as a low interest rate can help finance a home, C-band bidders are taking advantage of cheap money to help fuel their long term investment.

One bit of bright news in the new year is the C-Band auction. On its opening day December 8, bids for the 280 MHz of the 3.7-3.98 GHz band reached $2 billion; now they surpass $80 billion. Some call this section of radio spectrum "the beachfront", as if only the wealthy, exclusive set could occupy it. A more proper term is "affordable housing" for no other broadband technology can bring high quality connectivity to the every American more economically. Indeed, multiple bids from 57 companies to serve every part of America reflect an expectation of progress, growth, and innovation for the future. Unlike over-hyped tech IPOs, investing in mobile networks requires real world installation of infrastructure on the ground, service delivery to hundreds of millions of people, and a quality of experience that keeps customers subscribing month after month.

Mobile cellular wireless technologies maximize broadband equity

5G technology will achieve through *innovation* what broadband advocates have long sought through *regulation*: a high quality, high speed broadband connection to everyone everywhere. Provided the right spectrum, 5G can enable a high speed, high throughput connection through the air in all directions. This is technologically and economically superior to a wire in the ground which only can deliver data in two directions.

European renters vs. American home-owners

European spectrum licenses are offered for short terms of 15 years, forcing operators to be renters. US operators, on the other hand, which can buy spectrum licenses for a near unlimited term with the option to sell, behave like home-owners. They make long-term investments, build nationwide networks, and upgrade technology to improve their quality and value. There is no one operator that serves all of Europe, but the US has three 5G nationwide networks underway, with 5G networks from Dish and US Cellular in the making. This is the difference of owners' vs. renters' economics. Just as a low interest rate can help finance a home, C-band bidders are taking advantage of cheap money to help fuel their long term investment.

One bit of bright news in the new year is the C-Band auction. On its opening day December 8, bids for the 280 MHz of the 3.7-3.98 GHz band reached $2 billion; now they surpass $80 billion. Some call this section of radio spectrum "the beachfront", as if only the wealthy, exclusive set could occupy it. A more proper term is "affordable housing" for no other broadband technology can bring high quality connectivity to the every American more economically. Indeed, multiple bids from 57 companies to serve every part of America reflect an expectation of progress, growth, and innovation for the future. Unlike over-hyped tech IPOs, investing in mobile networks requires real world installation of infrastructure on the ground, service delivery to hundreds of millions of people, and a quality of experience that keeps customers subscribing month after month.

Mobile cellular wireless technologies maximize broadband equity

5G technology will achieve through *innovation* what broadband advocates have long sought through *regulation*: a high quality, high speed broadband connection to everyone everywhere. Provided the right spectrum, 5G can enable a high speed, high throughput connection through the air in all directions. This is technologically and economically superior to a wire in the ground which only can deliver data in two directions.

European renters vs. American home-owners

European spectrum licenses are offered for short terms of 15 years, forcing operators to be renters. US operators, on the other hand, which can buy spectrum licenses for a near unlimited term with the option to sell, behave like home-owners. They make long-term investments, build nationwide networks, and upgrade technology to improve their quality and value. There is no one operator that serves all of Europe, but the US has three 5G nationwide networks underway, with 5G networks from Dish and US Cellular in the making. This is the difference of owners' vs. renters' economics. Just as a low interest rate can help finance a home, C-band bidders are taking advantage of cheap money to help fuel their long term investment.

Just as misguided policy can create housing shortage, policy failures have created the spectrum "crunch". While policymakers tout their generosity in making scant 280 MHz for 5G, the federal government sits some 2800 MHz of "beachfront" spectrum, most of it underused. The spectrum "sharing" regime with the US Navy for 70 MHz is novel, but it not workable model to build a national network. Its many restrictions make it unusable for 5G, and its spectrum value reflects this, just $0.2 MHz/Pop. Another cause of the spectrum crunch is the discriminatory giveaways of "free" or unlicensed spectrum, resources which otherwise are worth tens, if not hundreds, of billions of dollars. It is confounding that at the time of financial crisis the FCC makes 1200 MHz of spectrum freely available, essentially a gift to Silicon Valley companies with trillion dollar market capitalizations and whose executives have a higher net worth than the GDP of many countries. To make matters worse, this free "unlicensed" spectrum has little to no security requirements and is open to all comers, including Chinese government-owned equipment makers. 5G networks which run on licensed networks, on the other hand, must conform to high security standards, achieved both by superior design and the restriction of Huawei and ZTE equipment.

The revenue generation from the C-band auction reflects in part that government policy has made spectrum needlessly scare. Over time, technology and the market have a way to work around bad policy decisions. For policymakers who refuse to reform a century old federal spectrum system, they are counting on America's mobile operators to compensate for their inaction.

Day 1 Of C-Band Spectrum Auction Raised $2 Billion

10 December 2020

https://www.forbes.com/sites/roslynlayton/2020/12/10/day-1-of-c-band-spectrum-auction-raised-2-billion/?sh=460725b74510

The highly-awaited C-band auction for the 3.7-3.98 GHz began December 8, raising $2 billion in gross bids from dozens of bidders in the mobile, telecom, satellite, and fixed wireless space. The auction, which consists of series of rounds over a few weeks, is on track to raise in excess $30 billion for federal coffers. This princely sum reflects the scarcity of valuable 5G spectrum, frequencies prized for their physical properties to enable high throughput over long distance. This C-band auction is critical to close the mid-band spectrum gap between the US and China, a key front of geopolitical competition and security. Auction results to date demonstrate the prowess of the Federal Communication Commission (FCC) in the spectrum domain and offer important policy lesson for other methods of spectrum allocation, like unlicensed and shared models (Hat tip to Frank Louthan and Ric Prentiss at Raymond James for their excellent financial summaries).

The C-band auction is one of the most successful examples of renewable resources deployed for economic growth.

Radio spectrum is valuable natural, renewable resource. As technology improves, frequencies can be redeployed on better, more efficient services. In the C-Band case, satellite companies agreed to vacate their holdings in exchange for accelerated payments from the auction, a relocation process to be finalized by December 2023. The prospective bidders will pay holders for their spectrum rights so they can deploy next generation wireless services like 5G, a more valuable use. As these providers deploy, greater competition will emerge in the broadband market, consumers will access better services, jobs will be created, and the economy will grow.

The FCC kept its eyes on the prize—mostly

While regulators in other countries used the pandemic as an excuse to postpone their 5G auctions, the FCC kept the C-band auction on schedule. FCC employees worked from home to codify bidding procedures for 280 MHz, ensuring granular bidding for 5684 licenses in 400 economic areas across the country.

The highly-awaited C-band auction for the 3.7-3.98 GHz began December 8, raising $2 billion in gross bids from dozens of bidders in the mobile, telecom, satellite, and fixed wireless space. The auction, which consists of series of rounds over a few weeks, is on track to raise in excess $30 billion for federal coffers. This princely sum reflects the scarcity of valuable 5G spectrum, frequencies prized for their physical properties to enable high throughput over long distance. This C-band auction is critical to close the mid-band spectrum gap between the US and China, a key front of geopolitical competition and security. Auction results to date demonstrate the prowess of the Federal Communication Commission (FCC) in the spectrum domain and offer important policy lesson for other methods of spectrum allocation, like unlicensed and shared models (Hat tip to Frank Louthan and Ric Prentiss at Raymond James for their excellent financial summaries).

The C-band auction is one of the most successful examples of renewable resources deployed for economic growth.

Radio spectrum is valuable natural, renewable resource. As technology improves, frequencies can be redeployed on better, more efficient services. In the C-Band case, satellite companies agreed to vacate their holdings in exchange for accelerated payments from the auction, a relocation process to be finalized by December 2023. The prospective bidders will pay holders for their spectrum rights so they can deploy next generation wireless services like 5G, a more valuable use. As these providers deploy, greater competition will emerge in the broadband market, consumers will access better services, jobs will be created, and the economy will grow.

The FCC kept its eyes on the prize—mostly

While regulators in other countries used the pandemic as an excuse to postpone their 5G auctions, the FCC kept the C-band auction on schedule. FCC employees worked from home to codify bidding procedures for 280 MHz, ensuring granular bidding for 5684 licenses in 400 economic areas across the country.

The highly-awaited C-band auction for the 3.7-3.98 GHz began December 8, raising $2 billion in gross bids from dozens of bidders in the mobile, telecom, satellite, and fixed wireless space. The auction, which consists of series of rounds over a few weeks, is on track to raise in excess $30 billion for federal coffers. This princely sum reflects the scarcity of valuable 5G spectrum, frequencies prized for their physical properties to enable high throughput over long distance. This C-band auction is critical to close the mid-band spectrum gap between the US and China, a key front of geopolitical competition and security. Auction results to date demonstrate the prowess of the Federal Communication Commission (FCC) in the spectrum domain and offer important policy lesson for other methods of spectrum allocation, like unlicensed and shared models (Hat tip to Frank Louthan and Ric Prentiss at Raymond James for their excellent financial summaries).

The C-band auction is one of the most successful examples of renewable resources deployed for economic growth.

Radio spectrum is valuable natural, renewable resource. As technology improves, frequencies can be redeployed on better, more efficient services. In the C-Band case, satellite companies agreed to vacate their holdings in exchange for accelerated payments from the auction, a relocation process to be finalized by December 2023. The prospective bidders will pay holders for their spectrum rights so they can deploy next generation wireless services like 5G, a more valuable use. As these providers deploy, greater competition will emerge in the broadband market, consumers will access better services, jobs will be created, and the economy will grow.

The FCC kept its eyes on the prize—mostly

While regulators in other countries used the pandemic as an excuse to postpone their 5G auctions, the FCC kept the C-band auction on schedule. FCC employees worked from home to codify bidding procedures for 280 MHz, ensuring granular bidding for 5684 licenses in 400 economic areas across the country.

The Nobel committee recognized auctions, rejected beauty contests

FCC auctions were recognized by the Royal Swedish Academy of Sciences in awarding the 2020 Economics Nobel Prize to Paul R. Milgrom and Robert B. Wilson, economists who engineered many of the FCC's pioneering auctions. "These frequencies are government owned, but private actors can often utilise them more efficiently," noted the Academy. Further it described the folly of the FCC's other methods of allocation, notably "beauty contests" in which the FCC grants spectrum to a particular party for a certain use without a competitive process or price. Sadly, earlier this year the FCC squandered a whopping 1200 MHz in the 6 GHz band to Silicon Valley tech companies under the rubric of "unlicensed use." Using current C-band metrics, Google, Netflix, Amazon, and other bandwidth hungry companies would otherwise have paid in excess of $100 billion for the frequencies. Considering the current financial crisis, policymakers should be looking more closely at such opportunities.

COVID Will Not Delay The FCC's 5G Spectrum Auction

7 August 2020

https://www.forbes.com/sites/roslynlayton/2020/08/07/covid-will-not-delay-the-fccs-5g-spectrum-auction/?sh=3fd9e16c138b

Telecom regulators in Europe, some 2 years behind on 5G, proffer COVID as an excuse to further delay spectrum actions. Meanwhile the Federal Communications Commission (FCC) speeds ahead. The lockdown turned the agency turned virtual overnight and disconnected some 1600 employees from their physical offices. All the same, the FCC has kept up its aggressive schedule on a dozen spectrum proceedings, some noteworthy for their innovative design and market approaches, including yesterday's vote adopting competitive bidding for the 3.7-3.98 GHz or C-band on December 8.

If COVID were not enough, the FCC has faced blistering attacks and intervention from other federal agencies for actioning its Congressional mandate to make more commercial spectrum available. Sadly, the view that the public interest should be interpreted as enabling every America to access wireless services for work, education, and health when they are locked down in the homes is not shared in all corners. Indeed, actors representing cable incumbents have successfully delayed the market processes that would have allowed Americans in rural areas to access 5G before the pandemic hit.

Credit goes to FCC Chairman Ajit Pai to deliver on the FCC's 5G FAST Plan, a comprehensive policy for 5G spectrum, infrastructure rollout, and modernizing regulation. The haste is warranted. As Commissioner Rosenworcel observed, "Other nations have their 5G plans in order and are poised to free up to five times more licensed mid-band spectrum than the U.S. by the end of the year, while we still wait for a national spectrum strategy that is more than a year overdue." Indeed, half of the world's 5G connections are in China, a success due in part to leverage the physical properties of mid-band spectrum which allow large amounts of data to delivered efficiently over long distances.

In the US, the slivers of spectrum allowed for market allocation and development have been wildly successful, but two-thirds of the spectrum beachfront is still held by federal agencies. The US approach was and is sub-optimal. As I detailed in my recent Senate testimony, political decisions prioritized the needs of federal agencies over consumers and precluded the natural development of a spectrum market, which was already underway in the 1920s. The management of federal spectrum hasn't changed in 98 years.

Pai recognized more than 30 FCC staff who worked tirelessly under an expedited timeline to develop the procedures for the upcoming auction. This includes upfront relocation payments to current C-band spectrum holders so that 5G can be enabled within 2-4 years, procedures to divide nationwide licenses into smaller units, and to support participation of small players, the creation of multiple bidding categories and bidding credits. Unsurprisingly wide range of policy actors advocating for consumers, taxpayers, and national security support the C-band proceeding.

Revenue estimates for the C-band auction range between $10-30 billion. This follows some $10 billion recently generated by the proceedings for 28 GHz, 24 GHz, and the upper 37 GHz, 39 GHz,

and 47 GHz bands. The FCC also successfully completed the incentive auction transition, a process to compensate and relocate broadcasters so that other providers could use the spectrum—something never tried before and something many believed could not be done. Commissioner O'Reilly is the unsung champion pushing the commercial spectrum envelope, not only on C-band but also the Citizens Broadband Radio Service (CBRS). This pioneering effort makes available unused military spectrum in the 3.5 GHz band on a county-by-county basis with 22,000 licenses, the most ever provided in a single FCC auction. The FCC has also innovated with the first-ever Rural Tribal Priority Window opportunity in 2.5 GHz band, with 280 applications received to date.

Most FCC chairs would wither under the pressure, but Pai, a regulatory superhero, galvanizes.

Thune: Time To Update Federal Spectrum Policy For 5G

24 July 2020

https://www.forbes.com/sites/roslynlayton/2020/07/24/thune-time-to-update-federal-spectrum-policy-for-5g/

U.S. Sen. John Thune, R-S.D., chairman of the Subcommittee on Communications, Technology, Innovation, and the Internet, convened a hearing titled, "The State of U.S. Spectrum Policy," on July 23, 2020. It examined the Federal Communications Commission (FCC)'s and National Telecommunications and Information Administration (NTIA)'s role in spectrum management and policymaking. Witnesses including Tom Power of CTIA, Mark Gibson of CommScope, Michael Calabrese of New America and myself discuss how the increased demand and competition for licensed and unlicensed spectrum resources have impacted spectrum policies in the United States.

Over the year he Commerce Committee has driven reforms to liberalize commercial spectrum allocation at the FCC. These practices have become a model for countries around the world. Reforms include flexible use, competitive bidding, spectrum repackaging, and dynamic sharing. Without these reforms, our trillion-dollar wireless economy and the millions of jobs it powers would not be possible.

As the Committee has improved outcomes for commercial spectrum, the same can likely be done for the government. Today federal spectrum is managed by NTIA and IRAC, the latter founded in 1922. The management of federal spectrum is essentially unchanged for 98 years, and it's time to review it.

In the 1920s, free market, common law property rights were alive and well for radio spectrum. The purpose of the 1927 Radio Act was to end free enterprise and enshrine bureaucratic control of the airwaves. The practical effect was to make spectrum allocation a political decision and to reward favored constituents.

By the time Nobel economist Ronald oase wrote his seminal articles on the FCC and IRAC, the US had some 40 years of administrative allocation. Coase laid the theoretical foundations for the market-based spectrum management. He described how the prevailing central planning of spectrum was wasteful and costly. He debunked the premise that government is needed to limit interference when this same function can be done through pricing.

Coase's proposals were mocked in his day, but experience has proven him right. The FCC has held some 100 spectrum auctions and raised over $100 billion for the Treasury. Today there are millions of spectrum licenses, tens of thousands of licensees, and an ever-increasing number of uses. There is a robust secondary market. However, this optimization only occurs on one-third of the relevant spectrum. The rights to the other two-thirds are held by the government. And this spectrum has a limited set of users and uses.

Spectrum is no different than other resource. It is subject to supply and demand. It can be packaged and priced like other goods and services. Moreover, there is no reason why federal agencies, which purchases inputs from the market, should not pay for their use of spectrum.

The "First Best" realization of Coase's recommendation is to liberalize the underlying resource—privatize the spectrum itself. This would entail sunsetting administrative allocation. Privatizing federal spectrum would be worth at least half a trillion dollars, maybe more, to the Treasury. Like the incentive auction, proceeds from the sale of federal spectrum could be returned to the respective agencies to fund equipment upgrades.

Spectrum conflicts within and between industries and federal agencies are ongoing. This will likely continue. Even though there is liberalized allocation within certain spectrum bands, the overall designation of these bands is still a bureaucratic decision.

"Second Best" would be the introduction of a pricing system for federal spectrum. This can be done without dismantling the regulatory authorities. For example, the FCC licenses commercial spectrum. NTIA could do this for federal spectrum.

While pricing is ideal, it may not be politically tenable. But there are ways to bring greater discipline and accountability. Chairman Wicker and Senators Schatz, Moran and Udall have this in mind with its SPECTRUM Now Act. This bill addresses the critical lack of mid-band spectrum for 5G with a feasibility study of federal efficiency, relocation, and sharing with commercial users.

Senator Wicker's hearing on broadband during the pandemic highlighted that networks performed admirably under crisis. But these networks are needed even more. 100 million schoolchildren face the prospect of distance learning this fall, and yet, policy struggles to allow the purchase the mid-band spectrum rights to serve these children with 5G, the quickest, most cost-effective way to bring connectivity to all. It's a valid policy question whether the federal government requires 2500 MHz of beachfront spectrum for radar and navigation when critical civilian needs at stake.

Indeed, many federal agencies have been reluctant to share, much less relinquish, their little used frequencies. They have resisted Congress' reasonable requests for transparency. Maybe market actors will have more success. Seven firms have signed up as Spectrum Access System administrators for the 3.5 GHz proceeding. One or more of these firms should make a public dashboard so that we can see for ourselves how little federal spectrum is used. Federal agencies should be graded on their spectrum efficiency, and these report cards should be part of the appropriations and agency authorization process.

This should be helped by the Spectrum IT Modernization Act sponsored by Chairman Wicker and Senators Cantwell, Inhofe, and Reed. This bill allows for the modernizing of the IT infrastructure for federal spectrum.

GPS Interference Fears Are Today's Y2K, Says Former UK Spectrum Director

8 May 2020

https://www.forbes.com/sites/roslynlayton/2020/05/08/gps-interference-fears-are-todays-y2k-says-former-uk-spectrum-director/

I caught up with Dr. William Webb, former director of Ofcom, the telecom regulator of the United Kingdom where he led the Spectrum Framework Review, the development of Spectrum Usage Rights, and the UK white space policy. As CEO of Weightless SIG, he led a standards body for global M2M technology. He now consults. Webb has published 17 books and over 100 papers on spectrum and holds 18 patents. We discussed spectrum policy challenges including the recent Ligado controversy.

Radio spectrum policy continually evolves with market demand for new wireless services and innovations in spectrum efficiency. However, these advancements sometimes collide with the historical granting of rights to federal agencies which are not necessarily required to use their spectrum efficiently and are wedded to technologies which can be difficult and expensive to upgrade. These challenges are common across countries. What can US policymakers learn from the UK?

Ofcom and telecoms provider Arqiva looked at the potential for interference into terrestrial TV reception when 4G was introduced into the 800MHz band. They concluded that 2-3 million households would experience interference. Ofcom went ahead anyway but with a huge mitigation program in place to send filters to those affected. In practice the interference experienced was only about 1/100th of that predicted. Indeed, in almost all cases where there have been dire warnings of interference, but enlightened regulators pushed ahead anyway minimal interference was actually experienced. It reminds me a bit of the Y2K catastrophe predictions 20 years ago—some problems were averted from the warnings, most never materialized, and the few that occurred were resolved quickly.

It reminds me of how the National Oceanic and Atmospheric Administration (NOAA) warned that the Federal Communications Commission (FCC)'s 24GHz proceeding would kill weather forecasting or how the Department of Transportation said that 5.9GHz and would cause car accidents. I don't begrudge agencies being concerned, but the institutional resistance to adopt new and better and technology can delay, if not deter, the development of valuable new services.

"Change of use" decisions are made by regulators with the expertise and authority to make them. The problem is that they tend to be risk averse. This is not so much of a criticism as an observation. After seven years at Ofcom, I understand why risk aversion is inevitable. Incumbent federal users tend to have much greater lobbying powers than the new entrants for political and sometimes, financial, reasons. The result is that many spectrum debates can bias towards the status quo. This manifests itself in time consuming studies and expensive tests that pile one worst case assumption on another to end up with a scenario that might cause interference, but is astonishingly unlikely and could be mitigated were it to occur.

Look at what's happening with Ligado. After a decade of study, revocation of spectrum access and resulting bankruptcy, multiple costly tests, and much heated debate, Ligado finally got permission from the FCC to start deployment of a 4G/5G solution in the L-Band where GPS is also located. However now the US Department of Defense, one of the most intransigent incumbents, claims that many military systems would become inoperable. If this is really so, then these systems are hardly fit for purpose. Any enemy, terrorist or malcontent could clearly easily jam them with high power in-band jammers that are sadly very available, even on the Internet. The fragile systems should be replaced with solutions that use multiple satellite systems, have best-in-class filtering, have antennas that can reject interference, have complex coding like cell phones, and more.

Resolving interference disputes should be easy with tests and studies, but it's not. Why not?

Interference studies can guide to the potential problem areas, but there are many variables to consider. Firstly, we need to decide what constitutes harmful interference, the regulatory standard observed worldwide. The incumbent will, understandably, claim that any change, however miniscule, is problematic – they have no incentive to do otherwise. This tends to lead them towards requirements that the noise floor only be changed by a very small amount although few, if any, go as far as the GPS community in arguing that the noise floor outside of their bands should also be within their rights to control – effectively claiming ownership of a much wider band than that which they were allocated, subverting all norms on efficient spectrum management.

Interference studies are just one piece of the puzzle. The service that might be impacted – in this case GPS – will change. By way of example, the TV interference case discussed earlier assumed existing TV receivers which had poor filtering. But the later models, post cellular allocation, were already being designed to accommodate the 800MHz cellular interference and as the cellular service was deployed over five years or so, the TV receiver population tended to improve as quickly.

Incumbents are not disinterested observers and any subjective views from them should be treated with caution. Instead, we need to view these studies from the perspective of the country where the right balance is needed between allowing new services while not *materially disrupting* the current ones. To find out whether disruption is material we need to look at whether the service – in this case typically location determination, though timing is also important – becomes sufficiently less accurate to reduce its efficacy in use. When conducting the study, we need to keep asking whether we are being reasonable or whether we are looking at highly improbable worst cases.

So technology generally improves faster than the quality of testing. What should policymakers know about GPS which would be helpful in addressing interference disputes?

Given the timespan of this Ligado proceeding, newer GPS devices likely already have strong filtering with continuing improvements anticipated based on the ruling. They are also, increasingly, making use of multiple satellite constellations, including the new European Galileo system, making them much less vulnerable to interference. Studies suggest that GPS and Galileo are sensitive to different types of interference, so if one were suffering interference it is quite plausible that the other would not be. Many GPS devices, such as cell-phones, fitness trackers and more are changed quite regularly, but even expensive commercial, military and precision GPS receivers have a very finite lifespan. Assuming that the current devices are unchanging is normally an assumption that is far too risk-averse.

Despite best endeavors in overcoming risk-aversion in the initial decision, it is almost guaranteed to be excessively risk averse. For example, to assuage incumbent concerns, Ligado has agreed to extremely low power levels and a guard band of almost unheard-of magnitude (27MHz compared to typical values of 10MHz or less – for example the guard band in the UK between cellular and TV at 700MHz is proposed to be 9MHz wide as in figure 2.1 below.).

The way to address this risk-aversion is to allow the license conditions to be modified in the light of actual evidence. As the service is deployed, its real impact, as opposed to its modelled impact, can be studied. When it is clear that more interference could be tolerated, then guard bands can be reduced and power levels increased.

What is the cost of being risk averse?

It is always easier to see detrimental impact on existing services than detrimental impact on future new services that as yet do not exist. For example, if "TV white space" had been rapidly made available we might have widespread Internet of Things networks across the country, delivering important productivity and quality-of-life improvements. Equally imagine if services such as 4G, 5G and Wi-Fi6 had not been allowed due to incumbent intransigence - our society, especially now with Covid-19, would be much worse off. Liberating Ligado's spectrum allows innovative IoT and 5G networks to be deployed in spectrum bands with far better propagation than the 3GHz bands others suggest, enabling new services to be widely deployed more quickly and ubiquitously. The FCC made the right decision to balance risk-aversion with innovation.

I understand that the UK military actually pays a fee for their use of spectrum. Can you talk about the process to set up that arrangement and how it works? Could that work in the US?

The concept grew from the expectation that military and other public-sector users likely had more spectrum than they really needed. It had been easy for them in the past to request large assignments, and there was no incentive to give any up – indeed the opposite, no military planner would want to be known as the person who gave back spectrum subsequently needed. Determining what spectrum was of little value to them was almost impossible for outside observers to do because of the confidential nature of the usage. So instead, after commissioning an independent report, Ofcom decided to apply an annual charge to the UK military as an incentive to return spectrum and so reduce the fee. Once returned, the spectrum can be incorporated into a "market forces" management model allowing flexibility in its use. Such an approach could work just as well in the US – the same fundamental issues and drivers apply here as the UK.

How Much Spectrum Should Be Unlicensed?

16 March 2020

https://www.forbes.com/sites/roslynlayton/2020/03/16/how-much-spectrum-should-be-unlicensed/

The answer is somewhere in between zero and 100 percent. A spectrum license allows its holder to operate within a portion of the radio spectrum with interference and crowding, a quality of service enabled for a fee. Unlicensed uses enjoy the spectrum freely but makes no promises about congestion; an inefficient user can hog the space. The FCC allows some to operate in specified bands without licenses, for example low power baby monitors and garage door openers. The killer

app of unlicensed spectrum is Wi-Fi. To date, the FCC has allocated roughly 1000 MHz below the 6 GHz band to unlicensed, and recently proposed another 1200 MHz in the band itself. However, the many existing users of the band—public safety, positive train control, natural gas and oil pipelines, electric grids, and breaking news—are reluctant to be encroached. The FCC believes that interference mitigation technology, Alternative Frequency Coordinator (AFC), can allows unlicensed uses over top of licensees. Here are some approaches to evaluating how much spectrum should be unlicensed.

Scientific Method: Test and Learn

Richard Bennett, co-inventor of the first Wi-Fi standard, observes that Wi-Fi needs more and better spectrum than it has, though he does not believe that the 6 GHz band is necessarily the best location for expansion. His recommendation is to test the sharing concept with 480 MHz of the 6 GHz band, evaluate its performance, and then improve the proposed mix of unlicensed spectrum in suitable bands. It's a reasonable approach given the many users, risks, and the sheer size of the proposed allocation. Moreover Wi-Fi 6 promises a quantum level improved efficiency and could further change the optimal spectrum allocation.

Economics: what is next best use of the spectrum?

A rational economics perspective suggests that all spectrum be licensed; allowing scarce resources to be allocated to their highest and best use and maximizing revenue to the public. However, as spectrum markets are imperfect, policymakers evaluate qualitative tradeoffs between unlicensed and licensed spectrum for the technologies and business models they enable. Wi-Fi and licensed mobile wireless such as 4G and forthcoming 5G contribute several hundred billion dollars to the US economy annually. The Wi-Fi Alliance, a powerful trade organization of more than 800 global companies, leads the 6 GHz effort and touts that its technologies add $500 billion. However it has never cut a check to the US Treasury for the use of the public airwaves. By contrast, licensing spectrum has added $117 billion to the public's coffers, valuable revenue for public safety, rural broadband, and other social uses.

Now, policymakers need not choose one technology or the other for the band; the cellular wireless industry offers to split the spectrum evenly, purchasing the rights to the upper portion of the 6 GHz band for an estimated $20 billion, compensating incumbents to repack nearby, and making the lower portion of the band available for unlicensed. The FCC has allocated a scant 70 MHz of mid-band spectrum, the essential frequency for 5G, but the power limits for the CBRS band are too low. Lack of sufficient licensed spectrum for 5G is a critical concern for national security and international competition, as China has allocated 700 MHz in the band for 5G; Japan, 1000 MHz. Moreover, *licensed* spectrum is required to win the global race to 5G. The C-Band proceeding which attempts to allocate 280 MHz is not finalized, and if it is deterred for some reason, then US will have no mid-band spectrum in the pipeline and will likely lose the 5G race.

Alternative approaches

Free market advocates observe that regulation is inherently political, and the FCC's exercise of spectrum decision is a regulatory taking. Leading telecom economist Tom Hazlett describes how the 1927 Radio Act was promulgated because policymakers of the day did not understand spectrum

markets and preempted the common law property rights regime that emerged on its own. This approach suggests that there would be no FCC to make spectrum decisions.

The Wi-Fi Alliance claims that that the industry's future requires its access the entire 6 GHz band, and that it will need an additional 1500 MHz by 2023. Given its tremendous spectrum needs, the group could consider other solutions. For example, a spectrum consortium which purchases spectrum on behalf of its members and ensure quality of service, security, and so on. In fact, specialized firms perform these services already. Moreover, Wi-Fi Alliance members like Google, Microsoft, and Amazon are sophisticated spectrum users with their own network strategies and mountains of cash. They could purchase spectrum to ensure the delivery of their services.

Final Considerations

There is strong consensus that at least some portion of the 6GHz band should be made available for unlicensed. Testing the efficacy of Wi-Fi 6 is reasonable, and 500-600 MHz for unlicensed with strong interference protections would double the allocation of Wi-Fi spectrum available today. The FCC itself has additional tools to determine the optimal allocation of unlicensed spectrum. Its Office of Economics & Analytics was established precisely for these questions, and it offers credibility and transparency to FCC decisions by documenting assumptions and methods. There is no right answer to the question, but the FCC can improve its proposals. At the very least, the FCC must ensure that its vital 5G proposal is secure before it moves to unlicensed.

On Spectrum, NTIA Sides With Bureaucracy Against 5G And The FCC

9 December 2019

https://www.forbes.com/sites/roslynlayton/2019/12/09/on-spectrum-ntia-sides-with-bureaucracy--against-5g-and-the-fcc/

The US is engaged in a global race to 5G which promises a new trillion-dollar economy with millions of jobs. While the US may have millimeter wave spectrum deployed, makers of standards essential patents for 5G, and a broad user base, the key challenge is still securing adequate mid-band spectrum (FCC). Most of the world's countries have focused on prioritizing the so-called mid-band spectrum because of its ideal properties to transmit high quantities of data over long distances, vital to bring 5G to rural areas. Unfortunately, in the US 5G providers must scrounge for bits and pieces of mid-band spectrum because federal agencies, like the Department of Defense (DoD), which sits on or near the lion's share of these beachfront frequencies, does everything it can to control it.

DoD like many other federal users never purchased their spectrum, nor do they pay a fee for its use, as agencies in other countries do. Unsurprisingly government agencies are inefficient users, if they use the spectrum at all. They do this without apology and even demand protection of their wasteful, inefficient use. Instead of delivering the automotive safety technologies as agreed, the Department of Transportation (DoT) has sat on the 5.9 GHz for 20 years. The Department of Education has similarly failed to deliver on the 2.5 GHz for some 50 years. Sadly, some of the most valuable spectrum lies fallow at a critical moment in America's wireless development.

The Federal Communication Commission has tried to help with a roadmap to transition spectrum to more efficient uses, allowing license holders to sell their rights to entrants. Indeed, satellite industry providers offered to sell their licenses for 5G, and with Congress' help an auction should take place before the end of 2020.

Knowing the importance of 5G and following Congressional mandates, Chairman Ajit Pai of the FCC has tried to enable commercial spectrum opportunities, but the swamp has struck back at every turn to block the opportunities that can deliver for Americans. As we have seen in 24 GHz, 6 GHz, 5.9 GHz, C-band, 3.1-3.55 GHz, 2.5 GHz, 1675-1680 MHz, and the L-Band, where bureaucrats within the many agencies –NASA, NOAA, the Department of Energy, the Department of Education, the Department of Defense and the Department of Transportation have engaged in delay tactics, if not outright sabotage, to thwart the progress of 5G. There is a repeated pattern of regulatory agencies opposing FCC proceedings *after* they have been concluded and with unsubstantiated claims. Consider the pseudo-scare about weather equipment manufactured by NOAA after the 24 GHz auction raised billions of dollars, and the claims' threats to weather equipment had been disproven. A similar tactic was recently deployed without evidence or scientific justification by Defense Secretary Esper to Chairman Pai against approving 40 MHz of deployment-ready L-Band spectrum for 5G.

Given the importance of spectrum to the economy and the expectation of its evidence-based recommendations, it is troubling that the National Telecommunications and Information Administration (NTIA) in a recent letter to the FCC said that sufficient spectrum is available for industry to deploy 5G networks and that holding back 40 MHz of licensed mid-band spectrum from being deployed wouldn't hold back 5G. It is troubling, too, that they would rely on old letters from DoD and DoT with their now discredited claims to support that preposterous assertion. It could be that NTIA, without strong leadership at its helm, has forgotten its statutory mandate to serve as the chief advisor to the President on spectrum matters. It sure seems like it given that this letter is an about-face from the position they took when they had strong leadership.

In May 2019, NTIA Assistant Secretary David Redl noted the lack of spectrum for industry and the need for reform if the US is to continue its leadership. He and NTIA Assistant Secretary for Legislative and Intergovernmental Affairs resigned abruptly thereafter, possibly in protest to bureaucrats dishonoring the statutory duty of the agency and the capture of the agency by larger departments in an effort to protect their spectrum holdings. Without strong leadership at the helm, NTIA has languished further in its duty to serve as the chief advisor to the President on spectrum and support the President's unambiguous goal to win the global race for 5G. Indeed, in October 2018 the President requested NTIA develop a sustainable spectrum strategy for America's future to be delivered in July 2019. The document is six months overdue and there is no indication that it will ever be delivered. Not only is securing US leadership in 5G a crucial goal for the Administration because of its promise of jobs and economic growth for the US, the failure to do so puts America in technological peril versus its chief rival, China, which has many advantages in 5G. NTIA houses some of the most respected spectrum laboratories in America and partners with highly respected standards institutes. This recent letter dis-serves the many outstanding scientists and professionals committed to advancing America's spectrum future with state-of-the-art research and development.

The FCC needs to keep its eyes on the 5G prize and its Congressional mandate.