Silicon Flatirons

Spectrum Hall of Shame & Fame: Candidate Thumbnails

3 September 2018

The 2018 Silicon Flatirons conference, "Spectrum Hall of Shame: The Worst (and Best) Radio Policy Decisions of All Time," aims to learn from past policy decisions to inform current and future rulemakings.

Spectrum policy evolves to fit changing circumstances, but new policies don't always work out as planned. There have been great successes and striking failures. This note provides capsule summaries for some of them to help the conference audience follow along. They are merely introductory sketches of very complex proceedings; the material should not be taken to represent the views of the Silicon Flatirons Center, or any of the people or organizations mentioned.

Contents

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1. 700 MHz band plan

In 2008 the FCC auctioned some of the 700 MHz frequencies freed up in the transition to digital TV. Legislation forced an early auction, dividing the band in a way that has not been followed by other countries. The 698–806 MHz range was split into the Upper and Lower 700 MHz bands. The Lower 700 MHz frequencies were divided into paired A, B, and C Blocks as well as unpaired D and E Blocks. The Upper 700 MHz frequencies were also divided into blocks. Though operators were expecting that the Lower 700 MHz frequencies would be fully homogenized into a single 3GPP LTE band specification, the standards group created four different band classes: 12,13, 14, and 17. Band class 17 was proposed shortly after the auction closed to cover the B and C Blocks, in addition to the existing band class 12 standard which covered the A, B, and C Blocks. Similarly, the band class 13 standard was adopted to only support the Upper 700 MHz C Block. Band class 14 is devoted to Upper B and public-safety. This all meant that AT&T band class 17 LTE devices would not work on the Verizon band class 13 network because the frequencies do not overlap. Further, AT&T devices could not be used with band class 12 networks since they use Lower 700 MHz A Block frequencies, excluded from the band class 17. The lack of interoperability resulting from the band specifications significantly impacted band class 12 hardware suppliers because of AT&T's exclusive use of band class 17 hardware. Interoperability issues were finally resolved by Chairman Clyburn during her interim appointment in 2013 when she adopted an order requiring support for band class 12 devices.

- Neal Gompa, *700MHz mobile spectrum: A sad tale of regulatory and interoperability failure*, Extreme Tech (May 2013), https://www.extremetech.com/electronics/154655-700mhz-mobile-spectrum-a-sad-tale-of-regulatory-and-interoperability-failure/2.
- *Lower 700 MHz Service*, FCC (Apr. 2017), https://www.fcc.gov/wireless/bureau-divisions/mobility-division/lower-700-mhz-service.
- Mike Dano, *Will the FCC require all 700 MHz LTE equipment to interoperate?*, Fierce Wireless (2018), https://www.fiercewireless.com/special-report/will-fcc-require-all-700-mhz-lte-equipment-to-interoperate.

2. Auction set-asides in the PCS C Block

Personal Communication Services (PCS) encompass a wide range of wireless mobile technologies and services. The PCS spectrum was auctioned in 1995/96 as separate blocks for narrowband, broadband, and unlicensed use. Pursuant to a Congressional directive in the Communications Act to promote economic opportunities for a wide variety of applicants, Blocks C and D of the licenses for broadband PCS were set aside for Designated Entities (DEs), i.e., small business, women, minorities, and rural telephone companies. To assist with the financial viability of such DEs, the FCC allowed DEs to purchase the spectrum with a very low down-payment and favorable instalment payments.

NextWave entered the market as a DE and obtained $4.7 billion in licenses from the C Block auction. The licenses were soon repossessed by the FCC after NextWave and other wireless operators failed to meet their payment obligations. While litigation with NextWave was still pending, the FCC re-auctioned the C Block. It was purchased by companies like Alaska Native (80% owned by AT&T) and Salmon PCS (85% owned by Cingular Wireless). Litigation continued for almost ten years. The Supreme Court ultimately held that NextWave was protected by federal bankruptcy law and it was re-awarded the spectrum. NextWave settled with the FCC, returning some licenses in exchange for $5 billion and keeping others, which it promptly sold to Verizon for $3 billion.

- Peter Cramton et al., *The Effect of Incumbent Bidding in Set-Aside Auctions: An Analysis of Prices in the Closed and Open Segments of FCC Auction 35*, 32 Telecommunications Policy 273-290 (2008), http://www.cramton.umd.edu/papers2005-2009/cramton-ingraham-singer-incumbent-bidding-in-set-aside-auctions.pdf.
- Thomas Winslow Hazlett, *Political Spectrum*, 238 – 241 (2017).

3. Awarding cellular licenses by lottery

The FCC awarded two 20 MHz licenses for cellular service in the 800 MHz band by Metropolitan Statistical Areas (MSAs), one to a certificated wireline carrier for that MSA, and one to a party not certificated as such (the "non-wireline" license). The Commission used comparative hearings to select between mutually exclusive applications for both licenses in the top 30 MSAs. However, in all cases there was only one wireline carrier in the MSA. Even where there was more than one, the carriers were able to quickly settle.

The non-wireline carriers, however, faced protracted hearing proceedings and litigation. With the wireline side of the communications industry heading towards monopoly, the FCC decided in May 1984 (upon grant of authority by Congress) to switch to a lottery system to award licenses beyond the top 30 markets. The FCC's decision to switch to a lottery system was intended to drop the barriers to market entry and allow smaller companies to obtain licenses. During the first round of the lottery, the Commission received more than 5,100 applications; this increased to 37,000 applications in the final round. The lottery had created a new set of problems: since it was open to anyone, a myriad of players tried to get a piece of the action. Many winners had no intention of using their licenses and quickly sold off their shares to large companies, perpetuating the pattern that plagued comparative hearings.

- Reily Gregson, *Cellular licenses: a gold rush*, RCR Wireless News (Jan. 2001), https://www.rcrwireless.com/20010122/carriers/cellular-licenses-a-gold-rush.
- Ben Christopher, *The Spectrum Auction: How Economists Saved the Day*, Priceonomics (Aug. 2016), https://priceonomics.com/the-spectrum-auction-how-economists-saved-the-day/.
- Thomas Winslow Hazlett, Political Spectrum, 197 – 207 (2017).

4. Cellular next to GPS ("LightSquared")

In 2011, the FCC approved a conditional waiver of the Ancillary Terrestrial Component (ATC) rule that allowed LightSquared to restructure its spectrum holdings in the L Band. LightSquared insisted that its services would meet the Commission's requirements for MSS/ATC operation in the L Band; opponents were concerned about the potential for interference. Other issues raised during the proceeding included the inability of GPS receivers to reject signals outside the GPS band, leading to interference; the expectation of the GPS industry that the adjacent bands were "quiet" bands allocated to satellite, rather than "louder" terrestrial service; and whether the FCC could and should adopt receiver standards. The FCC suspended the waiver indefinitely in 2012. LightSquared filed for bankruptcy three months later.

Ligado rose from the ashes of LightSquared. In November of 2015, it submitted a new report to the FCC regarding the methods by which their ATC services could exist without substantial interference. Ligado proposed that it and GPS industry partners adjust their spectrum use in order to create less interference, including suggesting that weather data users obtain satellite information via the internet instead of over-the-air broadcast. This proposal and the Department of Transportation's Adjacent Band Compatibility Assessment has generated further controversy, and there is still no end in sight.

- *LightSquared Request for Modification of its Authority for an Ancillary Terrestrial Component*, Order and Authorization, DA 11-133, (2011).
- *LightSquared Request to Modify Its ATC Authorization*, IB 12-340, Notice of Ex Parte, 60001306505 (2015).
- Paul Kirby, *Ligado Responds to Concerns about 1675-1680 MHz Sharing*, National Public Safety Telecommunications Council (Aug. 2016), https://blog.npstc.org/2016/08/24/ligado-responds-to-concerns-about-1675-1680-mhz-sharing/.

5. D Block public safety auction

The Digital Television Transition and Public Safety Act of 2005 granted the FCC authority to reallocate and auction licenses to the 700 MHz band. It required that 10 MHz of the band, known as the D Block, be auctioned provided that the winning bidder form a public-private partnership under the direction of the PSST (Public Safety Spectrum Trust Corp, a nonprofit consisting of public safety groups) to build a nationwide public safety broadband network.

However, nobody bid enough on the D Block in the ensuing 2008 auction to meet the $1.3 billion reserve price. The 2008 report of the FCC's Office of Inspector General report noted that "potential bidders stated that the uncertainties and risks associated with the D Block, including, but not limited to, the negotiation framework with PSST, the potential for default payment if negotiations failed, and the costs of the build-out and the operations of the network, taken together, deterred each of the companies from bidding on the D Block."

Seven years after the 2005 legislation, the Middle Class Tax Relief and Job Creation Act of 2012 removed the auction requirement on the D Block, and added it to spectrum already licensed to public safety, the adjacent 10 MH PSST block. $7 billion was provided for network construction. The Spectrum Act set up FirstNet (First Responder Network Authority) to manage the network. FirstNet has suffered from governance turmoil, and currently seven of the 15 board positions are open.

- FCC Office of Inspector General, *D Block Investigation*, (Apr. 2008), https://docs.fcc.gov/public/attachments/DOC-281791A1.pdf.
- Matthew Lasar, *700MHz D Block autopsy: public safety net concept was doomed*, Ars Technica (Apr. 2008), https://arstechnica.com/uncategorized/2008/04/700mhz-d-block-autopsy-public-safety-net-concept-was-doomed/.
- Donald Evans, *FCC Takes Another Crack at D Block Rules*, CommLawBlog (Oct. 2008), https://www.commlawblog.com/2008/10/articles/cellular/fcc-takes-another-crack-at-d-block-rules/.

6. DSRC in 5.9 GHz

The FCC set aside 75 MHz of spectrum in the 5.9 GHz band (5.850–5.925 GHz) in 1999 to be used for vehicle-related safety and mobility systems. Dedicated Short-Range Communications (DSRC) in the 5.9 GHz band allows cars to connect to their surroundings to provide better driving safety, a scenario known as V2X (Vehicle-to-Everything). However, nineteen years after the allocation, there are still no substantial DSRC implementations. Toyota has announced that DSRC would be deployed in vehicles sold in the U.S. starting in 2021.

In the past few years, certain parties in the communications industry have advocated a shift away from DSRC (favored by many auto-makers) and toward C-V2X (Cellular Vehicle-to-Everything, a technology created by Qualcomm). Wi-Fi is also trying to establish itself in this application. DSRC and C-V2X have strongly opposed the entry of another player into the band. The current debate includes disagreement about whether DSRC requires a dedicated band, and which technology is most appropriate for implementation.

- Kelly Hill, *What is DSRC for the connected car?*, RCR Wireless News (Oct. 2015), https://www.rcrwireless.com/20151020/featured/what-is-dsrc-for-the-connected-car-tag6.
- Monica Alleven, *Sharing in 5.9 GHz band gets renewed focus, but automakers still hitched to DSRC*, Fierce Wireless (May 2018), https://www.fiercewireless.com/wireless/sharing-5-9-ghz-band-gets-renewed-focus-but-auto-makers-still-hitched-to-dsrc.

7. DTV transition

As digital technology expanded the scope and quality of cable- and fiber-delivered programming, it became clear that over-the-air broadcasters would likewise need to convert to digital signals to compete. Congress mandated the conversion from analog to digital broadcast in 1996, setting a deadline of 2006 and authorizing the FCC to coordinate the transition. The switch to DTV was intended to make broadcasters more competitive with the relatively unregulated cable industry. It would do this by lowering costs and creating new opportunities for broadcasters. Because of digital signal compression, each 6 MHz TV channel could be split and used for multiple programming streams.

Though the transition was originally set to take place on December 31, 2006, Congress pushed the date back multiple times, first to December 31, 2008, then to February 17, 2009, and finally to June 12, 2009. Michael Rogers estimated that roughly 70 million televisions would have gone blank if the transition happened on its original date. During the DTV transition delay, over-the-air television viewership and revenue decreased sharply. Few station operators have been able to make use of their capacity to offer extra channels, or to repurpose underutilized spectrum for mobile or other premium services.

- Michael Rogers, *The end of analog TV*, NBC News (Apr. 2005), http://www.nbcnews.com/id/7593620/ns/technology_and_science-innovation/t/end-analog-tv/#.W3GX-ehKi70.
- Eliot van Buskirk, *How We Bungled the Digital Television Transition*, (Feb. 2009), https://www.wired.com/2009/02/how-the-governm/.
- John Eggerton, *Nielsen: 2.1 Million Homes Still Unready After DTV Transition*, Multichannel News (June 2009), https://www.multichannel.com/news/nielsen-21-million-homes-still-unready-after-dtv-transition-267309.

8. H Block auction

The FCC auctioned the then-remaining frequencies in its 2014 inventory as the H Block. This was the most significant auction it had held since 2008. The H Block auction was criticized from the beginning. Though conventional wisdom placed a higher value on H Block when grouped with larger licenses, the block was auctioned on its own. This was in part due to lobbying from Sprint and T-Mobile and the FCC's willingness to support an increase in their spectrum holdings.

As the auction approached, Sprint and T-Mobile began to question the viability of the H Block. This surprised many, as Sprint had received multiple concessions from the FCC about the auction's design and structure. With the exit of Sprint and T-Mobile, Dish Network remained as the sole nationwide bidder. The auction had become a retail sale. Dish won all 176 lots at the minimum bid price of $1.5 billion.

- *Auction 96: H Block*, (Mar. 2014), https://www.fcc.gov/auction/96.
- Sprint abandons pursuit of H Block spectrum. November 2013. https://www.fiercewireless.com/wireless/sprint-abandons-pursuit-h-block-spectrum.
- Larry Downes, *The FCC 'Mobile Darwinists' Fail Again*, Forbes (Dec. 2013), https://www.forbes.com/sites/larrydownes/2013/12/09/the-fccs-mobile-darwinists-fail-again/#b9d6c0731701.

9. Harmful interference criteria

47 C.F.R. § 2.1(c) defines harmful interference as "interference which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations". The criteria of "endangers the functioning" and "repeatedly interrupts etc." are debatable. The FCC has not established

technical standards for determining harmful interference, or assigning or measuring interference tolerances. This has led to much confusion about legal levels of interference.

The current standard gives the FCC a great deal of flexibility. It allows the agency to consider a great variety of factors, such as power levels, patterns and characteristics of service degradation, and locations of existing transmitter and receivers. It enables the Commission to declare when interference has occurred, but does not provide guidance on when interference will be deemed to occur in the future. As a result, incumbent spectrum users could delay or prevent lawful new uses. New technologies can be sidelined, and in-demand frequencies can remain vacant or ineffectively used. Opponents of the current approach propose that a more clearly delineated rule be adopted. They argue that this would offer more certainty about what's permissible, allow for more innovation, and facilitate inter-party dispute resolution.

- Paul Margie, *Can You Hear Me Now?*, 5 STAN. TECH. L. REV. (2003), https://www.hwglaw.com/wp-content/uploads/2003/01/5F63582B07A07460630CB603F28DFBAF.pdf.
- IEEE USA, *Clarifying harmful interference will facilitate wireless innovation*, IEEE-USA Committee on Communications Policy (2012), https://ieeeusa.org/wp-content/uploads/2017/07/IEEEUSAWP-HarmfulInterference0712.pdf.
- Thomas W. Hazlett and Sarah Oh, *Exactitude in Defining Rights: Radio Spectrum and the "Harmful Interference" Conundrum*, 28 Berkeley Tech. L.J. 226, (2013).

10. Interleaving public safety and cellular in 800 MHz

From the mid-1970s through the mid-1980s, the FCC allocated spectrum in the 800 MHz band to various Private Land Mobile Radio services (PLMRS), including commercial and public safety communications systems. Given analog transmission and combiner technology, the FCC interleaved the frequency assignments. Several large ventures, led by Fleet Call, sprang up to consolidate these holdings and provide cellular service. After an FCC waiver to use digital cellular technology, Nextel (as Fleet Call became), by far the largest PLMR consolidator, began intensive use of the interleaved 800 MHz frequencies in the early 1990s.

After substantial interference between its operations and other PLMRS operators, Nextel suggested restructuring the 800 MHz band. Interference arose due to the interleaving, and low-height cellular base station transmitters sometimes overloading nearby LMR receivers. Nextel proposed two separate blocks in the 800 MHz band, one for public safety and one for commercial operations. Nextel would surrender its existing licenses and receive new allocations in exchange for covering public safety relocation costs – a cheaper solution than purchasing new licenses at auction. This was presented as a three-year process (excluding operations in the Canadian and Mexican border regions), starting in 2005 and ending in 2008. However, more than a decade later the restructuring is not yet fully complete, and there have been reports that public safety users are still experiencing interference.

- Dan Veeneman, *Nextel Proposes Restructuring 800 MHz*, Signal Harbor (Feb. 2002), http://www.signalharbor.com/ttt/02feb/index.html.
- Donny Jackson, *Ten years later, 800 MHz rebanding proves to be an enlightening exercise,* Urgent Communications (July 2014), http://urgentcomm.com/blog/ten-years-later-800-mhz-rebanding-proves-be-enlightening-exercise.

11. MVDDS–DBS sharing ("Northpoint")

In 1998, Northpoint Technology, Ltd. petitioned the Commission to license a terrestrial multichannel video and broadband data service (MVDDS) in the 12 GHz band, the same band allocated to the direct broadcast satellite (DBS) service. After a contentious application process, and even legislatively mandated studies to evaluate interference levels, the Commission authorized MVDDS on a co-primary, non-harmful interference basis with DBS, indicating that it would define MVDDS technical rules and requirements in a later order.

In 2002, the FCC established complicated technical criteria for sharing the band. Finding that a strict non-interference standard was impractical and overprotective, the FCC planned to establish a "permissible" level of interference. In doing so, the Commission sought to find a compromise that was a "reasonable balance of the parties' competing interests." It settled on allowing MVDDS interference to cause up to a 10% increase in the baseline DBS outage rate. The resulting rules were complicated, having to deal with MVDDS, DBS, and NGSO satellite systems, and the four-year delay proved too long for the start-up companies. Recently, the MVDDS 5G Coalition filed a petition for rulemaking to permit MVDDS licensees to use their 12 GHz spectrum for 2-way mobile broadband services.

- *FCC Affirms MVDDS Authorization and Adopts Services Rules for the 12.2–12.7 GHZ Band*, FCC News (Apr. 2002), https://transition.fcc.gov/Bureaus/Wireless/News_Releases/2002/nrwl0207.html.
- Ted Hearn, *DBS Goes to Court on Spectrum Sharing*, Multichannel News (Jul. 2002), https://www.multichannel.com/news/dbs-goes-court-spectrum-sharing-157791.
- Monica Alleven, *Dish, partners in MVDDS coalition petition to get 12.2 –12.7 GHz band into 5G realm*, Fierce Wireless (May 2016), https://www.fiercewireless.com/tech/dish-partners-mvdds-coalition-petition-to-get-12-2-12-7-ghz-band-into-5g-realm.

12. Open Skies policy for domestic satellite communication

In the late 1960s, the United States was faced with a crucial decision about the future of its domestic satellite industry. The fundamental policy issue was whether the country should pursue a monopoly or competitive industry structure. At that time, the FCC was on a course that would have retained Comsat as a monopoly provider of domestic satellites. The topic gained the attention of the White House and its Domestic Satellite Policy Working Group, headed by Clay T. Whitehead. This culminated in a White House Press Conference in January 1970 that declared that, rather than monopoly provision, any technically and financially qualified company should be authorized to launch a domestic communications satellite. This statement of policy became known as "Open Skies," and was approved by the FCC in January 1972.

The Open Skies policy and associated FCC rules went beyond facilitating competition and innovation in the supply of the satellites themselves, eventually leading to the proliferation of cable TV programming delivered directly to cable head-ends. It can be argued that this not only "changed the entire landscape of television in the United States and throughout the world" but provided the financial wherewithal for the build-out of today's broadband digital cable networks.

- *Office of Telecommunications Policy*, Wikipedia (Jun. 2018), https://en.wikipedia.org/wiki/Office_of_Telecommunications_Policy
- Adam Bernstein, *Clay Whitehead, 69; Changed TV Landscape*, Washington Post Obituaries (Jul. 2008), http://www.washingtonpost.com/wp-dyn/content/article/2008/07/28/AR2008072802665.html?noredirect=on.
- Robert Wold, *Legal Legacies: Milestones in Satellite History – From our Archive*, Via Satellite (Dec. 2017), https://www.satellitetoday.com/telecom/2017/12/14/legal-legacies-milestones-satellite-history-archive/.

13. PCS overlay auction and microwave relocation

After years of incumbent holdout, the FCC auctioned PCS licenses in the 1.9 GHZ band in 1995. Incumbent microwave operators had claimed that switching frequencies would disrupt the services they offered to public safety providers, leading to loss of life. The licenses were auctioned as overlays that allowed mobile operators to enter the band, while grandfathering incumbents in. Microwave operators were given the option of being paid to vacate their frequencies early during "voluntary" negotiations or wait until "involuntary" negotiations. The voluntary phase gave PCS licensees an almost unlimited range of options to convince incumbents to relocate. This included upgrading systems, laying new infrastructure, and even providing PCS services to incumbents. If voluntary negotiations failed, PCS operators would merely have to provide "comparable facilities" to force incumbents out. At the time, the auction was the biggest to date.

- Edmund Andrews, *Winners of Wireless Auction to Pay $7 Billion*, NY Times (1995), https://www.nytimes.com/1995/03/14/business/winners-of-wireless-auction-to-pay-7-billion.html.
- Cramton, *The Efficiency of the FCC Spectrum Auctions*, 41 Journal of Law & Econ. 727 (1998).
- Reily Gregson, *PCS SHOULD JUST GIVE RELOCATION A FAIR CHANCE, SAY INCUMBENTS*, RCR Wireless (Sept. 1995), https://www.rcrwireless.com/19950918/archived-articles/pcs-should-just-give-relocation-a-fair-chance-say-incumbents.
- Thomas Winslow Hazlett, Political Spectrum, 278 (2017).

14. Reallocation of upper UHF band (channels 70–83) to cellular service

In May 1970, the FCC reallocated spectrum in the 806–947 MHz band to provide an additional 115 MHz for mobile radio systems. This spectrum was reallocated from previous UHF television channels 70–83. In 1974, the Commission allocated 40 MHz of this spectrum for common carrier cellular communications systems and 30 MHz for private radio systems. In 1981, the FCC concluded that licensing two 20 MHz cellular systems would serve the public interest, and divided the 40 MHz into two blocks of 333 channels each. The Commission granted 333 channel pairs to each of the two cellular licensees in each area, and the first commercial cellular service in the U.S. debuted in 1983. Although initial market penetration was projected to be only 1-3 % of the total population, the number of cellular subscribers in the U.S. increased from 204,000 in 1985 to 1.6 million in 1988, and continued to grow.

- *An Inquiry into the Use of the Bands 825–845 MHz and 870 MHz and 870–890 MHz for Cellular Communications Systems; Amendment of Parts 2 and 22 of the Commission's Rules Relative to Cellular Communications Systems*, CC Docket No. 79-318, *Report and Order*, 86 FCC 2d 469, 471, 476 at para. 4, 15 (1981).

15. Secondary spectrum markets & leasing

In 2003, the FCC adopted an order that established policies and procedures to facilitate broader access to spectrum using leasing arrangements. It also streamlined procedures for approving license assignments and transfers of control. In 2004, a further order provided for immediate processing of certain qualifying spectrum leasing, and license assignment and transfer transactions. It also established a new regulatory concept, the "private commons," to provide additional access to spectrum in licensed bands. Under the secondary market initiatives, licensees that hold "exclusive use" licenses can lease spectrum to third parties using two different arrangements: 1) "spectrum manager" leasing, which permits parties to engage in leasing arrangements without prior FCC approval as long as the licensee retains both *de jure* and *de facto* control over the leased spectrum; and 2) *de facto* transfer leasing, which creates a streamlined approval process for leases that involve a transfer of *de facto* control. The FCC moved to forbear from requirements for leasing parties to provide prior public notice. The Commission also extended leasing rights to services that had heretofore been barred from participation in secondary markets, including public safety service license holders.

- John Mayo & Scott Wallsten, *Enabling efficient wireless communications: The role of secondary spectrum markets*, 22 Issue 1 Info. Econ. and Pol'y 61 (2010).
- *Secondary Market* Initiative, FCC (May 2016), https://www.fcc.gov/wireless/bureau-divisions/technologies-systems-and-innovation-division/spectrum-leasing/secondary.
- *Spectrum Leasing*, FCC (May 2016), https://www.fcc.gov/wireless/bureau-divisions/technologies-systems-and-innovation-division/spectrum-leasing.

16. Spectrum license auctions

Ronald Coase's 1959 paper, The Federal Communications Commission, argued that the price system would outperform administrative allocation in dealing with externalities (e.g., costs imposed on a party which did not choose to incur that cost) and other spillovers. Coase's suggestions were not well received by industry officials and regulators, but came to fruition with the first-ever FCC license auction on July 25, 1994. The Coasian approach, combined with flexible-use policies that allow users to choose services and technologies, has become the cornerstone of many innovations including 2G, 3G, and 4G cellular mobile service.

The FCC began holding spectrum auctions in rapid succession. Most recently, it announced auction #102 in April 2018. The spectrum license auction model has spread around the world. The auction approach does have weaknesses, e.g. when the number of competitors is too small.

- Jonathan Blake (1994) "FCC Licensing: From Comparative Hearings to Auctions," Federal Communications Law Journal: Vol. 47(2), Article 7.
- Thomas Hazlett, David Porter, and Vernon Smith, *Radio Spectrum and the Disruptive Clarity of Ronald Coase*, George Mason Law & Econ. Res. Paper No. 10-18 (Apr. 2010), https://ssrn.com/abstract=1583098.
- Thomas W. Hazlett, Roberto E. Muñoz, and Diego B. Avanzini, *What Really Matters in Spectrum Allocation Design*, 10 Nw. J. Tech. & Intell. Prop. 93 (2012).

17. Spread spectrum unlicensed

Unlicensed operation using spread spectrum technologies was first authorized in May 1985, in the 900 MHz, 2.4 GHz, and 5.7 GHz ISM bands. These rules eventually led to technologies such as Wi-Fi, Bluetooth, and cordless phones, and similar unlicensed rules in the lower 5 GHz band. This shared-use regime gave industry and users an alternative to exclusively licensed spectrum. Nowadays, licensed and unlicensed are often seen as complements rather than competitors.

The unlicensed rules allow anyone to operate a device that is certified to comply with various standard, on a non-interference basis (i.e., unlicensed devices may not cause harmful interference, and must accept interference from others). The rules governing unlicensed devices limit transmit power to low levels in order to minimize interference, and thus the regime lends itself to short range applications, notably hotspots.

- John Herman, *Why Everything Wireless Is 2.4 GHz*, Wired (Sept. 2010), https://www.wired.com/2010/09/wireless-explainer/.
- Paul Milgrom, Jonathan Levin, and Assaf Eilat, *The Case for Unlicensed Spectrum* (Oct. 2011), https://ssrn.com/abstract=1948257.
- *Early Civil Spread Spectrum History*, Marcus Spectrum Solutions LLC, http://marcus-spectrum.com/page4/SSHist.html (last visited Sept. 2, 2018).

18. TV white spaces

In May 2004, the FCC issued an NPRM seeking comment on a proposal to allow unlicensed radio transmitters to operate in broadcast television channels that were not being used in a particular location. The unused television spectrum in those locations, often referred to as "white spaces," would provide additional capacity for both fixed and mobile broadband devices.

Over the next 14 years, the FCC issued a series of orders for such operation. Beginning with the 2008 Second R&O, fixed devices were required to employ "both geo-location/database access and spectrum sensing capabilities" to identify usable channels, while portable devices had to either "1) be under the control of a fixed device or a personal/portable device that employs geolocation/database access and spectrum sensing or 2) employ geo-location/database access and spectrum sensing itself." Subsequent orders resolved issues including wireless microphone registration and certification of TV Bands Database administrators. By 2011, nine entities had been designated to serve as administrators. Despite this, widespread public deployments have been slow to emerge. Promised significant investments addressing the digital divide have not yet occurred. There have also been complaints from broadcast interests about the quality of databases, and program oversight.

- *Unlicensed Operation in the TV Broadcast Bands Additional Spectrum for Unlicensed Devices Below 900 MHz and In the 3 GHz Band*, Dkt. 04-186, NPRM: FCC 04-113, First R&O and FNPRM: FCC 06-156, 2nd R&O and MO&O: FCC 08-260, 3rd MO&O: FCC 12-36 (2004).
- Letter from Austin Schlick, Director, Communications Law, Google Inc., to Gary Epstein, Chair of the Incentive Auction Task Force, Federal Communications Commission, GN Docket No. 12-268 (filed Apr. 21, 2014).
- *2014 Quadrennial Regulatory Review – Review of the Commission's Broadcast Ownership Rules and Other Rules Adopted Pursuant to Section 202 of the Telecommunications Act of 1996*, 31 FCC Rcd 9864, (2016).

19. Ultra-Wideband

In 2000, the FCC adopted an NPRM seeking comment on the operation of ultra-wideband (UWB) devices under Part 15 rules. UWB devices use extremely short pulses with wide bandwidths of up to 1GHz. The FCC stated that "UWB devices appear to be able to operate on spectrum already occupied by existing radio services without causing interference."

The Commission adopted a First R&O to allow the use of some UWB devices, including ground penetrating radar, vehicular radar, and communications systems, while promising to issue a Second R&O to enable wider use of UWB devices within 12 months. It wrote that it was "concerned . . . that the standards we are adopting may be overprotective and could unnecessarily constrain the development of UWB technology." In the event, the Commission did not relax the constraints it had placed on UWB devices. Over the next eight years, it issued multiple MO&Os addressing dozens of petitions for reconsideration from UWB and incumbent licensees alike before closing the relevant proceeding via a Third MO&O in 2010. While some types of UWB devices, including stud-finders and wireless USB hubs, are available in consumer products, the dream of widespread deployment in laptops and smartphones has not yet been realized.

- *Revision of Part of the Commission's Rules Regarding Ultra*-Wideband, ET Docket. No. 98-153, NPRM FCC 00-163, 1st R&O FCC 02-48, 2nd R&O and 2nd MO&O: FCC 04-285 3rd MO&O and MO&O: FCC 10-151 (1998).
- *WiMedia Announces New Agreements With Bluetooth SIG and Wireless USB*, Market Wired (Mar. 2016), http://www.marketwired.com/press-release/wimedia-announces-new-agreements-with-bluetooth-sig-and-wireless-usb-1237968.htm
- D-Tect 150, Bosch, https://www.boschtools.com/us/en/boschtools-ocs/stud-finders-d-tect-150-29179-p/.

20. WCS next to SDARS

In 1997, the FCC allocated spectrum in the 2305–2360 MHz band, dividing it between two 15 MHz Wireless Communications Services (WCS) bands on either side of the 25 MHz Satellite Digital Audio Radio Service (SDARS) band. Stringent technical rules were imposed on neighboring WCS to protect weak SDARS satellite signals from harmful interference, including limits on power and out-of-band emission (OOBE). These OOBE limits were so restrictive that mobile WCS devices were rendered impractical, and in 2010, the FCC adopted new rules that prohibited operations in the 2.5 MHz portions of the WCS bands closest to SDARS. The rules relaxed the tight OOBE limits while reducing power limits in other portions of the bands. However, these rules were quickly mired in multiple Petitions for Reconsideration.

In 2012, the FCC adopted revised rules based on a joint proposal from SiriusXM and AT&T to enable WCS to utilize its full allocated 30 MHz. These rules eliminated the guard bands and established conditions for identifying and resolving harmful interference to SDARS. However, interference complaints continue, twenty years after the initial allocation. SiriusXM currently has an application for new terrestrial repeaters (expected to reduce interference levels and endorsed by AT&T) under review at the FCC.

- Joan Marsh, *Breaking Down Barriers in the WCS Band*, AT&T Public Policy (Jun. 2012), https://www.attpublicpolicy.com/wireless/breaking-down-barriers-in-the-wcs-band/.
- Neal Gompa, *AT&T acquires NextWave for more WCS spectrum*, Extreme Tech (Aug. 2012), https://www.extremetech.com/electronics/133848-att-acquires-nextwave-for-more-wcs-spectrum.
- Sheppard Mullin, *FCC Adopts New Rules Governing WCS Spectrum*, FCC Law Blog (Nov. 2012), https://www.fcclawblog.com/2012/11/articles/fcc/fcc-adopts-new-rules-governing-wcs-spectrum/.

21. Wireless local number portability

The FCC proposed wireless local number portability rules (WLNP) in 1996, following a requirement in the 1996 Telecom Act. (Wireline customers had been able to switch from one local carrier to another for some time.) Petitions for forbearance – some granted – and legal challenges by the CTIA (1997) and Verizon Wireless (2001), supported by most wireless providers, delayed implementation. A June 2003 ruling by the DC Circuit of the U.S. Court of Appeals cleared the way for the FCC to implement the rules in November 2003 after a delay of seven years. Verizon Wireless switched from being a fierce opponent of WLNP implementation to a staunch advocate. The introduction of WLNP led to a reduction in wireless prices, particularly for high-volume users.

- Minjung Park, *The Economic Impact of Wireless Number Portability*, The J. of Indus. Econ. Vol. 59(4) (Dec. 2011), https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-6451.2011.00471.x.
- Nicole Stach, *Wireless Local Number Portability and Its Effect on Competition: Can There Be Too Much of a Good Thing?*, CommLaw Conspectus Vol. 12 (2004), https://scholarship.law.edu/cgi/viewcontent.cgi?article=1296&context=commlaw.
- Stephen Kessing, Wireless Local Number Portability: New Rules Will Have Broad Effects, Duke L. & Tech. Rev. No. 6 (2006), https://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1110&context=dltr.