PERSPECTIVES ON SPECTRUM POLICY REFORM
Position papers for the conference "Looking Back to Look Forward: The Next Ten Years of Spectrum Policy", November 13, 2012

November 8, 2012

Introduction

The regulatory foxtrot - slow, slow, quick, quick, slow - means that participants in the spectrum policy dance need to keep an eye on both their current and future partners. Multiple milestones in spectrum management policy line up this year: it's a century since the sinking of the Titanic and the 1912 Radio Act, ten years since the FCC Spectrum Policy Task Force Report (SPTFR), and the end of a four-year Administration that saw the FCC's National Broadband Plan, a Presidential Memorandum calling for 500 MHz of spectrum to be found for wireless broadband use, and a report of the President's Council of Advisors on Science and Technology (PCAST) about realizing the full potential of government-held spectrum.

It is a time when pressure on spectrum allocations keeps growing due to the drumbeat of new broadband wireless applications, a crowded dance floor with a growing diversity and density of conflicting radio operations, and a crescendo of technologies such as smarter radios and heterogeneous networks. This presents an opportunity to look back at lessons learned, and prepare for challenges of the next four and ten, if not one hundred, years.

This article collects position papers presented at the conference *Looking Back to Look Forward: The Next Ten Years of Spectrum Policy* held on Tuesday, November 13, 2012 from 1:00 - 6:00 pm at the Pew Research Center in Washington, DC.[1] The conference was organized by the Silicon Flatirons Center, and co-sponsored by CTIA-The Wireless Association and Public Knowledge.

[1] http://www.siliconflatirons.com/events.php?id=1203

U.S. SPECTRUM POLICY: THE WAY FORWARD

KATHRYN C. BROWN[2] *& CHARLA RATH*[3]

Soon after Chairman Genachowski took the helm at the FCC, he focused on the growing demand for mobile broadband spectrum and said, "while it's not the time to panic, it is the time to plan."[4] Policymakers from the White House to Capitol Hill should be commended for embracing that challenge – but there is much to do to ensure that, in the years ahead, the United States has a more effective, more productive spectrum policy. If we can free up enough spectrum to make massive wireless bandwidth ubiquitous, unparalleled benefits to society and businesses are within reach – from enhancing health care infrastructure and enabling remote energy management to being able to watch video programming on any device, anywhere.

But the status quo will not get us there. We must change the process for allocating spectrum and adopt a framework that results in a more predictable, streamlined path to getting spectrum in the hands of those who can use it to generate these social advances and drive our economy. There is no "silver bullet" or a single, one-size-fits-all solution. The plan must consist of multiple tools, including incentive auctions, freely operating secondary markets, band clearing/reallocation, geographic and temporal sharing, and continued exploration of advanced sharing techniques.

Develop a fair, transparent process for incentive auctions. Incentive auctions are an important opportunity – a market-based tool to unlock and reassign underused spectrum. They offer incumbents significant incentives either to make spectrum available so that it may be relicensed for a more productive use or to benefit by making more efficient use of more limited spectrum. A voluntary approach is also a "win-win" for all involved: the public benefits from additional spectrum for high-demand uses and new auction revenues and incumbents recognize a portion of the value of enabling new uses of their spectrum – all under a market-oriented approach that facilitates this transition. The current incentive auction proceeding promises to serve as a model for future repurposing efforts with other incumbent licensees. The Commission should develop an incentive auction process that is fair and transparent to encourage incumbent participation and open to all bidders to ensure spectrum is put to its most productive use.

Facilitate freely operating secondary markets. The FCC should also establish a truly streamlined approach to encourage private sector transfers of spectrum between licensees with excess or underutilized holdings to those who need spectrum and will commercialize

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[4] Remarks of Chairman Julius Genachowski, FCC, NAB Show 2010, Las Vegas, NV (Apr. 13, 2010) (emphasis removed).

it. The current process can take more than a year for approval and is often used to impose additional license conditions that are tantamount to backdoor regulation of the industry. Turning the secondary market system into a mechanism to impose policies unrelated to the transaction is harmful to putting available spectrum to more productive and efficient use. The highly competitive nature of the retail wireless market dictates that regulatory intervention in secondary markets should be strictly limited to cases in which there is a finding of market failure in the retail wireless market.

Continue to pursue band clearing/reallocation. In addition to repurposing spectrum through market-based initiatives like incentive auctions and a well-functioning secondary market, the FCC and the Administration must continue to free up government spectrum that can be better used for commercial mobile services. Spectrum below 3 GHz is and will continue to be the foundation for mobile broadband, and federal incumbents should be cleared and relocated to different bands when practical. Doing so can free up spectrum bands for flexible, exclusive-use licenses, which will yield long term economic benefits when used for wireless broadband, as well as generate short term auction revenues for the U.S. Treasury. The Administration's and the National Broadband Plan's goal of recovering 500 MHz of spectrum in ten years cannot be met without clearing and reallocating spectrum currently assigned to federal users to wireless broadband use.

Focus on geographic and temporal sharing near-term. Near-term sharing efforts should focus on geographic and temporal sharing, using lessons learned from existing wireless networks. To that end, Verizon supports the current industry-government working groups examining sharing and other ways to repurpose the 1695-1710 MHz and 1755-1850 MHz bands under the auspices of the Department of Commerce's Spectrum Management Advisory Committee ("CSMAC") as a model for future sharing efforts. Verizon has committed $5 million dollars and personnel to explore workable methods of sharing spectrum with certain federal users. Verizon, T-Mobile, and AT&T are working together in an "Industry Spectrum Sharing Initiative" with a specific focus on how to clear and relocate government systems in the 1755-1780 MHz band. The initiative is looking at four government systems with which commercial users may be asked to coexist in this 25 MHz of spectrum, either during a transition period or indefinitely because it is not feasible or economically rational to relocate specific systems. These efforts will help us achieve ways to repurpose government spectrum – a key element of national spectrum policy.

Explore advanced sharing techniques long-term. Over the long-term, sharing technologies such as dynamic spectrum access and geo-location based sharing may be worth exploring – but presently such sharing cannot be seen as a substitute for clearing and reallocating spectrum. It is much too early to tell how – and how fast – the technologies involved will develop or what effect they will have.

As said, no "silver bullet," no single, one-size-fits-all solution, but a comprehensive approach that pursues all options. That's what we'll need to ensure that there's enough spectrum available to truly take advantage of all that broadband mobile has to offer. The future is wide open, and we can't see all of what's coming. But we do know that

spectrum is the “rocket fuel” for innovation. And that innovation, shepherded, tested, and revised many times, will create something of lasting value to our business and to society that might not have been seen at the outset.

BEYOND KOLKATA: DELIVERING ON THE FUNDAMENTAL GOALS OF THE COMMUNICATIONS ACT

MICHELE C. FARQUHAR[5]

Home to more than 4.5 million people, Kolkata, India has a fascinating transportation network. A recent visit to the city revealed bicycles, motorbikes, taxis, buses, rickshaws, cyclerickshaws, cars, trucks, and trams crowding roads already thickly congested with pedestrians, students, street vendors, and parked cars. Perhaps as a result sharp-witted Indian critics have described traffic conditions in Kolkata's urban core as "hell" or worse.

Yet however uncertain and, at times, chaotic, the journey, Kolkata's transportation infrastructure continues to move people and goods through the city. Indeed, the striking part of the network is not the congestion or pollution, both of which one can find in abundance, but the resiliency and ingenuity of the system itself. As if by common understanding, drivers who find their lane blocked, identify the obstacle and rapidly commandeer control of the oncoming traffic lane. When faced with oncoming traffic in their lane, drivers approaching from the opposite direction may assume control of the open space or the sidewalk.

Kolkata's transit conditions are far from ideal. But for an aging metropolis that spreads across some 728 square miles and is home to every imaginable form of transport, the system still works. With little central planning, haphazard investment and limited law enforcement, the network supports more than hundreds of billions of dollars of economic activity and provides the foundation for one of India's great cities.

Perhaps the President's Council of Advisors on Science and Technology (PCAST) had Kolkata in mind when it issued its report on spectrum use in the United States. The report, entitled *Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*, never mentions the roads of Kolkata, but it addresses a strikingly similar challenge: how to drive economic growth in an increasingly congested, increasingly chaotic environment where access to large, unencumbered swaths of infrastructure will prove time consuming at best and politically impossible at worst.[6]

PCAST had a fairly simple recommendation: share the road. With the volume of mobile broadband data more than doubling every year over the past four years and continued growth expected, PCAST concluded that the "the traditional practice of clearing government-held spectrum of Federal users and auctioning it for commercial use

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[6] *See Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*, Report to the President, President's Council of Advisors on Science and Technology (July 2012), *available at* http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

is not sustainable" and recommended spectrum sharing instead. PCAST identified three key initiatives: "[1] immediate sharing by new low-power devices in two existing Federal spectrum bands; [2] [the] formation of a Spectrum Sharing Partnership Steering Committee (SSP) of industry executives to advise on a policy framework to maximize commercial success; and [3] [the] creation of an urban Test City and a Mobile Test Service that can support rapid learning in spectrum management technology and practices."

Detractors and supporters of exclusive-use licensing pounced on the PCAST report. Spectrum license holders portrayed the report as either far too optimistic about the prospects of commercially successful spectrum sharing, or far too pessimistic about the ability of the Federal Communications Commission to identify additional spectrum for licensed use, or both. Meanwhile, unlicensed spectrum users lavished praise on the report as a long-overdue antidote to putting auction revenues associated with exclusive-use licensing ahead of the innovation and entrepreneurship seen in the less heavily regulated unlicensed bands.

Both sides make strong arguments. For example, the commercial wireless industry's main lobbying organization, CTIA, was undeniably right when it noted that "[c]leared spectrum and an exclusive-use approach has enabled the U.S. wireless industry to invest hundreds of billions of dollars, deploying world-leading mobile broadband networks and resulting in tremendous economic benefits for U.S. consumers and businesses."[7] Meanwhile, the Wireless Innovation Alliance, which boasts Microsoft, Google and other technology titans as members, also struck a chord when it noted that "computerized radio technologies could make better use of spectrum [than exclusive use licensing] . . . [by] potentially improve[ing] efficiency [over exclusive use spectrum-licensing models] by a factor of 40,000."[8]

Yet seemingly lost in the debate over the relative merits of exclusive-use licensing and shared-use licensing is any sense of the many other policy objectives that the Communications Act charges the FCC with satisfying. These include: affordable service, rapid deployment, rural access, safety of life, and access for the disabled. Regardless of whether the government pursues dynamic band-sharing more aggressively than exclusive-use licensed spectrum auctions, or vice versa, the spectrum assignment model that the Federal Communications Commission chooses to pursue has little bearing on the core concerns of section 1 of the Communications Act, which charges the FCC to "make available, so far as possible, to all the people of the United States a rapid, efficient,

[7] Posting of Christopher Guttman-McCabe to CTIA Blog, http://blog.ctia.org/2012/07/20/pcast-report/ (July 20, 2012).

[8] Posting to WIA News Center, http://www.wirelessinnovationalliance.org/index.cfm?objectid=B5E0CED6-B591-11E1-96E9000C296BA163 (June 6, 2012) (citing Brian X. Chen, *Companies Try to Create Room on Radio Spectrum,* N.Y. TIMES, June 6, 2012, *available at* http://www.nytimes.com/2012/06/07/technology/as-wireless-spectrum-is-squeezed-sharing-is-seen-as-solution.html?_r=0).

Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges."[9]

The FCC and its leaders have written eloquently and at some length about each of these goals. Universal Service, the FCC has written, is one reason why the United States has such a high telephone penetration rate, and Chairman Genachowski has noted the calls for universal broadband, which is "an essential ingredient for American economic competitiveness and job creation."[10] Former FCC Commissioner Deborah Taylor Tate called public safety and homeland security "the Commission's most important area of authority."[11] And as the Commission noted in its *Seventh Broadband Progress Report and Order*, that speed of deployment is "an essential component of [broadband] availability."[12]

But what the FCC has not done – and what the community of lawyers, scholars, economists and engineers that set the agenda for the FCC must do – is to focus less on whether to pursue licensed or unlicensed models of spectrum deployment and more on precisely how the FCC can satisfy the lofty goals of the Communications Act. The question is not whether a licensed or an unlicensed model will better serve the public. But rather what factors, under either model, will frustrate consumer expectations, raise prices, hamstring competition, or limit deployment. In an unlicensed environment, for example, constraints on access to critical rights-of-way threaten to limit the ability of unlicensed devices to provide critical capacity for broadband services. Similarly in a licensed environment, the lack of interoperability across common spectrum bands will curtail investment, harm consumers, and frustrate deployment. On both of these issues

[9] 47 USC § 151.

[10] Federal-State Joint Board on Universal Service, Schools and Libraries Universal Service Support Mechanism, Rural Health Care Support Mechanism, Lifeline and Link-Up, CC Docket No. 96-45, CC Docket No. 02-6, WC Docket No. 02-60, WC Docket No. 03-109, *Order*, 20 FCC Rcd 16883 ¶ 8 (2005); Connect America Fund, A National Broadband Plan for Our Future, Establishing Just and Reasonable Rates for Local Exchange Carriers, High-Cost Universal Service Support, Developing a Unified Intercarrier Compensation Regime, Federal-State Joint Board on Universal Service, Lifeline and Link-Up, Mobility Fund, WC Docket No. 10-90, GN Docket No. 09-51, WC Docket No. 07-135, WC Docket No. 05-337, CC Docket No. 01-92, CC Docket No. 96-45, WC Docket No. 03-109, WT Docket No. 10-208, *Statement of Chairman Julius Genachowski*, 26 FCC Rcd 18396 (2011).

[11] *Hearing on Oversight of the Federal Communications Commission Before the H. Comm. on Energy and Commerce Subcomm. on Telecomm. and the Internet*, 110th Cong. (2007) (statement of Deborah Taylor Tate, Commissioner, Federal Communications Commission).

[12] Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data and Improvement Act, GN Docket No. 10-159, *Seventh Broadband Progress Report and Order on Reconsideration*, 26 FCC Rcd 8008 ¶ 1 (2011).

and many others, the FCC has only taken the first steps to identify solutions to these problems.[13]

The FCC faces strong and compelling arguments from the advocates of both licensed and unlicensed spectrum. Neither model will singlehandedly solve the problem or carry the day. And industry and the FCC will almost certainly pursue an "all of the above" solution with extensive use of both licensed and unlicensed spectrum. Advocates and policymakers should therefore avoid the tantalizing philosophical debate about the merits of the different spectrum-assignment models and instead get down to the hard work of deciding how these existing and fairly well understood models will promote competition, consumer welfare, rapid service, public safety and the other critical goals of the Act.

The FCC should ensure that competition and continued investment drive deployment, and it should consider these and other core policy goals when auctioning spectrum or allowing shared access. Likewise, industry and public interest advocates pushing for more spectrum resources should not overlook the need to establish equitable, pro-competitive rules of the road before a multitude of devices compete for limited space on our communications infrastructure. Not long from now, government radar, consumer smartphones, utility meter readers, WiFi hot spots, and other innovative devices will share spectrum bands. But with advance planning and careful attention to the fundamental goals of the Communications Act, the United States might prove able to capture some of the ingenuity of Kolkata's commuters without replicating its cacophony of horns and notoriously slow-moving traffic.

[13] *See* Promoting Interoperability in the 700 MHz Commercial Spectrum, Interoperability of Mobile User Equipment Across Paired Commercial Spectrum Blocks in the 700 MHz Band, WT Docket No. 12-69, RM-11592, *Notice of Proposed Rulemaking*, 27 FCC Rcd 3521 (2012); Acceleration of Broadband Deployment: Expanding the Reach and Reducing the Cost of Broadband Deployment by Improving Policies Regarding Public Rights of Way and Wireless Facilities Siting, WC Docket No. 11-59, *Notice of Inquiry*, 26 FCC Rcd 5384 (Apr. 7, 2011); Petition for Declaratory Ruling To Clarify Provisions of Section 332(c)(7)(B) To Ensure Timely Siting Review and To Preempt Under Section 253 State and Local Ordinances that Classify All Wireless Siting Proposals as Requiring a Variance, WT Docket No. 08-165, *Declaratory Ruling*, 24 FCC Rcd 13994 (2009); *Order on Reconsideration*, 25 FCC Rcd 11157 (2010), *cert. granted.*

NOT A ZERO SUM GAME – WHY OBJECTIONS TO THE PCAST REPORT MAKE NO SENSE

HAROLD FELD[14]

It is difficult to imagine why the report from the President's Council and Advisers on Science and Technology (PCAST) on the future of federal spectrum would engender controversy, let alone rabid opposition. In a world where policymakers constantly fret over maintaining sufficient access to wireless capacity for meeting rapidly-increasing demand, the recommendation that we can expand commercial access by making "spectrum sharing the default" in bands previously allocated exclusively for federal use should be common sense. Indeed, the majority of stakeholders greeted the PCAST Report as a bit of welcome news on the "spectrum crunch" front. Unfortunately, a handful of academics, lobbyists and members of Congress remain convinced that spectrum policy is a zero-sum game where any advance in sharing federal spectrum comes at the expense of auctioning exclusive licenses.

Such an ideological approach cannot, of course, change the engineering or economic realities that make clearing new federal spectrum for auction impossible in the near-term. But it can have real costs. Insistence that we forgo spectrum sharing because any gain in spectrum sharing somehow undermines the value of exclusive licenses costs us as a nation much needed access to spectrum, while simultaneously ceding our current lead in spectrum sharing technology to our international competitors.

What PCAST Said

The PCAST Report found that efforts to migrate federal users to clear frequency bands for auction, particularly in the frequency ranges useful for mobile broadband, had become increasingly expensive and complicated over time. PCAST expressed doubt that the military or other federal users could clear bands for auction in the relatively near term. This hardly constituted news. For the last several years, a steady stream of reports from agencies such as the National Telecommunications Information Administration (NTIA) and the Congressional Budget Office (CBO), as well as from advocacy groups and think tanks, have confirmed that the days of easily clearing federal spectrum bands to create exclusive licenses to auction to wireless carriers are gone. Clearing new spectrum for auction will take years, and may ultimately cost more than an auction could raise.

At the same time, however, technology for sharing spectrum among multiple users has developed to a point where non-federal users could operate low-power WiFi-type devices in bands allocated exclusively for federal use. Given the intense demand for all kinds of spectrum access – both high-power licensed use and low-power shared use – the Report recommended that rather than continue with the current system of allocating bands for exclusive federal use, federal users should share these frequencies with non-federal users

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on a non-interfering basis. Sharing of federal bands should become the default, recommended PCAST, with exclusive federal use continued only where necessary. Such a policy shift would help alleviate the overall demand for access to spectrum, without interfering with the effort to migrate federal users from bands suitable for auctioning exclusive licenses.

In other words, the report recommended adding an additional approach to make more spectrum available. One would scan in vain to find any recommendation that the federal government give up on the continuing effort to free federal spectrum for auction -- unless one views spectrum sharing as intrinsically inimical to exclusive licensing. In that case, the recommendation that the federal government consider spectrum sharing as the default rather than view federal exclusivity as the default alone is sufficient to constitute an assault on clearing and auctioning.

An Ideological Opposition Is The Enemy of Positive Pragmatic Policy

Such an ideological, scorched earth approach may suit the lofty halls of academe where, as Henry Kissinger observed, politics are so vicious precisely because the stakes are so low. For the vast majority of stakeholders looking for pragmatic solutions to the problem of enhancing wireless capacity to meet ever-expanding need, viewing spectrum access as a zero sum game where any new development in sharing spectrum somehow undermines exclusive licenses is a luxury the spectrum starved cannot afford. Unfortunately, a handful of policy makers and die-hard lobbyists unwilling to abandon the orthodoxy of the past have embraced this Manichean view of a universe where the Gods of the Marketplace wage eternal battle for exclusive licenses against Socialist Demons supporting federal use or non-exclusive spectrum sharing. And while all the ideological devotion in the world cannot change the underlying facts identified by PCAST that make clearing and auctioning federal bands impractical in the near term, it is unfortunately possible to delay deployment of spectrum sharing technology. As in wireless networks themselves, a few well-placed but ill-configured transmitters can create sufficient interference to drown out any useful signal.

THE STUNTED PUBLIC INTEREST VOCABULARY IN THE BROADCAST SPECTRUM AUCTION

ELLEN P. GOODMAN[15]

I have a law student who recently told me that she was looking to work in the policy area. She wants to help people, give voice to the voiceless she said. It was clear from her questions that she didn't think communications policymaking afforded this kind of opportunity. It just wasn't about justice in that way. Of course, I pushed back on that notion. There is a long history of public interest advocacy in communications policy. The Communications Act expresses as central policy goals that everyone have access to the tools of communication, that control over communications infrastructure be widely distributed, that there be competition and innovation in communications services, that there be content of public interest and import, and that communications systems serve as vehicles for democratic participation and justice.

All of this "public interest" richness lies within communications policy. But there has been a contraction in the public interest imagination. Sure, there are still public interest battles being fought in broadcast regulation, but we are moving to a post-broadcast world. Nowhere is this more evident than in the transition of spectrum from broadcasting to commercial wireless broadband. This movement of spectrum appropriately responds to shifts in demand from broadcast to mobile. Given their very different network characteristics, mobile and broadcasting require very different policies, and no one could sensibly argue that broadcast regulation would be appropriate for wireless infrastructure. At the same time, however, the public interests in widely distributed communicative capacity endure – interests that the market does not always support.

Policy discourse around spectrum auctions fails to grapple with the full array of public interests. The attempts to address these concerns in broadcasting fall by the wayside in the spectrum migration to wireless. If we distill the public interest agenda into a concern for distributed access to communicative capacity, it finds a single expression in the broadcast auction debate: the push for unlicensed spectrum. Unlicensed spectrum promises broadband opportunities in underserved areas, free broadband, broadband uncontrolled by the major commercial carriers, space for what the net heads call "innovation without permission," and other good things. Unlicensed spectrum can potentially satisfy many public interest aspirations. But the unlicensed spectrum discussion has been far too dry and insular to ignite public passions. Without them, it is impossible to build the coalitions that are needed to move communications policy from the paths of least resistance.

The Great Spectrum Migration from Broadcasting

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This impoverishment of the public interest discourse is evident in the proceeding that begins to implement the spectrum migration from broadcasting. The FCC has recently asked for public comment on an extraordinary proposal. It is the plan to conduct "forward" and "reverse" auctions in the broadcast television spectrum band. These auctions will identify broadcasters who will sell some or all of their spectrum at the lowest price and wireless providers willing to pay for the bandwidth. It's been a long time coming – this re-commissioning of broadcast spectrum to wireless. At least since the mid-1990s, it was clear that digital broadcasting would allow broadcasters to function with less spectrum, and that market changes would allow America to do with less broadcasting.

The creativity of the FCC's implementation proposal astounds. It includes new ways of organizing spectrum blocks (into what it calls band plan "families" and "extended families"), new kinds of flexibility for bidders, new spectrum products (including interference rights), and of course the innovation of clearing spectrum by letting willing sellers participate in the auction revenues. The FCC has announced as its goal the reallocation of 120 MHz in the 600 MHz band some time in 2014. After that, the remaining (presumably fewer) broadcasters would be "repacked" into a smaller band. As striking as what the FCC proposes is what's missing: a robust and varied conception of the public interest. The phrase "public interest" is nowhere to be found in the 200-page proposal. That's not to say that public interest goals are entirely absent. The FCC says that it wants "to unleash investment and innovation, benefit consumers, drive economic growth, and enhance our global competitiveness" while preserving broadcast television (NPRM, ¶10). These "economic growth" goals are great… who could oppose them? But they do not suffice, certainly not with respect to this spectrum.
First of all, it's a lot of spectrum. It's much more than the FCC has ever sought to auction and, most importantly, it's prime low-band spectrum. It may be someday that wireless systems are spectrum agnostic. We are not there yet and this "beachfront" spectrum still has more utility for the most popular applications than any other spectrum band. The broadcast band auction, if it proceeds as hoped, will make available more than twice as much spectrum as the FCC auctioned in 2008 in the neighboring 700 MHz band for nearly $20 billion. As many have observed, this is a unique opportunity to allocate rights to this kind of spectrum resource.

Second, this is spectrum that has borne a special public interest load. It has been governed, more or less effectively, according to a social compact. Broadcasters got valuable licenses to provide a commercial service. In return, their spectrum rights were burdened by various service obligations thought to benefit the public. These benefits could not be described as principally economic, although communications access and service is always touted as a condition of economic prosperity. No, the principal argument for market interventions in broadcasting was that market transactions would not produce all the public good that we needed from a critical and scarce communications resource.

Public interest policies in broadcasting were expressed not only in service requirements, but in the very architecture of the broadcast band. Broadcast spectrum was zoned so as to

reserve some spectrum "parkland" for noncommercial operators who provided different kinds of service to the public. Channels were allocated so as to distribute control over infrastructure both geographically and demographically. Structural regulations --- including media concentration limits, foreign ownership rules, diversity requirements, local control rules, noncommercial broadcasting rules – were all designed to effectuate the goals as the architecture of broadcasting itself. The central goal was to distribute communicative power widely. Broadcast towers would be a staple of civic life, alongside libraries and city halls. One need only look at the broadcast table of allocations to see that this kind of distribution was not efficient in terms of spectrum use. It was not technically required. It was done out of a political commitment to decentralized control and local autonomy.[16]

The reverse auction in effect allows broadcasters to "cash out" of the social compact. We can put aside the question of whether broadcasters who participate in the auction gain an unfair windfall. The equities are complicated and, in any case, the outcome politically required. We can also put to rest the question of whether broadcast policies should be pursued in new allocations. They should not. Instead, the question is whether the social compact that has existed with respect to public airwaves needs new form. Is there a "conservation of public interest value" as the broadcast spectrum migrates to wireless use? And has sufficient attention been paid to public interests in free service and widely distributed infrastructure? The auction model reduces the public interest in spectrum to mere economic efficiency. Spectrum efficiency gains are a public interest, to be sure. Indeed, a broad conception of efficiency could encompass many public interest goals. We might say, for example, that spectrum is most efficiently used when it enables the most people to communicate the most. The narrower understanding of efficiency means that when we reclassify the broadcast "public airwaves" as mere "spectrum," we also reclassify public interest pursuits from wide ranging access and service goals to the singular goal of economic growth.

Unlicensed and the Spectrum Act of 2012

This consideration of the public interest – how to define it and how to implement it – was sorely lacking in the run up to the Spectrum Act of 2012. This is the legislation that gave the FCC its marching orders to undertake this complicated auction while at the same time imposing serious constraints on the agency's flexibility. Congress was dealing with broadcasters who insisted on protections for their service and for nascent mobile broadcasting efforts. The wireless industry wanted to depress the price that broadcasters could command as part of a "reverse" auction, and to maximize the amount of licensed

[16] The Communications Act instructs the FCC to ensure a wide distribution of radio-based service. *NAB v. FCC*, 740 F.2d 1190, 1198 (D.C. Cir. 1984) ("[T]he FCC's paramount responsibility is to achieve a 'fair, efficient and equitable distribution of radio service … so as to make available, as far as possible, to all the people of the United States, a rapid, efficient, nation-wide, and world-wide wire and communications service.'"), quoting 47 U.S.C. § 151(c).

spectrum captured from the band. In addition to these pressures was the government's fervent desire to squeeze as much revenue as possible from the auctions for deficit reduction.

Public interest concerns crystalized around one question: how much spectrum would be available for unlicensed use after the transition from broadcasting. Public Knowledge and New America Foundation led the charge on unlicensed, fighting to preserve unlicensed access to the white spaces within the "repacked" broadcast spectrum and to obtain new bands for unlicensed use in the re-allocated spectrum. However broadly the public interest might be, and has been, conceived in communications policy, it was reduced in this case to unlicensed spectrum. That case, moreover, was reduced to almost purely economic terms: unlicensed spectrum usage expands opportunities for innovation and consumer surplus.

Unlicensed advocates argued that unlicensed uses should be considered co-equal to licensed uses, rather than relegated to the margins of what the commercial carriers purchased. This argument found support in the FCC's 2010 Broadband Plan, which recommended that the FCC "make a sufficient portion [of spectrum] available for use exclusively or predominantly by unlicensed devices."[17] The Public Interest Spectrum Coalition, led by Public Knowledge, argued that "super-WiFi," of the kind that an allocation for unlicensed uses might support, would foster innovation and economic growth. [18] It also made the structural argument that the commercial wireless model of large capital investments in a hub and spoke cellular network architecture would not satisfy the demands of an "Internet of things" and other emerging spectrum uses. In other words, economic prosperity requires what Public Knowledge's Harold Feld has called a "mobile ecosystem" of diverse licensed and unlicensed architectures.

The public interest community made its case for unlicensed spectrum in the same terms that dominate spectrum management debates. This is a discourse focused almost exclusively on auction revenue and economic productivity. Framed in these terms, the disagreements become about how to balance current revenue with deferred value and how to measure different forms of economic productivity. Public interest advocates stressed the economic productivity of distributed unlicensed networks like WiFi. Feld referred to a 2009 study of home networking by USC economist Ergin Bayrak that estimated the consumer welfare contributions of WiFi at $18 billion. Harvard Law School's Berkman Center issued a report stressing how heavily dependent were commercial wireless providers and other commercial spectrum users on unlicensed

[17] The National Broadband Plan, Section 5.6, http://www.broadband.gov/plan/5-spectrum/#s5-6.

[18] Testimony of Harold Feld, Legal Director of Public Knowledge On behalf of the Public Interest Spectrum Coalition Before the U.S. House of Representatives Committee on Energy and Commerce Subcommittee on Communications and Technology, Hearing on Promoting broadband, Jobs and Economic Growth through Commercial Spectrum Auctions, June 1, 2011. http://www.publicknowledge.org/written-testimony-behalf-pisc-us-house-representat.

technology.[19] It went on to advocate "unlicensed strategies to develop new generations of innovation."

This strategy hit its mark. Public interest advocates, along with their commercial allies, were able to convince a bipartisan group of House Representatives of the value of unlicensed spectrum. In a letter, these lawmakers urged their colleagues to allow unlicensed operation in the reallocated broadcast spectrum. They claimed that unlicensed devices contributed $16-37 billion to the economy and that unlicensed spectrum would "unlock billions of dollars in private investment, new innovations, job creation, and economic growth."[20] The strategy hit its mark, but the mark was relatively small. As the legislative process progressed, a public interest "win" came to be defined as preserving authority for the FCC to allow unlicensed operations *at all* in newly allocated spectrum. Public interest advocates succeeded in fighting back a provision in the House bill that would have essentially outlawed unlicensed in recaptured broadcast spectrum.[21] A new allocation for unlicensed in the old broadcast spectrum was off the table.
In the end, the FCC proposes to allow unlicensed operation only at the margins of the vast new territory opened up for wireless broadband. The Spectrum Act of 2012 requires the FCC to auction as much spectrum as possible for licensed uses, while protecting the remaining broadcast service from interference. What is left for unlicensed is to be scrounged out of the "guard bands" that the FCC will designate as buffer channels between licensed spectrum blocks. Knowing exactly what it was doing, Congress instructed the FCC to make these bands as narrow as possible to serve their designated purpose of protecting new licensees (and existing broadcasters) from interference. In other words, The FCC may admit new unlicensed use, but only at the fringes of licensed channels and only as dictated by other requirements (guard band needs).

Neglected Public Interest Values

There was another big legislative story in 2012 regarding digital networks. It was the SOPA/PIPA firestorm when grassroots and "netroots" activists quickly shut down legislative attempts to give copyright holders greater power to control network traffic. What had been a relatively esoteric copyright issue came to be understood in terms of free speech and access. The same phenomenon has happened before in communications policy, for example around media ownership questions. Relatively technical questions

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[19] Yochai Benkler, Open Wireless v. Licensed Spectrum: Evidence from Market Adoption, Nov. 7, 2011 (Berkman Center Report) ("Eighty percent of wireless healthcare; seventy percent of smart grid communications; and forty to ninety percent of mobile broadband data to smartphones and tablets use unlicensed strategies.")
http://cyber.law.harvard.edu/publications/2011/unlicensed_wireless_v_licensed_spectrum.

[20] Letter of Reps. Eshoo and Issa, et al, to Chairman Camp and Chairman Baucus, Feb. 9, 2012, http://eshoo.house.gov/images/stories/Final_Letter_to_Conferees_Supporting_Unlicensed_Spectrum_02-.

[21] It would have done this by requiring the FCC to auction off allocation decisions, meaning that unlicensed users would have to outbid licensed users before the FCC could make an unlicensed allocation. Given the nature of unlicensed use, this would never happen.

about control over communications systems are translated into stories that tell themselves and speak to public sensibilities. Unlicensed spectrum has not fired the passions of the public in this way, despite its contributions to consumer welfare.

There has not gathered around unlicensed spectrum the broad array of social justice and civil rights participants that have engaged in past communications policy battles. One reason for the relative quiet is that spectrum is just too wonky for the mainstream. At least as articulated thus far, the discourse around spectrum allocations is too technical and too divorced from questions of participation, access, diversity, freedom, and control. Another reason has to do with convergence. It used to be that distinct services (telephone, cable, broadcast) raised distinct public interests. Interests in affordability, access, privacy, or diversity of expression pooled around single-purpose services, and the groups working on these issues focused on one or another communications policy. If the concern was content, for example, the focus was broadcasting. If the concern was price, the focus was cable or telco. Of course, the wireless services that spectrum supports are all-purpose. Virtually any one can implicate any of the traditional public interest concerns, and the assignment of spectrum resources implicates them all. The public interest debate has not yet caught up to the new realities.

Because engagement around the public interest in spectrum is thin, the FCC auction proposal frames the issues narrowly. They are essentially confined to the question of how much spectrum is allocated or otherwise made available for unlicensed use. How big will the guard bands be for unlicensed operation? What interference protections will be required? It will not be apparent to the larger world of public interest advocates that unlicensed spectrum is, among so many other things, doing the work of the "reserve spectrum" that early media justice advocates fought for in the broadcast band. It's the space where entry is easy and cheap, where experimentation can happen, where capital demands are reduced, and where access and service goals can be fulfilled in ways the market for spectrum licenses does not support.

What would a more robust public interest discourse look like? For starters, it would ask more far-ranging questions. Will and should there be free, universally available wireless connectivity and service in place of the broadcast service that is shrinking? If so, is unlicensed the best mechanism to achieve that? Is any equipment or interoperability regulation necessary to further that goal? What of the likely loss of noncommercial broadcast spectrum? Should the "liquidated value" of that spectrum be returned in some way to the noncommercial media mission and noncommercial communications infrastructure? What of open Internet and access issues? What of local control over wireless capacity and municipal broadband? What is the relation between these questions and channelization plans and auction design?

The first step in dealing with these questions is to recognize that there are public interest costs and benefits in the migration from broadcasting to wireless. Broadcasting is free to the consumer, universally available, locally rooted, and regulated in the public interest. For better and for worse, and to varying degrees over time, broadcasting has involved a trade of spectrum assets in return for public service benefits. Some of these are service-

related (noncommercial service, educational programming, diverse and local service). Some of these are infrastructural (broadcasting capacity in every locale, universal coverage). With the loss of broadcasting, and broadcasting spectrum assets, comes a loss of certain kinds of service and we need to keep asking whether the new benefits are commensurate.

Second, the unlicensed spectrum debate needs to be framed in more human terms. Allocating spectrum for unlicensed access is not just about innovation and economic growth, as important as those values are. It is also about providing control over communications capacity to more than a few wireless carriers. It is about democracy and justice and freedom of speech. It is about rural service and access and the wide distribution of communications infrastructure. When I consulted on the FCC's massive 2011 Report on the Information Needs of Communities, I asked unlicensed advocates to document the specific ways in which unlicensed networks support democratic values. The question was how, beyond providing free hotspots and home networking, unlicensed technologies had specially enabled information and journalism flows important to life in a democracy. There was a story to be told there, especially in rural and underserved areas.

These are values expressed in broadcast policy and served by unlicensed spectrum. The connection between the two should be explicit. Moreover, the FCC ought to ask with respect to its auction policies whether there is a "conservation of public value" as the spectrum migrates to new uses. If the value proposition for unlicensed spectrum were more robustly stated and more broadly endorsed, the Spectrum Act might read differently and, in any case, it might be easier to press the limits that law imposed on the FCC to make maximal spectrum available for unlicensed.

Third, unlicensed spectrum shouldn't bear the full brunt of public interest values. It may be too late to expand the purview of the current broadcast auction proceeding, so these comments should be understood more broadly. In the 700 MHz auction in 2008, the FCC did not allocate spectrum for unlicensed use. But it did condition some of the commercial wireless licenses on compliance with net neutrality or open network principles.[22] Verizon Wireless won these licenses and it made a difference in how it operated its network. Since then, in 2010, the FCC adopted open Internet principles, but their legality is under question at the D.C. Circuit as is their potency with respect to mobile networks in any case. We may be looking at a situation, at least until statutory reform, where the only open network provisions that can be enforced are in the context of a licensing condition. The FCC did enforce this condition against Verizon in July 2012.[23]

[22] Specifically, licensees offering service on C Block spectrum "shall not deny, limit, or restrict the ability of their customers to use the devices and applications of their choice on the licensee's C Block network," subject to narrow exceptions.

[23] FCC News Release, *Verizon Wireless To Pay $1.25 Million to Settle Investigation Into Blocking of Consumers' Access to Certain Mobile Broadband Applications (July 31, 2012)* http://www.fcc.gov/document/verizon-wireless-pay-125-million-settle-investigation (enforcing license conditions against Verizon Wireless, which had tried to prevent customers from using tethering applications).

A robust open network principle as a license condition would be something to consider. Again, the merits of such a proposal should be viewed in light of longstanding public interest values of access, service, and distributed communicative capacity.

Other policy choices the FCC is considering in the broadcast auction implicate public interest values. These include interoperability requirements and "use it or lose it" requirements to force licensee network build out. There are strong economic efficiency arguments to be made for a licensing regime that squeezes maximal productivity from spectrum. There are also expressive freedom arguments.

Until we wring some of the wonkiness out of spectrum policy, we won't be able to engage important constituencies in decisions about wireless architecture. Bright students seeking to do justice are unlikely to see communications policy as a place to play if the public interest is limited to efficiency and economic productivity. There is a more expansive set of interests that needs plain articulation and broader socialization.

U.S. SPECTRUM POLICY- WHEN THE RUBBER MEETS THE ROAD

KATHLEEN HAM & SARA LEIBMAN[24]

The U.S. government's spectrum policies have long demonstrated a keen awareness that bringing additional spectrum to the commercial sector is necessary to encourage innovation and create and maintain a competitive wireless industry. The policies have become increasingly bold over the years, recognizing that consumer demand for data-intensive mobile services will soon overtake carriers' supply of bandwidth.

Over the years, the government's plans have reflected the growing spectrum crisis by laying out with more specificity the actions that must be taken. At the same time, however, the process of moving encumbered and valuable bands to the commercial wireless sector has become increasingly complex. And, as with any strategic plans, the true difficulties arise when the time comes to convert visions to reality. Stakeholders fight for their own interests and oppose all initiatives that could alter a favorable *status quo*, leaving regulators with the almost impossible task of weeding through dozens of proposals and counter-proposals, and setting the best path forward. As a result, we have had some high points and some low points at the implementation phase, and many goals are yet to be accomplished.

Big Plans

Congress' grant of auction authority to the Federal Communications Commission (FCC) in 1993, and the ensuing sale of spectrum licenses for personal communications services, marked the beginning of our modern wireless industry. Dozens of new companies entered the business, fighting for customers and investors in an exciting Wild West environment.

By 2002, however, the FCC recognized that its policies would have to change to keep pace with the ever-increasing demand for spectrum and advances in technology. The Commission created its Spectrum Policy Task Force, which looked at ways to encourage the most effective and efficient use of the airwaves and ensure there is sufficient spectrum allocated for commercial, public safety, and other communications services. The Task Force ultimately recommended that the Commission consider setting interference standards, quantify use of spectrum, increase use of "white spaces," and develop a more flexible regulatory model for licensed and unlicensed use.

Eight years later, in March 2010, the FCC unveiled its National Broadband Plan, which established an ambitious roadmap for bringing broadband Internet access to all areas of the United States. The plan included numerous provisions aimed at making up to 500

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MHz of spectrum available for wireless broadband, including reallocation from federal users, broadcast television, and mobile satellite services (MSS), within 10 years.

The National Broadband Plan was quickly followed up by a memorandum from President Barack Obama directing the National Telecommunications and Information Administration (NTIA), in coordination with the FCC, to identify 300 MHz spectrum that could be freed up within five years for exclusive or shared use, and develop a timetable for reallocation. NTIA developed a 10-year plan for identifying spectrum, including identification of four spectrum bands for study as part of a "Fast Track" Analysis. In January 2011, NTIA released the results of its Fast Track Report, which concluded that the 1695-1710 MHz and 3550-3650 MHz bands could be made available for commercial mobile use, albeit with exclusion zones impacting service to a significant percentage of the population and limiting the utility of the spectrum for commercial services.

As a follow-up to NTIA's report, the President's Council of Advisors on Science and Technology (PCAST) issued a report concluding that the traditional practice of reallocating and clearing spectrum bands used by federal agencies is not a sustainable model, and that the best way to increase commercial capacity is to enable blocks of spectrum to be shared. Although increased sharing is certainly part of the future, the report presents sharing as the only path for the future, rather than one tool available for making more efficient use of spectrum. PCAST also presents sharing as a mechanism that can be broadly applied to large swaths of spectrum through use of a database, when the reality is that developing sharing mechanisms and criteria is a complex process that requires case-by-case analysis. Nor does the report address the need for licensed commercial spectrum to be available reliably and on a primary basis to most of the U.S. population, which is essential to provide investment certainty. Importantly, however, the PCAST report points to the need for changes to facilitate access to spectrum and therefore represents a step forward in the process.

Implementation Wins and Woes

Moving from big strategic plans to implementation has always been slower than many in the wireless industry would like. Nevertheless, in the past decade, we have seen some important achievements. Two major spectrum auctions were held – in 2006, for Advanced Wireless Services (AWS) spectrum that had been reallocated from federal agencies, and in 2008, for reallocated broadcast spectrum in the 700 MHz band. During this period, the FCC also took key steps to remove regulatory barriers to leasing and purchasing spectrum in the secondary market, and it promulgated rules for more flexible use of the MSS bands.

Much more needs to be done, however, to ensure the looming spectrum shortage does not undermine competition in the commercial wireless industry. The National Broadband Plan and the President's memorandum required the FCC and NTIA to set an aggressive five-year schedule for making at least 300 MHz of spectrum available for wireless broadband. We are now starting to see some real action that not only has the potential to make valuable spectrum available, but also to provide a new foundation for how to make

spectrum available in the future through use of incentive auctions and other processes that facilitate collaboration between government agencies and the private sector. While we are still at the beginning of developing these new tools, they have the potential to speed the availability of spectrum and to result in greater and more efficient sharing among users.

NTIA took one step in changing how we manage spectrum when it created a joint government/industry initiative for collaboration between government users and the private sector to study whether and how sharing is possible in the 1755-1780 MHz band, as well as to explore relocation possibilities in cases where sharing is infeasible. By creating working groups to conduct detailed analyses on a system-by-system basis, NTIA has taken an important step toward a new framework where the technical experts can exchange information that determines the feasibility of, and maximizes the potential for, spectrum sharing.

In addition to NTIA's working group process, the FCC has given the go-ahead for the industry to test for potential interference and coexistence, working with the government users. This effort will provide real-world information to inform the discussion – something that has often been lacking in past efforts.

Another important step was taken when, in September 2012, the FCC acted on a congressional grant of incentive auction authority by voting to begin proceedings on how best to encourage voluntary relinquishment of television broadcast channels. While developing the details of a much more complex auction procedure will take time, the use of an auction for licensees to voluntarily relinquish spectrum has the potential to speed the movement of spectrum from one use to another.

The FCC will have to develop an entirely new type of auction and determine the appropriate mechanisms to encourage participation. Small entities on both sides of the auction will need more governmental support than ever because of the inevitable complexity of the design. The FCC is not a novice when it comes to creating auctions out of virtually nothing. The electronic simultaneous multiple-round auctions the FCC introduced in the 1990s were masterful achievements, and the Commission provided extensive training and advice for all prospective participants. There is no doubt that with industry support it can accomplish the same outcome in the current, even more complex, environment.

Because the choices of available spectrum are increasingly encumbered, the procedures being designed today to make spectrum used by federal entities and broadcasters available for wireless broadband will serve as models for all foreseeable future spectrum reallocations. Accordingly, the government must get it right and we must all work hard to ensure that we succeed. Given the rapidly growing demand for broadband, all stakeholders must also move quickly to get beyond the planning stages and into the "rubber meets the road" phase before the spectrum crisis hits home.

THE PROMISE AND PROBLEMS OF STRATEGIC PLANS

CHARLES L. JACKSON[25]

Observations on Planning

Our assigned topic is "the promise and problems of strategic plans." I fear that everything I have to offer on this topic has been said by others before and that they said it better as well. So, I will begin by quoting one of those others.

Plans are worthless but planning is everything. That's a famous aphorism; it is usually attributed to President Eisenhower—but when he used it in a speech he called it a statement he heard long ago in the Army. Eisenhower explained that when an emergency arises, your preexisting plans are usually useless; he went on to say,

> But if you haven't been planning you can't start to work, *intelligently at least*. That is the reason it is so important to plan, to keep yourselves steeped in the character of the problem that you may one day be called upon to solve--or to help to solve.[26]

I believe that staying "steeped in the character of the problem" is the greatest benefit of strategic planning at the FCC.

For an institution such as the FCC—where the statutory mission remains unchanged for years or decades but the specific priorities change as technology, markets, and the membership of the Commission changes—commitment to a five-year or ten-year strategic plan is an unrealizable ideal. Much the same is true of NTIA.

There are a wide variety of theories of regulation—ranging from cartoonish versions of regulatory capture in which FCC decisions are made by the CEOs of AT&T and Verizon playing rock, paper, scissors—to complex theories from political scientists in which regulatory issues fall into multiple categories and institutional response varies by category. I suspect that most in this room are in the latter camp—probably we would all agree that the decision-making process for network neutrality issues differs from that for updating cable television technical rules.

But, there are some universals to the FCC process. One such universal is the organization of day-to-day policy development around the rule-making process. The rule-making process has the virtue of great specificity, but it is not always well suited for considering broad policy issues—say, the extent to which receivers should be regulated. Strategic planning, as exemplified by development of the broadband plan or the Spectrum Policy Task Force, provides a mechanism for analyzing issues such as the appropriate

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[26] Remarks at the National Defense Executive Reserve Conference, November 14, 1957.

regulation of receivers in a general context—one not constrained by the specifics of a band plan or the needs of a single industry or the requirements of a specific technology. The visible outputs of strategic planning are, of course, the plans themselves. But, an at least equally important output is the increased knowledge and understanding of the issues by the FCC and the larger community.

I think it is also important to note that some current policies, generally regarded as delivering enormous value to consumers, arose from internal planning and analysis at the FCC. Perhaps stimulated by the FCC's experience with Citizens Band radio, the FCC staff in the late 1970s and early 1980s had discussed the design of an unlicensed service with many of the technical and regulatory features underpinning today's multi-billion-dollar unlicensed industry.[27] This important innovation did not come from academia or industry—rather it occurred when it did because FCC staff had the time and opportunity to think about future policy problems.

In a similar fashion, it was the FCC staff, not industry, academia, or public interest lobbyists, that pushed for technical flexibility in the rules for several services including videotext and second-generation cellular.[28] Innovations facilitated by that policy have delivered billions of dollars of benefits to American consumers and many billions more to consumers around the world.[29]

The Psalmist, at least in some translations, had the last word on planning: The plans of the diligent lead surely to abundance, but everyone who is hasty comes only to poverty.[30]

Idle Crystal Gazing

In addition to our thoughts regarding planning, Pierre also asked us to prognosticate regarding future regulatory issues. I'll provide my views, but I warn you that they are little more than empty speculation.

[27] A 1979 memo describing a general-purpose unlicensed service written by Carlos Roberts, then head of the FCC's Office of Plans and Policies, is available at http://www.jacksons.net/Carlos_Roberts_Memo_Unlicensed_1979.pdf. Mike Marcus's history of the rulemaking that led to the modern unlicensed rules is available at http://www.marcus-spectrum.com/resources/WiFi-rev.pdf.

[28] More recently, such as in the digital TV rulemaking process, some industry and academic parties have supported technical flexibility.

[29] Ironically, the FCC tried hard to provide such flexibility in the rules for digital broadcasting but the broadcasting industry rejected such flexibility. Today, of course, the broadcasters would kill to get the flexibility that they rejected years ago.

[30] *World English Bible,* Proverbs 21:5.

One:

Opportunistic spectrum use—sometimes referred to as *cognitive radio*—is overhyped and overpromised. Nevertheless, it will be used successfully—although the use and benefits will be quite modest.[31]

Two:

The 100 MHz of unlicensed spectrum at 5 GHz made available by legislation earlier this year will generate between ten and one hundred times more consumer benefits than will unlicensed use of the TV white space.[32]

Three:

Marty Cooper is right (as he has often been)—spectrum efficiency will continue to increase.[33] We know of the promise of multi-user MIMO, interference cancellation, and multi-user detection. These technologies promise huge gains in spectrum efficiency, and we do not know what remains to be invented. These technologies are easier to deploy in individual systems such as a cellular network than in uncoordinated sharing. But, even in uncoordinated systems, they can provide substantial benefits (look up 802.11ac).

Four:

We will continue to expand the range of frequencies that can be exploited (look up 802.11ad). The vision of the low UHF as "beach-front property" will come to be seen as a quaint anachronism—one promoted in the early 21st century mostly by lawyers not engineers.

Five:

The problem of the rising noise floor in the exploitable radio spectrum will continue to grow. Regulatory responses will be haphazard and ineffective. The negative impacts on consumers will be significant—but few will notice or complain.

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[31] Many past and current spectrum uses can reasonably be characterized as cognitive opportunistic use—in the early 1900s wireless telegraphy operators employed carrier-sense protocols and used dedicated calling channels to set up communications on a pool of dynamically allocated channels. Relatedly, a Coast Guard publication describes current practice in VHF maritime radio as, "Channel 16 is used for "hailing" (calling another vessel) only. Once you have contacted a vessel you should move your conversation to a "working channel." That is, one designated as "non-commercial" such as channel 68." (http://www.uscg.mil/D1/prevention/NavInfo/navinfo/documents/C-Communications.PDF) Given that various forms of cognitive radio have been around for more than a century, I'm not exactly going out on a limb predicting that it will continue to be used. .

[32] If, ten years from now, it is clear that the 5 GHz spectrum delivered 10,000 times more benefit than the TV white space, please do not call me up and tell me that my prediction was wrong. I just softened the real prediction so that it would not seem shrill.

[33] See http://bits.blogs.nytimes.com/2012/05/31/qa-marty-cooper-spectrum-sharing/.

THE PROMISE AND PROBLEMS OF STRATEGIC PLANS: FROM THE SPECTRUM POLICY TASK FORCE TO THE PCAST REPORT

MICHAEL J. MARCUS[34]

The basic problem of strategic planning for spectrum in the US is that the US spectrum regulatory entities do not seem to have a historic interest in maintaining *any* consistent policy program. FCC has adopted a variety of spectrum policy statements/strategies in the past several decades, but seems to prefer in general *ad hoc* decision making on items on its docket.

While NTIA appears to have the President's Section 305 power to regulate federal users, the anomalous position of the head of NTIA as an assistant secretary of Commerce effectively puts *most* federal spectrum decisions in the hands of the IRAC membership - whose focus is not necessarily the *overall* national interest. (The realities of current federal budget processes are a key factor in discouraging individual IRAC member agencies from pursuing broader interests.) While attempts have been made to bring more Silicon Valley-style "adult supervision" to the IRAC process little visible progress has been made to date although implementation of the PCAST spectrum report's Section 5 recommendations would be a great step in that direction.

By contrast, other countries have been able to adopt spectrum strategies and stick with them while gradually revising them in view of changing circumstances. Institutionally FCC has had little interest in this, especially in recent years. Spectrum has been the stepchild of Commission policy although the recent focus on mobile broadband has increased its priority in that context. Discussions with former FCC commissioners reveal that none of those contacted had been asked about spectrum issues at all during the selection and confirmation processes. While Chmn. Powell had a great interest in all aspects of spectrum policy, his immediate successor from the same party had minimal interest. Comm. Ness had a great interest in spectrum but that has never been equaled since her departure in 2001. In recent memory, FCC has not had any commissioner with actual experience in the ICT industry – a fact accepted by many as inevitable. The decrease of the number of commissioners from 7 to 5 in the 1980s may have had the unintentional effect of decreasing interest in long range problems such as spectrum.

John Robinson's outstanding 1985 history of FCC spectrum policy (OPP Working Paper 15) lists many policy statements over the FCC's first 4 decades. In 1999 FCC adopted a Spectrum Policy Statement. Then in 2002 it released the Spectrum Policy Task Force reports and started several related rulemakings. While the TV whitespace rulemaking is nominally completed as of today, the reality is that there is no significant commercial use of these provisions and there is no clear schedule of when white space device use will even be permitted in most of the country due to the messiness of implementing the

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Commission's chosen solution of how to protect wireless microphones that use dated technology.

It is somewhat straightforward to pick a long term spectrum plan. The really complicated thing is implementing that plan so that spectrum use evolves from the present to the desired plan. This needs transition plans that recognize the externalities that some spectrum users might have to incur transition costs that are of no direct benefit to them. In DTV for example, this was eased by using spectrum auction revenues to subsidize the "NTIA boxes" to ease the transition for households who were not early DTV adopters.

Innovative and efficient wireless technology does not develop through "spontaneous generation" independent of regulatory policy. Wireless R&D must attract private capital to translate new concepts into workable systems. Uncertain and changing spectrum policy discourages that capital formation as financial markets finds industries with less regulatory certainty to be more attractive for R&D investment. State capitalism is a major issue in most other countries' spectrum policy. The US can compete successfully but only if spectrum policy becomes more transparent and stable. Otherwise we will end up focusing on technologies designed in Europe to be made in China.

THE VIEW AHEAD: TECHNOLOGY OPPORTUNITIES

PRESTON MARSHALL[35]

It is an unfortunate fact that spectrum policy often instigates innovation and technical opportunities, rather than the converse, as we would wish. Spectrum policy that is driven by existing products will inherently support the continuity of these products, rather than innovation.

The ecosystem that evolves in spectrum-dependent innovation will closely mirror the ecosystem of spectrum availability. Technology opportunities arise not only from the inherent sciences driving wireless communications, but also from the opportunities provided by spectrum policy. Today, innovation occurs in two extreme domains, the long-term exclusive licensed spectrum, and the unlicensed spectrum. The unlicensed spectrum has seen particular innovation, with new generations of wireless LANs appearing almost annually. A simple principle might be that flexible spectrum availability is an incentive and motivator for innovation.

There are a number of avenues such innovation could take. These include:

Flexible Mixing of Licensed and Unlicensed Spectrum and Technologies. Some form of spectrum sharing is inevitable. It is likely that the resulting model will inherit features from the two competing models of today (exclusively licensed spectrum, and unlicensed spectrum). Each provides unique features, and is enabling for certain investment and operational models. It would be unreasonable to assume that the vast pool of sharable spectrum would be "locked" into sole use through either model.

Fusion of WiFi and Cellular. Wi-Fi is the dominant technology for unlicensed, local communications. LTE is the dominating cellular standard. However, LTE is being increasingly applied to local applications, such as in Femtocells, and Wi-Fi has become the major media for cellular smartphone Internet access. WiFi has advantages in its ability to operate independently of infrastructure and high volume/low cost. LTE has advantages in its ability to provide handover and high QOS.

A reasonable prospect is that flexible spectrum policies, such as those proposed by PCAST, could breakdown the "partition" between licensed technologies (LTE/5G) and unlicensed Wi-Fi. Access points could offer LTE/5G services on licensed or unlicensed spectrum, depending on wholesale arrangements, and the economy of scale could enable the future of both of the candidate technologies to create "best of breed" solutions.

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Flexibility in spectrum licensing arrangements could enable fundamental innovation in both the market and technology opportunities in local service provision. This would imply that services would be most optimal if they could serve both

Automated Co-Existence Management. Most of the cognitive radio discussion has revolved around methods of frequency selection. However, it is clear that frequency isolation is not sufficient to ensure spectrum coexistence, as is seen in the process of resolving interference issues arising from properly isolated spectrum proposed by LightSquared and M2Z. In a dynamic sharing environment, or even a flexible use spectrum policy (such as proposed by the Spectrum Policy Task Report), then the technology will have to inherently address the adjacent band coexistence impacts

Tunable Filters. While military systems have generally provided tunable RF devices, civil spectrum management practices have resulted in little benefit to civil systems, so these applications have generally relied on massively lower cost fixed RF filters. Full exploitation of the spectrum policies proposed in the PCAST report will require the availability of tunable filters in civil devices that want high confidence of accessing spectrum in congested bands. This is not just a consequence of spectrum sharing, but is probably highly advantageous to existing cellular architectures, as the proliferation of frequencies and diplexer arrangements in world-wide LTE deployments is way beyond the capacity of fixed filter solutions. Also, the timeline for regulatory solutions is clearly not supportive to rapid or deterministic resolution of these issues. Today, these issues arise late in the deployment process.

Closed Loop Interference Management. All of the current approaches to spectrum interference avoidance are based on predicting propagation, and ensuring separation (in frequency and space) sufficient to reduce the probability of interference to an acceptable level. Unfortunately, that means that most of the time, the separation is far in excess of what is needed (on the order to 10's of times in space), resulting in massive losses in the potential utility of the spectrum (100's of times). Even the TVWS or PCAST proposed approach are based on high-confidence levels of interference prediction. Dynamic Spectrum Access is somewhat better, but can not estimate propagation from the victim transmitter to the victim receiver, or between the sharing transmitter and victim receiver.

The optimal use of spatially shared spectrum is through closed loop interference management, between all of the heterogeneous devices that share the spectrum. LTE-A has much of this technology within an individual, homogeneous, LTE-A network, but this technology will need to be generalized to address the full range of communications and sensing technologies.

The incentives for al spectrum users to do this are the same as for LTE-A. For example, the PCAST report proposes to license shared spectrum based on the opportunity cost of the license. Reduction in the interference exclusion zone would reduce the extent, and therefore the likely cost, of a license. Users would thus have an incentive to reduce the exclusion zone by cooperation, rather than precluding operation over the widest possible area.

THE WIRELESS DATA DEMAND: TECHNOLOGY AND SPECTRUM IMPLICATIONS

EDWARD G. TIEDEMANN, JR.[36]

As a result of peak network data rates that are now in the megabits, low transaction delays, user interfaces that are easy and fun to use, good high level operating systems, tablet and ereader devices, large application community ecosystems, and the overall maturing of content for mobile devices, data usage has been skyrocketing. The general population now finds mobile data to be an integral part of their lives.

The most recent CTIA semi-annual data survey shows more than 100% year-over-year growth in the amount of mobile data traffic (bytes) handled. The current domestic traffic is more than 633 billion Mbytes over a six month period ending in June 2012. To put it into a slightly different perspective, every person in the US is receiving more than 11 Mbytes/day. The well respected Cisco Global Mobile Traffic Data Forecast, 2011-2016, is predicting a 75% compound annual growth rate for North America. Their forecast would lead to every person in the US receiving more than 200 Mbytes/day in 2016, almost a 20 times increase in just four years. Based upon traffic growth rates in wired systems, there is no indication that this rate would slow down past 2016.

As a result of this massive growth, Qualcomm embarked on the "1000x challenge" to increase the practical capacity of wireless networks by 1000 times. To succeed, efforts will have to be made in multiple dimensions including basic technology enhancements, further network buildouts, and making additional spectrum resources available. These efforts will take a considerable amount of time and money, and will require significant amounts of research and development. Qualcomm alone spent more than $3.5 billion on R&D in the last year.

Since the mid 2000's, the basic communications capacity of an air interface per antenna has not increased substantially. Techniques such as good power control, adaptive scheduling, and multipath mitigation, which previously brought us enormous strides in capacity, are close to the limit. Qualcomm has demonstrated some capacity enhancements by assigning users to a more lightly loaded adjacent cell from a heavily loaded cell. The use of additional antennas through techniques such as MIMO can increase capacity; however, the number of antennas that can be put on a small portable device is limited. Space limitations and zoning restrictions cause significant problems in adding antennas for macro cellular base stations, the traditional cells where antennas are on towers or on the sides of buildings. Furthermore, the capacity gains from MIMO are limited when cells are dense, due to the low signal-to-noise ratio in much of the cell.

Zoning restrictions, the cost and time to obtain permits, and the cost of physical space for housing equipment and antennas make large increases in the number of these macro cells

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impractical. Advanced ASICs, integrated RF, and low transmit power allows us to build really compact cells, which have volumes of only a few cubic inches. These small cells can be placed almost anywhere that very high speed connectivity to the network can be provided. The first generation of these small cells were femto cells which were deployed in homes and enterprises to enhance coverage and provide greater capacity. These femto cells were generally not closely integrated into the overall cellular network, which made handoff between them and the regular cellular network challenging. Small cells are evolving so that they will be well integrated into the cellular network. Our vision is that small cells should be able to plugged into a 110 volt power receptacle and connected into a high speed network, such as EPON (Ethernet Passive Optical Network). The device and network will be able to self-configure as in a plug-and-play peripheral for a computer.

While small cells can be used in any frequency band, they are particularly suited for high frequency bands such as 3.5 GHz where the antennas can be both compact and efficient (a 1⁄2 wavelength antenna is about 1.6" long). Since the propagation loss of going through a wall at 3.5 GHz is high, this band is well suited for deploying a large number of small, self- configurable, indoor cells.

In addition, these low-power small-cell deployments can co-exist well with incumbents in the 3.5 GHz band, such as radars along our coasts. For this reason, it is a very positive step that the FCC will be moving forward with a proposal to reallocate 3550 to 3650 MHz as a dedicated band for small cells.

For a number of years, Qualcomm and some of its industry partners have been developing a concept called Authorized Shared Access (ASA), which allows spectrum to be shared with licensed users. The first choice for new spectrum is to clear it of incumbents and allocate (auction) the spectrum by a certain date. However, there are many bands where incumbents cannot be moved. Furthermore, these bands may be underutilized in certain regions, at certain times, or on certain frequencies. ASA creates exclusive rights in a shared band, subject to the rights of the incumbents. By providing exclusive rights to the ASA user, this provides predictability so that operators and users can plan their investments and have a level of assurance that they will be able to maintain a desired quality of experience. Depending upon the rights maintained by the incumbents, they can manage access in geographic sub regions, manage time of usage, and can quickly reclaim use of the spectrum in emergency situations.

Since the spectrum used by the current cellular operators is fragmented (some operators have four different allocations), the data rate from any allocation is limited. The standards bodies have developed carrier aggregation, a concept which allows a handset to simultaneously operate on multiple bands. While providing the potential for significantly high data rates, there are practical limits in the amount of aggregation due to intermodulation issues in receivers and transmitters, power consumption, the cell coverage being different between bands, and the additional components that are required. Thus, allocations of large contiguous blocks of spectrum should be a future objective. Until the advent of 4G, there were essentially five bands used for cellular worldwide. The lack of spectrum harmonization has now significantly increased the number of bands (3GPP has defined 37 bands in which LTE can operate). All major worldwide cellular

bands cannot be practically supported in a handset. As a result, more models are required, thus increasing the complexity and the time to design and test handsets, which results in higher costs. Thus, attempts should be made to identify spectrum on a worldwide basis, even if the allocation can only be used in some geographic areas or through ASA techniques.

In addition to clearing and allocating spectrum in the traditional manner and allocating the 3.5 GHz band, releasing 195 MHz of spectrum in the 5 GHz band, which was identified by the Payroll Tax Cut legislation, will allow the latest generation WiFi air interface, 802.11ac, to reach its full potential. The 802.11ac specification supports bandwidths of up to 160 MHz and supports multiple antenna techniques for increased rates and range. In spite of the potential for increased range, coverage at 5 GHz is quite limited.

There is insufficient bandwidth in our existing bands to support the envisioned peak data rates for many services, such as streaming video and video download, which are becoming common on cellular networks. With larger screen sizes on devices, such as tablets, there is demand for higher resolution video. While the HEVC/H.265 video codec will be a significant step forward by being able to reduce the bit rates for streaming data by somewhat more than a factor of two compared to the AVC/H.264 codec, this needs to kept in perspective to the expected 25 fold increase (2011 to 2016) in video traffic predicted by Cisco.

In summary, to meet this tremendous traffic growth, all of our capacity enhancing tools will be required: new technologies, denser deployments, and rational allocation of additional spectrum.