Revisiting Spectrum Policy: Seven Years After the National Broadband Plan

The report from the 2016 Aspen Institute Roundtable on Spectrum Policy

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This report is written from the perspective of an informed observer at the Aspen Institute Roundtable on Spectrum Policy. Unless attributed to a particular person, none of the comments or ideas contained in this report should be taken as embodying the views or carrying the endorsement of any specific participant at the Roundtable.

Foreword

The Aspen Institute Communications and Society Program has a long tradition of convening two conferences each year devoted to communications policy. One, held in Aspen in the summer, addresses a specific issue of communications policy. The second, held in the fall at the Aspen/Wye River Conference Center, addresses cutting edge issues relating to the use of the electromagnetic spectrum.

The current report revisits the spectrum recommendations contained in a landmark 2009 report of the Federal Communications Commission setting forth a National Broadband Plan (NBP). That Plan is most remembered for its innovative recommendation that spectrum be repurposed from broadcasting to newer uses through the mechanism of an incentive auction, a process that took place in 2016-17. The intervening time has seen even more demand and new uses arise such as the need for spectrum for controlling drones and for billions of devices to communicate as part of the Internet of Things. So the fall of 2016 was time to revisit the spectrum portion of the NBP.

To address the issues, the Aspen Institute Communications and Society Program convened 25 leaders and experts in the technology, business, regulation, public interest uses and study of the spectrum. They met in November 2016 near Washington, DC, eventually breaking into three working groups. The following report, written by journalist and author, David Bollier, capsulizes and interprets the dialogue, insights and recommendations. As there are no votes taken during the meeting, the statements and positions stated in the report may or may not reflect the individual views of a participant or its employer. Rather, these are the rapporteur's interpretations of the sense of the group.

The report recognizes the importance of fiber and other technologies to the highest and best uses of spectrum. It also focuses a fair amount on the issues and policies of sharing spectrum, and of flexibility in its use. It points out the interrelationship of spectrum to many other key communications technologies and policies such as broadband, competition, and public interest benefits. And it lists the specific recommendations each working group offered, specifically in terms of new technologies such as drones and the Internet of Things, in terms of licensing

approaches (licensed, unlicensed and shared), and in terms of the place of US spectrum policy in the global context.

This Report is somewhat detailed in the intricacies of spectrum policy. Still we try to make it accessible to the lay person, as the decisions made in this specialized space will have significant repercussion for the broader world and how we live within it.

Acknowledgments

I would like to acknowledge and thank the entities represented in this Roundtable who have also contributed to the Communications and Society Program: AT&T, Charter Communications, Comcast Corporation, Google, Ligado, Microsoft, New Street Research, T-Mobile, Verizon Communications, and The Walt Disney Company. I also thank David Bollier, who brought a lay person's sensibilities to an arcane subject area and made it comprehensible; Kiahna Cassell, the Project Director for this roundtable, who organized the meeting and edited and produced this report, and Tricia Kelly, Managing Director of the Communications and Society Program, who supervised the operations and edited the final version of the report.

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In 2009, Congress asked the Federal Communications Commission (FCC) to develop a National Broadband Plan. In reviewing the landscape, the Plan team determined that the revolution in mobile digital technologies—smartphones, tablets and other devices—was soon going to create a scarcity of electromagnetic spectrum. To deal with the imbalance of surging demand for finite spectrum capacity, the Plan made several recommendations for increasing access to spectrum for broadband services. These included a two-sided incentive auction to encourage broadcasters to sell their spectrum to users who would put it to greater economic use, chiefly mobile carriers and other innovators. In addition to making more spectrum available for licensed use, the Plan recommended greater license flexibility, sharing of specific spectrum bands and designation of a greater amount of spectrum for unlicensed use.

Since the release of the Plan, the technological and market landscape has changed, creating a new set of spectrum policy challenges for the FCC. Imbalances in spectrum supply and demand have a somewhat different character today than in the past. While the previous focus had been on how to allocate scarcely used spectrum, the new focus is on how to reallocate inefficient uses of spectrum to more urgent and innovative uses. In addition, the rise of new technologies, such as the Internet of Things (IoT), autonomous vehicles, drones and personal monitoring devices, need to be considered. These will all require greater access to spectrum, but current regulatory processes for facilitating shifts in spectrum usage need to be studied and improved. While addressing such needs, the FCC needs to keep an eye on advancing the public interest goals of the Communications Act and collaborating closely with a variety of stakeholders to preserve mission-critical, safety needs.

To assess these challenges and propose possible solutions, the Aspen Institute Roundtable on Spectrum Policy (AIRS) met for two days at the Aspen Wye River Conference Center in Queenstown,

Maryland, from October 23 to 25, 2016. A diverse group of twenty-five researchers, technologists, regulators and spectrum policy experts from industry, academia and nonprofit groups reviewed the history of the National Broadband Plan while discussing how spectrum policy might be adapted to address new technological, marketplace and social realities. The group's intensive discussions resulted in a set of new policy recommendations for reallocating and improving spectrum usage in the coming decade.

Charles M. Firestone, Executive Director of the Aspen Institute Communications and Society Program moderated the sessions. This report, by rapporteur David Bollier, provides an interpretive synthesis of the key themes and points of discussion at the conference.

Allocating Spectrum

The Successful History of the National Broadband Plan and the Unmet Challenges

Future efforts to improve allocations, designations and use of spectrum must be understood in the historical context of the past eight years. The 2009 stimulus package—formally, the American Recovery and Reinvestment Act—directed the FCC to create a national plan to improve the deployment, adoption and use of broadband in the US. The plan, released in March 2010, set forth in Chapter 5, a comprehensive strategy to "ensure that there is sufficient, flexible spectrum that accommodates growing demand and evolving technologies."

An historic convergence of two disruptive technologies—the Internet and mobile communications—prompted the broadband plan. The Obama administration, industry and consumers wanted to ensure that the new technologies could continue to expand and facilitate economic growth and opportunity while also ensuring broad access and affordability for consumers. By facilitating the use of mobile and digital technologies, the plan also sought to enhance healthcare, public safety, community development, education, and energy independence, among other national purposes.

To review the seven-year history of the National Broadband Plan—what we learned from it and what changes may be necessary in the future—John Leibovitz, the former Deputy Chief of the Wireless

Bureau and Special Advisor to the Chairman for Spectrum Policy at the FCC, made a brief presentation.

One important element of the National Broadband Plan, Leibovitz noted, was to create a market for spectrum currently allocated for broadcast use so that market forces could drive the reallocation of that spectrum for wireless broadband purposes. This was a novel policy shift at the time, spurred by surging demand for spectrum by mobile telephones, tablet computing and other wireless devices and the lack of spectrum supply. 4G wireless networks were soon to be launched, and it seemed clear that new steps would be needed to assure adequate spectrum.

At the time, supply of spectrum for mobile broadband was quite limited, said Leibovitz. There was a major auction of spectrum in 2006 (Advanced Wireless Services 1 spectrum, Auction 66) and another one in 2008 (the 700 MHz band, Auction 73), both of which had taken years of planning and organization. "So while it was clear that mobile broadband was taking off, especially data demand," he said, "it was not clear how in terms of spectrum the FCC should deal with this growth. That was the problem we were addressing."

To define the needs and possible solutions more precisely, an interagency team that included the FCC, the National Telecommunications and Information Administration (NTIA), and the White House, among others, was created. The team assessed the situation and set goals, including a goal of making 500 megahertz of spectrum available. Leibovitz said that the team took a practical, heterogeneous approach, drawing upon many people's ideas. "We knew there was no magic bullet," he said. "We did a bottom-up analysis of supply and demand, and tried to come up with achievable goals."

Leibovitz said, "The idea for an 'incentive auction' came out of that process"—the idea that broadcasters could be incentivized to voluntarily relinquish spectrum usage rights in exchange for a share of the proceeds from an auction of new licenses to use the repurposed spectrum. The goal was to use market forces to help reallocate spectrum rights, making more wireless broadband available to telecom carriers and easing wireless congestion for consumers.

The key to the success of the incentive auctions, said Leibovitz, was a careful consideration of which constituencies must be part of the plan

and a precise rendering of the problem that needed to be solved. The idea for auctions also included a timeline for action; a clear assignment of roles for agencies such as the FCC, NTIA and international bodies; and a well-designed implementation process. "If we are going to revisit and recalibrate plans for reallocating spectrum in the future," he said, "we need to follow these steps again."

Lawrence Strickling, then-Assistant Secretary for Communication and Information at the NTIA, echoed this assessment, adding that the National Broadband Plan worked because it set a specific numerical goal for spectrum transfers. Summarizing a presidential memorandum issued a few months later, Strickling said that the President "directed the NTIA to work with the FCC to develop a roadmap and create a pipeline of spectrum opportunities." The goal was originally to free up 500 megahertz of spectrum, said Strickling; the current pipeline seeks to free up another 130 megahertz of spectrum. The FCC and NTIA facilitated the whole process by providing a descriptive inventory of the various bands of spectrum, for both government use and commercial opportunities. NTIA also committed itself to a transparent decision-making process and the release of reliable information to inform the entire process, he said.

The Distinctive Challenges for Spectrum Policy Today

Participants broadly agreed that the Broadband Plan provides many important innovations that ought to inform future policymaking, yet it is also clear that circumstances today are different and arguably more complicated than they were in 2009.

John Leibovitz wonders whether spectrum rights today should be handled within a broadband policy framework at all, largely because emerging technologies—the Internet of Things, autonomous vehicles and drones—present such novel and complicated usage issues. On the other hand, he noted, "There was not much of a spectrum pipeline for policymaking and implementation in 2010; that apparatus is there now. There is an ongoing set of proceedings and precedents for asking and addressing questions. The challenge remains: How to come up with 'win-win' projects that make everyone better off in some material way?"

If the major problem in 2010 was how to shift spectrum from broadcasters to wireless broadband networks, the more significant problem today is how to reallocate spectrum assigned to federal agencies and

to enable more efficient sharing of bands of spectrum. "The challenge now is how to use the policy tools that we have—of which there are many—and get federal agencies to see opportunities to convert some spectrum into money, which they could use to buy next-generation systems to expand their capabilities," said Leibovitz. The Federal Aviation Administration and Department of Defense, for example, have considerable spectrum that could be shared or reassigned, as do several science services and agencies.

Spectrum policymaking is more complicated today…because in an environment in which the same spectrum bands are used for multiple purposes, "everything is more crowded."

In addition to reallocating spectrum, the challenge today is also about how to adjudicate among quite varied services that are seeking spectrum, said Leibovitz. While mechanisms exist for dealing with spectrum allocation within a single industry, he said, we do not currently have systems for resolving competing demands for spectrum when there are diverse players. "You see this in 5G networks with satellite and terrestrial services, and domestic and international networks. Engineering solutions [that enable spectrum sharing] are one type of solution. But they can be a brittle approach for dealing with long-term problems" involving spectrum allocations.

Spectrum policymaking is more complicated today, said one participant, because in an environment in which the same spectrum bands are used for multiple purposes, "everything is more crowded." This makes it more important to clarify people's expectations and devise effective enforcement mechanisms. There must be clearly defined rights and reliable ways to resolve disputes. But it may be possible to bypass some of the familiar regulatory conflicts such as the either/or dichotomy of "licensed spectrum vs. unlicensed spectrum"—"by moving to a system of dynamic sharing of spectrum," said Michael Calabrese, Director of the Wireless Future Project of the New America. This may be the solution most suited to meet the needs of drone users, for example.

Similarly, policies directed at receivers, not transmitters, may offer new solutions because they could enable stipulated forms of spectrum sharing without violating the exclusive rights of licensees. "It would be interesting to think about a specific band or opportunity" to experiment with such a scheme, said Blair Levin of the Brookings Institution. "Could we prototype a new system within the existing system? That might be hard to do, but it is worth exploring."

"How to get more spectrum is not the problem so much as how to use what we have."
- Jonathan Chaplin

Participants saw other ways in which today's technological and market circumstances make spectrum policymaking more complicated than in 2010.

Michael Calabrese of the New America noted that an original goal of the National Broadband Plan was universal coverage. Now there is a greater need for improving the capacity of spectrum bands. He also noted that policy previously treated fixed, landline telecommunications differently than mobile. Now fixed telecommunications is feeding mobile usage, and the two realms are converging. Finally, said Calabrese, the feasibility and appeal of dynamic spectrum sharing has soared, opening the door to new types of technology-driven solutions for expanding spectrum usage.

A critical impetus for this change was a 2012 report that the President's Council of Advisors on Science and Technology (PCAST) issued, which proposed a shift from single-use allocations of spectrum to sharing spectrum regimes. Among PCAST's proposals was the creation of 1,000 megahertz-wide "spectrum superhighways" and the regulation of receivers to prevent spectrum interference. Once PCAST broached these possibilities, it opened the door for a larger conversation. It became clear that many spectrum bands are grossly underutilized—an insight that made it fair game to propose that all spectrum bands become more efficient. "How to get more spectrum is not the problem so much as how to use what we have," said Jonathan Chaplin,

Managing Partner of New Street Research, noting that unresolved policy issues could help make spectrum more available.

The many recent changes in the tech landscape could make it more complicated to devise effective, suitable regulatory processes to improve spectrum usage. For example, noted Blair Levin, "One of the most important things for spectrum usage, oddly enough, is not spectrum, but what's in the ground—fiber cables—because fiber is needed for backhaul connections to telecom networks. Policies for unlicensed spectrum could also help open up more access to spectrum."

Crafting a coherent regulatory approach will be difficult going forward because different emerging technologies are developing at rapid but differential speeds…. *- Larry Strickling*

However, any policies are likely to run into different technical barriers and the varying developmental speeds of different technologies. Richard Bennett, Founder and Editor of High Tech Forum, emphasized that TCP/IP—the technical protocols of the Internet—"are not a good set of protocols for spectrum sharing. Yet we won't have the full benefits of 5G wireless networks until we get the Internet to work with them. These issues are connected. For example, we need better Wi-Fi access points to improve Wi-Fi performance so that users won't drop packets and have delays in TCP/IP transmissions. We need to figure out how to stream more data, faster, with these protocols over whatever spectrum is being used."

In a brief presentation, Lawrence Strickling discussed the "unfinished business" of the National Broadband Plan, drawing upon lessons from the past seven years and new technological realities.

Crafting a coherent regulatory approach will be difficult going forward, said Strickling, because different emerging technologies are developing at rapid but differential speeds: "Smart grid technologies are moving slowly right now, but other, like autonomous vehicles, are developing faster. Whatever applications our policies focus on today

won't be the right set of apps or uses in three, four or five years," he said. "So we need to make policy structures flexible enough to enable unanticipated uses in the future. The National Broadband Plan was originally meant to address the spectrum crunch, but now it's being used to manage 5G infrastructure. That's the challenge—devising an evolutionary policy framework."

"…The National Broadband Plan was originally meant to address the spectrum crunch, but now it's being used to manage 5G infrastructure. That's the challenge—devising an evolutionary policy framework." *– Larry Strickling*

Strickling also believes that the Plan does not address how to manage spectrum sharing and orchestrate new usage regimes for federal agencies that depend upon spectrum. One useful step in this direction would be for the FCC and NTIA to conduct a holistic "interference analysis" to determine what boundaries are needed to prevent unacceptable interference in specific bands of spectrum. "There are lots of parochial concerns being aired and debated, but we can't set policy that way," Strickling said. Related to this issue is the need for an effective, credible enforcement regime.

Other issues have risen to the foreground that were not present in 2010: the emergence of 5G wireless as a regulatory issue; the changing ways that spectrum for public safety purposes can be used, perhaps in conjunction with commercial uses; the need for appropriate cybersecurity measures, especially as the Internet of Things expands; and real-time data analysis to intelligently define and address the problems to be solved.

Cybersecurity is a particularly vexing problem in a wireless context because wireless makes the scale of the problem radically larger. "Wireless is different [than wired, dedicated applications] because it is intrinsically open," said Dennis Roberson, Research Professor of Computer Science at Illinois Institute of Technology. "Anybody can

connect in, and it is easier to deploy, so the system is much more vulnerable. The 'attack plane'—that is the number of places where access to the network is possible—is much larger with wireless." It is quite true that cyber-attacks are global in nature and not confined to wireless systems, said Roberson, but wireless networks enhance a criminal's or a state actor's ability to penetrate the network to intercept or disrupt communications and/or hack computers connected to the network. That said, the group agreed that this conference devoted to spectrum policy could not adequately deal with this vast issue.

Cybersecurity is a particularly vexing problem in a wireless context because wireless makes the scale of the problem radically larger.

Federal Agencies and Spectrum: How to Reallocate Use Rights?

Perhaps the most significant challenge in freeing up more spectrum federal agencies currently hold is to devise methods to reallocate spectrum multiple parties use for other, more efficient and valuable uses. Historically, more than thirty federal agencies used spectrum in the 1755-1850 band, sometimes quite heavily. However, they rarely took account of the actual value of their spectrum in their procurement and usage decisions, said Lawrence Strickling of NTIA. This is largely because agencies have regarded spectrum merely as a communications tool to perform some statutory mission; they do not really have any incentive to experiment with new technologies or innovate with unused portions of a spectrum band. OMB Circular A-11 requires agencies to take the value of spectrum into account when making procurement decisions.

"Basically, agencies want two things with respect to spectrum," said Strickling: "They want to know that they will have the resources to figure out the implications of various spectrum proposals, and they want to know that any outcome will not be rammed down their throats." The Spectrum Pipeline Act of 2015, which provides $500 million to help agencies conduct spectrum decision making, helps, but they could use more money in assessing how to use spectrum more efficiently.

The pressure will only become more intense as the process for reallocating spectrum now held by federal agencies, proceeds.

Peter Tenhula, Deputy Associate Administrator for Spectrum Management at the NTIA, noted that Congress first directed agencies to reallocate spectrum from government to non-governmental players in 1993. Before the Pipeline Act, NTIA starting to see "a retrenchment of agency interests and a stiffening of resistance" in some agencies. So while federal agencies have always been keen to assert their interests, the pressures surrounding agency usage rights of spectrum has intensified.

That said, Strickling believes "we're undergoing a cultural change within agencies." In a paradoxical way, "growing demand for spectrum could be helpful, not harmful, to this situation," he said. Richard Bennett of High Tech Forum speculated that "it may motivate greater cooperation among agencies in how they will use spectrum, and also greater cooperation between private and public sectors." Because government-side demand on spectrum is growing as much as private sector demand is, there seems to be a mutual awareness that everyone needs to be more flexible and consider spectrum-sharing innovations.

The Federal Aviation Administration is one innovator that is proposing research and development projects that would potentially free up spectrum, with the expectation that it could receive some portion of funds from the auction of that spectrum to fund its own infrastructure needs. As John Leibovitz explained, the FAA would like to combine many old radar systems into a single, unified radar system using new technologies. But first it must be able to test the system to see if it works. If the new system works, the FAA could reap billions of dollars of money from a spectrum auction and use those funds to buy a new radar system that would improve its radar effectiveness—a win-win scenario.

"The FAA is a prototype example," said Leibovitz. It shows how to provide incentives to agencies to improve the efficiency of their spectrum usage, or at least eliminate the disincentives to it. "Agencies don't necessarily want more spectrum," he explained. "They want more capabilities. If we give federal agencies the freedom to think about these things, it could stimulate greater sharing and access to spectrum." So how to move this idea forward? Paula Boyd, Director of Government and Regulatory Affairs for Microsoft, noted that "a lot of

new sharing mechanisms have been introduced in the spectrum space in recent years. It would be good to assess what has worked, why, and in what context."

"Agencies don't necessarily want more spectrum… They want more capabilities."
– John Liebovitz

To help provide a broad overview of how spectrum policy might move forward, Blair Levin, Senior Fellow at the Brookings Institution and one of the key architects of the National Broadband Plan, made a presentation outlining what he has learned.

The key premises for any plan going forward should be to promote abundant bandwidth and avoid inefficient or non-uses of spectrum. The prime barrier to abundant, efficient use is a practical system for reallocating spectrum. However that occurs, a national broadband plan should include regimes for shared, licensed and unlicensed spectrum. Reallocating spectrum can be extraordinarily difficult, however, because the respective timetables for the regulatory process, technology development and markets at a global scale, are not in sync, said Levin.

Since the government is the legal owner of spectrum, it could in principle just take back unused or underused spectrum. But this presents a variety of litigation risks and political resistance, which policymakers have sought to avoid by instead using "incentive auctions," as described above. If a new market entrant sees enough opportunity that it is willing to pay for the spectrum, the incumbent rights-holder can vacate the spectrum band, enabling its reallocation. Spectrum rights have also been transferred through other means, such as invoking eminent domain, overlay and underlay auctions and bounty rights. Through such means, spectrum once held by satellite services moved to terrestrial services, and broadcast spectrum moved to mobile broadband. It remains unclear which types of providers may ultimately acquire spectrum government agencies currently hold. In any case, none of these transfers of spectrum has been fully accomplished, said Levin. But the transfer of government-held spectrum to new entities will pose a major challenge for the new administration.

The key premises for any plan going forward should be to promote abundant bandwidth and avoid inefficient or non-uses of spectrum.
– Blair Levin

Levin outlined possible tactics for reallocating government spectrum. They include:

- a government incentive auction;
- a GSA for spectrum (similar to the GSA's management of government real estate);
- private sector bounties;
- plans for staged reductions of spectrum use (similar to military base-closing commissions);
- budget numbers to assign a value to spectrum;
- a fund to finance spectrum relocations and upgrades; and
- spectrum sharing.

The task of reallocating spectrum raises many new questions: The first is whether to reallocate spectrum to shared, unlicensed or licensed uses, said Levin. The government must also determine whether spectrum should be allocated band-by-band, under long-term plans or through pre-set allocations. If spectrum is to be shared, then there must be incentives for incumbents to invest in shared usage scenarios, and new management and measurement systems, not to mention processes for complaints and remedies if sharing protocols are violated. No one wants to make big investments in a sharing regime if they will not get adequate returns from it, so ensuring that the ecosystem of spectrum is fully developed—and that returns are thereby generated—is also important.

While dealing with these novel policy questions, many traditional questions remain, said Levin. Should spectrum be allocated to broad, flexible uses or to specific needs? (The proliferation of potential uses such as autonomous vehicles, drones, Internet of Things, and new government uses makes this question more difficult.) How can the

spectrum used for different environments be protected? (This requires better interference test metrics, a process for such testing, and a process for complaints and remedies.) And how to incentivize companies in all environments to invest in the new spectrum regime? (Given asymmetric entry points to networks, who will bear what costs, and will the incentives favor licensed over unlicensed spectrum?) Levin also noted that while shared spectrum regimes hold promise, they have not yet been proven to work at scale.

Levin noted that there are other challenges: Spectrum holders must be induced to adjust their use in a fair and timely way. Sharing facilities to make 5G viable must be enabled without hurting competition and investment incentives. Finally, the political expectations of legislators (to raise money for the federal budget) may not be aligned with the policy goals (to provide incentives for efficient spectrum reallocation and competition).

The Need for Better Testing and Evaluation

Levin's presentation stimulated a deeper discussion about testing and evaluation of spectrum uses. "Interference analysis is a key challenge," said Dennis Roberson, Professor at Illinois Institute of Technology. "It would give us the testing to name and identify what harmful interference really means, technically, in a sharing context. There is no real agreement about that right now in most cases. We've got to establish and test these criteria in a rigorous way instead of having warring tests with different criteria and results, often based on folklore." Roberson stressed that this is essential as spectrum uses become "crammed more closely together." It will also be essential in establishing criteria for regulatory enforcement.

It would be particularly useful to have actual, on-the-ground data about real spectrum usage to improve the quality of future spectrum policy, said Roberson: "We don't really know how spectrum is being used. We theorize far too much. We need better instrumentation, particularly in cities, so we can know definitively what the opportunities are."

However, interest in this issue has is increasing dramatically; the National Science Foundation held a workshop on spectrum measurement in the spring of 2016, for example. The hard part is not installing

sensors, said Roberson, but "analyzing terabytes of data in meaningful time-frames to meet operational needs. It is a huge Big Data problem." He explained that while many entities collect data, it is generally different types of data captured in different formats, and does not necessarily include metadata about the context of the data (when, who, where, etc.), which is needed to properly assess the data that is captured. Roberson also explained that there is no standard methodology for evaluating the data that is collected.

While "everyone using a network is already measuring utilization as an operational necessity," said Richard Bennett of High Tech Forum, "any assessments by outsiders are necessarily partial. That's because the data is in the hands of operators, including measurement chips in electronic devices and people with Wi-Fi access points in their homes. The data is there, but it's highly distributed and privately held. There are enormous issues in identifying these sources and de-identifying the data. And who is going to pay for aggregation and analysis of the data? That's the issue."

To complicate matters further, there are often sensitive national security concerns for certain spectrum bands, which trump all other concerns. For example, spectrum bands used by the Secret Service when the President comes to a city will see a spike in usage. That data cannot and should not be published, though it may be accessible over the airwaves. This is "an overhang on policy," said Lawrence Strickling. "All the measurement in the world won't solve those kinds of problems."

What might be the most appropriate institution to move a testing and evaluation agenda forward? And how would it be established and financed?

Lawrence Strickling of NTIA argued that "industry has to get serious and put money into testing, especially for spectrum sharing." Strickling's NTIA colleague, Peter Tenhula, noted that there is no wireless industry equivalent for CableLabs, which does testing and evaluation of cable television standards. He noted that the Center for Advanced Communications (CAC) in Boulder, which the NTIA and the National Institute for Standards and Technology established, serves as "an honest broker for testing and evaluation, but it is still in its infancy." At the moment, other than CAC, there are no good places

to provide neutral, disinterested evaluations, he said. "More resources for that would be great."

Some participants argued that individual standards-setting committees ought to reflect a broader diversity of players, including economists and policy experts, and not be populated only by specialists from relatively ingrown technical fields. Technical standards sometimes amount to "the propagation of religious rites," said one participant, which can result in unrealistic and narrow technical standards that block potentially valuable uses of spectrum for other services that are often either not known, or if known not understood by the members of the existing standards body.

Resolving debates about technical performance standards could help speed up the regulatory process and ensure more trustworthy, credible results—and thus minimize the impact on consumers.

There was some disagreement over whether an authoritative testing lab ought to be an industry-supported entity or a government lab. One set of voices argued that a government lab has too many budget uncertainties and time delays in performing analyses. This is a major issue for industry, given the fast pace of technological innovation. On the other hand, said others, an industry-supported lab may not have the impartiality and credibility, and may or may not be any better at producing speedy results.

Nonetheless, some participants noted that industry has a growing motivation to develop a greater capacity to test and evaluate technical standards. The eclectic industries now emerging around the Internet of Things realize that they will need access to spectrum if their sectors are to grow; its conferences nearly always have panels on spectrum policy these days. Similarly, consumer-oriented tech companies are trying to anticipate complex regulatory impediments and spectrum policies that might delay new product introductions, said Nicol Turner-Lee, Vice President and Chief Research and Policy Officer for the Multicultural

Media, Telecom and Internet Council. Resolving debates about technical performance standards could help speed up the regulatory process and ensure more trustworthy, credible results—and thus minimize the impact on consumers.

How to Encourage Spectrum Build-Out

One shifting challenge in today's telecommunications environment is how to encourage licensees to make the greatest possible use of their spectrum. In the 1990s, it became clear that the geographic size of licenses mattered. This did not necessarily mean that a licensee made a 100 percent build-out of its spectrum. For example, Verizon reaches 98 percent of the US population by providing service to a large portion of the geographic land mass. It is harder and more expensive to reach the last 1 or 2 percent of the population because they tend to be in sparsely populated regions (about 70 percent of the US population resides in about 40 percent of the land mass).

In terms of maximum build-out for new spectrum allocations, "that can be hard to do when you don't know what you're building out," said Charla Rath of Verizon Communications. Operators will be building 5G networks in many areas where people do not live. So if the FCC uses a population metric to determine service, an operator would get no credit for providing mobile services in locations with high densities of transient crowds, but no residences, such as big transportation centers or sports stadia.

Michael Calabrese of New America believes that "we need to be thinking very differently about build-out requirements. It made sense to have coverage requirements for spectrum because that was the public policy goal. But as we move up to higher frequencies, it doesn't make as much sense," because usages will be more specialized. An extreme instance, he said, would be the use of millimeter waves, in which build-outs would naturally target high-traffic locations. This issue may be somewhat moot in any case because build-out requirements have not historically been rigorously enforced, he said.

Calabrese said it may make more sense to re-auction spectrum every few years "to avoid fossilization of spectrum usage. Secondary markets have not proven very effective in reallocating spectrum." Re-auctions could also avoid the need for incentive auctions. But Jonathan Chaplin

of New Street Research argued, "You could reach the same objective by getting rid of restrictions on how spectrum may be used—allow flexible use. Then secondary markets could work more flexibly and effectively."

Enforcement of build-out requirements may be problematic for political reasons, suggested Blair Levin of the Brookings Institution. "Here's something you never read in the books: As soon as the government starts to enforce build-out requirements, the response of the licensee is always, 'Oh, I was just about to build out in [state where the current Senate majority leader comes from].'" The penalty for failing to build out is an automatic revocation of the spectrum license. That's a very strong deterrent, said Levin, but that's also the reason why it is never invoked. It is "an absolutely destructive weapon."

Are New Policymaking Approaches Needed?

While the discussion did not propose any specific new policymaking structures, many participants noted the limitations of the legacy system for making spectrum policy. Andrew Clegg, Spectrum Engineering Lead at Google, suggested that current regulatory regimes that separate spectrum only into licensed and unlicensed uses, may make it difficult to regulate access to spectrum. It may be necessary to think of ways to overcome the friction that this introduces, he said, such as more flexible allocations, especially in light of 4G/LTE network technologies and Wi-Fi. Charla Rath, Vice President, Wireless Policy Development for Verizon Communications, made a similar point, noting that "newer users of spectrum tend to be more flexible [than existing ones], and are more willing to share a band, but the regulatory structure can be too rigid to accommodate innovative use cases."

Lawrence Strickling of NTIA agreed that an unanswered challenge in the years ahead is "how to devise policy structures that are flexible enough to deal with rapid technological change and unanticipated uses. As a principle, we must keep the capacity to allow different uses and innovations over time—to keep the door open for new ideas." The policy framework must be capable of evolving, he said.

The rise of new models for accessing digital networks underscores the need for a flexible policymaking framework, said Michael Calabrese of the New America. "Users don't necessarily need a traditional terrestrial cellular network," he said, noting the emergence of high-capacity

satellite networks, HALO, and small-cell wireless networks feeding off high-capacity wireline connections that can tailor access to the needs of a particular area. [HALO, or High Altitude, Long Operation Wi-Fi, consists of networks that will use aircraft at about 52,000 feet above cities to provide broadband service to 60 square-mile areas.] Conversely, Calabrese added, innovations such as high-altitude broadband platforms (e.g., drone aircraft) and meshed satellite constellations are making wired networks less critical for providing basic connectivity.

New Policies to Serve New Users of Spectrum

The second half of the Aspen Institute Roundtable on Spectrum Policy consisted of three breakout groups that gave focused consideration to regulatory challenges in three areas:

A. Internet of Things and Drones: New Users and Uses

B. International Issues, including Satellites

C. Sorting the Uses: Licensed, Unlicensed and Shared

What follows is a detailed review of the special circumstances in each field and a set of recommendations for how policy can best support the technology sectors, economic growth, government needs and the public interest.

Internet of Things and Drones: New Users and Uses

Working Group A considered how drones and technologies based on the Internet of Things (IoT) are creating novel uses of spectrum, which in turn require a wholesale assessment of how regulatory policies should be structured. How should the Internet of Things fit into the whole universe of policies, especially telecommunications?

There are some bodies who have or are currently investigating the options, including an historic IoT working group and a current working group studying drones and satellites within the FCC's Technological Advisory Council. The General Accountability Office is currently completing a report on IoT to attempt to understand its general dynamics and situate IoT issues within existing policy frameworks. It helps to understand that IoT technologies span a highly diverse array of fields and applications, so the very term IoT may suggest generic similarities

among the technologies that are tenuous at best. For example, IoT includes everything from drones and autonomous vehicles to industrial sensor systems, home security systems, environmental sensors and wearable sensors. They are likely to have different performance demands and therefore use different communications networks; have different scales, degrees of independence and control regimes; pose different safety risks; and function with different market economics.

So how, then, to regulate IoT technologies? Working Group A came to a general consensus that applications that do not affect public safety and are not related to critical infrastructure—i.e., smart appliances, home security systems, wearable sensors, medical devices, location cuffs—can be accommodated under current licensed and unlicensed spectrum standards. This conclusion also applies to the anticipated evolution of IoT technologies.

However, for IoT applications that affect the safety of life and critical infrastructure—e.g., autonomous vehicles, drones, sensors for chemical, biological or nuclear defense, industrial infrastructure—a different set of policy concerns should apply. While licensed spectrum can still be acceptably used, the group concluded that there must be a rigorous prioritization of service for these critical, safety-related applications. For example, an unmanned drone—which can sometimes be as large as a conventional cargo aircraft—needs to communicate its control information on an on-demand basis. Such IoT uses can potentially be accommodated on high, mid- and low-band spectrum, but require adequate coverage and capacity.

Working Group A identified key technical considerations that come into play when making policy for IoT technologies. These include:

- Are transmissions short range or long range?
- Is the data rate low or high?
- Are there energy use constraints? Battery life concerns?
- Is the need for real-time data (e.g. control information vs. store-and-analyze)? Examples include remote surgery, secure access, robots, autonomous vehicles, etc.
- Does the system sense and take independent (preventative) action or report information for human decision-making?

In setting policies, legislators and regulators also should consider:

- Architecture (direct-to-Internet; aggregation points such as Wi-Fi access points; device-to-device/mesh networks);
- Reliability needs versus application needs;
- Standards (existing versus new);
- Privacy;
- Cybersecurity and spoofing (important for some applications such as home security, but not as important for FitBit devices);
- Connectivity; and
- Aggregate effects of devices (spectrum can be consolidated if there is an aggregation of units, but it likely cannot be if there are many individual discrete units).

Working Group A identified a different set of concerns for drones, along with appropriate policies for regulating their usage. There are three basic classes of drones: *hobbyist drones* that are 55 pounds or less, fly at less than 400 feet and can be controlled through line of sight transmissions, *light commercial drones* that are very similar, but with greater capacities such as control without line-of-sight connections; and *large aircraft* up to and including Boeing 767 size aircraft, run by cargo/logistics delivery companies. Many industry groups are working on these issues. The FAA and NASA are currently conducting trials, but there are many concerns to identify and rules to formulate.

Among the concerns: Users must have *real-time control,* which requires secure spectrum access to ensure reliability and safety. *Safety* is a significant concern, especially to protect against hacking and spoofing, or other variables that could jeopardize control (flight factors, physical payload).

Payload variables can also affect the safety of drones. The weight cannot be above certain limits, and broadband availability must be sufficient to avoid interference problems in transmissions. Variables such as real-time data analysis versus store-and-analyze functions must be taken into consideration. The *size and weight* of a drone can matter, also, along with its *range* of travel.

The Panel identified the most likely applications of drones in small and large categories, with "small" being less than 55 pounds—

the current drone weight limit specified by the Federal Aviation Administration—and "large" being anything from 56 pounds to the size of cargo planes. The most common drone uses include:

- *Commercial* uses (small and large), for the delivery of packages, news reporting, mapping—especially of real estate, inspection of cell towers and electric infrastructure, and monitoring of important perimeters (e.g. nuclear power plants, airports or other sensitive commercial installations).
- *Governmental* at the federal, state and local levels (small and large), for the delivery of packages, law enforcement and public safety interventions, military uses, monitoring of important perimeters (e.g. military bases or sensitive government installations), and search and rescue uses.
- *Criminal/Terrorist* uses (small) such as espionage, "casing" a location for future crime, and the delivery and transport of payloads.
- *Personal* (small), for the hobbyist, photographers, gamers, etc.
- *Academics* (small), for education and research purposes.

In each of these cases, the panel concluded that drones can use existing (and enhanced) licensed and unlicensed spectrum and standards for *payload communications* and *line of sight control.* However, when the drone is *not* controllable through a line of sight, it must have "dedicated spectrum" on a licensed, time-based standard, which carriers could provide through various prioritization and preemption techniques, such as SAS [spectrum access system]. The drone operator in such cases must pay for service from an appropriate service provider.

The group concluded that IoT technologies generally need access to the entire stack of spectrum—high, middle and low spectrum, all together—to cover the range of services required ranging from latency sensitive applications and to applications requiring in-building cover and therefore the ability to penetrate through walls and so forth. With the entire stack, policy could be developed to provide prioritization for certain types of mission-critical, safety needs, and perhaps for certain commercial uses as well. An unresolved question is whether entities like Federal Express or UPS could reliably use spectrum to exercise remote control drones the size of cargo aircraft.

It is envisioned that carriers could provide licensed "dedicated spectrum" to drones on demand, at the times needed, through a sophisticated prioritization and preemption system (which the current 4G/LTE standards supports). If large drones needing such spectrum never took off in flight, for example, the spectrum would not be affected, and would just be used on a cellular basis. SAS-like structures might be used if needed for high-priority purposes, but would not necessarily serve as a general default. While SAS is regarded as a very good model for sharing spectrum, participants noted that the technology, at least in 4G/LTE wireless contexts must be proven first. (This raised the question if such preferential treatment would amount to a violation of net neutrality rules. Perhaps not, if the offer were made to everyone.)

The higher-level spectrum policy framework should look like this, the panel concluded: Applications that implicate safety of life and critical infrastructure—e.g., heavyweight commercial drones or autonomous cars—should use licensed spectrum and carriers should modulate usage through a prioritization and preemption model to ensure that time-sensitive, safety-related communications can work reliably. All other communications should be supportable by either licensed or unlicensed spectrum as appropriate for the specific application.

Jonathan Chaplin of New Street Research summed up the sentiments of the panel, saying, "We favor spectrum use policy that gets us away from dedicated spectrum for dedicated users for dedicated purposes. We want a spectrum allocation framework that maximizes for efficiency and utilization, to make the best use of a scarce resource. But we need sophisticated prioritization processes for critical safety issues and non-line-of-sight drones." This approach would shift control to carriers, who have the capacity to exercise this kind of management. Carriers might not necessarily set the rules, but they would administer them.

One concern was the contingencies of shared spectrum for drones. Carl Povelites, Assistant Vice President of Public Policy for AT&T Services, worried that "innovation and investment would be chilled by the uncertainties about what you can and cannot do with the spectrum, because people could be preempted by prioritized uses." That is why "exclusive flexible spectrum" may be the best approach here, explained Dennis Roberson of the Illinois Institute of Technology. "Carriers would control the spectrum directly. That would be lost with shared

spectrum, which in turn could affect investment (because control of the spectrum would be less predictable)."

Other complications arise, however: How would a carrier or regulators prioritize a lifesaving drone in the air versus autonomous cars on the ground? The group conceded that the economics of the preemption/prioritization scheme are also uncertain and perhaps too complicated and expensive. Can SAS technology be made more versatile and reliable? And how can the system prevent bad actors from spoofing transmission signals, such as signaling "I'm an aircraft." The panel emphasized that implementation and technology development over time will be critical, but that this policy framework remains theoretically appealing and practical for drones.

Working Group A consisted of Dennis Roberson (coordinator), Charla Rath, Marjory Blumenthal, Paula Boyd, Jonathan Chaplin, Emilie de Lozier, Nicol Turner-Lee and David Bollier.

Sorting the Uses: Licensed, Unlicensed and Shared

Working Group B was charged with coming up with new policy recommendations based on expected spectrum needs in the coming decades, with methods for going beyond those needs if necessary. Of course, it is difficult to predict future spectrum uses and needs; uncertainty is certain. As Larry Downes, a member of Working Group B and Project Director of the Georgetown Center for Business and Public Policy, put it, "We generally get less change than we expect in five years, but more than we expect in ten years." Change happens slowly, then suddenly and unexpectedly.

Given these caveats, Working Group B expects that in five to ten years, interference issues will become less of a deterrent to flexible licensing, making unlicensed bands more responsive to new users and increasing the ability of secondary markets to reallocate licensed bands as needs change. That is because even as unpredictable new apps create substantial demand for spectrum already allocated, transmitters and receivers will become much better both at avoiding interference with nearby frequencies and in dynamically changing bands when a user with higher priority appears.

The group presented three recommendations:

Recommendation No. 1: Adopt a flexible use paradigm for new applications.

Public policy should promote flexible use for both licensed and unlicensed spectrum, as recommended in item 5.1 of the National Broadband Plan. Flexible service rules should be limited *solely* by interference tolerances—a "harm claims threshold" with other proximity bands (licensed) and within bands (unlicensed). This recommendation anticipates that both transmitters and receivers will increasingly minimize interference.

This recommendation harkens back to the work of Ronald H. Coase, whose 1959 essay, "The Federal Communications Commission," argued, "There is no analytic difference between the problem of interference between operators on a single frequency and that of interference between operators on adjacent frequencies. The latter problem, like the former, can be solved by delimiting the right of operators to transmit signals which interference, or might potentially interfere, with those of others. Once this is done, it can be left to market transactions to bring an optimum utilization of rights." Downes elaborated: "If we define interference as a property right, then private negotiation can better resolve issues without FCC intervention or detailed regulation or allocations to carve up spectrum bands."

This approach has never really been tried, however, noted Downes, because of political involvement in the policymaking process, rent-seeking behavior by incumbents, and agency incentives to consolidate power rather than allow markets to resolve conflicts. For example, relying on market resolution with credible government enforcement as a backstop did not work (at least in the initial rounds of negotiation) in the dispute between LightSquared (now Ligado) and various GPS device manufacturers over potential interference with GPS signals (where a private solution would involve payments to retire a legacy technology), the group noted. In addition, the tort system, which Coase saw as the more efficient solution, is an increasingly expensive and uncertain venue for resolving issues.

Working Group B believes that the best solution to interference disputes requires an institutional design that favors negotiated rulemaking and a single vote at a federal agency (the top executive or bureau chief). Arbitration can be used as a stick to prod a resolution, or mediation as

a carrot. In any case, the group proposed that the burden of showing harmful interference should shift from the entrant to the incumbent user of spectrum (an adjacent user for licensed spectrum, an existing user for unlicensed spectrum).

The group acknowledged that this approach may not work if the parties are in asymmetrical power or information relationships—e.g., in which the newer user is smaller, poorer and lacks relevant data on the technical characteristics of the incumbent's equipment. Other issues to pay attention to: Is the arbitrator an expert? How should incumbents be incentivized to accept the paradigm? (VIA, the Voluntary Incentive Auction, is perhaps a good example.) And should there be different incentives for federal incumbents (versus a simple fiat)?

Recommendation No. 2: Adopt a new model to free up capacity and move inefficient assignments to the flexible use paradigm.

The group recommended that the FCC should apply both carrots and sticks to get obsolete technologies and incumbents to vacate existing spectrum as quickly as possible so bands can be reallocated for new uses and under flexible license that could subsequently be reassigned in the secondary markets. In the interim, before the obsolete uses are retired, obsolete spectrum assignments under inflexible licenses should be regarded as "transitional bands" and shifted to tiered access ("shared") with new users (the term "shared spectrum" has baggage as a rhetorical term). The Commission should look for low-hanging fruit, particularly with existing government uses, to achieve win-win scenarios when possible.

"Why didn't Recommendation 5.1 of the National Broadband Plan work?" the group asked. Its answer: Legacy technology on inflexible licensed bands were not always retired rationally. It concluded that three factors seemed to unintentionally encourage this inefficient result:

- Technology itself. The replacement technology is not necessarily better and cheaper.
- Politics. Inertia and rent-seeking can delay any shift.
- Economics. Business case issues—especially, a lack of aligned incentives—often impede migration, especially for government users.

There are some "informative examples" of these dynamics in action, including the transition envisioned for white spaces in broadcast spectrum, 3.5 GHz, spectrum frontiers, the GPS/Ligado case, LTE-U, 5350-5470, channel sharing via, and broadcast TV.

The group suggested that easing inefficient assignments to obsolete uses may well come through multi-tiered uses. Rather than thinking in terms of "exclusive versus shared use" for these bands, the transition to a new flexible license can be encouraged by shifting to multi-tiered and/or prioritized access. Examples include plans for FirstNet and 3.5 GHz. Non-flexible legacy licenses for specific and obsolete technologies (criteria for specifying these technologies need to be determined) should be considered "transitional bands." Examples might include AM radio, some radar and 1.7 GHz (DoJ/IRS analog video surveillance to digital). The Commission should actively look for private-public partnership opportunities (technical, political and/or economic) to retire obsolete technologies and make a transition for these bands to the flexible use licensed/unlicensed paradigm. In the interim—which could possibly last a very long time given the particular technologies and applications being used—transitional bands would follow a tiered model to minimize wasted opportunities.

Recommendation No. 3: Rethink universal access.

National leaders generally agree on the aspirational goal of 100 percent broadband access and adoption across the United States. That challenge is beyond the scope of spectrum rules to advance, but the goal of universal inclusion is embedded in the law and the National Broadband Plan. This recommendation is prompted by the rise of new data and new technologies, which require re-scoping the assumptions of the universal access program and its implementation.

The group recommended that technology for serving the remaining unserved areas should remain neutral; fiber is not a realistic requirement for these areas. Fixed wireless, cellular and satellite technologies are now all viable delivery vehicles for broadband, even at speeds currently defined by the FCC. For these reasons, existing programs (such as the Connect America Fund, The Rural Utility Service loan program, Lifeline, etc.) must be re-scoped based on technology improvements and new types of digital divides that have arisen. (Satellite carriers may be impacted by the Frontiers Notice of Proposed Rulemaking.)

The presentation of Working Group B provoked a discussion about whether Recommendation No. 1 could truly work. What would be the standard or policy mechanism for determining the "harm claims threshold" of spectrum interference?

Michael Calabrese of New America theoretically agreed with the recommendation, but complained that it "assumes the problem away" because it does not explain the mechanism by which the FCC is going to retroactively assign a harm claims threshold to each service. For GPS systems, for example, this standard would make existing uses non-tenable, he said. Downes replied that there would be no retroactive enforcement or arbitration for existing uses; the technology—in this case, GPS receivers that are not sufficiently sensitive to their own assigned bands—would simply be retired as soon as possible, perhaps with financial assistance from new entrants in adjacent bands. One participant, citing the GPS/Ligado case, suggested that a dispute could be arbitrated by experts that both parties agree upon; this could ease the transition to a new spectrum-use model.

Richard Bennett of High Tech Forum argued that "it's not that difficult to define the 'harm' standard. For GPS, for example, the harm-point would be if your target receiver is lost. That's an observable phenomena needed by people navigating by GPS, based on a probabilistic analysis. It is a harm claim that could be backed up with technical analysis." Bennett cited as another example: the degradation of data rates caused by a service in an adjacent band.

Calabrese objected that the FCC would nonetheless have to define the harm threshold; Bennett disagreed. In any case, the goal would be for disputants to talk to each other to try to resolve any problems, not to look to FCC or courts for adjudication. Given the huge variety of cases that would likely emerge, you might have standards that evolve, similar to case law, suggested Charlie Firestone of the Aspen Institute.

Brian Regan, Associate Bureau Chief of the Wireless Bureau at the FCC, suggested that the framing of the issue might need to be enlarged: "Why not consider flexibility more globally for licensed spectrum, too, regardless of whether the technology is obsolete or not? Policy could provide flexible access to spectrum on a non-interference base for spectrum that has been licensed. And it could allow new uses in licensed spectrum on a non-interference basis. Essentially, the license is a prioritization."

Calabrese replied, "I thought that was what Recommendation No. 1 is proposing. Even where there are priority access licenses, spectrum would be available for opportunistic uses. As a general rule, that would be the best way to go, so long as no harmful interference to user or licensee." But Carl Povelites of AT&T Services noted, "This is putting a lot of optimistic faith in SAS technology and opportunistic use. Do they work well? What are the economics behind that?"

Richard Bennett took another view: "Whenever you have legacy systems trying to share spectrum, it will be uncomfortable for someone. We need to think of the spectrum as transition bands where you happen to have one application that will be on the way out. The question is, how do we facilitate that process so that we have flexible use everywhere?" Blair Levin cautioned that we should not necessarily assume rational government budgeting to facilitate this process. He recommended giving consideration to creating a spectrum reallocation fund that could be used for capital expenditure funds.

Working Group B consisted of Larry Downes (coordinator), Richard Bennett, Doug Brake, Andrew Clegg, Alex Hoehn-Saric, Aalok Mehta and Steve Sharkey.

International Issues, Including Satellites

Working Group C presented two recommendations for dealing with international spectrum and satellite issues.

> **Recommendation No. 1. The US should continue successful implementation of Recommendation 5.16 of the FCC's Broadband Plan.**

This recommendation urges the FCC to promote within the International Telecommunications Union (ITU) innovative and flexible approaches to global spectrum allocation that take into consideration convergence of various radio communication services and enable global development of broadband services. In addition, the group recommended that "the US should show the rest of the world (ROW) how to do this in the context of satellite and terrestrial services."

The group noted that flexible use policies were adopted by New Zealand in 2007, later by the World Radio Conference (WRC) in 2012 and as Agenda item 1.1 for mobile broadband for International Mobile

Telecommunications (IMT). But because there is institutional inertia and incumbents do not necessarily appreciate the value of flexible spectrum service, it is important to implement such practices domestically first, to show that it is feasible, and then try to work through the time-consuming international processes. It may be possible to deal with border issues bilaterally or through regional harmonization, the group suggested.

It is possible no global harmonization of flexible use will be possible, the group conceded. But that may not matter if US markets adopt such approaches. Major markets may scale without global reach. It may be possible for opportunistic spectrum access technologies to overcome the lack of international harmonization, via systems on chips defined by national boundaries. Since technical studies about the feasibility of this approach may be unrealistic, the group suggested that industry standards groups may wish to step in. If the "rest of the world" beyond the US and a few other adopters decline to move ahead, there may be an opportunity for auction revenues for developing countries.

> **Recommendation No. 2. The US should show the rest of the world (ROW) how to implement innovative approaches to spectrum allocation to ensure maximum flexibility for advanced communications services in the context of satellite and terrestrial services.**

The US could lead by example in extremely difficult cases (e.g., "Spectrum Frontiers") to demonstrate alternatives that "maximize flexibility and rely on market-based solutions to pick highest/best use over long run." This will require a repeal or refinement of the ORBIT Act auction ban for "international satellite" services.

This recommendation poses a several challenges and opportunities. There are multiple scenarios, such as granting flexible terrestrial and extra-terrestrial rights, and letting markets choose which to use over time. Companies could use existing satellite bands and grant terrestrial rights (e.g., Mobile Satellite Service Ancillary Terrestrial Component rules (MSS ATC)); they could use existing terrestrial rights and grant satellite rights; or they could use new spectrum bands and grant both (e.g., Digital Audio Radio [DARs] terrestrial repeaters).

There are many opportunities but also many technical complexities involved. There are opportunities for earth station protection zones,

monitoring, buyout options and short-lived small satellites. While there is a risk of "unjust enrichment," this could be dealt with via secondary markets. There may be problems with domestic-only satellite footprints as opposed to global coverage, but these might be dealt with via landing rights on a country-by-country basis. It is also possible that higher frequencies could be opened up, which would create an opportunity to create flexible spectrum rights from the core of the earth to the heavens.

Working Group C consisted of Bill Bailey, Michael Calabrese, Blair Levin, Brian Regan, Peter Tenhula and Carl Povelites.

Conclusion

Thus, the world envisioned by the National Broadband Plan in 2010 seems almost quaintly simple compared to today's spectrum and broadband world, which is experiencing an explosion of new uses, novel technologies and rich opportunities for economic growth, civic and governmental services, and social applications. It is not surprising, therefore, that a recurring if not dominant theme at the Aspen Institute Roundtable on Spectrum Policy is the importance of flexibility. There was a consensus that policy should promote flexible use of spectrum and the sharing of spectrum, and retreat from the historic assignments of fixed spectrum bands for dedicated uses.

Spectrum policy is not only about signal interference anymore; it increasingly requires coordination with policies involving broadband, net neutrality, privacy, consumer markets, and governmental and national security.

This new openness for flexible use reflects many new realities, especially increasing demand for spectrum from new technologies and services, such as drones, autonomous cars and the Internet of Things. Flexible spectrum use also makes sense given the frequently inefficient uses of existing spectrum, the extensive linkages between wired net-

works and wireless systems, and the emergence of new technologies to facilitate multi-tiered uses.

The challenge ahead is to develop suitable policies to facilitate flexible spectrum use, along with effective implementation of those policies and the technology build-out. To some extent, our ability to more efficiently use spectrum depends upon how efficiently we can expand networks and 'densify' network usage. This, in turn, poses many perplexing complications as spectrum policy becomes more implicated in other policies affecting electronic networks. Spectrum policy is not only about signal interference anymore; it increasingly requires coordination with policies involving broadband, net neutrality, privacy, consumer markets, and governmental and national security. This simple reality means that there must be better cross-sector dialogue and coordination as well as more authoritative testing and evaluation of technologies on how spectrum is actually used.

The National Broadband Plan inaugurated a new era of more efficient and productive spectrum usage, which has enabled many new technologies, markets, government services and economic benefits to expand. With the rapid evolution of this space and the change of Administrations, it is a logical time to revisit and refine the policy frameworks for managing the spectrum.

APPENDIX

Revisiting Spectrum Policy of the National Broadband Plan

Queenstown, Maryland
October 23-25, 2016

Roundtable Participants

Bill Bailey
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Note: Titles and affiliations are as of the date of the conference.

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Note: Titles and affiliations are as of the date of the conference.

About the Author

David Bollier is an author, activist, independent scholar and blogger well-known for his work on the commons as a new paradigm of economics, politics and culture. He pursues this scholarship and activism as co-founder of the Commons Strategies Group, an advocacy/consulting project that assists the international commons movement. Bollier has written or edited seven books on the commons, including *Patterns of Commoning* (2015), co-edited with *Silke Helfrich; Think Like a Commoner: A Short Introduction to the Life of the Commons* (2014); *Green Governance: Ecological Survival, Human Rights and the Commons* (2013), co-authored with Burns Weston; and an anthology of essays, *The Wealth of the Commons: A World Beyond Market and State* (2012), co-edited with Silke Helfrich.

Bollier spent many years in various policy jobs in Washington, D.C.—in Congress, the auto safety agency, with Ralph Nader and others—in the 1970s and 1980s. In 2001, Bollier co-founded Public Knowledge, a Washington advocacy organization for the public's stake in the Internet, telecom and copyright policy. For twenty-five years, until 2010, Bollier collaborated with television producer, writer and activist Norman Lear on a wide variety of non-television public affairs and political projects. Bollier blogs at Bollier.org and lives in Amherst, Massachusetts.

About the Communications and Society Program

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The Program's Executive Director is Charles M. Firestone. He has served in this capacity since 1989 and also as Executive Vice President of the Aspen Institute. Prior to joining the Aspen Institute, Mr. Firestone was a communications attorney and law professor who has argued cases before the United States Supreme Court. He is a former director of the UCLA Communications Law Program, first president of the Los Angeles Board of Telecommunications Commissioners, and an appellate attorney for the U.S. Federal Communications Commission.

Select Publications from the Aspen Institute Communications Policy Project

Setting the Communications Policy Agenda for the Next Administration, by Richard Adler

The 31st Annual Aspen Institute Conference on Communications Policy took place several months before the 2016 presidential election. "Setting the Communications Policy Agenda for the Next Administration" is the resulting report, synthesizing the ideas that emerged during the three-day dialogue. It explores areas where the new Administration should focus its efforts concerning communication policy. The report also includes recommendations to promote inclusion and expand opportunities for all citizens, how to encourage continued investment and innovation, and offers strategies to create a trusted online environment to protect citizen's digital lives. 2017, 59 pages, ISBN Paper: 0-89843-655-9, $12.00

Preparing for a 5G World, by Richard Adler

In October 2015, experts and leaders gathered on the Eastern Shore of Maryland to discuss the range of needs that the next generation of wireless innovation, 5G, is intended to address. This change in technology will bring forth many legal and regulatory issues as 5G reaches its full potential. Participants in the Aspen Institute Roundtable on Spectrum Policy focused on defining the key policy issues raised by the move to 5G and recommended actions to address these concerns. 2016, 67 pages, ISBN Paper: 0-89843-646-X, $12.00

Skirting Bottlenecks: Policies to Support Network Evolution, Digital Inclusion and Data Security, by John B. Horrigan

The Thirtieth Annual Aspen Institute Conference on Communications Policy, titled "The Future of Broadband Competition," took place on August 12-15, 2015 in Aspen, CO. Robust competition among communications providers has always been a crucial goal for policymakers, lead-

ing to robust, innovative and efficient delivery of services. But what does the competitive communications marketplace of the future look like? 32 leading communications policy leaders and experts gathered in Aspen to investigate policy goals that can ensure this robust, competitive marketplace, and consider how broadband markets can promise delivery of economic and social benefits that improve the quality of life in America for all. The report, written by rapporteur John B. Horrigan, offers five recommendations for the future of broadband competition. 2016, pages, ISBN Paper: 0-89843-643-5 , $12.00

Making Waves: Alternative Paths to Flexible Use Spectrum,
by Dorothy Robyn

The 2014 Aspen Institute Roundtable on Spectrum Policy (AIRS) gathered 26 of the top telecommunications policy experts at the Aspen Wye River Conference center in Queenstown, MD, to investigate whether the U.S., in light of recent progress in alternative approaches to spectrum allocation, should make the more drastic move to a regime that has all spectrum, other than some carved out for specific public benefit, to be considered general use spectrum eligible for the highest and best use available. The report, written by Roundtable rapporteur, Dorothy Robyn, tackles the task of describing what general purpose spectrum actually is; discusses the practical, political and institutional limits and ways to overcome them; and details the necessary technical advances and regulatory actions to make general purpose spectrum a reality. 2015, 68 pages, ISBN Paper: 0-89843-625-7, $12.00

The Atomic Age of Data: Policies for the Internet of Things,
by Ellen P. Goodman

The Twenty-Ninth Annual Aspen Institute Conference on Communications Policy, titled "Developing Policies for the Internet of Things," took place August 13-16, 2014 in Aspen, CO. As the world becomes increasingly connected and more objects become embedded with sensors, the Internet of Things is poised to explode, with estimates of 25 billion connected devices by 2020. 35 knowledgeable participants gathered to examine how specifically should communications policies accommodate the new Internet of Everything? This report explores the nascent promises and challenges of the IoT. In examining the interplay

between the vast increase in data created on the Internet of Things (IoT), and the resultant strain on the networks that carry this information, and the group came to a realization. Data needs to be thought of as "infrastructure." 2015, 72 pages, ISBN Paper: 0-89843-623-0, $12.00

Video Veritas: Building a 21st Century Video Platform for a High-Performance Society, by John B. Horrigan

The Twenty-Eighth Annual Aspen Institute Conference on Communications Policy focused on the future of video regulation. The resulting report, written by John B. Horrigan, looks at the changing landscape of video regulation and the fundamental shift in how video is being viewed. While cable and broadcast television continue to be the dominant modes of transmission, over the top delivery of content via the Internet provides new ways to distribute personalized and targeted programming directly to the viewer. This, and the proliferation of mobile devices and tablets can deliver video to the viewer anywhere, anytime. As a result, the advertising-based broadcast business model is undergoing significant challenge and change. This report examines the evolving video ecosystem and offers recommendations for policy that can accommodate the new video market. 2014, 54 pages, ISBN Paper: 0-89843-603-6, $12.00

Spectrum as a Resource for Enabling Innovation Policy, by William Webb

The 2012 Aspen Institute Roundtable on Spectrum Policy (AIRS) convened shortly after the presidential election to consider ways that spectrum policy could improve the economy through innovation. The 32 leading communications policy experts in attendance focused on how spectrum policies could help create an environment that makes it easier to use spectrum as a resource for innovative new goods and services. The participants first identified problems facing new entry and innovation today, and then recommended solutions, looking specifically at the interstices among licensed and unlicensed approaches, spectrum sharing and flexibility, and new institutional arrangements to manage these solutions. The report, written by British spectrum expert William Webb, sets forth 11 recommendations that he gleaned from the conference dialogue to guide future spectrum policy development with regard to facilitating innovation. 2013, 45 pages, ISBN Paper: 0-89843-584-6, $12.00

Rethinking Communications Regulation, by Richard Adler

As the Internet and other information and communications technologies grow exponentially, and as a new ecosystem is emerging that could conflate previously distinct methods of communication into a single digital medium, questions arise as to whether the traditional silos of regulation are still appropriate. The report resulting from the 27th Annual Aspen Institute Communications Policy Conference addresses the overarching concern as to whether the Communications Act needs a radical revision. Written by rapporteur Richard Adler, the report considers the key goals of a new communications regime and offers regulatory and non-regulatory approaches for achieving these goals in a digitally connected world. 2013, 65 pages, ISBN Paper: 0-89843-583-8, $12.00

The Reallocation Imperative: A New Vision for Spectrum Policy, by Preston Marshall

The report resulting from the 2011 Aspen Institute Roundtable on Spectrum Policy addresses new ways of allocating, clearing, using and/or sharing spectrum controlled by private parties and government agencies. Written by rapporteur Preston Marshall, the report attempts to step back and establish a broad vision for reallocating spectrum in the United States in the public interest, discussing new approaches that will facilitate more effective and efficient spectrum use. A number of recommendations are laid forth to guide future spectrum policy development, Congressional actions, and technology explorations. 2012, 54 pages, ISBN Paper: 0-89843-570-6, $12.00

Updating Rules of the Digital Road: Privacy, Security, Intellectual Property, by Richard Adler

Given the current growth and importance of the Internet, the report of the 2011 Aspen Institute Conference on Communications Policy titled *Updating Rules of the Digital Road: Privacy, Security, Intellectual Property*, highlights the elements that will allow for greater use of broadband as the common medium: security, privacy and intellectual property regulation. Written by rapporteur Richard Adler, the report explores a range of threats that plague the use of today's communications media and provides a series of recommendations which aim to ensure that users' communications are secure, private and protected.

The report reflects the issues and ideas raised by business leaders, academics, and policy experts at the Twenty-Sixth Annual Aspen Institute Conference on Communications Policy. 2012, 70 pages, ISBN Paper: 0-89843-563-3, $12.00

Spectrum for the Next Generation of Wireless, by Mark MacCarthy

Spectrum for the Next Generation of Wireless explores possible sources of spectrum, looking specifically at incentives or other measures to assure that spectrum finds its highest and best use. It includes a number of recommendations, both private and federal, of where and how spectrum can be repurposed for wireless use. In November 2010, the Aspen Institute Communications and Society Program convened the Aspen Institute Roundtable on Spectrum Policy, where 31 experts and leaders addressed the consequences and solutions to the increasing demand for spectrum. Spectrum for the Next Generation of Wireless is the report resulting from the Roundtable discussions. 2011, 68 pages, ISBN Paper: 0-89843-551-X, $12.00

Rewriting Broadband Regulation, by David Bollier

The report of the 25th Annual Aspen Institute Conference on Communications Policy in Aspen, Colorado, considers how the United States should reform its broadband regulatory system. Participants looked at international models and examples and examined how data and communications should be protected in the international arena. The resulting report explores a range of policies for U.S. broadband regulation, many of them derivative of the National Broadband Plan adopted by the Federal Communications Commission only a few months before the conference.

Participants also ventured into new and interesting territory with the novel concept of "digital embassies." They saw this as a way of dealing with jurisdictional issues associated with the treatment and protection of data in the cloud, i.e., data that is provided in one country but stored or manipulated in another. The concept is that the data would be treated throughout as if it were in a kind of virtual embassy, where the citizenship of the data (i.e., legal treatment) goes along with the data. This policy seed has since been cultivated in various other regulatory environments. 2011, 37 Pages, ISBN Paper: 0-89843-548-X, $12.00

Scenarios for a National Broadband Policy, by David Bollier

The report of the 24th Annual Aspen Institute Conference on Communications Policy in Aspen, Colorado, captures the scenario building process that participants used to map four imaginary scenarios of how the economy and society might evolve in the future, and the implications for broadband policy. It identifies how certain trends—economic, political, cultural, and technological—might require specific types of government policy intervention or action. 2010, 52 pages, ISBN Paper: 0-89843-517-X, $12.00

Rethinking Spectrum Policy: A Fiber Intensive Wireless Architecture, by Mark MacCarthy

Rethinking Spectrum Policy: A Fiber Intensive Wireless Architecture is the report resulting from the Aspen Institute Roundtable on Spectrum Policy, held at the Aspen Wye River Conference Center in November 2009. Written by rapporteur Mark MacCarthy, the report captures the insights of the participants, exploring innovative ways to respond to the projections of exponential growth in the demand for wireless services and additional spectrum. In addition to discussing spectrum reallocations, improved receivers, shared use and secondary markets as important components for meeting demand, the report also examines opportunities for changes in network architecture, such as shifting the mix between fiber and wireless. 2010, 58 pages, ISBN Paper: 0-89843-520-X, $12.00

ICT: The 21st Century Transitional Initiative, by Simon Wilkie

The report of the 23rd Annual Aspen Institute Conference on Communications Policy in Aspen, Colorado addresses how the United States can leverage information and communications technologies (ICT) to help stimulate the economy and establish long-term economic growth. The report, written by Roundtable rapporteur Simon Wilkie, details the Aspen Plan, as developed in the summer of 2008, prior to the economic meltdown beginning in September 2008 and prior to the election of Barack Obama as President. The Plan recommends how the Federal Government—through executive leadership, government services and investment—can leverage ICTs to serve the double bottom line of stimulating the economy and serving crucial social needs such as energy efficiency and environmental stewardship. 2009, 80 pages, ISBN Paper: 0-89843-500-5, $12.00

A Framework for a National Broadband Policy, by Philip J. Weiser

While the importance of broadband access to functioning modern society is now clear, millions of Americans remain unconnected, and Washington has not yet presented any clear plan for fixing the problem.

Condensing discussions from the 2008 Conference on Communications Policy and Aspen Institute Roundtable on Spectrum Policy (AIRS) into a single report, Professor Philip Weiser of the University of Colorado at Boulder offers a series of specific and concrete policy recommendations for expanding access, affordability, and adoption of broadband in the United States. 2008, 94 pages, ISBN Paper: 0-89843-484-X, $12.00

The Future of Video: New Approaches to Communications Regulation, by Philip J. Weiser

As the converged worlds of telecommunications and information are changing the way most Americans receive and relate to video entertainment and information, the regulatory regimes governing their delivery have not changed in tune with the times. These changes raise several crucial questions: Is there a comprehensive way to consider the next generation of video delivery? What needs to change to bring about a regulatory regime appropriate to the new world of video? The report of the 21st Annual Conference on Communications Policy in Aspen, Colorado, outlines a series of important issues related to the emergence of a new video marketplace based on the promise of Internet technology and offers recommendations for guiding it into the years ahead. 2006, 70 pages, ISBN Paper: 0-89843-458-0, $12.00

Clearing the Air: Convergence and the Safety Enterprise, by Philip J. Weiser

The report describes the communications problems facing the safety enterprise community and their potential solutions. The report offers several steps toward a solution, focusing on integrating communications across the safety sector on an Internet-Protocol-based backbone network, which could include existing radio systems and thus make systems more dependable during emergencies and reduce costs by taking advantage of economies of scale. The conference participants stressed that the greatest barriers to these advances were not due to lagging technology but to cultural reluctance in adopting recent advances. Writes Weiser, "The public safety community should migrate away from its

traditional reliance on specialized equipment and embrace an integrated broadband infrastructure that will leverage technological innovations routinely being used in commercial sectors and the military." 2006, 55 pages, ISBN Paper: 0-89843-4, $12.00

Reforming Telecommunications Regulation, by Robert M. Entman

The report of the 19th Annual Aspen Institute Conference on Telecommunications Policy describes how the telecommunications regulatory regime in the United States will need to change as a result of technological advances and competition among broadband digital subscriber lines (DSL), cable modems, and other players, such as wireless broadband providers. The report proposes major revisions of the Communications Act and FCC regulations and suggests an interim transitional scheme toward ultimate deregulation of basic telecommunications, revising the current method for universal service subsidies, and changing the way regulators look at rural communications. 2005, 47 pages, ISBN Paper: 0-89843-428-9, $12.00

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