Recasting PCAST after the WRC-19

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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 2019 Annual Aspen Institute Roundtable on Spectrum (AIRS) Policy convened at a critical moment, though participants could not have known it at the time. When the group met in early December on the bucolic Maryland Eastern Shore, none could have imagined the global upheaval that would come just weeks later in the form of the COVID-19 pandemic. The ensuing global lock-down and shift to home has shined bright light on our spectrum infrastructure and its central role in a functioning civil society.

While the group could not have imagined what was to come, they nonetheless delved into issues highly relevant to today. Specifically, the group focused on the impact of the 2012 report on spectrum policy from the President's Council of Advisors on Science and Technology (PCAST) that suggested spectrum allocation support innovation and technology ventures to advance both economic growth and equity. They delved into the importance of 5G and the race with China. And critically, they focused on the digital divide, a crisis made more acute during the pandemic.

The resulting report, written by rapporteur Ruth Milkman, offers recommendations that address these themes. As you read through the filter of our current global crisis, they only become more relevant.

Acknowledgments

I would like to acknowledge and thank the organizations represented at this conference that have also contributed financial support to the Aspen Digital Program. They are Google, Microsoft, AT&T, Comcast, Facebook, New Street Research, T-Mobile, Verizon, Charter, Dodge and Cox, the National Association of Broadcasters, and EchoStar Corporation.

I also want to thank Ruth Milkman, conference rapporteur, for her informative account of the conference discussions, and our participants for their contributions to these complex issues.

Finally, I want to thank Dr. Dominique Harrison, Project Director, for producing the conference and editing this report.

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Introduction

The President's Council of Advisors on Science and Technology (PCAST) issued an influential report in 2012 on how spectrum policy could drive innovation and economic growth. The report makes policy recommendations and concludes that the U.S. government should adopt policies to share 1,000 MHz of underutilized federal spectrum to implement shared-use spectrum pilot projects. Eight years later, the urgent need for access to spectrum is still a critical issue both nationally and globally.

Currently, one of the most novel recommendations of the PCAST report is in the process of being implemented to accommodate shared federal and non-federal use of the band: the FCC's Citizens Broadband Radio Service (CBRS) framework for the 3.5 GHz band. Still, the set of spectrum policies that will best advance economic growth and equity continue to be a topic of deep discussion, with different perspectives from economists, engineers, and lawyers focusing on a myriad of industries (*e.g.*, satellite, terrestrial wireless, platforms that rely on unlicensed spectrum) and user groups (*e.g.*, federal, commercial). In the fall of 2019, the International Telecommunication Union (ITU) held the World Radio Conference (WRC-19) in Egypt, a month-long meeting of 192 countries seeking global harmonization of spectrum policies. Permeating all discussions of spectrum policy in the current timeframe are the interwoven topics of the increased influence of China's wireless industry, 5G, and U.S. national security.

Three Eras of Spectrum Policy

A presentation from Preston Marshall, Engineering Director at Google, regarding the 2012 PCAST report, framed the 2019 Aspen Institute Roundtable on Spectrum Policy dialogue. Marshall described the PCAST report as an important inflection point in spectrum policy, with sharp divisions between policies before the report, revised thinking after the report, and another approach that is currently in place.

Starting in the 1990s, according to Marshall, the U.S. government designed spectrum policy to feed spectrum to operators—primarily mobile providers—as needed, driven by consumer, budget, and operator requirements. The people who focused on spectrum policy were largely budgeteers, spectrum nerds, and the wireless industry. In contrast, Tom Hazlett, Hugh H. Macaulay Endowed Professor of Economics at Clemson University, frames this slightly differently in that the basic thrust of spectrum policy in the 1990s was to apply market forces to spectrum use rights, in order to encourage competition and direct airwave resources to the highest-value uses. In the early 2000s, a rival perspective began to gain hold as popular use of unlicensed bands increased. Marshall described the 2012 PCAST report as a pivot point, setting new goals including 1) spectrum policy should drive innovation in both wireless and non-wireless arenas, and 2) policymakers should consider alternatives to exclusive, perpetual licenses. More recently, 5G (the fifth generation of mobile services) has driven nations to view spectrum policy as important to their national industrial policy, to nurture domestic industries, expand networks, promote innovation, and drive economic activity.

The PCAST study envisioned spectrum as an engine of innovation technology and new business models, with the opportunity for minimal upfront investment, and entry that is scalable. The study also emphasized sharing (non-exclusive access rights) over exclusive licenses and the Federal Communications Commission adopted a sharing approach for the CBRS band. Rikin Thakker, Vice President of the Multicultural Media, Telecom and Internet Council and faculty member in the department of electrical and computer engineering at the University of Maryland, College Park said that particularly in "academia…there had been discussion of dynamic spectrum sharing for many, many years, but PCAST finally brought a mechanism for dynamic spectrum sharing" in the CBRS band. The CBRS Alliance, which facilitates sharing, now has 150 member companies, including verticals and innovators, many of which are small companies.

Michael Calabrese, Director of the Wireless Future Project at the Open Technology Institute, noted that the PCAST approach sought to open spectrum to a wider variety of players and to make access more decentralized and therefore more local, particularly looking ahead to an Internet of Things (IoT) world. CBRS originally aimed specifically at those goals.

How does one evaluate CBRS and determine whether it is successful, and whether that success can be replicated for shared use of other wireless bands? Calabrese suggested the measure from a technical perspective should be whether the rules allow the spectrum to be fully deployed. From a philosophical perspective, the question would be whether whole new ecosystems emerge that would not have under other spectrum management regimes, such as big-bang auctions. Calabrese and Marshall also noted that the PCAST approach focuses on sharing underutilized federal bands. Tom Hazlett added that the evaluation of CBRS should include an assessment of the opportunity costs and that the United States should have used a property rights approach similar to Ireland's. Marshall responded that the opportunity cost of CBRS was low because of federal government users in the band.

5G is not being treated as just "another generation" cell phone but rather as a force multiplier for the economy.… This competition treats 5G as an industrial policy issue more than a spectrum or technology issue.

More recently the focus of spectrum policy has turned to 5G, garnering attention at the highest levels of executive branch agencies. This is happening outside the traditional spectrum processes and 5G is not being treated as just "another generation" cell phone but rather as a force multiplier for the economy. In the United States, the desire to go "faster" by both government and the private industry is an impetus to change, often surpassing budget considerations. There is a global competition among countries that is driving the push to repurpose spectrum below 6 GHz. This competition treats 5G as an industrial policy issue more than a spectrum or technology issue.

Marshall summarized three visions of spectrum management drivers and priorities, which correspond to his views of the three eras of spectrum policymaking (see Figure 1).

Figure 1. Three Visions of Spectrum Management Drivers and Priorities

	Before PCAST (2012)	PCAST	Current 5G Focus
Key Objective (s)	Support Next Generation of Cell Phones and Carrier Needs	Support Innovative Technology and Business Models	Get 5G Spectrum Fast
Who Concerned	Commercial Wireless Community	+ Tech and Venture Communities	National Policy, Competitiveness, Security
Importance of Revenue	Spectrum Actions Associated with Budget Needs	Insignificant Compared to Economic Opportunities	Will take the $$, But not a Driver Compared to Rapid Availability

Source: Preston Marshall Presentation at the 2019 Aspen Institute Roundtable on Spectrum Policy (AIRS).

Some roundtable participants suggested that the priorities of government decisionmakers have shifted to give more primacy to national security, with the involvement of the Department of Defense (DoD) officials at the highest levels in matters of communications policy. The DoD has sought to revoke and terminate licenses for Chinese telecommunication providers, overruling the FCC's authority, to ensure national security of American communication and data services. Blair Levin, Non-Resident Senior Fellow at the Brookings Institution pointed out that many stakeholders are using China and 5G to advocate for the same policies for which these stakeholders have been advocating all along. The COVID-19 pandemic highlights the exposure of U.S. vulnerabilities and weaknesses to cyberattacks and emphasizes a sense of urgency to defend against cybercrimes.

China as a Threat and Driver of U.S. Spectrum Policy

China's efforts to lead in 5G have fundamentally changed the ways in which countries approach wireless technology. "China totally changes the rules for leadership of the next generation," said one participant who went on to say that with its "Made in China 2025" strategic plan, "China has put a marker in the ground" to lead the world in 5G and other technologies. This participant suggested that the implementation

of this plan essentially is the "equivalent of Sputnik going up in 1958."

It was recently reported that China is set to release another plan, "China Standards 2035". Online publisher TechCrunch states that the plan sets global standards for the next-generation of technologies and was developed to "seize the opportunity" that COVID-19 creates.[i] The Chinese government's focus on the combination of 5G and Artificial Intelligence (AI) technologies means that the United States needs to figure out a way to become the leader in the area, similar to the way it did it in the space race. Given the current COVID pandemic, what can the United States learn with regards to technology and innovation? The answer to this question can help the U.S. stay ahead in setting standards for emerging technologies.

The focus on 5G is a matter of global competition, which is really a nation-state competition.
- Dennis Roberson

What does it mean to win in 5G? The focus on 5G is a matter of global competition, which is really a nation-state competition, stated Dennis Roberson, Professor at Illinois Institute of Technology and President & Chief Executive Officer at Roberson and Associates. During the 2G and 3G expansion, the United States lost its whole infrastructure business; other countries and regions developed their own digital standards and spectrum bands to spur technological innovation. Germany, Sweden, and Finland, among other countries, were the first in 2G and gained widespread adoption in their respective countries. The United States won in "4G because it had the intellectual property of Qualcomm… the operating systems of Android and iOS, and the best applications," suggested Blair Levin. In addition, Verizon decided that an early and robust 4G roll-out would be a significant differentiator for the country. The stakes are different with respect to China. It is one thing to lose 3G to Western European vendors, said one participant. It is another thing for non-democratic counties to dominate the industry.

i Emily de La Bruyère, Nathan Picarsic, "China's next plan to dominate international tech standards," TechCrunch, April 11, 2020, available at https://techcrunch.com/2020/04/11/chinas-next-plan-to-dominate-international-tech-standards/

If one looks at the competitive space now, it is very different than 10 to 15 years ago, when Chinese vendors were not taken too seriously. These vendors are now much more strongly positioned in the 3rd Generation Partnership Project (3GPP), a standards organization which develops protocols for mobile telephony, and other standards bodies. They are also well positioned in the Intellectual Property domain with ownership of a huge treasure trove of patents that have been included in the standards (i.e. Standards Essential Patents). Plans to supersede China's buildout of emerging technologies will continue to be a top priority for U.S. government agencies.

Infrastructure and Applications

Infrastructure and applications that work on the aforementioned backbone became a topic of concern for conferees. A participant posited that "the Western world must provide enough infrastructure and devices so that it can lead this next generation of applications, and not be dependent on the Chinese stack." Paula Boyd, Director of Government and Regulatory Affairs at the Microsoft Corporation said that the "focus on 5G dominance is appropriate, but…when we focus on 5G, we should think not just about solving for the technology, but about what it can do" for communities. There needs to be an infrastructure that "will deliver the ability for Americans to get access to cloud services, and for those cloud services (*e.g.*, healthcare, gaming, commerce) to grow," said Boyd. She continued that PCAST may not have been thinking about economic growth in this way, but today the focus should be about driving economic growth in cloud services and applications—that is part of how to think about measuring success and the end goals to achieve. Jennifer Manner, Senior Vice President of Regulatory Affairs at EchoStar Corporation, noted that 5G is not just about terrestrial wireless, but that getting service to everyone will require other technologies including satellite, High Altitude Platform Service (HAPS) and unlicensed spectrum (*e.g.*, Wi-Fi).

"…when we focus on 5G, we should think not just about solving for the technology, but about what it can do" for communities. – ***Paula Boyd***

4G deployment is an example of infrastructure driving economic growth, particularly in the application space. According to Preston Marshall at Google, "If you think of cellular in two pieces, the infrastructure and the edge, American companies totally dominate the edge."

"The software applications throughout the world are American apps, largely because U.S. carriers deployed 4G," noted Marshall. He went on to say that "everyone incrementally adopted the U.S.-based ecosystem." In the end, the economic system that wins ultimately drives the world market and wins the wealth creation that comes with it. In other words, the United States must lead in 5G-dependent innovations, whatever they are.

"… if you think of cellular in two pieces, the infrastructure and the edge, American companies totally dominate the edge." ***– Preston Marshall***

The concept that wealth creation occurs at the edge rather than with network operators is a fundamental issue, and a "great breakthrough of the PCAST report," stated Jonathan Adelstein, President & Chief Executive Officer of the Wireless Infrastructure Association. The externalities are enormous, and "the benefits go to somebody other than the company that actually made the investment," said Adelstein. China is pushing on an area where the externalities are vast. If China can lead in 5G, it can create material benefits of growth in the Chinese economy, as well as potentially depriving the United States of domination at the edge in terms of applications. If China can dominate in both 5G and AI, it is also likely to be the place where the next generation of applications are developed because the platforms will be Chinese, rather than American.

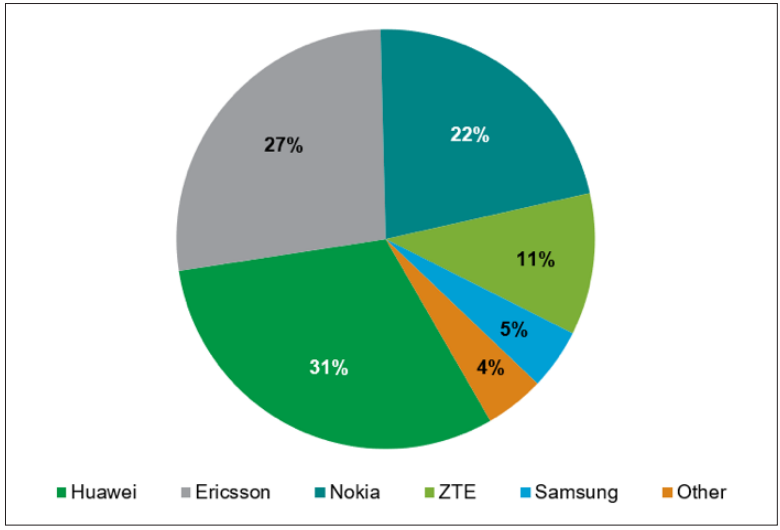
Mark Gorenberg, Managing Director of Zetta Venture Partners, noted that "China has doubled down on winning the AI race, [which] is very dependent on data, and [that] all of these devices are gathering lots of lots of data." Thus, the core view of China may be that "the more Chinese ubiquity in the world, the more likely China is to lead in AI" and its cascading technologies, stated Gorenberg. He added that the United States may be ahead in non-consumer applications of AI, such

as "enterprise use of data for core applications like marketing and sales, and language translation."

Techniques Used by China

China is positioning itself in multiple ways to be the driver of the next round of wealth creation. Dennis Roberson stated that Chinese branded phones dominate the global market for smartphones, although not the U.S. market. Both Huawei and ZTE are in the top 5 infrastructure providers globally (see Figure 2).

Figure 2. 2G/3G/LTE Mobile Infrastructure Market Share 2018



Source: Emma Charlton, "5 Things To Know about Chinese Tech Giant Huawei," World Economic Forum, July 3, 2019, available at https://www.weforum.org/agenda/2019/07/5-things-to-know-about-chinese-tech-giant-huawei/.

China uses many techniques, including government backing of its national technology companies. The Chinese approach is to have companies compete within China on a start-up idea, and once there is a winner, the Chinese government then takes that company out to the rest of the world, stated Mark Gorenberg. For instance, China is selling mobile handsets in Africa and Latin America, noted Blair Levin, and the United States is not. To the extent that leadership includes having

other parts of the world follow, China is far ahead in Africa and Latin America, and even Western Europe is not fully aligned with the United States. Additionally, Chinese companies have mastered the technique of appearing in force and on every key delegation or committee in international settings, such as the World Radio Conference (WRC), or 3GPP. This is a technique that Motorola formerly used to help achieve U.S. dominance in certain spheres, and Huawei is now using it to great effect. Dennis Roberson said that "China has really come to the fore," it established 5G as a national objective and is "marching down the path to implement" it.

Because the United States is not politically organized in the same manner as China, there may be a disconnect between the goal to reach, the desired outcome, and the actual investment. For the last several years, the race to 5G and the need to beat China animated U.S. wireless policy, commented Phillip Berenbroick, Policy Director at Public Knowledge. And yet, there seems to be underinvesting in international processes, such as the WRC process, which would be an appropriate place for the United States to show leadership and to gain trust and play a leadership role for the rest of the world.

Another area of underinvestment may be in research capability. Roberson noted the loss of research capacity in the United States, compared to Europe and China. Europe has research projects that engage academics, organized by the European Union (EU) and funded through EU funds. With the loss of Lucent and its world-famous Bell Labs, and Motorola's wireless operations, along with the demise of Motorola Labs to a European vendor, the United States no longer has ability to deploy industry-funded projects that meet national interests. Furthermore, although the United States achieved many successful outcomes at WRC-19, competitive corporations inside the United States are simply not organized to influence the WRC and other international processes in the manner that China is. In fact, as WRC-19 pointed out, even securing a coherent U.S. position on various WRC matters is extremely difficult with various government agencies at odds with one another.

In addition to controlling its industry, China has a timeline driven by Made in China 2025, which caused one participant to inquire about the timeline in which the Chinese are making spectrum available for 5G, and whether the United States is operating with sufficient speed

and urgency. If the United States is interested in condensing timelines, one suggested approach would be to expand sharing of the spectrum currently used by federal agencies. The Citizens Broadband Radio Service (CBRS) is one example of reallocating federal spectrum rights. The question remains if we can take that framework and push it down in the band, to expand the 3 GHz frequencies available for commercial use and/or apply it to other bands.

China is "winning because they see the overall investment in people, infrastructure and applications, and they see them as interconnected." - ***Nicol Turner-Lee***

China is "winning because they see the overall investment in people, infrastructure and applications, and they see them as interconnected," said Nicol Turner-Lee, Fellow at the Center for Technology Innovation at the Brookings Institution. China has an integrated plan for acquiring technology, training its people, building its companies and creating a platform for applications. Turner-Lee said that in speaking about the new PCAST, the focus should be to move away from the concept that spectrum policy is about making sure that mobile carriers have a good supply of spectrum and rather it is about creating the environment in which innovative technologies can thrive, and Americans receive the full array of services and applications that are possible.

A Matter of National Security and National Competitiveness

China presents a national security issue as well as an economic issue of national competitiveness. Security concerns are eminent with regard to their technology. Preston Marshall said that a discussion about security cannot simply focus on Chinese companies like Huawei, because there are other supply chain issues. Specifically, the parts that Huawei uses are by in large the same parts that Nokia and Ericsson use and these parts are predominantly produced in China. So, there are security concerns about backdoor exploits and the ability to cut off services when using any infrastructure equipment that has components made by Chinese companies.

Spectrum policy issues are vital to national defense and homeland security in other ways, too, noted Dale Hatfield, Adjunct Professor and Executive Fellow at the University of Colorado at Boulder. Spectrum policy "is not just about getting people connected, but making sure that the Department of Defense, for example, has the radars it needs to defend the United States," and making sure the U.S. has the remote sensing needed to assess global warming, said Hatfield.

Federal Policy for Spectrum

The 5G race is thought about in three ways: security, economics, and a resulting 5G dependent ecosystem. The success of all of this is predicated on our national communications policy.

Federal spectrum policy needs more flexible tools to increase access to federal spectrum, particularly on a shared basis.

Federal spectrum policy needs more flexible tools to increase access to federal spectrum, particularly on a shared basis. The most important near-term change is to reform the Spectrum Relocation Fund (SRF) to expand the ways in which federal users could use SRF monies. The longer-term objective is an automated spectrum management environment, building on the work done for the CBRS band.

The Desired End State for Spectrum Access

It is a given that the United States must respond to widespread demand for increased spectrum access. The desired end state is access to spectrum that is not a constraint on economic growth, social progress, public safety, or national security. Therefore, sufficient spectrum should be available for all of these purposes, although multiple purposes might be accommodated in a single band. On the mobile and commercial wireless side, there is a new emphasis on competition from a global perspective and national security. Spectrum for commercial uses, including mobile, should be made available through a balance of

licensed and unlicensed access. The desired end state should include access to cloud services and applications for all.

The desired end state is access to spectrum that is not a constraint on economic growth, social progress, public safety, or national security.

A full and ongoing inventory of spectrum uses and a well-planned and consistently maintained spectrum map for both federal and non-federal spectrum are needed, particularly if the U.S. is to have an automated national spectrum management capability that will enable additional spectrum sharing. For example, if the management of spectrum for wireless services is tied in with the expansion of fixed telecom infrastructure (*e.g.*, continued build-out of fiber), shifting some services and uses to the fixed infrastructure will free up spectrum for other purposes. In addition, the following are likely to be required: cooperative federal and non-federal relationships that enable private transactions, incentives for efficient spectrum use, and federal user adoption of commercial services and technologies.

Government should also consider how to reform the Spectrum Relocation Fund. Directing additional funds towards the spectrum management ecosystem would increase the chances of getting to the desired end state. Monies could come from interference enforcement fines and application fees, as well as auction proceeds. These funds could be targeted toward automated spectrum management systems and a national spectrum inventory. A key change would be enhancing the Spectrum Relocation Fund (SRF), which is used to reimburse federal agencies for their transition costs when a band is re-allocated for commercial use, and also may be used under certain circumstances to study spectrum pipeline plans for other bands. It would be extremely helpful to allow federal agencies to use SRF monies toward better technology and system upgrades, rather than just comparable capability. This would create incentive for win-win situations in which both federal and commercial users can benefit. One of the PCAST report recommendations is "to create a spectrum efficiency fund so that revenues

associated with spectrum are not limited to spending on that same set of frequencies but may be used flexibly" for other frequencies or equipment, stated Michael Calabrese of the Open Technology Institute.

The group discussed other ways to use funds, *e.g.*, auction proceeds or fines from enforcement of spectrum regulations, in a manner that would facilitate increased access to federal spectrum. Many of these approaches would require legislation. Funds could be used for spectrum research, development, testing and evaluation, including test beds. As sharing and congestion increase, funds will also be required for interference protection, detection and resolution. Auction funds might also be used for broadband infrastructure deployment, as well as mapping the middle mile and the last mile. Other ideas include improving receiver performance, especially for critical infrastructure related systems, and providing the NTIA with more responsibility and authority to manage federal spectrum, analogous to the manner in which the General Services Administration (GSA) manages property for the federal government.

Government should also evaluate spectrum sharing approaches. The Citizens Broadband Radio Service (CBRS) is a radio-frequency band established to facilitate shared federal and non-federal radio spectrum use. The CBRS band is a poster child for the PCAST report, but it is important to have a clear-eyed assessment of how it is working, and lessons learned from the implementation of the sharing framework in that band. Specifically, there is a need to know whether the band is working for General Authorized Access (GAA) users, which do not get individual licenses, as well as for Priority Access License (PAL) holders, once the auction is complete, and the PALs have been issued. It is also imperative to understand whether the Spectrum Access System (SAS) model is repeatable—and to what end, and what can be learned about dynamic sharing. The evaluation should also include whether it is possible to speed up the process of developing the sharing mechanism. One participant said that his organization is getting feedback "that some parts of the CBRS ecosystem may not be the way forward, [such as] the sensor" component. Perhaps there are new incumbent informing models that could be used, and the framework could be tweaked a bit. And economic results can and should be compared to outcomes using different models of spectrum allocation in the 3.5 GHz band that are being widely deployed in other countries.

The group discussed how to define success in the CBRS band, and in what timeframe this will be possible. As GAA use begins, that will provide some information, but many people thought that a full assessment would not be possible until the PALs have been issued and deployment has occurred. It is important for the SAS to be working as a technical matter and enabling sharing, said Steve Sharkey, Vice President of Government Affairs, Technology and Engineering Policy at T-Mobile, but the critical question will be whether the SAS is working to enable services to be available in the way that is needed. Preston Marshall posited that the title of the PCAST report is not "lots of radios," it is "economic growth." In evaluating the success of the CBRS experiment the question should be whether there is growth in new startups, new employment, and new activity.

The process now for CBRS use is in fact very regulatory, and to change it you have to go back to the regulator, stated Charla Rath. This is unlike the process of dynamic sharing that takes place in exclusively licensed spectrum. Preston Marshall added that "the FCC gave [the wireless] community incredible latitude," for example, "to decide coexistence and channel assignments." This is because the FCC assumed that the multi-stakeholder process would function, without companies complaining to the FCC or the Hill.

The problem with reform continues to be fragmentary rights, stated Tom Hazlett. He continued:

> GAA is not exclusive whereas PALs have some exclusivity associated with them. The SAS has its algorithms for assigning channels. And this fragmentation of ownership of the use is an expensive transaction, and that is why you will need to go back to the regulators. Suppose it is just a mess and you have got to clear it up? Who do you make a deal with? …Contrast this to the L Band, where LightSquared made a deal with Inmarsat to make contiguous spectrum and interleaving in the band became an issue. Hundreds of millions of dollars changed hands between the satellite carriers to get that done. The part they could not fix because of fragmentary rights, and there is no owner in GPS, are those border conditions that are still ongoing 15 years later. This is a transaction cost that is blocking something of value and eliminating the ability to make a deal.

The CBRS discussion revealed some disagreement over Hazlett's conclusions: others at the conference thought that the path the FCC took, as imperfect as it was, was significantly better than any practical alternative, given the widespread federal incumbents in the band. Jonathan Chaplin said if CBRS is a disaster, for example because of the fragmentation of ownership described by Hazlett, it only demonstrates that it is extremely difficult to fix certain types of problems. But if it is not a disaster, "it could unleash significant value across bands of spectrum that are difficult to get to today," said Chaplin.

Hazlett offered conclusory thoughts: When evaluating regulatory options, such as the CBRS sharing framework, it is important to consider the opportunity cost; and, in asking whether a regime works, the question should be whether it works better than the alternatives. We should "constantly be looking at new models and considering the costs and benefits," and perhaps we could call that dynamic regulatory thinking.

Bidirectional Sharing is access sharing among federal and commercial users: federal government has access to commercial spectrum as well as commercial users having access to federal government spectrum. In the big picture, the federal footprint of spectrum use is constantly shrinking over time, typically "because [of] repurposing for commercial use," said one participant. Generally, the assumption is that federal spectrum use is not going to expand in the band that is repurposed. But as federal uses change over time, it is worth seeing whether there are opportunities for expanded bi-directional sharing.

For certain federal systems, such as the military air-to-air/air-to-ground system, testing requires a huge peak spectrum need, one participant noted. This kind of occasional use might be a candidate for bi-directional sharing. There are also geographically isolated areas where the military would like to train using specific spectrum they will be using in other venues. "Every wireless carrier does those kinds of agreements on a regular basis," stated Rath. Steve Sharkey added that those spatially isolated areas are part of the mix, but that federal users also ask for spectrum in more populated areas. Many think that the greatest amount of unused capacity remains in federal bands. And the federal users are not moving any time soon. "There are lots of things that the NTIA and the federal government could be doing to promote

further sharing and that would be in line with the PCAST idea of abundance," stated Calabrese. "It could be clearing, but more likely in the near term it is going to be sharing and that may require a federal SAS."

The Digital Divide

Americans have varying access to broadband service depending on where they live, some may simply not be able to afford connectivity. Users may also have starkly different needs. Roundtable participants agreed that there is no "one-size-fits-all" solution, but rather a need for a "toolbox" of solutions to address the digital divide. 5G will affect various aspects of the digital divide. Overall, getting everyone connected to broadband networks would be good for the American economy, income equality, and getting rural areas connected to broadband network.

…there is no "one-size-fits-all" solution, but rather a need for a "toolbox" of solutions to address the digital divide.

Elements of the Digital Divide

There are multiple elements of the digital divide. Although the focus is often on coverage, (whether you have a signal), it is also important to know about capacity (what data rate is possible). Is the service 4G or 5G, and what frequency bands are being used (low, mid, millimeter wave)? Device availability and affordability, along with service affordability, also come into play. Whether massive IoT and low-latency IoT capabilities are available will also be elements of the digital divide in the future.

In rural areas, coverage is the primary determinant followed by capacity. There are relatively dense rural environments, such as in Mississippi, as well as sparse rural environments, as in South Dakota. New technologies, such as low-earth-orbit satellites (LEOs) and fixed wireless could be game changers. In contrast, 5G millimeter wave is unlikely to be impor-

tant in the rural environment because the technology only covers short distances or dense areas, such as urban environments.

In the urban environment, coverage problems are less relevant (4G and 5G with low-band coverage and mid-band capacity allow penetration of buildings), but with greater population density, capacity becomes more of an issue due to concentrated demand. Satellites may be less helpful in urban areas. Conferees discussed the potential benefits of a fixed wireless solution such as Starry's offering, a wireless 5G home Internet service. Starry's hardware solution to use rooftop buildings for their fixed wireless technology has enabled the company to provide affordable alternatives to large internet providers.

5G is likely to make the rural digital divide worse, and in many cases considerably worse. There are significant technology-based challenges: millimeter wave spectrum is not likely to be useful in rural areas; edge computing requires low latency which is hard to produce in rural areas. In short, capabilities that exist in urban environments may not exist (or will be extraordinarily expensive) in rural areas. It may be that service and speed in rural areas are "just ok," compared to "excellent" in urban areas, given a combination of technology, geography, and finances. 5G may also exacerbate the divide among cities, suggested Doug Brake, Director of Broadband and Spectrum Policy at the Information Technology and Innovation Foundation. Cities that already have a big network with local talent and jobs may be better able to put this new technology to use than many other cities.

A counter-theory is that "5G increases the digital divide as it is defined geographically, but not necessarily as it is defined economically," suggested Jonathan Chaplin. If 5G delivers massive amounts of capacity, it will drive down the unit cost of data. For people in urban areas in reach of millimeter wave and ultimately mid-band spectrum, it ought to help more people access service and applications at affordable prices. This does depend on the price of a device dropping radically.

There is a need for creative solutions to address the digital divide, including spectrum-based solutions and subsidy programs. Designing solutions requires an understanding of the needs of different types of users. Diverse solutions will be required to match local use cases, and these solutions are likely to include: 4G/5G, satellite, Wi-Fi, and fixed wireless. Additional mid-band spectrum would help address both rural

and urban divide challenges. Subsidy programs are likely to be required and should be technology neutral, consistent with policy objectives. Phillip Berenbroick at Public Knowledge said that if there are subsidies for service deployment, it may be necessary to have a baseline level of speed/capacity/latency. If you are focusing aid for deployment to a specific geographic place, you probably are getting one bite at the apple, not providing aid for fiber and Digital Subscriber Line (DSL), and giving people a choice in carriers. In short, government should provide more mid-band spectrum and subsidies for coverage and capacity.

It is important to have a fixed solution and not just a mobile solution, especially for families with school-age children, in order to leverage broadband connectivity at an affordable price that enables computers and not just handheld devices, stressed Paula Boyd at Microsoft. She added, "To me, a kid can't survive on a mobile connection. They can't go through the educational experience from kindergarten through high school on a mobile connection." When people have access to fixed broadband, they likely spend less to get the connectivity and capacity that they need. Connectivity that meets all of the needs of a family at an affordable price is important. As mobile networks become more capable and have more capacity, there is the potential to meet those needs with a mobile service. Michael Calabrese at the Open Technology Institute specified that for mobile services to meet this connectivity goal would require the price per gigabyte to drop by 90 percent.

Connecting rural areas can help solve global issues, too. Precision agriculture increases food production for a growing global population. Similarly, rural areas can be connected in order to collect data on climate change, which will be critical to solving these bigger issues. J. Stephanie Rose, Ph.D. student at the School of Computing & Information at the University of Pittsburgh said that if the United States comes up with rural solutions, they may translate into global humanitarian efforts, which potentially could lead to more support and stability from abroad. Humanitarian efforts such as global adoption may also lead to "buy in" from other countries as the United States seeks to lead with respect to 5G infrastructure.

In addition to connectivity, there is a need for solutions that focus on training, technical education, and the labor force. There is currently a limited workforce with the capabilities to roll out the new technologies.

Some work is being done, but there are enhancements that would be helpful, such as apprenticeship programs. To assist, the Department of Labor could establish broadband deployment as a discrete focus area. Labor could be drawn from the communities served, which would benefit the community economically and also produce a trained workforce.

In addition to connectivity, there is a need for solutions that focus on training, technical education and the labor force.

The group expressed a strong sense that both equity and excellence are important. But it is hard to believe that the solution that creates rural broadband is the same solution that leads to the fastest rollout of 5G in the United States.

States and cities have a major role to play in the roll-out of 5G. Federal, state, and local government should work together to address the roll out of emerging technology. Localities can provide incentives for the provision of technological capabilities, for example by creating easy paths to permitting and infrastructure, or by encouraging shared infrastructure. Charla Rath cautioned that infrastructure sharing "becomes more of an issue in a 5G world where carriers are already densifying the network they use for 4G. In certain areas there is a lot of tension between cities and carriers, but legitimately cities need to think about how many different times" they will be asked for approval for multiple antennas and placements, and should they be pushing for infrastructure sharing. Rath also noted that carriers are cognizant of the first mover advantage, and the loss of that advantage to free riders if the first carrier is required to share. Many cities want to move forward, but there have been "two [wireless] carriers who had a very significant spectrum advantage over the two other national carriers," stated Blair Levin of the Brookings Institution. Accordingly, whereas rhetorically the carriers with the spectrum advantage wanted the cities to speed up, they wanted cities to do it in ways that would advantage those two carriers and not in ways that would effectively level the playing field. There may be a tension between trying to drive down costs and recognizing

that for individual carriers, there is a real value to keeping the current barriers in place.

In CBRS, sharing is called "the condo model," said Preston Marshall of Google. He said that "CBRS has a unique property in that everyone has a right to the band; they do not have to have separate RF bands." People can share it whenever you want. There are a few companies that have been privately trying to syndicate that, and it is the same idea presented in PCAST. The entity who builds infrastructure that can be used in common will have the lowest marginal cost. Ideally, this offers opportunities to try out a business model on a small scale that ultimately could be applied at a larger scale. One participant said that the Chinese do a huge amount of network sharing and have since mandated it.

To understand the value of the technology coming their way, the Chief Information Officers and Chief Technology Officers of states and cities, along with their citizenry, need more education. Universities may be able to help with technical education. States and cities also need access to technical skills to be able to address the challenges of rolling out the technologies that are right to address their particular needs. Zero-rating dot.gov services can reduce the cost to citizens and also create incentives for the local government to provide more services. Local leaders will need to ensure that specific communities are not prioritized over others. An approach to counter digital redlining, creating inequities through the use of digital technologies, would be for cities to provide incentives targeted at low-income areas, such as subsidizing open-access fiber, providing access to street furniture for small cells, or leveraging municipal utilities.

International Harmonization of Spectrum Allocations

The International Telecommunication Union allocates specific spectrum bands for high-level uses (fixed satellite service, mobile service, etc.). This process happens every few years (currently on a 4-year schedule) at the World Radio Conference (WRC), which lasts for four weeks and involves 192 countries. The WRC may also identify bands for certain uses, such as International Mobile Telecommunications (IMT).

There is an important difference between allocations and identifications. Under the ITU treaty, the only activity described is allocation and there are a limited number of allocation categories, such as Fixed Service,

Mobile Service, or Fixed Satellite Service. There is also the practice of "identification," within an allocation, identifying spectrum for a particular set of uses, such IMT. While identification is commonly used, it has no status under the treaty. Identification may appear as footnotes in the table of allocations and some countries use identifications as guideposts for their national spectrum policies. It is necessary to have an allocation (*e.g.*, Mobile Services) before obtaining an identification (*e.g.*, IMT).

Both allocations and identifications are important to U.S. spectrum policy, and to promoting global harmonization, thereby allowing services and equipment to be used in the same or similar bands globally. For example, there are spectrum borders as well as geographic borders, and when you take your phone from one place to another, it helps a lot if the spectrum allocation is harmonized. For users who have medical applications on their devices, the availability of harmonized spectrum and the ability to use a device globally may be life-saving. The priority is always to get the allocations in place, said a participant; allocations are more important than identifications.

World Radio Conference 2019

The WRC-19 ran from October to November 2019, with decisions on numerous international spectrum issues of importance to the United States. The United States left the conference with more globally harmonized 5G spectrum, said Jennifer Manner. Officials at WRC identified significant spectrum for IMT and for High Altitude Platform Services (HAPS). In addition, satellite operations were provided with flexibility for Earth Stations in Motion (ESIMs) to be used on ships or planes. The WRC also allocated more spectrum for satellites and for RLANs (Radio Local Area Networks). On the regulatory side, the WRC adopted milestones for Non-Geostationary Satellites (NGSOs) to prevent speculative filings. The conference also adopted future agendas for WRCs in 2023 and 2027, including which bands should be studied for IMT going forward. These bands are below 10 GHz and include the C Band.

There is a certain amount of flexibility in the implementation of the results of WRCs. Sometimes there is a global agreement, and everyone agrees that a particular band is going to be used for a particular service. Alternatively, there may be Region 1, Region 2, or Region 3 agreements that a particular band is going to be used for a specific service. In the

absence of a regional agreement, there may be a footnote that says this is how it is going to be in the United States, or the United States and Bolivia, for example. The United States makes use of footnotes when it is not in lockstep with the rest of the world or the region. Without a footnote (if the United States operated differently from the rest of the world) there would be no protection at all, and the service would be operating on a non-interference basis, which would be highly unusual.

This flexibility has historically been important because there is a tension between harmonization and the United States moving with policies in advance of the rest of the world, noted Michael Calabrese. On balance, however, identifications have had more benefits than drawbacks for the United States. They are also helpful in allowing the United States to drive a global framework, such as a global market for equipment, said Steve Sharkey. Identifications have been reasonably successful in building a focus on which bands are used for certain services and helping to drive policymaking in the United States and other countries.

Global Harmonization and the Value of the ITU Process

Building on the discussion of CBRS, the group considered whether dynamic sharing would eliminate the need for global harmonization, especially over time. Dynamic sharing requires that devices have recourse to more than a single frequency assignment or frequency plan, stated Preston Marshall of Google. For example, CBRS radios must support the full 150 MHz. In addition, dynamic sharing works better with Time Division Duplexing (TDD) than with Frequency Division Duplexing (FDD). Charla Rath said that over time (*i.e.*, 20 years), these issues could be resolved, and then dynamic sharing would reduce the value of global harmonization. There would still be a need for some kind of global framework for the bands to be supported in the devices and have the infrastructure to take advantage of dynamic sharing, though perhaps 3GPP could provide part of this framework. In addition, for some government services, such as radio astronomy, it may be essential to have particular frequencies allocated worldwide, and there is no substitute for the ITU to address this need.

Global harmonization has always been important to some services, such as satellite systems. And it is increasingly important to terrestrial mobile services. Even though the people who work with the ITU com-

plain about the WRC process and the difficulty of working with the organization, it performs an important function for spectrum-based services, and the ITU/WRC process is the best of the available alternatives.

Nonetheless, there are certain disadvantages to the WRC process. The main issue is that it consumes significant federal government and private sector resources. U.S. delegates are supposed to commit to be at the WRC for a month. And there are seven study groups, which meet for ten days, three times a year. An additional challenge for the United States is that, by statute, the WRC ambassador cannot be appointed until six months before the WRC.

At past WRCs, the United States was seen as a primary leader in policy development. Now, the United States has lost its primacy and is instead seen as one of a group of leaders, together with China, Russia, India, the United Arab Emirates, France, and a couple of others. But without a country acting as the primary leader, regional groups have become more important and Manner reported that the regional groups negotiated the final outcome on big issues at WRC-19. Harking back to the China discussion, Manner stated that Huawei is doing a brilliant job at the ITU and had approximately 77 people at the conference, not all of them identifiable as Huawei. She also said that the Huawei representatives and China in general expanded their leadership roles at the most recent WRC.

Some participants suggested that government periodically re-evaluate participation in the World Radio Conference. Numerous people have questioned whether getting 192 countries together for four weeks is the right use of the ITU, or whether there is a better way to review and revise the Radio Regulations. As an alternative, Commissioner Michael O'Rielly has suggested using the G-7 to establish international spectrum allocations. Other vehicles might include the private sector standards setting bodies, such as 3GPP and the European Telecommunications Standards Institute (ETSI), the European standards body. However, standards setting bodies are led by equipment vendors, such as Nokia, Ericsson, and Huawei, and lack government input. Further, federal uses will not be standardized through private standards bodies, stated one participant. When governments are trying to protect important government services, the ITU is better than a private standards organization because governments have a voice in the ITU but are observers at 3GPP. In addition, the importance of a government use such as radio

astronomy, particularly if it is competing with a commercial use such as high-density fixed satellite service, is more likely to be recognized in a forum like the WRC. Private standards-setting bodies such as 3GPP also lack transparency, making it difficult for academics and civil society organizations to understand what is going on, according to Dale Hatfield of the University of Colorado at Boulder.

There is a trade-off between the value of coordination and the cost of coordination. This trade-off is different according to the services (satellite versus mobile) and the users (commercial versus government). For instance, coordination can yield economies of scale, which are valuable. Satellite values economies of scale, and obtains additional value from the coordination process, because many satellite systems operate globally and cover multiple countries. Additionally, the ITU process is used by the United States to signal where it is going, and the United States tends to be in the forefront of new spectrum uses. Historically, the United States has frequently been several steps ahead of the rest of the world, pioneering a new use for a given band, as with PCS spectrum in the 1990s, 700 MHz in the 2000s, or 600 MHz in the 2010s. Occasionally, the WRC process helps push the United States forward, as with Advanced Wireless Service (AWS-1).

The costs of the ITU process include the need for serious resource commitments (including both funds and sending people to the conference for a month and preparatory meetings), as well as the economic cost of spectrum not being available, or not being available as soon as it might otherwise have been. In addition, there is the need for vigilance to measure rigor in the process. In the end, for satellite services, the value of global harmonization and other benefits of the ITU process far exceed the costs. For government users, similarly, the WRC process is likely to be significantly better than available alternatives in which the government does not participate in the same way.

The group agreed that the value of the ITU process currently appears to outweigh its cost because it creates the opportunity for coordination (and attendant benefits) and there is flexibility in implementation. The alternatives to the ITU process appear to be less desirable, particularly those that involve private sector groups such as 3GPP. To paraphrase Winston Churchill, "The ITU Radiocommunication Sector (ITU-R) is the worst form of coordination, except all those other forms."

Conclusion

In seeking to define spectrum policies that promote both growth and equity, the group revisited the PCAST report recommendations and the 2019 World Radio Conference, and focused on three topics: federal spectrum policy, the digital divide, and whether the WRC continues to be useful to the United States. Woven through the discussion were concerns about China as a global competitor and a threat to U.S. national security, and how to assess the success of the CBRS framework, which is still in process.

Conferees emphasized the importance of having multiple tools to use, including a CBRS-like model, and on modifying the Spectrum Relocation Fund to allow for more flexibility in spending to achieve more optimal solutions for both federal and commercial users. The group agreed that the U.S government should reform the Spectrum Relocation Fund, and that the monies can be used to administer an automated spectrum management system. They also agreed that the U.S. government should develop a national spectrum inventory.

To help address the digital divide, additional mid-band spectrum should be made available by the government to provide coverage for urban and rural communities. Further, the digital divide is not really a single divide, but has to be considered in a nuanced, granular way, with a toolbox of solutions to address the different divides. Subsidies should also be provided for fixed services for people living in rural areas to promote affordability.

Lastly, the federal government should occasionally re-evaluate participation in the World Radio Conferences to determine whether the benefits outweigh the costs. The group concluded that the WRC currently is more advantageous than disadvantageous for the United States and that it is better than the identified alternatives.

While there are many challenges that are looming with the advent of emerging technology, there are more opportunities in the creative use and application of spectrum technologies. Federal, state, and local government will need to work together to realize the many promises inherent in the current digital society.

APPENDIX

Recasting PCAST after the WRC-19

Queenstown, Maryland
December 8-10, 2019

Roundtable Participants

Jonathan Adelstein
President & Chief Executive Officer
Wireless Infrastructure Association

Phillip Berenbroick
Policy Director
Public Knowledge

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Information Technology and Innovation Foundation

Michael Calabrese
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Open Technology Institute

Jonathan Chaplin
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New Street Research

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Dale Hatfield
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Tom Hazlett
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Clemson University

Derek Khlopin
Senior Advisor, Office of the Assistant Secretary
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Note: Titles and affiliations are as of the date of the conference.

Colleen King
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Blair Levin
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Jennifer Manner
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Preston Marshall
Engineering Director
Google

Mark McHenry
President
Shared Spectrum Company

Ruth Milkman *(rapporteur)*
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Carl Povelites
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Global Public Policy
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PhD Student, Informatics and
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Note: Titles and affiliations are as of the date of the conference.

About the Author

Ruth Milkman is a partner in Quadra Partners, LLC, a strategic-advisory firm providing integrated expertise across business, finance, and public policy in the context of converging communications technologies.

Ms. Milkman served as the Chief of Staff of the Federal Communications Commission from 2013 to 2017 and Chief of the FCC's Wireless Telecommunications Bureau between 2009 and 2013. From 1998 to 2009 she worked as one of the leading telecommunications lawyers in Washington as co-founder of Lawler, Metzger, Milkman and Keeney, a firm serving clients ranging from start-ups to large established telecommunications companies and private-equity firms. Before joining Lawler, Metzger, Ms. Milkman held a variety of senior positions at the FCC, including Senior Legal Advisor to Chairman Reed Hundt and Deputy Chief of the International and Common Carrier Bureaus.

Ms. Milkman has a B.A. from Harvard University and a J.D. from the University of Michigan Law School. She served as a clerk for the Honorable J. Harvie Wilkinson III on the U.S. Court of Appeals for the Fourth Circuit.

About Aspen Digital

www.aspeninstitute.org/aspendigital

Aspen Digital empowers policy makers, civic organizations, companies and the public to be responsible stewards of technology and digital media in the service of a more just and equitable world. Through convenings, fellowships, publications, interactive toolkits, and thought leadership, we work towards values-based and human solutions to digital challenges. Aspen Digital shines a light on urgent global issues across the news information ecosystem, cybersecurity, emerging technology, urban innovation and the technology talent pipeline — and then turns ideas into action. Our flagship initiatives include the Tech Policy Hub, Aspen Cyber Summit, Cybersecurity Group, Center for Urban Innovation, Communications Policy, Emerging Technology Trust Initiative, Institutional Innovation, and the Tech X Talent Project.

Previous Publications from the Aspen Institute Communications Policy Project

In Harm's Way: Smart Regulation of Digital & Network Technologies, by Carol Mattey

Misuse of personal information, manipulation of platforms to influence elections, and failure to extend broadband to underserved areas are a few of the problems facing governments at all levels. Increasingly, policymakers are taking up the challenge of shaping legal solutions to these problems, only to find they lack both the tools and technical expertise to regulate wisely, meaningfully and efficiently. Given the current technological environment, what goals are appropriate to assure that emerging technologies are used to benefit the populace and do not harm society? Participants of the 34th Aspen Institute Conference on Communications Policy, which took place in Aspen, Colorado in August 2019, examined regulatory frameworks that can provide a successful model for future problems as they inevitably appear. The report of the Conference explores approaches to impede harms from digital and network technologies that address user protection, promote consumer choice and competition, and foster access to essential services. 2020, 62 pages $12.00

Spectrum Policy and the Future of Satellites, by Doug Brake

There is a growing demand for spectrum resources that have traditionally been reserved separately for terrestrial or satellite uses. In an effort to expand their services, spectrum users are looking to use or share the bands reserved for others. While there are some regulatory provisions to enable sharing of spectrum, current guidelines do not facilitate sharing among satellite or terrestrial services. This report focuses on tensions between satellite use of spectrum and terrestrial uses. Written by rapporteur Doug Brake, it explores how best to enable the flourishing of satellite operations through effective spectrum policy while balancing the unique requirements of satellites with competing spectrum uses. 2019, 53 pages, $12.00

Next Generation Digital Infrastructure: Towards a New Regime for Promoting Investment, Competition and Consumer Protection, by Carol Mattey

Advances in information communication technologies are providing greater penetration, new services and connectivity to the world. In a connected nation, traditional norms of federalism are increasingly challenged and policymakers are wrestling with difficult questions of whether and how to manage the ongoing transformation of the communications sector. The report of the 32nd annual Aspen Institute Conference on Communications Policy, written by rapporteur Carol Mattey explores regulatory structures to incentivize the deployment of communications infrastructure to unserved areas, and ways to promote competition and protect consumers on the internet. 2019, 40 pages, $12.00

Rethinking Institutions of Spectrum Management, by Ruth Milkman

There is rapid growth in spectrum demand. With the emergence of 5G, Internet of Things, and unmanned vehicles, spectrum policy issues have become more complex. The report, Rethinking Institutions of Spectrum Management, written by roundtable rapporteur Ruth Milkman, examines the urgency for a different structure for spectrum management that could better serve spectrum-related needs and includes recommendations for incremental change within the current institutional framework. 2018, 57 pages, $12.00

Streams of Connectedness & New Media: Fragmentation, Innovation and Democracy, by John B. Horrigan

While greater consumer choice in media has spurred connectedness and diversity of creative voices, it can breed fragmentation, which in turn can degrade public debate. Participants of the 32nd Annual Aspen Institute Conference on Communications Policy, which took place in Aspen, Colorado in August 2017, explored policies for the new media landscape and identified two issues stakeholders should confront going forward: inclusion and content quality. Conferees grounded their recommendations in current Federal Communications Commission Chairman Ajit Pai's statement of principles—digital empowerment, the need for ubiquitous Internet access, the power of competitive free markets, and light-touch regulation. The report, written by John Horrigan, includes three proposals to address challenges in the new media land-

scape, such as investment in access and inclusion, changes in regulation to promote network deployment, and leadership and education. 2018, 40 pages, $12.00

Revisiting Spectrum Policy: Seven Years after the National Broadband Plan, by David Boldlier

In Autumn 2016, the Aspen Institute Communications and Society Program convened 25 leaders and experts in the technology, business, regulation and public interest for the Aspen Institute Roundtable on Spectrum Policy. The report, a result of the Roundtable, synthesizes the ideas that emerged from participant dialogue and recommends new spectrum policies that incorporate emerging technologies, consider various licensing approaches, and frame U.S. spectrum policy from a global perspective. 2017, 48 pages, ISBN Paper: 0-89843-660-5, $12.00

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, leading 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 solu-

tions. 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 broad-

band 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

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