

Spectrum Policy and the Future of Satellites

Doug Brake, Rapporteur



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The report from the 2018 Aspen Institute
Roundtable on Spectrum Policy

Doug Brake
Rapporteur



THE ASPEN INSTITUTE

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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 year 2018 presented a remarkable year for satellite policy. With renewed vigor reminiscent of the 1990s, a slew of new satellite firms are aggressively exploring non-geostationary deployments for a wide variety of applications. Open source components, miniaturization, lower-cost launches and re-useable rockets are fueling a surge of new proposed constellations. Some of these involve swarms of satellites — hundreds or even thousands of coordinated units. The established geostationary satellite operations sector is seeing growth as well.

It is not immediately clear that new firms exploring the field recognize the complexity, difficulty and long time-horizons associated with obtaining rights to spectrum use. Incumbent satellite operations, while more sophisticated in navigating the international and domestic bureaucracies of spectrum control, recognize the growing pressure for other technologies, such as terrestrial 5G networks, to access what was historically considered “satellite spectrum.” Together these developments raise new questions and issues for spectrum regulation and management.

The 2018 Aspen Institute Roundtable on Spectrum Policy (AIRS), which took place October 29-31, 2018, centered on tensions between satellite use of spectrum and terrestrial uses. The resulting report, written by rapporteur Doug Brake, 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.

Conferees discussed the current satellite spectrum management system, examining the challenges posed by the complicated International Telecommunications Union (ITU) filing process, the difficulty in developing alternative methods of allocating a limited, global resource, as well as the limited enforcement mechanisms available in the current regime. Roundtable participants also discussed a number of more specific policy proposals to help improve conditions for competitive, innovative satellite services. Three of the most salient recommendations included (1) mechanisms to more explicitly incorporate receivers into the spectrum management process, (2) moving toward a risk-informed assessment

of harmful interference, and (3) increasing the flexibility in accessing and using satellite spectrum, which could be done through a “spectrum sandbox” and a new “General Satellite Service” classification at the ITU.

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I also want to thank Doug Brake, conference rapporteur, for his extensive and informative account of the conference discussions, and our participants for their contributions to these complicated topics. However, not every recommendation or statement in the report reflects the views of all attendees or their employers; rather, they are the rapporteur’s view of the general sense of the group.

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

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The Aspen Institute
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SPECTRUM POLICY AND THE FUTURE OF SATELLITES

Doug Brake

Spectrum Policy and the Future of Satellites

Doug Brake

Introduction

Satellites play a unique role in the information and communications landscape. From a communications standpoint, satellite-based systems are able to offer virtually ubiquitous coverage. They offer compelling connectivity to ships at sea, airplanes and for rural areas where infrastructure costs make terrestrial broadband service both difficult to deploy and uneconomical. Their international nature brings unique benefits, as well as challenging regulatory considerations: Every satellite system must be registered at a United Nations (UN) specialized agency called the International Telecommunications Union (ITU); use of radio frequency spectrum must be coordinated where required by ITU rules; and operators must obtain licenses in each country in which they want to provide service. The ITU plays a central role in managing satellite use. It is through recording in the ITU's Master Register that frequency assignments associated with a satellite system have the right to international recognition and are taken into account by other spectrum users in order to avoid harmful interference.

Broadband data and communications services often get the lion's share of policy attention. Satellites, however, are not a monolith, and differences in use-cases vary tremendously. Weather and climate monitoring, navigation, global time synchronization, reconnaissance satellites and television distribution are some of the critical space-based systems. Each of these systems has a different spectrum use profile, a unique set of interference concerns and a different set of policy considerations. Furthermore, the diversity and number of satellites is rapidly changing. Firms like SpaceX, OneWeb, Amazon and Virgin are working to deploy large constellations of broadband satellites. The potential to deploy these new systems is based on significant technological advances that are driving down the size, weight and therefore the costs of deploying smaller, specialized devices into orbit.

Understanding this diversity and the rapidly changing landscape is key to appreciating the unique spectrum challenges in forward-

looking satellite policy. As such, in October 2018 the Aspen Institute Communications and Society Program convened key stakeholders, policymakers and competing corporations to discuss these issues and work toward finding new solutions and consensus where possible. The group could not address the policy minutia of all these different types of satellites and their uses during a two-day moderated dialogue. Instead, they explored a key theme—the changing satellite landscape with more and smaller satellites operating in orbits closer to the Earth, structured in larger constellations, all seeking access to an increasingly limited amount of available spectrum. This report is a synthesis of those discussions.

Satellites are no longer large and few, but increasingly small and numerous.

Largely speaking, the satellite sector is not alone in its growing demand for spectrum. Terrestrial communications services, such as 5G, are the most obvious source of demand for more spectrum. Cisco estimates a 46 percent compound annual growth rate of mobile traffic through 2022, with streaming video driving much of the acceleration.ⁱ Spectrum is of course a key limiting input to meeting the demand for data traffic, and the FCC and regulators internationally have prioritized the allocation of spectrum for 5G services. Some of this spectrum, notably the high-band spectrum, is anticipated to be shared or adjacent to existing satellite services.

Much of the regulatory structure and international coordination processes governing the sector were developed when satellites were “large and few,” leading to regulation that was “workably inefficient,” in the words of Clemson University Professor Thomas Hazlett. Satellites are no longer large and few, but increasingly small and numerous. While some are the size of a bus and weighing over 6,000 pounds, they can also be smaller than a lunchbox.ⁱⁱ Constellations can now be composed of hundreds or even thousands of satellites.

Different classes of use-cases fall into specific regulatory classifications or service definitions. For example, the Fixed-Satellite Service (FSS) provides service to earth stations at specific geographic locations.

The Mobile-Satellite Service (MSS), as one might imagine, provides services to mobile earth stations, such as satellite telephones. Satellite Digital Audio Radio Service (SDARS) provides mobile satellite radio (for example, SiriusXM is a licensee). Another important distinction in the satellite regulation realm is between active services—which both transmit and receive radio signals—and passive services, which only receive.

Spectrum Use-Cases

There is a variety of orbit types for satellites. Each type corresponds to certain performance characteristics which require differing regulatory regimes. The most important distinction is between geosynchronous orbit (GSO, also referred to as GEOs) and non-geosynchronous orbits (NGSO). Geosynchronous satellites appear fixed in the sky, as they move at the same angular velocity as the Earth and orbit parallel to the Earth's rotation. One common subcategory of GSO satellites is geostationary satellites, which are parked above the equator. GSO satellites provide coverage over a fixed area of the Earth.

In order to maintain a stable orbit, the satellite must be at a relatively far distance from Earth. GSO satellites are roughly 36,000 kilometers (22,000 miles) from Earth's surface—about a tenth of the distance to the moon. As the name implies, non-geo or NGSO satellites are simply not at the specific height needed to maintain the same rotational speed as the Earth without falling into the planet's gravitational pull. Usually the NGSO orbits of interest are significantly closer to the Earth's surface compared to GSO.

One category of NGSO satellites that is seeing particularly strong growth today is Low Earth Orbit or LEO satellites. LEOs orbit at about 2,000 kilometers (1,200 miles) or less. In between LEO and GSO orbits is the Medium Earth Orbit (MEO). There are a number of satellites in MEO orbit, perhaps the most important is the Global Positioning System, or GPS satellite constellation.

GSO and LEO satellites have different characteristics that result in strengths and weaknesses for different applications. When it comes to coverage, a single GSO can cover a very large area with constant service. LEO satellites require a constellation of multiple overlapping orbits to achieve the same coverage, and have increasing complexity of the devices on both ends and potentially resulting gaps in the area served

if the constellation is not engineered to provide continuous coverage. GSO satellites appear fixed in the sky, so earth stations do not have to move to track the transmitting satellite, which is particularly important in higher frequency bands due to their narrow beam widths. On the other hand, LEO satellites require more expensive antenna systems to track the transmissions. The frequent handoffs between LEO satellites can result in variability in service that may not be suitable for some applications. GSOs can more easily coordinate spectrum use according to their specific location in orbit using static analyses. Their stability, large coverage and relative simplicity have made GSO satellites the traditional workhorse for many applications, and their orbital slots are highly sought after.

...latency is “becoming the new digital divide.”

- Dennis Roberson

However, despite the advantages of GSOs, one of the main drawbacks of GSO satellites for communications purposes is the long delay it takes for information to travel the distance up to the high orbit and back. Jennifer Manner, Senior Vice President of Regulatory Affairs at EchoStar Corporation, noted that the high-orbit GEOs have about 600 milliseconds of latency. Many broadband applications are relatively insensitive to this level of latency, but for some applications it is a noticeable delay. Such a delay can be somewhat disruptive to interactive voice communications, for example. Other applications that depend on feedback loops on either end of the communication, such as some video games, are virtually unusable at such latencies. According to Professor Dennis Roberson, in some ways latency is “becoming the new digital divide.” Many of the newest innovations—such as augmented reality—depend on very low latency, to provide real-time feedback to the user.

The lower orbit of LEO satellites allows communications with a fraction of the latency of GSO satellites, leading to a great deal of excitement around potential LEO use for broadband and other communications purposes. Companies such as SpaceX, Kepler, Telesat,

LeoSat and others have acquired new authorization from the FCC to provide satellite service within the United States with constellations of thousands of satellites.

A Dynamic Satellite Industry Amid Growing Spectrum Demand

The number of new satellite systems, particularly satellites in NGSO orbit, is anticipated to expand dramatically. The use of satellites in low earth orbit is expected to increase by at least an order of magnitude in the coming years as economies of scale, rocket reusability and open-source designs offer unprecedented low costs in the manufacturing and launch of satellites. Although much of the roundtable discussion focused on growth in new satellite services, the importance of traditional, established operations should not be discounted.

Declining Costs and New Broadband Constellations

Sean Casey, Vice President of Business Development at Atlas Space Operations and former satellite investor, gave a presentation on the wave of disruption from new satellite companies enabled by lower cost launches and equipment. He noted that the overall investment growth in the new space race is mostly due to a handful of large, if still new, companies, most notably SpaceX and OneWeb. However, he outlined a number of trends that are driving the cost of satellites down to where their funding fits into existing Silicon Valley investing practices.

With the entrance of a multiple private-sector rocket options, the cost of payload launches is decreasing rapidly (Casey estimated the cost of payload for smaller satellites is about \$2,000 per kilogram of weight, working off of the Space X Falcon 9 rocket expenses of roughly \$60 million per launch). Companies are also reselling rocket capacity, allowing for economies of scale from payload aggregation, further driving down the costs of getting satellites into space.

Much of the interest is in new LEO constellations that are designed from the ground-up for lower-latency broadband service. Several companies are looking at large LEO constellations for broadband. If the metric is the number of planned satellites, SpaceX appears to be leading the pack and has been authorized to operate nearly 12,000 satellites. Many others are in the race, however, Telesat—a Canadian company—

has plans for just over 500 satellites, and Amazon aims for over 3,200 satellites under their “Project Kuiper” program.

Small Satellites and Other New Entrants

Small satellites, although limited in their applications compared to larger, more expensive and higher-powered satellites, are seeing significant growth. Generally, any satellite less than 500 kilograms is considered “small,” but much of the interest is around even smaller, so-called nano- and picosatellites, that are generally less than 10 and 1 kilograms respectively. These small satellites have very different performance characteristics compared to their large geostationary cousins.ⁱⁱⁱ As might be expected, smaller satellites tend to be much less expensive. Hardware can be purchased for \$100,000 or less, depending on functionality, compared to tens and even hundreds of millions of dollars for traditional satellites. Small satellites use lower power and relatively simple antennas to transmit at lower data rates. Usually small satellites have no propulsion systems and short lifespans. Despite their relative simplicity, there is tremendous expansion in educational and research applications, amateur experimentation and commercial operations.

The CubeSat design, introduced in the early 2000s, is a driving force in this wave of satellite start-ups. The CubeSat is a modular design comprised of 10 cm cubes. Modules can be linked together to add different functions or components. These uniform designs allow for sourcing of commercial, off-the-shelf components and open-source software and hardware.

The CubeSat was initially developed by Bob Twiggs and other engineers at Stanford and California Polytechnic State University with the goal of allowing aerospace students to build and fly an engineering payload within the timeline of a single academic year. Dale Hatfield, Adjunct Professor and Executive Fellow at the University of Colorado at Boulder, emphasized the importance of this educational consideration to enabling low-cost, rapid access to satellite spectrum, explaining that “you may want to try to do something within a couple of semesters and so forth... if we’re going to continue to have young people involved in aerospace engineering... you need that as part of your pipeline.”

Planet Labs is an example of an early innovator in the application of the CubeSat form factor, and is expanding considerably. The company

has launched over 100 satellites and is not alone in expanding into the fast-growing satellite-based IoT, analytics and Earth exploration services. Several small start-ups are in the investment and growth phase.

The level of sophistication and awareness of spectrum policy among these small new entrants varies. Some participants asserted a number of small satellite start-ups have “questionable spectrum assets.” One participant remarked, discussing a chart of satellite-related start-ups, that “half of those companies [being discussed] have no rights.” Some roundtable participants expressed concern about basic spectrum awareness in some of the smaller start-ups, and even with investors, of the need to acquire rights to use specific frequencies. Chris Weasler, Head of Global Spectrum Policy at Facebook, noted that it “doesn’t feel obvious” to investors that there is a firm understanding of the licensing requirements or how interference is resolved.

The ITU itself has recognized that “many nanosatellite and pico-satellite operations to date have been non-conforming to the Radio Regulations.”^{iv} This obviously presents a concern, not only for interference-free operation, but also for the potential to stifle the growth of these new services. Sean Casey compared the lack of easy access to spectrum to the lack of affordable rents in the Bay Area, worrying that “if you have to pay a high price premium for spectrum access, then that may be a barrier to entry to the industry just in general and lock people out.”

History Repeating?

For many roundtable participants, the vigor of today’s satellite sector has echoes of the past. This is not the first time the industry has seen an outpouring of excitement around NGSO deployments. In fact, LEO constellations were a component of the overall tech boom and bubble during the late 1990s. Major companies like Teledesic, Iridium and Globalstar invested tens of billions of dollars into their voice-centric systems that were ultimately undercut by broadly available terrestrial cellular service. Participants pointed out that Teledesic was one of the largest failures, along with Skybridge, TerreStar, Globalstar and LightSquared, as notable bankruptcies. The Iridium constellation was nearly decommissioned but saved at the last minute and continues today as a modestly successful company.

The relative success of terrestrial voice services—cellular wireless systems—was a significant cause of the popping of the 1990s satellite bubble. Cellular offered a compelling service at a lower price point. Even if it could not be used at sea or in many rural areas it had adequate coverage for most major urban centers and along most major freeway systems. To some extent the tensions between satellite and terrestrial allocations continue to echo through spectrum management today.

...an important consideration to achieving policy goals is to use satellite and terrestrial systems together. Historically, it has been an either/or discussion.... – Valerie Green

Satellite users are not alone in their growing demands for spectrum—a wide variety of commercial terrestrial uses, notably 5G (and before it 4G), and government users continue to require access to more spectrum resources. As former Assistant Secretary for Communications and Information and NTIA Administrator David Redl stated in a speech subsequent to our gathering, “The era of easy spectrum decisions is over.... That’s true across the board, whether you’re a satellite operator, a terrestrial wireless provider, or an unlicensed user. Spectrum has become more important than ever to our daily lives and government missions. Competition for spectrum resources has never been more contentious.”^v

However, different wireless systems are not necessarily at odds. Valerie Green, Executive Vice President and Legal Officer of Ligado Networks, noted that an important consideration to achieving policy goals is to use satellite and terrestrial systems together. Historically, it has been an either/or discussion—terrestrial or satellite—when the policy focus should be on recognizing the ways in which satellite and terrestrial networks can complement each other. This may be especially true where satellites can give ubiquitous coverage in rural areas, augmented with a terrestrial network in towns and in larger congregations of people.

Satellites and Spectrum Management

Satellite spectrum allocation is managed through long-standing, dated regulatory processes and the satellite industry is somewhat constrained by the established spectrum policy order. Satellites are managed for two crucial reasons: to avoid any physical damage from collisions in space and to avoid harmful radio frequency interference. To help mitigate the potential of interference and to manage the orbital slots used by satellites, the industry is tightly regulated at both a national and international level.

Interference occurs at a radio receiver when radios attempt to use the same spectrum, at the same time, in the same place. Spectrum managers work to maximize the valuable use of spectrum by keeping interference to an acceptable level. There are a variety of mechanisms used to control the potential of interference between different satellite systems, and between terrestrial and satellite users that share spectrum. Generally speaking, policymakers have to be concerned with interference wherever there is a receiver listening on the same frequency or, in some cases, nearby frequencies where others are transmitting. Spectrum managers typically use power limits or require coordination between services to prevent harmful interference. For example, limitations on Equivalent Isotropically Radiated Power (EIRP) and elevation angle are applied to terrestrial stations to protect earth stations and vice versa while power flux-density limits are applied to space stations to protect terrestrial receivers. Power limits may also be used to protect satellite systems from each other, most notably to protect GSO satellite systems from non-GSO constellations.

Satellite management is necessarily an international affair. Downlink transmissions from geostationary orbit can cover one-third of the Earth. The earth stations that receive satellite transmissions and “landing rights” to access a market are also regulated but on a national level. A certain level of management of limited resources like orbital slots and spectrum is necessary to maximize productive use; however, the current regulatory system is a highly complicated, multi-step process that is long and requires deep expertise to navigate. As John Leibovitz, Venture Partner at Columbia Capital, stated when it comes to the actual institutions that have been managing satellite spectrum, “There’s a certain way people have been doing things for a really, really, really long

time,” and “there’s a tendency to fall back on prior existing constructs of regulation and expectations of the way the institution” has managed spectrum in the past. It is worth laying out at least a simple overview of current processes of satellite spectrum management before discussing how it could potentially be improved.

International Processes

On the global level, the ITU within the United Nations undertakes the regulation and coordination of spectrum. The ITU process results in a document called the Radio Regulations, with detailed footnotes guiding UN member nations in their own spectrum management. The Radio Regulations consists of articles, appendices, resolutions and recommendations that are contained in four volumes. The Radio Regulations are developed through meetings called World Radiocommunication Conferences (WRCs), where the 193 Member States of the ITU meet every four years to update the treaty.

ITU member nations generally develop national spectrum management regulations consistent with the Radio Regulations developed at WRCs. International spectrum harmonization is an important tool in driving global economies of scale in equipment and devices. However, countries have the sovereign right to administer the radio frequency spectrum in their own territory provided they do not cause interference to others. Some countries do deviate from the Radio Regulations, usually those (such as the United States) with strong enough markets to command attention of equipment manufacturers regardless of harmonization.

Since the ITU is a treaty-based organization, much of the work is done through formal delegations led by Member States and by ITU Sector Members. The United States participates in the ITU through a delegation led by the State Department. Filings for spectrum rights and orbital slots are made at the ITU through the administration of member countries. This means that individual satellite firms work through the administrations of each country, not directly through the ITU, when they want to submit a filing to the ITU for the spectrum they want to use.

Getting any particular policy or allocation change through the ITU is therefore a long, slow process. WRC meetings occur every three to

four years, with the next WRC set to occur in October and November 2019, and the next after that is scheduled for 2023. Generally the scope of the agenda for these meetings is sometimes previewed eight years in advance (two WRC's meetings) and is set by the prior WRC (four years in advance), meaning significant reforms to ITU Radio Regulations (like some contemplated at the AIRS roundtable) will likely have to wait until after 2023.

At the highest level, the ITU Radio Regulations allocates spectrum to different services such as the fixed-satellite service or the mobile service. Separating the frequencies used by different types of service allows the architectures that are compatible with one another to share spectrum. The Radio Regulations also spells out specific protections, for example requiring non-GSO systems to protect GSO satellites in the FSS or BSS allocations from interference. The ITU also processes satellite network filings and records frequency assignments that successfully meet all the requirements of the Radio Regulations in the Master Register Priority of rights to spectrum. This filing process is an important mechanism in determining the relative rights of satellite operators.

Priority Rights: First to File

The primary mechanism to determine spectrum rights in the international arena is simply by the nation first to file paperwork with the ITU for a particular frequency band and, if appropriate, orbital location service. The level of priority—based upon the sequential order filings are made with the ITU—determines opening positions and relative rights when coordinating use of satellite spectrum. Those who are first to file with the ITU are expected to accommodate new entrants, but this expectation is not well defined and it is the later filing that must get the agreement of the earlier filing in coordination. The system is first-come, first-served, except for the planned bands.

Julie Zoller, Chief Government Affairs Officer with Omnispace, stressed the significance of the priority system at the ITU, saying that she “can’t emphasize enough” the importance of date priority in the international process. She explained “[Y]ou can be first to market, you can be first in orbit, you can have the greatest technology, but if you have no priority in the ITU filing process, you can lose, because the people ahead of you can become a stumbling block for that innova-

tion to happen. Date priority is incredibly important in the scheme of understanding who's going to succeed on a global level."

"[Y]ou can be first to market, you can be first in orbit, you can have the greatest technology, but if you have no priority in the ITU filing process, you can lose.... – Julie Zoller

As Valerie Green of Ligado Networks put it, "It's best if you think of it as the Wild West." Indeed, the first-to-file priority rights has echoes of how land was granted to those working frontier land in pioneer days. This system is somewhat similar to the FCC's now-defunct "Pioneer's Preference" program that offered spectrum rights to those who developed new technologies to access unused spectrum. This was adopted prior to Congress authorizing the Federal Communications Commission to auction terrestrial spectrum rights, thus lessening their value. The primary goal of the Pioneer's Preference program was to incent development of more efficient spectrum technology. However, the relative abundance of spectrum resource has changed, making such programs more difficult to justify. Perhaps at one time spectrum rights were as abundant as frontier land, but this has not been the case for technologically accessible spectrum in the United States for at least 30 years.

The logic of the system of priority through first filing is also undermined by the ratio of filings to actual satellite operations. There are a significant number of filings with the ITU that never materialize in real launches or operations, and eventually are cancelled. The tremendous advantage of being first to file incents firms to be zealous with filing for potential new satellite services, and also provides an avenue for strategic misinformation to keep competitors second-guessing the competition. Some participants confirmed that there is functionally a market for "first filings," with equipment manufacturers now often filing themselves in order to attract new business. Service operators who approach equipment companies to manufacture a new satellite are sometimes offered a packaged deal—the satellite along with the first filing rights.

This priority system is also made more difficult by the rise of NGSO systems, especially with the large number of satellites envisioned for

some broadband-focused LEO constellations. As John Leibovitz of Columbia Capital explained, the ITU first in time, first-in-right rules made more sense when geostationary service was the primary focus. There, the orbital slot for the service functions like a property right, and others can effectively share the same band of spectrum if sufficiently separated. “But the NGSOs kind of throw a wrench into that whole thing,” Leibovitz said, “The coordination is much more complex, because you’ve got this dynamic aspect of constellations passing each other and passing your competitors’ ground stations.”

Role of Auctions (or the lack there-of)

The reliance on first filings for determining relative rights to spectrum access is one of the most salient distinctions between satellite spectrum use and the more liberalized flexible-use licenses familiar in terrestrial mobile wireless. In terrestrial wireless, the FCC auctions spectrum licenses according to frequency and geography. The economic rationale behind auctions is that they reveal those who are most confident they can produce the greatest value of a limited resource. Auctions for satellite spectrum are generally barred.

The economic rationale behind auctions is that they reveal those who are most confident they can produce the greatest value of a limited resource.

The Open-Market Reorganization for the Betterment of International Telecommunications Act, or ORBIT Act, is a key law governing the satellite industry in the United States. The ORBIT Act, signed into law in 2000, came amid the privatization of the historically intergovernmental satellite organizations Intelsat and Inmarsat. Designed to help manage the privatization of major satellite constellations, the ORBIT Act is cited as a bar to auctioning of satellite spectrum.

But the exact extent of the ban on auctioning of satellite spectrum in the ORBIT Act is not immediately clear. The text of the ORBIT Act denies the FCC the authority “to assign by competitive bidding orbit allocations or spectrum used for the provision of international or global

satellite communications services.”^{vi} Some participants asserted that the law had been interpreted too broadly in the implementing regulations, and only prohibits international satellite spectrum auctions or auctions for orbital slots, but allows for domestic auctions of satellite spectrum and landing rights.

The group explored the possibility of even broader roles for auctions of satellite spectrum and associated rights. Steve Sharkey, Vice President of Government Affairs, Technology and Engineering Policy at T-Mobile, noted that in theory, national-level satellite spectrum auctions, while they may result in somewhat fragmented service and added expense to achieve scale, would not be all that different from how terrestrial mobile spectrum is auctioned today. Wireless operators bid on spectrum rights of certain geographic size, generally not nationwide licenses. Sharkey explained, mobile operators focus first on large markets, then “once you get some of the key markets, where you’re looking for New York or L.A. or big markets... you build that scale, and then smaller markets are going to go for a lot less.” At least for competitive systems, an auction could in theory function similarly for satellite operators: Bidding would take place for rights to serve different countries with a given band of spectrum, companies would then aggregate those rights up with an initial focus on the most important markets, filling out the rights to meet demand.

Jennifer Manner at EchoStar Corporation pushed back on the idea, not just on an operational basis, but also whether auctions were necessary, particularly on the space station side because of successful sharing to-date. She explained, “Satellites have been very successful, no matter what folks feel, at sharing spectrum.” Manner pointed to examples where operators have voluntarily shared spectrum, allowing firms to use more or less capacity in different markets.

Even if auctions could be a beneficial tool for allocating rights, there are institutional questions concerning potential auctions. One government participant asked whether the ITU could potentially hold global auctions for satellite spectrum and orbital slots. Others with more experience dealing with the organization were skeptical of the institutional capability to conduct such an undertaking—“I don’t trust the ITU to hold a global auction,” said one participant. The ITU would not be able to offer enforceable rights through an auction without significant

changes to the ITU convention and buy-in from participating nations. Technically the ITU is not a global regulator, but instead akin to an administrator of an ongoing treaty that member countries signed onto. As Julie Zoller pointed out, even if the ITU were to offer an auction, “You don’t know what countries are going to give you landing rights or a license until you go out there and go country to country.” Ultimately the spectrum rights for satellite users rest with the nations that participate in the ITU and have submitted satellite network filings. Therefore, if a sufficient number of nations wanted to make significant changes to the ITU’s processes or develop a new model for allocating spectrum, they could do so.

Coordination and Private Delegation

When it comes to direct cooperation between different satellite systems, different bands are governed by different levels of formal processes. “Coordination” is a specific phase in the process of avoiding interference whereby satellite operators, working through administrations, exchange information about proposed satellites, work through the potential interference scenarios and agree on mitigation measures to avoid harmful interference.

“At the end of the day, what the satellite world is really based on is a matter of coordination and working among operators and trades.”

– Jennifer Manner

Coordination is an ongoing process, functionally similar to a negotiation, that allows for satellites sharing the same spectrum to operate without causing harmful interference. The specific coordination procedures are laid out in the ITU Radio Regulations.^{vii} The importance of coordination in the management of satellite spectrum should not be underestimated. As Jennifer Manner put it, “At the end of the day, what the satellite world is really based on is a matter of coordination and working among operators and trades.”

However, not all services are subject to coordination requirements. As Julie Zoller explained, “In most frequency bands, you find satellite

allocations are governed by a coordination process, but there are circumstances where there's no coordination, where you're protected by things like equivalent power flux density limits that are applied to non-GSOs to protect GSOs." But many satellite services have to go through coordination processes, some of which are more amicable than others.

Satellite spectrum sharing can be quite complex, but the coordination process allows private firms to do much of the technical heavy lifting to maintain successful sharing of satellite spectrum. Delegating the complex and costly process of avoiding interference to private parties, and encouraging them to share and coordinate their spectrum use without the costs of the ITU regulation is "natural," in the words of Thomas Hazlett. When satellites become small and many instead of large and few "the administrative overhead of going with the same system is just exploding, exponentially problematic," he said.

Harold Feld, Senior Vice-President at Public Knowledge, however, expressed concern with the level of reliance on largely voluntary industry coordination, noting that "there are frequently people who see some advantage in being the first person to break the rules, whatever they are" where an established framework is rapidly disrupted. This concern is magnified "if we assume the ITU process is going to become too slow and unworkable and we assume the FCC cannot move fast enough or there's a real question of how you enforce when there's lots and lots of different sovereign nations that are involved in playing these games." Feld's enforcement questions echoed Hazlett's sentiments and he said, "The problem with this whole transition is that when you cede this kind of responsibility to the marketplace, then you immediately have the question of what are the adjudication procedures when disputes arise outside of the regulator."

Enforcement

One refrain during the roundtable is the need for improved enforcement or dispute resolution processes, especially if regulators continue to rely on the coordination process and private parties to resolve interference concerns. As the radio environment becomes more complex and more diverse, users are expected to get along and resolve inevitable interference disagreements. Enforcement of rules and expectations becomes a more important concern.

Dale Hatfield, Adjunct Professor and Executive Fellow at the University of Colorado at Boulder, stressed that the enforcement issue is underappreciated, saying even if parties “can negotiate these things, ultimately you’ve got to have somebody that has the ability to enforce it.” Hatfield stressed this concern and its relation to the inherently open nature of wireless systems at the physical layer, and the potential implications for security flowing from that concern.

However, the current enforcement regime, even where there are clear rules, can be lacking. Within the ITU there is a venue to hear disputes: the Radio Regulation Board. However, many roundtable participants agreed that the Radio Regulation Board does not have sufficient power to have the final say in resolving any disputes or enforcing coordination agreements. In the words of one participant, “The reality is the ITU is not going to choose a winner or a loser.”

Potential Policy Responses to Satellite Spectrum Dynamics

In addition to the general challenges posed by the complex ITU filing process, the difficulty in developing alternative methods of allocating a limited, global resource, and the limited enforcement mechanisms available in the current regime, roundtable participants discussed several specific policy goals and objectives, and offered up potential policy responses.

Policy Objectives

Satellites play a crucial role in commerce, security and innovation. Although a key over-arching theme of the roundtable was identifying outdated processes that might limit otherwise burgeoning investment in new space-based tools, there are other policy objectives that satellite spectrum policy must take into account. Some of the broad concerns include the important role of satellites in serving extremely high-cost areas to help close the digital divide and serve rural parts of the United States—and the world—that have limited connectivity infrastructure. Satellite spectrum policy should also consider its impact on innovation, in space services itself, adjacent industries and throughout the economy. Policymakers should also consider the role of competition in satellite policy.

Rural and Digital Divide. Nicol Turner Lee, Fellow at the Center for Technology Innovation at the Brookings Institution, pointed out that, “Satellites are unique in their ability to cover a very wide area. Satellites can play an important role in bridging the digital divide, particularly in rural areas.” Policymakers may want to enable a healthy satellite industry that can continue to improve broadband performance and leverage the broad coverage and reliability of the service.

Blair Levin, Non-Resident Fellow at the Brookings Institution, noted that policymaking relying on satellite broadband as an acceptable solution for rural connectivity, “involves a lot of things other than actual facts and data.” Aside from the hard data comparative cost and performance of running fiber to every home versus allowing the area to be served by satellite alone, policymakers have to make a value judgment about what level of connectivity is adequate for rural areas (although more of the hard data is needed as well, Levin noted).

To some extent, these value judgments are built into the existing subsidy allocation mechanism at the FCC. The Connect America Fund (CAF), the primary government subsidy mechanism to support deployment of broadband infrastructure to rural or otherwise high-cost areas (e.g. disadvantaged portions of urban environments) aims to be technologically neutral in the type of access network that can receive a subsidy. However, it does functionally handicap satellite participation in the program. Subsidies are allocated through what is essentially a reverse or procurement auction, and bids are weighted depending on the performance characteristics a particular network can be expected to achieve. For example, if a bidder is offering to lay fiber that can achieve faster speeds, that bid will be weighted such that it can beat out a somewhat less costly, but more meager upgrade. This bid weighting mechanism takes latency as well as speed into account in a way that functionally prevents robust satellite participation in CAF. Jennifer Manner noted it was a “70-point disadvantage for satellite ...because of latency, capacity and speeds.” In particular, the FCC’s requirement of 100 milliseconds of latency effectively precludes GSO participation. This despite the fact, she says, satellite can outcompete CAF supported builds in some markets, such as in parts of Alaska.

Claude Aiken, President and Chief Executive Officer of the Wireless Internet Service Provider’s Association, provided a different perspective

from the terrestrial side, noting that when rural fixed wireless providers build out to an area previously only served by satellite broadband, the new terrestrial provider often takes “90-plus percent of the customers.” He identified data caps, latency and cost as competitive challenges for satellite broadband, but recognized that for some portion of rural areas it remains a legitimate solution.

Enabling Innovation. The burgeoning interest in new satellite systems is an obvious area of innovation that policy should seek to enable, or at least avoid constraining. As discussed above, a sizable proportion of the investment in new space systems is broadband-focused, but entrepreneurs and new entrants are also developing new applications in remote sensing, environmental observation and space tourism. Satellite-based tools like GPS have been key enablers of disruptive new services when coupled with the powerful capabilities of terrestrial-based wireless networks. Earth exploration and passive measurement services provide crucial information that feeds into numerous systems to inform daily decision-making. Traditional satellite services—direct broadcast television, satellite radio and voice communications continue to innovate as well.

Given the diversity of applications and satellite spectrum uses, policy tools to support innovation in the area tend to be abstract rather than specific. Satellite services require significant investment and development costs before offering service. Such economic characteristics require certainty and stability—satellite operators must have the confidence that a stable regulatory environment exists and an operational environment with acceptable interference before investing the tens or hundreds of millions of dollars needed to provide service. Good regulatory tools to define those expectations, and adequate institutions to provide enforcement are needed.

However, there is also the concern of undue barriers to entry potentially challenging new entrants to explore new services, technologies or techniques. One of the crucial concerns identified at the roundtable was the potential constraint of a complex bureaucratic system at the ITU, and how it might stifle otherwise viable new services.

Competition. Different satellite services have had different levels of success in competing in the broader information technology ecosystem. Given the experience of the 1990s, where significant satellite

investments ultimately proved uncompetitive with terrestrial cellular wireless telephony, the group focused on those areas where satellite services have proven successfully competitive with terrestrial services, and on what lessons could be learned. Some obvious success stories include Direct Broadcast Satellite television (DBS), Satellite Digital Audio Radio (SDAR), on high-throughput satellite (HTS) that is able to offer fairly robust broadband service, such as that of HughesNet and Viasat. There is an expectation—as yet untested—that future NGSO satellite constellations, such as those being developed by Telesat, OneWeb, SpaceX, LeoSat, Amazon and O3b networks, will eventually be competitive with terrestrial broadband networks.

Generally speaking, satellite is most competitive where today's broadband infrastructure is unsupportable due to the economics of low population density. Other key customers of satellite service include planes and boats, especially as they traverse the various oceans and seas that make up most of the planet's surface, and trains, especially transcontinental trains traversing large land areas that are relatively uninhabited. Satellite communications can also be very effective in connecting the many far-flung operations of an enterprise customer, or connecting unique industries like mining and forestry where key operations are often far away from any existing infrastructure.

Satellite also gains market share where resiliency is particularly essential—such as during emergencies or disasters—and to provide backup for crucial public safety or national security services. Satellite can also provide competitive service for broadcast video distribution, and also narrowband services, such as IoT and smart agriculture connectivity. Additionally, there are important government systems that rely on satellite that operate outside of competitive concerns. Other than these cases, satellite is often a complement to other terrestrial service with a relatively small user-base compared to terrestrial wireless.

Harold Feld noted concerns with an aggressive shift in restructuring spectrum management toward a system that places too high a value on the most profitable uses of spectrum which can in turn undermine important but unprofitable systems. The high sunk costs and network effects of some satellite services, can have some natural monopoly tendencies, and, as Harold said, “Here are some generally regarded critical uses of satellite communication technology that make it very important

to have a satellite industry, but they don't seem to be enough to support a competitive marketplace."

Policy Proposals

A number of more specific policy proposals would assist in enabling innovation in satellite services, clear the path for competitive entry of new satellite-based entrepreneurs, and potentially help bridge the digital divide through ubiquitous high-speed broadband. A spectrum management system could better maximize the productive use of spectrum—satellite or otherwise—through a clearer, risk-informed articulation of rights and expectations around the potential for harmful interference, rather than relying on competing technical filings spelling out worst-case scenarios. Reforms to make licenses more flexible, either through a "satellite sandbox," or more modest changes to reduce the rigidity in service classifications would benefit satellite specific spectrum policy.

Incorporate Receiver Standards Responsibly. As spectrum uses become far more intense across all dimensions, and more services are packed closer together in frequency, time and space, it is inevitable that interference disputes will occur. One policy proposal relates to how spectrum managers define those borders and articulate the rights and expectations on either side by responsibly incorporating receiver standards into the regulator's toolkit.

Spectrum managers have historically thought about borders between spectrum users largely in terms of "time, area and spectrum," and as Professor Dennis Roberson pointed out, contemporary problems are increasingly concerned with area as it relates to three dimensions instead of two. As Roberson explained, "There are significant technical challenges with thousands of low earth orbiting satellites zinging around the planet and trying to interact with airplanes, and drones, and cars that are moving at high rates of speed." This incredibly complex environment calls for "a regulatory structure that can deal efficiently and effectively with this ever more complex environment." One tool Roberson pointed to is a move toward a risk-informed approach to understanding harmful interference. A second is to better define the boundaries between what is permissible or accepted interference between services and what is harmful interference.

Efforts to incorporate receivers' performance into regulatory consideration has been a recurring topic at Aspen AIRS roundtables. Interference depends on both the transmitter and the receiver, and in many ways spectrum management has historically focused much more on the transmitter (or in many cases only on the transmitter) than the receiver. Thresholds can work to define the power level receivers would be expected to tolerate at a particular area before having an actionable claim for harmful interference. Harm claim thresholds can be thought of as the protection criteria that define the borders of any particular spectrum right.^{viii}

The lack of good tools to incorporate considerations of receiver performance into regulatory decisions helps explain some of the most protracted spectrum disputes. For example, the LightSquared debacle likely could have been resolved more quickly if regulators had a good way to communicate expectations around receiver performance to involved parties. Blair Levin, who led the development of the National Broadband Plan released in 2010, noted that "the failure of the National Broadband Plan to address receiver standards [was] one of the great errors of that effort.... The fact that we still haven't done it is perhaps evidence of why we didn't do it then, but every day we delay is a problem."

Move Toward Risk-Based Interference Analysis. The need for better risk analysis when it comes to the potential for harmful interference is a recurring theme at this and other Aspen AIRS roundtables. Risk-informed interference assessment seeks to understand the real-world nature of the impact interference would have in terms of the frequency and magnitude of harm on the system level.

Dale Hatfield from the University of Colorado at Boulder argued for this approach, "We've got to stop doing things based upon worst-case interference analysis." He pointed to the work of Pierre de Vries, a previous Aspen AIRS participant, and the FCC Technological Advisory Council.^{ix} As Hatfield explained, "We can get an awful lot more yield out of this [spectrum] if we get away from the old sort of way of doing things where you use worst case. Very little probability of happening, and even if it happens, it doesn't cause any harm, but yet we still give somebody sort of a property right." Professor Dennis Roberson also stressed the importance of policymakers making this transition away from decision-making from worst case scenario to "We need to use a

risk informed approach versus the classical worst case approach. It's mandatory," he said.

Increase Flexibility. There are several ways to make the rights to use spectrum more flexible, and thereby allow operators to more quickly develop technology and adapt their systems to new uses. When it comes to flexibility in spectrum authorizations, proposals range from the more radical or experimental approach of total flexibility in a given band, to more modest alterations to licensing structures. For example, create a more general service classification. How to achieve the right balance of flexibility and confidence providing interference-free service through spectrum licenses has been another perennial topic discussed at AIRS roundtables.

One proposal shared by several participants is a so-called "satellite spectrum sandbox." The basic idea offers a band of spectrum with very minimal technical rules and otherwise extreme flexibility to facilitate easy entry and use of the spectrum. This is akin to the unlicensed frequencies in the 2.4 and 5 GHz bands, for example. The FCC does maintain an experimental licensing program and amateur spectrum access, but this group envisioned a much more permissive regime with a much longer spectrum availability than that provided by the experimental licensing program, at least allowed in one band.

One working group suggested that the "unlicensed" satellite spectrum should be located at a very high frequency and have a very large bandwidth to enable a large number of users with relatively light technical rules. Such an experimental sandbox would significantly reduce barriers to entry and potentially help foster satellite innovation by enabling experimentations with a satellite service before a firm explores procuring rights to its own protected spectrum. This would empower an emerging satellite ecosystem that cannot invest in expensive exploration of spectrum acquisition and bridge the chasm for innovators and investors.

Another participant suggested a private commons approach, whereby "you would assign the license to somebody who wants to operate it as a private commons, not an infrastructure based or service based licensee like we always assume, but one that just establishes standards for equipment that operates from the core of the Earth to the heavens, and manages the spectrum accordingly." This approach would be somewhat similar to the Aeronautical Radio, Inc. (ARINC) model

that allows a consortium of airlines to manage spectrum for their own systems, however the ARINC model does not allow flexible use, as was envisioned by the roundtable. Another potential legal model to follow is the private commons authorized under the FCC's secondary market policies.^x A management organization with the right incentives to see productive use of a band could oversee development of agreed-upon technological protocols that would facilitate sharing between different satellite and terrestrial systems.

Amateur operations and experimental licenses could also provide spectrum management models that could either be expanded or provide useful lessons for a potential satellite spectrum sandbox. Amateur satellite operations in the U.S. are allowed under FCC regulations. Operators must meet a number of technical requirements, and ITU paperwork is coordinated through the FCC's International Bureau. The FCC and ITU require that amateur satellite spectrum use be coordinated through the International Amateur Radio Union. The FCC is in the process of updating its rules for small satellites, many of which rely on either amateur or experimental authorizations.^{xii}

Some were skeptical of this radical freedom, noting that the ITU and national regulators would not be likely to get on board with privatizing their spectrum management responsibilities. Even if these organizations supported such an idea, it would take a long time to implement on the ITU's schedule, as it would have to be put on agenda for WRC-23 or WRC-27.

Others raised operational concerns. There are important spectrum protocols to control satellites, known as Tracking, Telemetry and Command (or TT&C), that provide crucial communications between the spacecraft and the ground, for example, to adjust the satellite's orbit, make changes to the solar panels, or update software controls. It is important these services operate on an interference-free basis, so even if unprotected, and unlicensed operations were permitted, protected TT&C services would have to be provided.

One easier incremental step on the way to an unlicensed satellite band, or an alternative to it, would be to offer more flexibility in how licenses are structured around service classes.

There was broad consensus among the roundtable participants that the ITU should work to move away from the narrow classifications of

different satellite services (i.e. fixed, mobile or broadcast) and allocate spectrum as a “General Satellite Service.” Such a transition to a more flexible satellite licensing regime would come with significant benefits, most notably it would allow firms to adjust to market signals much more easily.

However, a GSS allocation would come with some tradeoffs. There would be real technical challenges because of potential interference between dissimilar services and different architectures, and harmonizing regulations would be complex. The proposal would likely face opposition by incumbents who benefit by the current system, as well as the ITU itself. Despite these challenges, many participants strongly felt this was a relatively low hanging fruit to improve the agility of satellite services to adapt to market conditions. It is likely the new general classification would have to be introduced in a new, clear band before attempting to reform prior allocations.

There was a proposal from the United States presented to the ITU in the 1980s to create a General Satellite Service, but according to Jose Albuquerque, “It was shot down in the ITU just because the regulations are so complicated that to try to make a change of this magnitude would just not work.”

Conclusion

Satellite spectrum plays a key role in space exploration, innovation and economic growth throughout a number of industries. Burgeoning investment in new, small satellites is exploding, alongside serious work in larger constellations to provide ubiquitous high-speed broadband. However, many of the institutions and processes for satellite spectrum management were designed for an era when fewer satellites provided simpler services. More and more diverse spectrum users put pressure on significant reforms to enjoy continued innovation and development in the industry. Work to improve the definition of rights, the analysis of interference, and the flexibility in allocations along with appropriate and efficient arbitration mechanisms and enforcement guarantees would assist in enabling a flourishing satellite industry into the future.

Endnotes

- i. Cisco Visual Networking Index: Forecast and Trends, 2017–2022 White Paper (updated February 2019). Available online: https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.html#_Toc532256809.
- ii. Some of the smallest satellites are being deployed by Swarm Technologies Inc. See Application of Swarm Technologies Inc. for Authority to Launch and Operate a Non-Voice, Non-Geostationary Lower Earth Orbit Satellite System in the Mobile-Satellite Services, IBFS File No. SAT-LOA-20181221-00094, (filed Dec. 21, 2018) at attachment Narrative Exhibit, 1-2. Available online: https://licensing.fcc.gov/myibfs/download.do?attachment_key=1592875. Each satellite has a total mass ranging from 0.31 to 0.45 kilograms, and dimensions of 11 x 11 x 2.8 cm ($\frac{1}{4}$ U cubesat form factor), excluding the deployable antennas.
- iii. For an overview of these small satellites from the ITU perspective, see ITU-R “Characteristics, definitions and spectrum requirements of nanosatellites and picosatellites, as well as systems composed of such satellites” Report ITU-R SA.2312-0 (2014). Available online: https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-SA.2312-2014-PDF-E.pdf.
- iv. Ibid at 11.
- v. David J. Redl, “Remarks of Assistant Secretary Redl at the SIA Leadership Dinner,” (May 6, 2019). Available online: <https://www.ntia.doc.gov/speechtestimony/2019/remarks-assistant-secretary-redl-sia-leadership-dinner>.
- vi. 47 USC § 765(f).
- vii. Coordination procedures for most service classes are found in Article 9 of the Radio Regulations.
- viii. See The Spectrum and Receiver Performance Working Group of the Federal Communications Commission’s Technological Advisory Council, “Interference Limits Policy and Harm Claim Thresholds: An Introduction” (March 2014). Available online: <https://transition.fcc.gov/oet/tac/tacdocs/reports/TACInterferenceLimitsIntro1.0.pdf>.
- ix. See The Spectrum and Receiver Performance Working Group of the Federal Communications Commission’s Technological Advisory Council, “A Quick Introduction to Risk-Informed Interference Assessment” (April 2015). Available online: <https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting4115/Intro-to-RIA-v100.pdf>.
- x. See Secondary Markets Second Report and Order, WT Docket No. 00-230, 19 FCC Rcd 17503, 17549-53 ¶¶ 91-99 (2004); see also Secondary Markets Third Report and Order, WT Docket No. 00-230, 22 FCC Rcd 7209, 7210-13 ¶¶ 5-9 (2007).
- xi. See Amateur Satellites Short Info Paper, IARU. Available online: http://www.iaru.org/uploads/1/3/0/7/13073366/short_info_paper.pdf.
- xii. Streamlining Licensing Procedures for Small Satellites, Notice of Proposed Rulemaking, IB Docket No. 18-86, 33 FCC Rcd 4152, 4160 ¶ 16 (2018).

APPENDIX

Spectrum Policy and the Future of Satellites

Queenstown, Maryland
October 29-31, 2018

Roundtable Participants

Claude Aiken

President and Chief Executive
Officer
Wireless Internet Service
Provider's Association

Jose Albuquerque

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International Bureau Satellite
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Federal Communications
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Sean Casey

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Jonathan Chaplin

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Harold Feld

Senior Vice President
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Charlie Firestone

Executive Director
Communications and Society
Program
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Valerie Green

Executive Vice President and
Chief Legal Officer
Ligado Networks

Dale Hatfield

Adjunct Professor and Executive
Fellow
University of Colorado at
Boulder

Tom Hazlett

Hugh H. Macaulay Endowed
Professor of Economics
Clemson University

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

John Leibovitz

Venture Partner
Columbia Capital

Blair Levin

Non-Resident Fellow
Brookings Institution

Jennifer Manner

Senior Vice President,
Regulatory Affairs
EchoStar Corporation

Giulia McHenry

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About the Author

Doug Brake is director of broadband and spectrum policy at the Information Technology and Innovation Foundation. He specializes in broadband policy, wireless enforcement and spectrum-sharing mechanisms.

He previously served as a research assistant at the Silicon Flatirons Center at the University of Colorado, where he sought to improve policy surrounding wireless enforcement, interference limits and gigabit network deployment. Prior to that, he served as a Hatfield Scholar at the Federal Communications Commission, assisting with the implementation of the advanced communications services section of the 21st Century Communications and Video Accessibility Act.

Brake holds a law degree from the University of Colorado Law School and a bachelor's degree in English literature and philosophy from Macalester College.

About the Communications and Society Program

www.csreports.aspeninstitute.org

The Communications and Society Program advances democratic values through communications and information technology policy. The Program convenes diverse global leaders and experts, frames issues for the exchange of insights on the societal impact of digital and network technologies, and catalyzes new policies and leadership that serve the public interest. It enables global leaders and experts to explore new concepts, exchange insights, develop meaningful networks, and find personal growth, all for the betterment of society.

The Program's projects range across many areas of information, communications and media policy, such as artificial intelligence, broadband and spectrum policy, race and media, institutional innovation, and diplomacy and technology. The Program has also run ongoing projects on trust, media and democracy, and on the future of public libraries.

Most conferences employ the signature Aspen Institute seminar format: approximately 25 leaders from diverse disciplines and perspectives engaged in roundtable dialogue, moderated with the goal of driving the agenda to specific conclusions and recommendations. The Program distributes its conference reports and other materials to key policymakers, opinion leaders and the public around the world. Its digital reports platform aims to inform and ignite broader conversations at the intersection of democracy and communications technologies.

The Program's Executive Director is Charles M. Firestone. He has served in this capacity since 1989 and is also a Vice President of the Aspen Institute. Prior to joining the Institute, Mr. Firestone was a communications attorney and law professor who argued two cases before the United States Supreme Court and many in the courts of appeals. 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 Communications Policy Project

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

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 Matthey 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 landscape, 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 Boldier

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

Making the Invisible Visible: Redesigning Business Processes for Exponential Organizations, by Richard Adler

The 2015 Roundtable on Institutional Innovation took place July 20-22, 2015 in Aspen, Colorado. The Roundtable gathered high level executives from leading organizations to address, and where appropriate reframe, approaches to institutional performance through innovation. This report, written by rapporteur Richard Adler, explores how corporate leaders are thinking about exponential business operations — utilizing digital technologies to leverage assets and scaling learning to accelerate innovation. It delves into strategies of modularization, rapid iteration, and utilizing transparent metrics, among others, all with the aim of becoming more adaptive and increasing performance of the organization. 2016, 44 pages, ISBN Paper: 0-89843-644-3, \$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 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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