The Reallocation Imperative:
A New Vision for Spectrum Policy

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The Aspen Institute

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Communications and Society Program
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Contents

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

Spectrum allocation and management in the United States is always a contentious matter. The current allocations were made long before the digital era and before cellular wireless changed how people communicate. Today, cellular network usage is skyrocketing because of the tremendous use of smartphones, tablets, e-readers and other devices as well as the apps and services accessed by those devices. As a result, new ways of allocating, clearing, using and/or sharing spectrum controlled by private parties and government agencies represent a ripe topic for discussion and action. The 2011 Aspen Institute Roundtable on Spectrum Policy (AIRS), "The Reallocation Imperative," met in the fall of 2011 to address the diverse approaches to the topic and attempt to step back to establish a broad vision for reallocating spectrum in the United States in the public interest.

Participants began by framing the need for reallocation, establishing where we are today, why there is a need for change and why it is necessary to frame this issue in terms of reallocation.

The group then aimed to map out elements of reallocation and discuss new approaches to spectrum allocation that could facilitate more effective and efficient spectrum use.

With these reallocation elements in mind, the group then set out to formulate a new vision for spectrum policy, delving into specifics while still addressing the most effective way to move from vision to action. Prevalent issues throughout the Roundtable included broad considerations of spectrum policy, the role of the government in encouraging innovation, the importance of licensed and unlicensed spectrum, spectrum sharing and the feasibility of reallocating federal spectrum.

As the following report details, the discussions were lively, knowledgeable and concrete. At the end of the report, the Roundtable rapporteur, Preston Marshall, sets forth a number of recommendations that he gleaned from the conference dialogue to guide future spectrum policy development, congressional actions and technology explorations. While these recommendations generally reflect the sense of the meeting, there were no votes taken. Accordingly, participation in the dialogue should not be construed as agreement with any particular statement in the report by the participant or his or her employer.

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April 2012

Executive Summary

In November 2011, the Aspen Institute Communications and Society Program held the latest in its continuing series of roundtable discussions on spectrum policy. The focus of this year's Roundtable was "The Reallocation Imperative." This Roundtable brought together federal government regulators, academic and technical experts, industry representatives and public interest groups. Although this Roundtable focused on spectrum reallocation, the scope of the discussion addressed a wide range of issues that have arisen as the need for mobile spectrum has become more critical, and as competing perspectives on the objectives of spectrum policy have emerged.

The Federal Communications Commission's National Broadband Plan framed much of the consideration of spectrum policy. This plan asserted that there is a need for an additional 500 MHz for wireless broadband services over the 10 years from 2010 to 2020 (and 300 MHz over the five years from 2010 to 2015). According to the plan, this need is to be met through reallocation from federal users, repurposing of existing civil sector spectrum through so-called voluntary incentive spectrum auctions (whereby incumbent licensees receive a share of the auction proceeds in exchange for vacating the spectrum for which they hold licenses), and auctioning spectrum in the commission's existing inventory.

There was general consensus at the Roundtable that current spectrum policy has been reasonably effective in meeting some of the goals originally intended for the auction process. These include the distribution of spectrum and raising government revenue. However, many participants felt that other goals of the auction process, such as promoting economic activity and competition, efficient use of the spectrum, avoiding concentration of licenses and providing rapid deployment, are not sufficiently addressed in the current policy. How policy could simultaneously address the need for revenue, meet the needs of the National Broadband Plan and still address these original auction goals was a focus of much of the roundtable discussion.

The conversations ranged from broad consideration of spectrum policy to its future direction. This policy must not only meet the needs

for expanded wireless broadband services, but it must also consider spectrum policy in the context of fostering innovation and associated economic activity, resolving the increasing co-existence issues among incompatible spectrum uses, the appropriate uses of licensed and unlicensed spectrum and the incentives and regulations required to repurpose existing commercial and federal spectrum allocations.

The role of federal government spectrum policy in fostering innovation was an emerging theme at the Roundtable. Participants generally agreed that the current process for spectrum access does not support rapid deployment of new technologies and services, and that it is incompatible with the model of innovation that was so successful for Internet innovation. However, a strong consensus on the solution to this problem could not be reached, in part, because of concerns over establishing an industrial policy or re-instituting a command-and-control regime for spectrum.

At the time of the Roundtable the issue of coexistence was illustrated by the controversy between the proposed LightSquared wireless service and current Global Positioning System (GPS) users. As a result, there was strong consensus that a more formal and explicit treatment of the rights of spectrum users, and the definition of the environments in which systems must operate, will be needed to address future coexistence issues. This issue is likely to become more critical as increasingly flexible spectrum policies enable spectrum license holders to seek more valuable uses for existing spectrum, and thus seek to deploy systems that may be incompatible with the adjoining spectrum users. Regulatory flexibility would provide more access to spectrum, but the inevitable consequence will be conflicts about these more flexible uses.

There was general consensus that both licensed and unlicensed wireless technologies have resulted in an explosion of innovation and associated economic activity and societal benefits. These technologies have, to a degree, become complimentary. For example, unlicensed technologies have become a significant augmentation to the commercial wireless services that depend upon a sufficient supply of licensed spectrum.

That said, participants noted the policy conflict if cleared spectrum is desired for additional unlicensed spectrum access or if spectrum shared between unlicensed devices and licensed incumbents becomes subject to auction. In particular, the use of auction revenue to fund realloca-

tion actions (such as relocation of federal users) and incentive auctions would appear to constrain expansion of unlicensed access into bands freed up in such a manner. The sharing of spectrum in time, geography or frequency on a noninterfering basis among multiple, compatible uses, either on a licensed or an unlicensed basis, was an important topic of discussion and is discussed in the report. There was general recognition that the complete relocation of federal users would not be a practical or sustainable strategy to satisfy the entirety of the future spectrum needs of commercial users. The federal spectrum candidates for relocation appear to have some impediments in the form of current incumbent systems. While spectrum sharing has been proposed for a decade or more, there remains interest in the idea that sharing may be one possible solution to provide expanded early access to spectrum without having to incur the cost of relocating every existing federal user or wait out the lengthy time such relocation would take. Furthermore, participants surmised, the use of incentives will be essential to repurpose non-federal spectrum, regardless of whether that spectrum was initially granted by the government without payment.

A number of recommendations developed during the course of the Roundtable appear in the report as considerations for future spectrum policy development, congressional actions and technology explorations.

The Reallocation Imperative: A New Vision for Spectrum Policy

Preston Marshall

The Reallocation Imperative

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Introduction

In November 2011, the Aspen Institute Communications and Society Program held the latest conference in its continuing series of roundtable discussions of spectrum policy, "The Reallocation Imperative." This Roundtable brought together academic technical experts, industry representatives, key officials from federal regulatory agencies (the National Telecommunications and Information Administration, Department of Defense, Office of Science and Technology Policy and the Federal Communications Commission) and representatives from foundations and public interest groups.

Although there have been no major national policy initiatives since the previous Aspen Institute Spectrum Roundtable, the issue of expanding wireless communications capacity has become more pressing. In addition to the continued and accelerating growth of cellular and smartphone usage, 2011 has seen the explosion of tablet devices onto the market. Tablets demand bandwidth that is similar to laptop and desktop systems, but they do so in a highly mobile, wireless-dependent modality that was almost unimaginable only a few years ago. Unlicensed services that some had seen as competition for commercial wireless services are instead being tightly integrated into carrier wireless services. Recently, carriers started or announced major initiatives to shift traffic from their 3G/4G networks onto unlicensed networks, where available, as well as to small cells, similar to the transition envisioned in the 2009 Aspen Institute Spectrum Roundtable, "A Fiber Intensive Wireless Architecture."[1]

There is a general perception that although spectrum policy has been relatively effective at provisioning bandwidth for wireless service providers, it has not been as effective in supporting the emergence of innovative technology and services and the economic activity that could result. One participant described spectrum as the "Valley of Death" for

innovation, due to the lengthy, unpredictable and entangled political, policy, regulatory and technical process of making spectrum resources available for rapid innovation.

Although this conference was titled in reference to spectrum reallocation, much of the discussion developed around the complexity of relocating existing federal systems. It therefore focused on the necessity of developing and adopting new spectrum management and policy frameworks for future spectrum allocations. These frameworks will need to address the need for wireless broadband spectrum along with broader issues of national interest, social and economic policy and the role of the government in arbitrating among public and private interests in the spectrum, and competing private sector interests.

At the Roundtable there was overwhelming agreement that simply clearing spectrum bands and auctioning them to the highest bidder was unlikely to be sufficient to meet the growing needs for suitable wireless spectrum. To achieve maximum spectrum utility and support the growth in wireless outlined in the FCC's National Broadband Plan, policymakers will likely have to implement other approaches to spectrum policy, including incentive auctions, a range of options for spectrum sharing and more elastic definitions of interference.

There was general agreement that while the current spectrum process has been effective in raising revenue and provisioning spectrum for wireless carriers, a number of other issues regarding spectrum policy have not been so adequately addressed. Balancing many aspects of spectrum policy was an important and ongoing concern throughout the Roundtable.

Finally, there was disagreement at the Roundtable over the degree to which the market processes solve all aspects of spectrum-usage policy. For example, some participants raised concerns about the market's ability to resolve the rights of adjacent spectrum users, and the economic role of unlicensed devices and services. Similarly, concerns were raised regarding the current market mechanism's ability to support the rapid development and deployment of new and innovative spectrum-based products and services.

Background

This report falls on the 100th anniversary of the events that drove the establishment of spectrum regulation in the United States. Interestingly, the issues that drove the push for regulation of airwaves as early as 1903 are similar to those that drive regulation today: assurance of competition, reduction of interference, interoperability and concern over the impact of market forces.

Europe saw the need for regulation of spectrum and wireless communications as a consequence of the exclusionary and anti-competitive practices of the Marconi Company due to their "rule of non-intercommunication." Governments were unwilling to leave spectrum resources in the hands of market forces. Therefore, at the Berlin International Radio Telegraph Conference in 1903, they began the process of establishing regulations that partitioned the spectrum into bands for different uses, enforced bans on anticompetitive practices and managed the conditions that could cause interference.[2] The fundamental frameworks established at this time are very much the guiding principles in the national and international regulation of spectrum today. Many of these underlying assumptions (exclusive use of spectrum, necessity for the government to manage interference and the role of markets, and others) were challenged at this conference.

The United States was actually one of the last western countries to accept the need for spectrum regulation. This relaxed attitude ended abruptly with the sinking of the Titanic in 1912. Lack of standardized radio communications policies and communications interference were partially blamed for the degree of loss of life, and the United States entered into a policy of regulating spectrum, and spectrum users, with the Radio Act of 1912.

Making additional spectrum available for expansion of wireless has been a necessity since the inception of commercial wireless services. Initially, the government made spectrum assignments at no cost to several wireless operators. However, spectrum licensing eventually transitioned to market-based auction mechanisms that not only removed government decision making from the process but also became significant sources of revenue to the federal government.

Spectrum Auctions. The growth of wireless services coincided with the emergence of a broad consensus that the government should not be the arbiter of the optimal use of spectrum and that a more market-oriented and market-driven mechanism should replace the government command-and-control framework. As far back as 1959, Ronald Coase advocated that the government should treat spectrum similarly to any other resource and manage it through market mechanisms.[3]

As far back as 1959, Ronald Coase advocated that the government should treat spectrum similarly to any other resource and manage it through market mechanisms.

A series of auctions of spectrum for wireless services appears to have established the auction as the preferred, market-based mechanism to transfer control of spectrum into the private sector, and through the pricing at auction more closely achieve its "highest and best use." At the same time, the auction process has been overlaid with a number of additional public policy objectives, including support for public safety users, entrepreneurs and minority-controlled enterprises. The auctions were also accompanied by a flexible-use spectrum allocation policy (the FCC avoided dictating the use of the auctioned spectrum). For example, Personal Communications Service (PCS) spectrum was allocated for flexible use. PCS licensees could use the auctioned spectrum for fixed or mobile technology.

In general, these auctions were successful. They provisioned spectrum to the emerging wireless carriers, and provided a significant amount of revenue.

The perceived demand for services and the ability to provide a consumer product to deliver the service has a major impact on auction revenues. The Wireless Communications Service (WCS) and Local Multipoint Distribution Service (LMDS) in February-March 1998 (Auction 17) demonstrated that auctions are not just a function of spectrum bandwidth and population coverage, but they are also highly sensitive to technology and equipment availability. In these auctions, the offered spectrum did not have consumer equipment available to

exploit it and had significant wireless environmental issues. The auctions failed to achieve the revenue targets, and some licenses were sold for essentially zero. In the case of LMDS, when the same spectrum was re-auctioned after equipment became available, the spectrum auction yielded significantly more revenue. The degree to which auction structure should reflect commercial practices and high-value uses became a subject for discussion. In another controversial approach, the FCC set aside the PCS C Block auction to assist entrepreneurs in obtaining spectrum. The auction actually yielded higher bids, on a per MHz basis, than the unconstrained A and B Block auctions, due to the favorable financing terms provided by the government. In the end, however, a large number of the successful bidders went bankrupt. Consequently, the bankruptcy litigation, subsequent auctions and court rulings created uncertainty, delayed use of the spectrum and resulted in a loss of revenue to the government.

The Federal Communications Commission continued a transition away from regulatory procedures as articulated in its 2002 *Spectrum Policy Task Force Report*.[4] The authors recommend removal of many restrictions on how licensees could utilize spectrum, the establishment of secondary markets for spectrum, the allowance of limited levels of interference in any band[5] and expanded opportunities for secondary sharing of bands through technology such as cognitive radio dynamic spectrum access (DSA) technology. While many of the recommendations of that 2002 report were not formally enacted, they strongly influenced subsequent policy thought on spectrum and manifested themselves in proposals such as the incentive auction concept in the FCC's National Broadband Plan.

The legal regime that established the FCC's authority to conduct spectrum auctions was not intended solely to focus on maximizing revenue, but also to consider nonrevenue factors—these include promoting economic activity and competition, using the spectrum efficiently, avoiding concentration of licenses and providing rapid deployment of services.[6] How these nonrevenue aspects of auction operation should be integrated into spectrum policy became a significant topic of discussion throughout the Roundtable. Some of these considerations have been addressed in subsequent congressional action, described at the conclusion of this report.

Growth in Wireless Bandwidth Demand. It is apparent to all observers that the demand for wireless access to the Internet is growing beyond any of the initial projections. Cellular architectures were initially developed for voice services, but the bulk of traffic is now Internet data. The data-focused Long Term Evolution (LTE) and LTE-Advanced (LTE-A) cellular architectures are beginning to be deployed on licensed spectrum, as the wireless carriers strain to keep up with the ever-increasing demand. The growth in user bandwidth is further accelerated by new products such as low-cost tablet devices that have become popular replacements for fixed devices that previously were the primary method of providing Internet access.

A number of projections for wireless bandwidth demand have been developed. The most quoted, and the ones cited in the National Broadband Plan, are by the Yankee Group, Coda Research, and Cisco Systems, which project wireless bandwidth usage to increase from 2009 to 2014 by factors of 23, 35 and 50 respectively.

National Broadband Plan. The FCC released its National Broadband Plan in March 2010. One chapter specifically addresses the spectrum implications of the plan, establishing the goal of providing an additional 300 MHz in 5 years, and 500 MHz in 10 years. Specific spectrum goals in this plan include the following:

1. Ensure greater transparency concerning spectrum allocation and utilization.
2. Expand incentives and mechanisms to reallocate or repurpose spectrum.
3. Make more spectrum available for broadband within the next 10 years.
4. Increase the flexibility, capacity and cost-effectiveness of spectrum for point-to-point wireless backhaul services.
5. Expand opportunities for innovative spectrum access models.
6. Take additional steps to make U.S. spectrum policy more comprehensive.

Although the Roundtable was not focused around these specific points, all but item four recur through the issues that dominated the discussion.

Implicit in the National Broadband Plan, and in a subsequent speech by Lawrence Summers of the National Economic Council (NEC), is that a "spectrum crunch" exists that might constrain the growth of wireless bandwidth access and that wireless broadband is the best and highest usage.[7] The Roundtable challenged both of those core assumptions. Some argued that wireless bandwidth could be provided through a number of architectures, independent of additional spectrum. Some thought a sole focus on spectrum for wireless broadband might preclude other innovative new technologies and services.

Additional spectrum could be made available through three mechanisms. Some current federal spectrum would have the existing incumbents relocated to other spectrum; existing commercial spectrum would be repurposed through a variety of mechanisms, including reallocating some unused spectrum and incentive auctions of broadcast spectrum holdings; and, the FCC would auction its existing inventory of spectrum.

Federal Spectrum Repurposing and Reallocation. In a June 2010 memorandum President Obama directed the Commerce Department to develop a plan to provide wireless broadband spectrum and to release the plan by October of that year. On November 15, 2010, the Commerce Department responded with the "Fast Track" report that addressed making 115 MHz available in 5 years. It also presented a long-range plan for making the full 500 MHz of spectrum available, 280 MHz of which was existing commercial spectrum that would be repurposed for use in wireless broadband services.

At the time of this Roundtable, no official position on federal band relocation or reallocation had been established, but there was recognition that the federal government could not rapidly vacate the required spectrum and relocate its systems to other spectrum. Given existing laws and policies there is also the potential that it could not do so economically.

These are the bands under consideration in the Fast Track report:

1. 1675–1710 MHz
2. 1755–1780 MHz
3. 3500–3650 MHz
4. 4200–4220 MHz and 4380–4400 MHz

None of these bands, with the exception of 3500 MHz band, has an extensive amount of spectrum. Reallocation of the 1755–1780 band is complicated by the fact that the 1710–1755 band was recently reallocated for the AWS-1 auction. Many of the federal incumbents now in the 1755–1780 band just completed their relocation from the 1710–1755 band and are again in a band now under consideration for reallocation. On the positive side, commercial users who deployed the 1710–1755 MHz band now have significant experience in relocating such systems.

Other bands under consideration appear to have some significant constraints on commercial use. Systems such as large, shipboard radars are impractical to relocate in the spectrum, so they must be protected from interference. When operating, they are themselves highly mobile sources of very significant levels of interference to any civil user of the band.

Non-Federal Spectrum Repurposing and Reallocation. One of the innovative approaches proposed in the Broadband Plan includes holding incentive auctions. In the incentive auction, existing spectrum license holders offer to relinquish the license in exchange for a portion of the proceeds they receive at auction. The government meets its policy objectives of providing more spectrum, and receives a portion of the revenue from the auction.

In this approach, the government would function as an intermediary in a secondary market for spectrum. The spectrum cannot be placed directly into the secondary market for wireless broadband because the licenses involved are constrained to the specific purpose for which they were initially granted (a purpose other than wireless broadband). Therefore, wireless carriers cannot acquire the spectrum to provide

wireless broadband service. The licenses would have value after the government removed these constraints on their usage, aggregated them, and made the license terms similar to that of spectrum obtained from the wireless auctions.

Research and Development. The Broadband Plan also has specific recommendations regarding direction, funding and tax treatment relating to spectrum, more general networking and Internet research and development. It recognizes that there are a large number of potential technologies that could address the spectrum shortfall, including more spectrum efficient technologies, more capable components and new architectures for services.

The Broadband Plan explicitly recognizes that federal government investment in research and development led to the growth of the Internet, and by consequence, the associated economic activity, and the emergence of, in its words, "multibillion-dollar companies that are global leaders in networking, search and other Internet-based businesses."

The Plan recommends that research be conducted to allow benefits over a much larger range of time, to include short-term and longer-term benefits, and suggests the National Academies develop a roadmap for research.

The Plan also recognizes that policy makers are forced to make decisions on new technologies without experimental or other evidence as to their effectiveness and impact on other users. Recommendation 7.6 states: "NSF, in consultation with the FCC, should fund both a wireless testbed for promoting the science underlying spectrum policymaking and a testbed for evaluating the network security needed to provide a secure broadband infrastructure."

There has been enthusiasm regarding the capabilities that might be available to resolve spectrum shortfalls due to the emergence of cognitive radio technology. However, only one large-scale field experiment with this technology has been conducted and reported. This experiment was with systems very different from those used in civilian wireless broadband.[8] Therefore, the policy, regulatory and commercial communities have little available evidence to make decisions regarding the suitability of these technologies.

A related recommendation is for the FCC to ease licensing of experimental use of spectrum. Flexible spectrum experimentation would enable accelerated research into spectrum-efficient technologies and services. To date, much of the academic research into spectrum technology and advanced architectures has been constrained by both the availability of flexible test and experimentation platforms and of suitable spectrum that could be used to create prototype systems more closely related to those used in commercial wireless. Access to experimental spectrum would remove one of these constraints. This would enable innovative academic research to be more directly applicable to the development of technology suitable for inclusion into commercial wireless systems.

Investment in this type of experimentation and research was proposed in the National Broadband Plan and has been an element of the administration's proposed Wireless Innovation Fund (WIF) research and development. Most recently, research was included in the Employ America Act funding. There was considerable discussion about the viability of a testbed that could serve both for research into the science of spectrum and as a way to validate specific technologies (the testbed technology to perform basic research in wireless is fundamentally different from that needed to validate specific engineering implementations).

Seven Fundamental Issues

Spectrum policy has innumerable issues and questions; however, the discussion at the Roundtable centered around seven fundamental and interrelated questions that frame and motivate spectrum policy:

1. **Structure:** There is a shift in the focus of cellular from "building out" for coverage to "in-building" to achieve density and to leverage other modalities, such as unlicensed access. What are the consequences of this for future spectrum policy?

2. **The Role of the Government in the Spectrum Market:** What is the role of the government in managing spectrum and making decisions? How applicable is the pure economic model for optimizing the spectrum? Are there, and/or should there be

policies to specifically promote innovation in technology and services, or should market forces alone determine best and highest use?

3. **Unlicensed Spectrum:** Is there a need to allocate more unlicensed spectrum? If so, which band or bands are best suited to unlicensed use? Is all proposed unlicensed use of equal value, or is there a reasonable way to determine priorities for future applications and relevance to the spectrum crunch? How is the requirement for unlicensed spectrum to be satisfied when auctions are seen as the best source of funds to clear spectrum and to supplement funding for other national purposes and deficit reduction?

4. **Highest and Best Use:** How can spectrum be recaptured and made available for its best use through whatever process or allocation is appropriate?

5. **Spectrum Sharing:** Definitions of spectrum sharing vary greatly. Much of the resistance to sharing may be driven by different assumptions of what it entails. How can a clear taxonomy of sharing concepts be established?

6. **Spectrum Rights Regimes:** Are specific spectrum rights regimes necessary? How should they be imposed, and what would they protect?

7. **Long-term Strategic Planning:** How can planning for federal spectrum usage be longer-term and more transparent for both current and future spectrum users in order to better adapt investments in spectrum dependent systems?

The Roundtable discussion cut across a wide range of topics, but centered around the preceding seven fundamental issues. Although they are discussed individually below, they are highly interrelated. For example, spectrum sharing is a potential enabler of additional unlicensed access; spectrum rights and responsibilities could enable more flexible access to the spectrum, etc.

Implications of Cellular "In-Building"

Throughout the discussion, there was implicit and explicit recognition that the basic architecture of wireless services is in transition. The slow but fundamental shift in cellular infrastructure from a focus on achieving coverage to the need to provide high density communications is changing the spectrum needs for future wireless services. This change might favorably impact the ability of cellular to exploit spectrum that may still have long-term federal or other incumbent users.

The slow but fundamental shift in cellular infrastructure from a focus on achieving coverage to the need to provide high density communications is changing the spectrum needs for future wireless services.

The fact that cellular providers have made significant use of short-range WiFi hotspots to off-load 40 percent of the smart phone traffic[9] is evidence that homogeneous, tower-based architecture is not the future of cellular. It will evolve to a heterogeneous mix of lower power, local communications (such as WiFi, femtocells and/or pico-cells) to meet the demand for bandwidth.

Even if an additional 500 MHz were made available for cellular, it would only double the available spectrum. To meet the projected need for a 50 fold[10] increase in user bandwidth, the effectiveness of existing spectrum must provide a 25 fold increase in bandwidth capacity. At the Roundtable there was a consensus that most of the increase in cellular bandwidth must come from spectrum reuse of the existing cellular spectrum. To meet the objectives of the National Broadband Plan, it will be essential not only to provide more contiguous spectrum but also to create a technological, economic and regulatory environment in parallel that fundamentally increases the effectiveness of how spectrum is used and the quantity available.

There was general agreement that increases in cellular capacity in existing spectrum can be achieved, but over time and at additional cost as carriers deploy new technologies. There was also general agreement that significant capacity is obtainable though use of unlicensed

spectrum. However, there was not agreement on what the deployment would cost compared to a conventional cellular deployment.

In a discussion of several examples, participants pointed out that the Metro PCS experience demonstrates that using only short-range spectrum was effective but demanded more capital expenditure resources. Some participants argued that low cost infrastructure deployments, such as femtocells and pico-cells, are as cost-effective or even less expensive.

Republic Wireless, which is using a mixed WiFi and cell-tower architecture with WiFi as the primary modality, demonstrates a counter case to the assumption that CMRS-type services must be based on exclusively licensed spectrum. Cablevision, for example, creates an unlicensed mobile cloud in its cable footprint to offer a competitive product to CMRS. Although the government's intent is to be technology-neutral in the auction process, the government has significant technology selection influence through the terms and conditions of the auctions.

It is not clear that the implications of this shift from providing coverage to addressing device and user density is fully reflected in spectrum policy and planning in either the private- or public-sector. Participants were equally uncertain whether small cell deployments were more or less expensive in terms of coverage cost. The planning for spectrum sharing in bands with high power Long-Term Evolution (LTE) deployments[11] would be fundamentally different from the planning for sharing with low-power pico and femtocell devices. The "keep away" distances speculated for the 3.6 GHz band would be very different if the auction winner elected to use a large number of local cells rather than the conventional tower and base station deployments.

Several participants speculated that the additional cellular capacity could be provided without more spectrum but potentially at a higher cost through in-building penetration (however, this is very geographic-specific). They felt that the need to reallocate spectrum is not so much an imperative requirement but rather a cost-control mechanism. The cost of this mechanism may be precluding other types of services in the spectrum. Certain urban outdoor WiFi deployments demonstrate that high levels of coverage are possible with low-cost technology over at least limited geographies; however, market examples of such networks over broad metropolitan areas are scarce at best.

The Role of Government in the Spectrum Marketplace

Perhaps the most contentious broad issue in the discussion of spectrum was defining the goal of government spectrum policy. There were clearly two positions on this:

1. The government should trust the marketplace; therefore, its job is to get spectrum into productive, private hands as soon as possible and allow the marketplace to determine the best and highest use.

2. The government should use its control over spectrum to encourage technological innovations and other activities that will create economic or societal value.

Current communications policies are compromises between these two positions, but some participants stated that spectrum policy was tilted toward the first of these principles, as the auction process has essentially precluded other considerations. The apparent desire to use spectrum auction revenue to close the national budget gap only added to this perception. Some view this as one of the fundamental constraints on congressional support for any policy that would reduce the immediate revenue from auctions.

The advocates of the second approach point to the inability of the current spectrum process to support the business cycle needed to establish new technologies in the marketplace. One attendee referred to spectrum as the "Valley of Death" for innovators and pointed to the indeterminate nature of the process to resolve issues such as those involving new entrants LightSquared and M2Z. The uncertainty in time and cost to obtain spectrum precludes the venture investments that have been the basis of much of the technology innovation elsewhere in the economy.

Although there appears to be no clear path to reconcile more immediate access to spectrum with the current auction and relocation processes, there was strong consensus at the Roundtable that fostering innovation requires a mechanism to provide timely and predictable *access* to spectrum. This mechanism would need to support the time

lines of innovation, such as seen during the growth of the Internet. The National Broadband Plan notes that, based on the most recent five major spectrum reallocations, the time from the first step to the spectrum being available varied from 6 to 13 years, with a median time of over 9 years.[12] This is far from supportive of innovation. Only highly stable applications and markets can consider an investment with such a long delay from inception to the marketplace.

One example of the inability to predict innovation, and thus plan for it, is the rapid evolution of the technology that has occurred in the unlicensed bands. At the time it was established, the benefit from unlicensed technology would have been difficult to foresee.[13] Many of the companies that have come to dominate this market segment did not even exist at the time this allocation was performed. Of course, history now shows the benefit of unlicensed operation, largely because the technology (e.g., IEEE 802.11) evolved to support a highly desirable use case—broadband access. The degree to which this highly-adopted unlicensed technology is being integrated into wireless services operating on exclusively licensed spectrum was largely unanticipated.

…fostering innovation requires a mechanism to provide timely and predictable access to spectrum.

As yet, there has not been an extensive public debate on the merits of more direct intervention in the spectrum market.[14] The advocates for continuing the current auction process consider the auction process as representing minimal interference in the market, and the alternative as a quasi-industrial policy. Auction advocates point to a long history of innovation and technological change in flexible-use, licensed services. Conversely, the advocates for more aggressive consideration of alternative policies argue that the current policies are implicitly based around, and therefore biased in favor of, established technology and architecture. These policies, they argue, are inherently hostile to the emergence of new technologies and architectures. In effect, they say, the government is picking marketplace winners by tailoring the auctions to maximize revenue from the established industry, using the established technology.

One practical implication of this is in the determination of which spectrum to auction. Some have suggested that spectrum auctions should be synchronized with the technology base in order to be successful. Since some of the bands under consideration for wireless broadband are quite high in the band compared to what is in use in commercial wireless services (3.6 and 4.2 GHz, for example) and for which equipment is available[15], the government's interest might be best served by not auctioning spectrum before the technology and engineering base is available to exploit it. In the meantime, perhaps such spectrum could provide short-term usage (such as unlicensed operation) provided that devices could actually cease using the band when licensed technology and equipment becomes available. Such an approach would likely maximize the revenue from spectrum licenses.

Others suggested that spectrum auctions should not be synchronized with technology. Such spectrum auctions would likely yield less revenue (as discussed in the background material). This lower cost of entry would be more likely to foster new and innovative services that could not emerge if competing with the established service and technology models.

It was suggested that the community should look at historically nonspectrum innovators that have come to the FCC for spectrum to understand why the process did/did not work for them. Why, for example, did the medical band advocates not see unlicensed spectrum as an option for their technology? Why did they believe the viability of their market required a dedicated (albeit only 4 MHz) band? This decision significantly delayed their opportunity to enter the marketplace, when unlicensed spectrum appeared to be an option for immediate deployment.

One suggestion to create more certainty in obtaining spectrum was to establish a fixed price for clearing federal spectrum. This would enable organizations to place these costs into business plans. Although such an approach would not reduce the delay in obtaining spectrum, a fixed price would provide predictability regarding the cost and availability of this key resource.

Participants recognized that the potential introduction of new principles of spectrum policy, such as spectrum sharing overlays or under-

lays, unlicensed access, receiver standards or spectrum usage rights, all have implications for existing licenses. While there was agreement that the government could impose additional restrictions or obligations on licenses that were not competitively purchased, there was considerable debate about the changes in the conditions of licenses that had been obtained in previous auctions.

Although auction design was not a specific topic of discussion, there was general concern about unintended consequences of non-revenue auction considerations. The experiences of the 1994 PCS C Block auction (not to be confused with the C block 2008 700 MHz auction), with its high rate of bankruptcy and litigation, made many Roundtable participants cautious of nonrevenue objectives as potential distortions of the spectrum market.

Since property law is often used as a metaphor for spectrum policy and principles, a number of participants speculated that as spectrum is affected by a number of changes—increasing density of utilization, new technology and shifting national priorities—the nature of property rights should change as well.

Some foresee the spectrum equivalent of imposing zoning restrictions, resource protection areas,[16] environmental protections and other forms of retroactive adjustment of property. This view argues that while breaking down the command-and-control framework that dominated spectrum policy is a beneficial action, it is likely that some features of the command-and-control regime will need to be retained, or even reinstated.

Some participants expressed the view that current spectrum policy is overly, and almost exclusively, focused on a property-rights metaphor. This metaphor precludes competition among different spectrum ownership, control and sharing models. Such models might include short- and medium-term rental, additional unlicensed and shared licensed spectrum. The current ownership model inherently undervalues options such as unlicensed spectrum, even though it is recognized as one of the engines of innovation within the marketplace.

This general issue was central to the more specific issue of the role of unlicensed spectrum and how it is balanced against other spectrum considerations and options.

Unlicensed Spectrum

There is no dispute that the current unlicensed spectrum has been successful. WiFi and Bluetooth have spawned entire industries and are being integrated into cellular service architectures to off-load traffic whenever WiFi access is available. "Roamable" WiFi services are also becoming available as adjuncts or alternatives to conventional cellular connectivity. WiFi is now being offered in conjunction with, or integrated directly within, the 3G/LTE cellular chip sets. The Broadband Plan explicitly called for additional unlicensed spectrum without explicit direction of where that spectrum would come from or how it would affect the availability of spectrum for wireless broadband.

While there was absolute consensus on the success of the current unlicensed spectrum, there was much less consensus on if, or how, additional unlicensed spectrum allocations, or access to spectrum, fit into future planning. Currently, broadband access applications for unlicensed spectrum occur in the bands heavily populated by "Wi-Fi" technology—2.4 and 5 GHz. Advocates for these technologies, as standardized by IEEE 802.11, argue that allocation of additional shared spectrum in the 5 GHz band would be beneficial for the industry and future innovation. Adding spectrum immediately adjacent to existing unlicensed spectrum would facilitate deployment of next-generation Wi-Fi technology (802.11ac), which uses wider contiguous channels to deliver significantly faster data rates. Some participants, focusing on bands other than those in use for Wi-Fi, expressed concern. It is less clear how unlicensed spectrum allocations could be integrated into a spectrum reallocation strategy that would raise the funds for relocation (from auction revenues) and be viewed by Congress as a funds-raising mission rather than a policy debate.

There is another major impediment to future unlicensed allocations. Some of the current allocations were for spectrum that was needed in guard bands between services. The imposition of low power limits appeared to negate the value of this spectrum for the then dominant applications. As the cellular industry shifts to "in-building" strategies, spectrum with reduced propagation and low power limits may become significantly more attractive at auction than the same spectrum would have been a decade previously.

The status of the unlicensed availability of the TV "white spaces"[17] is also of concern. Many believe this shared band can meet many unlicensed needs. However, there remained at the time, a concern that Congress might dictate that any available TV white space be auctioned for licensed use. In this case, future congestion in the primary unlicensed bands could greatly reduce their effectiveness in providing broadband offload to carriers and support to unlicensed users.

There was general agreement that it is unlikely that any additional, nationally cleared spectrum would be dedicated to unlicensed use in the current environment. Most of the concepts proposed at the Roundtable involve sharing arrangements similar to the TV white spaces. For example, although the 3550–3650 band might not be cleared for cellular wireless, it could be shared with low-power devices that would have to check geographic databases. Other proposals allow for sharing of unauctioned bands as they become available. Some propose that unlicensed bands be established based on a reserve price during the spectrum auction. Any spectrum that does not receive bids that exceed the reserve price would automatically be available for unlicensed use. Others advocate for noninterfering sharing of spectrum on a licensed basis for bands that cannot be completely cleared nationwide, 24/7.

No matter how technically feasible these sharing regimes might be, they face a fundamental burden—that primary spectrum users will oppose such sharing due to their fear of the "garage door opener scenario,"[18] in which widely deployed secondary devices obtain such market penetration that the primary users cannot fully exercise their rights in the spectrum.

The NTIA Commerce Spectrum Management Advisory Committee (CSMAC) had previously made the recommendation that:

> …the technical rules be designed to avoid creating obstacles to future reallocation or reorganization of the band due to the risk of substantial stranded devices and infrastructure. Access to new unlicensed bands should generally be conditioned in ways that reserve the flexibility to reallocate a band in the future or to change its operating rules.[19]

For example, secondary use of the spectrum should be limited to devices that have multiple bands of operation available to ensure that loss of access to any one band would not negate the value of the device or service. This technology feature would avoid subsequent pressure on band incumbents to not fully exercise their rights. It is critical that credible protection and assurances be offered to incumbents for any spectrum-sharing regime. There was strong consensus that without protection of the rights of primaries (such as proposed in the CSMAC report), spectrum sharing would be strongly opposed by both federal and non-federal allocation and license holders.

There was also concern that any piecemeal approach might not be adequate for some emerging unlicensed applications. Small segments of spectrum would not provide the high-bandwidth services that have been the focus of the localized, high-bandwidth technology that has been emerging in this space.

Highest and Best Use—Spectrum Recapture and Reallocation

Increased flexibility in the use of spectrum, and minimized government predetermination of spectrum use, was generally perceived as the best mechanism to ensure that spectrum is applied most effectively. Market-based auctions are considered a primary mechanism for accomplishing this on the assumption that they would place spectrum in the hands of those best able to extract value from it. In a dynamic market, and during a period of technological opportunity, this process might not yield the "highest and best use," but it would more closely approach it.

Recently, the most significant reallocations have been to enable the deployment of commercial wireless services. Spectrum for commercial use has been primarily provided through market-based auctions (although not the 255 MHz of unlicensed spectrum in the 5 GHz band that was opened in 2003). The pool of spectrum for this process has not been expanded significantly in the last decade. Just as it has been proposed that new mechanisms may be needed to determine the best method of distributing this spectrum, there was a consensus that new mechanisms will be needed to make spectrum available for repurposing.

The National Broadband report proposed incentive auctions to enable existing spectrum holders to repurpose spectrum, release it for auction and share in the revenue generated by the auction.[20] There is considerable controversy surrounding the idea that spectrum license holders who paid nothing for their spectrum[21] initially should be able to benefit financially from returning this spectrum. Because of a previous episode where some influential members of Congress accused broadcasters of receiving unjust enrichment, broadcasters have not been confident that Congress would allow the funds to actually flow to them in return for relinquishing the spectrum. Furthermore, some in the broadcasting industry take the position that there is an agenda to end over-the-air broadcasting completely and that incentive auctions are only one step in the process. This perception may not be without merit, as over-the-air reception of television is a small—and decreasing—segment of the television audience, and the value of the broadcast spectrum for other uses is only increasing.

There were a number of participants who advocated that federal government users should operate with financial incentives similar to the private sector users. Different regimes to accomplish this included allowing agencies to sell off the spectrum they are currently using or be forced to pay for the spectrum that they use.

The general reaction to this was that agencies would be unlikely to believe that Congress would allow them to retain any revenue generated or that Congress would simply reduce the budget to reflect lowered spectrum costs. In both cases, agencies would not obtain any net benefit from reducing spectrum usage, and presumably, they would have to deal with the operational consequences of the lost spectrum.

There was concern that relocation from the existing federal bands would be increasingly difficult and expensive. At least some sharing, rather than complete relocation, may be more effective for both federal and private-sector users. In the past, there was little transparency in the federal systems and usage, so the private sector could not work with federal users to determine how compatible spectrum sharing scenarios might turn out to be. There was a perception that the process may have been overly conservative due to lack of insight into federal uses (one carrier attendee noted that they had worked with the federal agencies to clear spectrum and that many of the expected technical issues did not arise).

A measure of this difficulty is that while the federal government's spectrum was the source of much of the spectrum transitioned to wireless usage, the federal portion of the spectrum has constantly eroded. The NTIA 10-year plan states that only 28 percent of the spectrum is exclusively allocated to the federal government, 37 percent is already shared with civil users and the remaining 35 percent is exclusively civil.[22] The resulting increased usage density has made relocation increasingly difficult, expensive and creates potential operational risks to the federal agencies.

The consensus was that federal agencies should yield whatever is practical but that an alternative approach could be to seek solutions based on *sharing* of federal spectrum, rather than complete relocation, along with more flexible access to the spectrum currently allocated to non-federal uses. Unfortunately, the federal sharing regimes are not ones that industry or federal agencies have the experience or technology available to address.

In future auction or sharing arrangements, additional transparency regarding federal systems and operations would allow different carriers to adapt to these systems instead of relocating them, and thereby reduce costs. However, different carriers would then be proposing different terms and conditions for the license on which they were bidding. This would create a much more complex auction, taking into consideration the "best value" to the government, rather than the highest price. No attendee felt comfortable that a methodology to construct such an auction framework exists, despite its attractiveness from a technology perspective.

The existing reimbursement law and regulation was also blamed for difficulties in sharing spectrum and lowering the clearing costs. Congress passed the Commercial Spectrum Enhancement Act (CSEA)[23] that the President signed December 23, 2004. This legislation created the Spectrum Relocation Fund (SRF) to provide funding for federal agencies to recover the costs associated with relocating their spectrum-dependent systems in bands that are auctioned. The CSEA has no provision for the costs for planning such activities, which are significant; does not consider that agencies might invest in technology that would make sharing a band possible as an alternative to relocation; and only applies to spectrum where auction funds can reimburse these costs.

The CSEA language was developed in the context of completely cleared spectrum and physical relocation of federal systems. The regimes discussed at the Roundtable are more subtle than the full relocation contemplated by the CSEA. The shift from physically providing dedicated spectrum to providing degrees of shared access to spectrum is not supported by the current language. Thus, federal agencies have valid arguments to not even entertain discussions of spectrum sharing, interference hardening, coordination processes and similar enhancements to the operation, technology or planning of shared access if their costs are not recoverable under the law.

One voluntary private sector spectrum recapture option currently under serious consideration is incentive auctions. Other mechanisms that utilize tax incentives and penalties were proposed for consideration. For example, if the right to share spectrum is considered to reduce the value of spectrum, let spectrum rights holders place sharing rights into the public domain and take a tax credit for the loss in valuation, much as a conservation easement does for real property. This could create new spectrum for unlicensed innovation without explicit allocations.

Similarly, if spectrum that was obtained at no-cost rises in valuation due to relaxed regulatory treatment, the federal government could claim a portion of this added value as a spectrum tax. This action would reduce the political sensitivity of private sellers benefiting from selling a resource they received from the government at no cost. Such a scheme could reduce the necessity for the government to operate the incentive auctions and provide a streamlined path to repurpose this spectrum.

The consensus that federal spectrum will likely be shared, rather than cleared, framed the next discussion.

Spectrum Sharing

For a decade, spectrum sharing has been considered an option for increasing the utilization of spectrum. Other than the geographical database sharing of television white spaces, there has been little application of it as a central feature of spectrum management.

There was a consensus that this might change as the government researched the practical issues involved in clearing spectrum for the

National Broadband Plan. A number of participants believed that some of the federal systems in the 1750–1850 band would be too costly and slow to relocate and that this would be the first time that spectrum sharing would be the basis of spectrum policy for licensed applications.

The advent of spectrum sharing among licensed applications points to the importance of defining a taxonomy of spectrum sharing concepts. Some participants believed that much of the resistance to the concept of spectrum sharing is rooted in differences in the assumed definition. As an example, some users of the term assume that spectrum sharing is implicitly opportunistic secondary sharing by unlicensed users. Other spectrum managers consider spectrum sharing to be coordinating use of a given frequency in different locations.

Spectrum sharing schemes could be organized in terms of:

> *Coordination:* Does each individual spectrum sharing application require some degree of coordination with the primary or incumbent user, or is access opportunistic and at the discretion or judgment of the secondary device?
>
> *License Status:* Is the sharing performed with no benefit to the primary user, or is it a right that is granted and controlled by the primary in return for some consideration?

This structure would describe regimes such as licensed opportunistic sharing and expedited secondary status in addition to the current unlicensed model. For example, a service could be deployed that used licensed spectrum, and charged a per device fee, paid to the spectrum holder. This would enable innovators to have products that avoided the congestion of the existing unlicensed bands, while not requiring the investment and delay of the auction process.

Consideration was given to the idea of opening up bands (such as 3,550–3,650 MHz) that have not been nationally clearable for sharing by low power devices with geographic restrictions. Success might create more interest in future auctions of portions of the band for regional usage. It would also require a new form of coordination between NTIA and the FCC to allow for civil use of spectrum that would retain federal status.

One additional consideration was that federal spectrum sharing would have to address not just sharing with communications systems but also with radar systems. Sharing with radars will be essential to achieving meaningful degrees of federal spectrum shared access. Although there has been research into sophisticated sharing mechanisms between communications systems, there has been little research and experimentation around sharing with radar systems other than low-power Dynamic Frequency Selection (DFS) in the 5.2, 5.3, and 5.47 GHz band. Radars may exhibit different tolerances for interference depending upon the nature of the radio technologies seeking to share. Several participants suggested that the 1755–1850 band might be the first band to be shared in part with commercial broadband networks. This is because the relocation costs of all users could be more than the revenues raised at auction. This band may mark the tipping point, where spectrum policy shifts from relocation of federal users to more extensive sharing with federal users. The challenge faced by the community is in creating trust in these sharing regimes among federal users and visibility into the utility of this spectrum among commercial users.

The 1755-1850 band may mark the tipping point, where spectrum policy shifts from relocation of federal users to more extensive sharing with federal users.

Many viewed the TV white space database-driven approach to spectrum sharing as a model for how primary spectrum users could conduct and control future spectrum sharing. Although the "sense and avoid" principles demonstrated in DARPA and other academic research programs offer extreme flexibility, it was clear that many incumbent users would have difficulty trusting these technologies (at least initially). The ability to directly control spectrum sharing through a database might reduce the perceived risk of spectrum sharing to an acceptable level. There was considerable discussion of how this could be implemented with little doubt that they could be used for most federal systems, except those that might need to be more confidential due to national security considerations.

It was suggested that there is strong synergy between the viability of sharing regimes and the need for additional unlicensed access to the spectrum. It might be a challenge for policy makers and Congress to forgo the revenue that auctioning dedicated, nationally cleared spectrum would provide. But power-limited, geographically shared spectrum might be considered inherently available for sharing under suitable restrictions. This could greatly enhance the spectrum already available for unlicensed spectrum, even without an explicit allocation of dedicated spectrum. Proponents recognize that future unlicensed spectrum may not be provided on a dedicated basis, such as in the current industrial, scientific and medical (ISM) bands.

A "public good" policy would have a "use it or share it" approach, instead of the build-out requirements imposed on some licenses.

A more radical view emerged as well: Spectrum licenses are intended to serve the public good. Spectrum that is unused is not providing any public good. A "public good" policy would have a "use it or share it" approach, instead of the build-out requirements imposed on some licenses. These build-out requirements have forced license holders to deploy uneconomic systems (such as just transmitting a signal) in order to meet license conditions and retain the spectrum.

Practically, such a principle could have a significant impact in rural communities where wireless carriers find it to be uneconomical to fully deploy systems in their nationwide spectrum. Wireless Internet service providers (WISPs) could deploy services to underserved communities using the unoccupied spectrum, while leaving it available for the primary license holder to reclaim and deploy systems.

Just as the CSEA was viewed as needing reform to benefit federal spectrum relocation, it was also viewed as an obstacle to permanent spectrum sharing regimes. The CSEA currently does not allow agencies to recover costs associated with sharing spectrum, or when spectrum is allocated to uses that might not yield immediate auction revenue, even if such uses were highly beneficial, such as unlicensed operation.

There was general consensus that the government should invest in research and development activities to develop and validate spectrum sharing models. Demonstrations that sharing had no, or minimal, impact on ongoing operations would be required to achieve incumbent acceptance of these regimes. Viability of the model to create value would be required to create investment and innovation interest.

Spectrum Rights Regimes

This conference occurred in the middle of considerable controversy over spectrum license holder and incumbent user rights, specifically the application by LightSquared to operate a wireless service in spectrum it is assigned adjacent to the Global Positioning System (GPS). Not only is this a controversy within the spectrum community, the significance of the potential impacts resulted in front page articles in the *Washington Post*, as well as in FCC proceedings,[24] community studies[25] and Congressional hearings into the process of approving its application. This issue provided a context and backdrop for discussion of a number of approaches to establish and implement mechanisms to control and specify the interaction of adjacent spectrum users.

The LightSquared controversy demonstrates the complexity of spectrum policy and the difficulty in equating spectrum to other types of economic transactions. The spectrum that LightSquared planned to use to deploy LTE service was licensed to LightSquared, but it was located adjacent to the GPS band. The GPS industry argued that GPS receivers were designed with the assumption that the adjoining band had no high power emitters; therefore, they would not be able to reject the LightSquared signal, even though the LightSquared signal was not in the GPS band.

Using real estate as a metaphor, the existing design of equipment used in the GPS service had placed an unwritten easement on the adjoining band. The policy that a new entrant must not interfere with existing spectrum users has the effect of placing all of the responsibility for protecting existing services onto the new entrant. This behavior provides no incentive for spectrum users to provide anything other than the minimal protection of their receivers, as even "bad" receivers could be used to argue against an entrant.

The subject of receiver standards has been widely discussed at previous Aspen Institute spectrum roundtables, and this one was no exception. There was considerable support for imposing some form of receiver criteria but little agreement on how, and in what bands, they should be imposed.

The United Kingdom developed a framework for spectrum usage rights (SUR) that defined the parameters of use for each spectrum license, and thus, it created expectations for adjoining license holders. These expectations would then form de facto protected receiver performance criteria. However, the UK experience was that no spectrum holder would support imposition of the spectrum rights. Incumbent users had disincentives to have SUR restrictions on their own spectrum licenses, even if they might benefit from their being in place on adjoining spectrum licenses.

As it turned out, the SUR framework was only in place for one spectrum license.[26] It was also pointed out that the lack of definition of rights and responsibilities of adjoining spectrum users was one of the impediments to innovation in spectrum dependent services and products.

There is no deterministic process to identify, much less resolve, potential interference issues. Some are resolved through direct negotiation, some through rule making and some even require Congressional action. In general, the new entrant faces the burden of resolving interference issues. This lack of certainty in time and outcome makes the spectrum process highly ill-suited to support the economic model that has been so successful in accelerating innovation in other segments of the economy. The lack of success of secondary markets may also be partially attributable to the lack of standards for resolving adjacent bands impacts.

Classical spectrum management practice has been to group "likes with likes,"[27] to reduce conflicts between different types of services. There was general consensus that as both private and public sector spectrum license holders are permitted, and in fact encouraged, to seek more productive use of the spectrum, there will be strong incentives to deploy systems that have very different effects on adjoining users. Issues such as those that arose in the NEXTEL-Public Safety[28] and LightSquared LTE deployments will become more common as

spectrum becomes more densely used. There was a strong consensus that the current process does not offer a suitable model to resolve these conflicts and that the lack of such a model will constrain innovative use of the spectrum.

All participants were reluctant to see the government "pick winners" in terms of the technological assumptions on band usage, while most participants believed that some process similar to the land usage planning or zoning processes was essential. The cellular operators believe they have established standards for their mobile devices and enforce these standards through the handset approval process. However, it was pointed out that these standards presume the current use of the adjoining spectrum bands and that the kind of flexibility envisioned by the Spectrum Policy Task Force Report would, in fact, invalidate those assumptions. The interference issues raised by the proposed introduction of Time Division Duplex in the M2Z proposal are an example of where the assumptions of cellular device coexistence could be violated with a flexible spectrum policy environment.

If you want to reduce spectrum regulatory constraints, then you must impose some constraints on the quality of the equipment used in the spectrum!

Most current U.S. cellular systems use paired uplink and downlink frequencies, referred to as Frequency Division Duplex (FDD). The paired up and down link are separated in frequency so that a handset device can easily reject the signal from any adjacent transmitting handset. Therefore, most cellular devices are not designed to be able to handle a wide range of signal amplitudes. In contrast, M2Z proposed to use Time Division Duplex (TDD) in unpaired spectrum. TDD is used in some wireless technology, such as WiFi and Bluetooth, but not in U.S. cellular architectures, although it is supported in some implementations of LTE. The use of TDD in bands adjacent to that of cellular handset receivers might cause interference to the handsets—the existing cellular handsets may not have sufficient dynamic range to process out the adjacent band signal and could fail when near a TDD handset.

This is an example of exactly the flexibility that has been desired in

spectrum regulation. However, it would have significant consequences because of the lack of specification of what could be done in adjoining spectrum. It might be that there is an inherent irony: If you want to reduce spectrum regulatory constraints, then you must impose some constraints on the quality of the equipment used in the spectrum!

In addition to the receiver standard proposal, the UK SUR included a proposal to define a "right to receive," in some bands, rather than the current rights, which are centered on the right to transmit.

The Need for Long-Term Strategic Spectrum Planning

Two observations made during the Roundtable point to the need for a longer term planning horizon in spectrum, and spectrum-dependent architecture planning. First, federal agencies have no long-term planning on spectrum available. So agencies have invested in new systems to implement one relocation that has then placed them in bands targeted during the next relocation. Clearly, the best strategy is for agencies to have a longer-term roadmap of what bands they need to migrate from and to. The relocation from these bands can then be accomplished during the technology refresh cycle of these systems, at greatly reduced cost and disruption.

…potential users of repurposed spectrum also need transparency and predictability in the likely future supply of spectrum.

Second, wireless carriers pointed out that potential users of repurposed spectrum also need transparency and predictability in the likely future supply of spectrum. Advanced identification of bands for transition to other uses will reduce risk, and enable investors to have knowledge of the future availability of this key resource. As it is, no one knows if any given auction is the last auction, and therefore cannot develop a reasonable plan to match needs and supply.

National Broadband Plan Recommendation 5.3 provides, "The FCC should maintain an on-going strategic spectrum plan including a triennial assessment of spectrum allocations."[29] There was a strong consensus that this is a positive recommendation, but that it addresses only

one half of the spectrum policy development, since it does not integrate federal spectrum use into an overall national plan for spectrum.

Significant portions of any new spectrum would have to be provided through changes in federal spectrum usage. Inclusion of the federal agencies, via the NTIA, would be essential to addressing both supply and usage of spectrum. The split nature of U.S. spectrum management effectively precludes either the NTIA or the FCC from independently articulating and implementing a national spectrum policy.

Although there were no specific conclusions on where this responsibility should be placed within the executive branch, the planning process must include the scope of both of these organizations. Additionally, a national spectrum plan should link to the budgeting process so that it reflects agency capital planning and investment in new spectrum-dependent systems such as weapons systems, communications systems, air traffic control systems, etc.

There was general agreement that long-term federal planning might be a less contentious planning effort than the immediate band reallocations, since the focus would be on directing future technology investments and not the viability of in-place systems upon which federal agencies are currently dependent. Coupling this spectrum planning process with the budgetary actions that fund the technology refresh process within the federal agencies and departments would provide agencies with more assurance that they will not face a capability shortfall.

The appropriate time frame for this planning would need to match the procurement and acquisition planning time lines of federal agencies. This planning scale would be quite a bit longer than the typical private sector organization since the lifetime of systems designed for aircraft carriers or the National Airspace System are measured in decades, not years. The only guide for federal agencies today is the NTIA "Red Book,"[30] which outlines the policies in place when systems are initiated rather than the desired policies at the time the systems are fielded and operated.

Recommendations and Conclusions

There were a number of recommendations that the participants reached during the Roundtable.

1. *Strong support for legislation to allow the FCC to hold incentive auctions.* While the concept of a spectrum licensee who paid nothing to the government for spectrum benefiting from its sale might appear to be unjust, the benefits of a voluntary process to repurpose that spectrum to meet the growing need for licensed mobile bandwidth is highly attractive and should be pursued. There was general support for extending the concept to other classes of existing spectrum licenses.

2. *General agreement that some form of specification to address the compatibility of spectrum users is essential for a highly dynamic spectrum management regime.* Receiver standards are the most mature proposal in this area, and the UK SUR process is a potential model. This recommendation will become more essential as spectrum usage becomes more dense and heterogeneous. It will also provide a mechanism to create deterministic deployment of new applications in the spectrum.

3. *More deterministic and timely mechanisms are needed to allow new entrants to acquire spectrum and to identify and resolve interference issues.* Without such mechanisms, the development of innovative uses of the spectrum will be highly constrained, or precluded entirely due to the unpredictable, lengthy, technical, regulatory and political processes involved in resolving interference issues.

4. *General consensus that interference resolution issues are generally weighted too heavily towards incumbent positions.* Currently, there is not a formal definition of what constitutes "harmful interference," and in practice, the standard is often argued from absolute positions even though modern communications technology is capable of tolerating and managing significant levels of interference. The success of WiFi in highly interfered

with environments is an example of how resilient technology can be[31] if the requirement is placed on systems at the onset. Spectrum policy must shift from examining whether current systems will face some degree of interference to the question of whether future generations of systems can be designed to operate in the presence of interference.

5. *The future of spectrum management will include dynamically managing a significant amount of nondedicated, shared spectrum bands.* Neither the public nor private sector has experience in these regimes or with these technologies. Lack of confidence in both the technology and potential sharing partners is a significant impediment to expansion of sharing regimes. Therefore, experimental evidence, such as that which would result from technology and engineering testbeds, is critical to reflect the potential contributions of advanced technology in spectrum policy.

6. *Investment in research to further develop and refine spectrum sharing and interference mitigation technology would have significant rewards for spectrum users and the U.S. economy.*[32] It would create innovative technology that can place the U.S. in the forefront of this important technology. In addition to the research element, participants recommended that the effort should ensure realistic pilot experiments of sufficient scale to create confidence by the stakeholders in future spectrum sharing regimes.

7. *Congress should update the Commercial Spectrum Enhancement Act (CSEA) to fund the costs incurred by federal agencies in providing access to the spectrum, regardless of the mechanism used.* This legislation should also support the planning and verification activities that must occur, even before the process of relocating, sharing or auctioning is decided on or executed. Limiting reimbursement to auction proceeds precludes a robust national spectrum policy that has a wide range of spectrum options.

Further Developments After the Roundtable

Since the Roundtable concluded, a number of significant spectrum policy events occurred:

- At the November 2, 2011 open meeting of the White House Office of Science and Technology (OSTP), the President's Council of Advisors on Science and Technology (PCAST), announced that it is launching a study focused on government-held spectrum. This study will address how to realize the full potential of government-held spectrum to spur economic growth.

- The final Middle Class Tax Relief and Job Creation Act of 2012 had a number of significant spectrum provisions, including authority for the FCC to assign spectrum for unlicensed use (some in Congress had proposed that all available spectrum be auctioned). The Act also authorized incentive auctions and provided 10 MHz of D Block spectrum for public safety, among other provisions. While all of the provisions were not consistent with the conclusions of the 2011 Roundtable, they generally supported the main tenets of increased spectrum use flexibility.

- The National Telecommunications and Information Agency (NTIA) issued their report on the 1755–1850 band.[33] As predicted by many of the attendees, this report raised serious questions about the viability of the current "clear and auction" approach to this congested band. The NTIA report proposed spectrum sharing as a mechanism to meet both civil and federal spectrum needs. It concluded:

  > However, the extent to which the spectrum can be made exclusively available to commercial interests requires further investigation, as some federal systems could remain in the band indefinitely.… NTIA also

> believes that spectrum sharing is a vital component of satisfying the growing demand for access to spectrum and that both federal and non-federal users will need to adopt innovative sharing techniques to accommodate this demand.

Developing the appropriate spectrum policy has become more complex ever since the issuing of the National Broadband Plan. As recently as March 2012 the lead on the report (and AIRS attendee) Blair Levin stated, "The FCC should rethink the spectrum parts of the National Broadband Plan in light of the experience of the last 2 years." He also said, "I think it's great [the FCC is] doing something on receiver standards, that's one I wish we had focused on."[35] Solving these issues will require creativity and intellectual persistence as society continues to innovate and desire new technologies.

Notes

1. Mark MacCarthy, *Rethinking Spectrum Policy: A Fiber Intensive Wireless Architecture* (Washington, D.C., The Aspen Institute, Communications and Society Program, 2010).

2. For more specifics on the establishment of radio regulation, see John Braithwaite and Peter Drahos, *Global Business Regulation* (Cambridge, UK: Cambridge University Press, 2000), 326–333.

3. Ronald H. Coase, "The Federal Communications Commission," *The Journal of Law and Economics* 2 (1959), 1–40.

4. Federal Communications Commission (FCC), *Spectrum Policy Task Force Report* (ET Docket No. 02-135, Nov. 2002).

5. The proposed approach was to establish "Interference Temperatures" limitations in bands. Devices could sense the level of interference in the band and use whatever power would not increase the interference level above the specified amount. This was a significant departure from the almost absolute limits on interference that had been the implicit policy.

6. See Congressional Budget Office, *The Budget and Economic Outlook: Fiscal Years 2001–2010* (Washington, D.C., 2000), Appendix B. Specific objectives of the auction process are established in 47 U.S.C. §309(j), especially (1), (3), (4), and (7)(A). An in-depth criticism of the spectrum auctions performance in meeting the nonrevenue goals is provided in Gregory F. Rose and Mark Lloyd, *The Failure of FCC Spectrum Auctions* (Washington, D.C.: Center for American Progress, 2006).

7. Lawrence Summers, "Technological Opportunities, Job Creation, and Economic Growth," speech at the New America Foundation, Washington, D.C., June 28, 2010.

8. For information on the experiments that were conducted and reported in the literature see Marc McHenry et al., "XG Dynamic Spectrum Access Field Test Results," *IEEE Communications Magazine* 45 (June 2007), 51–57; Preston F. Marshall, "Extending the Reach of Cognitive Radio," *Proceedings of the IEEE* 97 (April 2009), 612–625.

9. AT&T Inc., "AT&T Wi-Fi Network Usage Soars to More Than 53 Million Connections in the First Quarter," news release, April 22, 2010.

10. FCC, *Connecting America: The National Broadband Plan*, 76.

11. Long Term Evolution (LTE) and its follow-on, LTE-Advanced, are becoming the dominant technology for 4G services and are the assumed technology that would be deployed in spectrum cleared for auction for wireless services.

12. FCC, *Connecting America: The National Broadband Plan*, Exhibit 5-C, 79.

13. Authorization of Spread Spectrum Systems Under Parts 15 and 90, First Report and Order, Gen. Docket No. 81-413, 50 Fed. Reg. 25234 (May 9, 1985); In the Matter of Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License, First Report and Order, Gen. Docket 87-389, 4 FCC Rcd. 3493 (Mar. 30, 1989); Amendment of the Commission's Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Frequency Range, ET Docket No. 96-102, Report and Order, FCC 97-5 (Jan. 9,

1997). [This chronology courtesy of Yochai Benkler]. For more information on this process see Yochai Benkler, "Open Wireless vs. Licensed Spectrum: Evidence from Market Adoption: November 12, 2011, http://www.benkler.org/Open_Wireless_V_Licensed_Spectrum_Market_Adoption_current.pdf

14. Yochai Benkler provides an example of such an argument. See previous endnote.

15. Higher frequencies result in more communications path loss. Doubling in frequency (for example going from 1.8 GHz to 3.6 GHz) results in additional path loss of 4 times, so for the same transmit power and a nondirectional receiver antenna, the receiver would only receive 25% of the energy as at lower frequency. The environment (structures, weather) is also more likely to absorb signal energy at higher frequencies.

16. As an example, the environment of the Aspen Institute conference facility on the Wye River in Maryland (where the Roundtable was conducted), is protected by resource protection areas at locations that are hundreds of miles away from the Chesapeake Bay. These restrictions on private land use and soil disturbance were imposed retroactively on private property through legislative and local regulatory action.

17. TV white space is the unused spectrum between TV channels or unused TV channels. This spectrum is to be made available for unlicensed operation by devices that first query a database of permitted frequencies of operation. This mode of operation was provided for by a series of FCC decisions, culminating in the approval of database managers to provide the geographic query service.

18. The "garage door opener" scenario is based on the experience of the Department of Defense. Garage door openers were permitted unlicensed operation in a DoD occupied band on a "not to interfere and must accept interference" basis. These devices were in wide usage when DoD added a significant number of base communications systems to this band. At that point, the receivers in the garage door openers were desensitized, and the garage opener receivers failed. Although the openers had no legal rights in the spectrum, the political and public attention the issue raised showed incumbent users that sharing created what are essentially "squatter's rights," where a large-scale consumer investment would have the political effect of negating the incumbent's rights in the spectrum.

19. Commerce Spectrum Management Advisory Committee, *Unlicensed Uses Subcommittee Report*, Jan. 11, 2010.

20. FCC, *Connecting America: The National Broadband Plan,* 81.

21. An example of such a spectrum license holder would be a broadcaster who obtained a free license based on the then current licensing conditions but who would be willing to relinquish this spectrum for auction in return for a percentage of the auction revenue or some other consideration.

22. U.S. Department of Commerce, *Plan and Timetable to Make 500 Megahertz of Spectrum for Wireless Broadband* (Washington, D.C., 2010).

23. The CSEA establishes the ability of federal agencies to be reimbursed for their costs in relocating to other spectrum. The money is provided from auction funds, but it will not fund significant upgrades in capability. (This is not in the law, but it is the way OMB has interpreted the law. Some of these problems can be fixed if OMB were to reissue its advice on the statute.)

Now auction funds provide the initial funding of the planning and analysis required to consider and design spectrum sharing or other access strategies.

24. LightSquared has proposed establishing LTE cellular services in a band that it had a license for the use of satellite signals that would have signal strength. The Global Positioning System (GPS) user community, particularly the military and aviation segments, objected that high power signals adjacent to the GPS band would interfere due to both the potential out of band emissions of the LTE systems and by overloading the GPS receivers, which were not designed to reject such strong adjacent band signals. Details are in FCC, "Comment deadlines established regarding the LightSquared Technical Working Group report," Tech. Rep. DA 11-1133, June 2011.

25. National Space-Based Positioning, Navigation, and Timing Systems Engineering Forum (NPEF), "Assessment of LightSquared Terrestrial Broadband System Effects on GPS Receivers and GPS-dependent Applications," June 14, 2011.

26. This was an L Band license purchased at auction by Qualcomm, and the SUR was placed on it as a condition of the auction.

27. For a discussion of the current spectrum management practice of grouping users on the principle of "likes with likes," see FCC, *Spectrum Policy Task Force Report* (ET Docket No. 02-135, Nov. 2002).

28. The NEXTEL-public safety spectrum conflict arose from high-power cellular base stations reducing the sensitivity of the public safety communications equipment in adjacent spectrum. This required an extensive reallocation of both NEXTEL and public safety users. More information on this issue is provided in Lynette Luna, "NEXTEL interference debate rages on," *Urgent Communications*, Aug. 1, 2003, http://urgentcomm.com/mag/radio_nextel_interference_debate/.

29. FCC, *Connecting America: The National Broadband Plan*, 91.

30. Formally known as the *"Manual of Regulations and Procedures for Federal Radio Frequency Management,"* published by the NTIA and available from the Government Printing Office.

31. Since WiFi users have no dedicated spectrum, it is not uncommon to see a large number of networks all operating on the same frequency, at the same time, in close proximity to each other. Because interference protection was not provided in the unlicensed bands, the technology that has evolved is highly interference tolerant and can be effective in environments in which equipment designed on the assumption of interference protection cannot be effective.

32. See Mark MacCarthy, *"Spectrum for the Next Generation of Wireless"* (Washington, D.C., The Aspen Institute Communications and Society Program, 2011), 33, 41.

33. U.S. Department of Commerce, *An Assessment of the Viability of Accommodating Wireless Broadband in the 1755-1850 MHz Band*, March 2012.

34. Ibid., Executive Summary, iii.

35. Quoted in *Communications Daily*, March 16, 2012.

APPENDIX

The Reallocation Imperative: A New Vision for Spectrum Policy

November 13-15, 2011
Aspen Wye River Conference Center
Queenstown, Maryland

Roundtable Participants

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Preston Marshall is a research professor at the Ming Hsieh Department of Electrical Engineering and Deputy Director of the Information Science Institute at the University of Southern California's Viterbi School of Engineering, where he leads research programs in wireless, networking, cognitive radio, decision theory and decision support systems and advanced computer architecture.

Dr. Marshall has 30 years of experience in networking, communications and related hardware and software research and development. Over the last decade, he has been at the center of cognitive radio research, including 7 years as a program manager for the U.S. Defense Advanced Research Projects Agency (DARPA), where he led many of the key cognitive radio programs, including the neXt Generation Communications (XG) program, which demonstrated the viability of Dynamic Spectrum Access (DSA) policies, and Wireless Networks after Next (WNaN), which integrated DSA and interference tolerance into mobile networking technology.

He has numerous published works, including *Quantitative Analysis of Cognitive Radio and Network Performance* and the upcoming *Scalability, Density, and Decision-Making in Cognitive Wireless Networks*, and has many appearances as invited and keynote speaker at the major technical conferences related to wireless communications. He was awarded the Software Defined Radio Forum's 2007 Annual Achievement Award and the Defense Superior Service Award in 2008. He has been a guest editor for *IEEE Proceedings* and *Communications* and chairs the Steering Committee for the IEEE International Symposium on Dynamic Spectrum Access Networks (DYSPAN) Conference.

Select Publications from the Aspen Institute Communications and Society Program

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

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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

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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 line (DSL), cable modems, and other players such as wire-

less 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

Challenging the Theology of Spectrum: Policy Reformation Ahead, by Robert M. Entman

This report examines the theology of spectrum—that is, the assumptions and mythology surrounding its management and use. The report looks at how new technologies affecting spectrum, such as software-defined radio, can challenge the conventional wisdom about how spectrum should be managed. Such innovations allow for access to unused frequency space or time on frequencies that are otherwise licensed to an exclusive user. 2004, 43 pages, ISBN Paper: 0-89843-420-3, $12.00

Spectrum and Network Policy for Next Generation Telecommunications, by Robert M. Entman

The report of the 18th Annual Aspen Institute Conference on Telecommunications Policy offers policy alternatives in both spectrum and network policy to achieve new gains for the telecommunications field. The first essay suggests new management approaches to encourage more efficient uses of spectrum while preserving the commitment to reliability of service and public safety values. The second essay debates the competitive structure of the telecommunications industry and its implications for building next-generation networks (NGN) and identifies three areas to encourage optimal development of the NGN: operate the NGN on a price-deregulated basis and begin to address access regulation issues, secure the intellectual property rights of content suppliers, and adjust the system of subsidized pricing to bring about competitively neutral pricing. 2004, 92 pages, ISBN Paper: 0-89843-394-0, $12.00

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The Program's Executive Director is Charles M. Firestone, who has served in that capacity since 1989, and has also served as Executive Vice President of the Aspen Institute. He is a communications attorney and law professor, formerly 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.