Spectrum as a Resource for Enabling Innovation Policy

William Webb, Rapporteur

The Aspen Institute

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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

Shortly after the presidential election, the 2012 Aspen Institute Roundtable on Spectrum Policy (AIRS), "Spectrum as a Resource for Enabling Innovation Policy," met on November 14-16, 2012 to consider ways that spectrum policy in the coming four years should enter into the larger concern for improving the economy through innovation. That is, how can spectrum policies help create an environment that makes it easier for innovators to use spectrum as a resource for new technological goods and services?

The 32 leading communications policy experts who met at the Aspen Wye River Conference Center in Queenstown, Maryland began by assessing the state of spectrum in the United States. Considering the recommendations of recent reports from the National Telecommunications and Information Administration and the President's Council of Advisors on Science and Technology, participants identified problems facing new entry and innovation today. They then recommended solutions, looking specifically at the interstices between licensed and unlicensed approaches, new measures to foster innovation, spectrum sharing/flexibility and new institutional arrangements to manage these solutions.

As the following report details, the discussions were lively, knowledgeable and at times, contentious. Throughout the report, the Roundtable rapporteur, William Webb, sets forth eleven recommendations that he gleaned from the conference dialogue to guide future spectrum policy development with regard to facilitating innovation. While these recommendations generally reflect the sense of the meeting, there were some opponents to the viewpoints recorded and 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.

Acknowledgments

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Comcast Corporation, *Corporate Partners*; Cisco Systems, Credit Suisse, Motorola Mobility, National Association of Broadcaster, Qualcomm Incorporated, Time Warner Cable, T-Mobile USA, Inc., Verizon Wireless and The Walt Disney Company, *Corporate Associates*.

I also want to acknowledge and thank William Webb for his extensive and informative account of the conference discussions and our participants, listed in the Appendix, for their contributions to these complicated topics. Finally, I want to thank Ian Smalley, Project Manager, for producing the conference and this report, along with the Communications and Society Program Assistant Director Patricia Kelly, who oversaw its editing and publication.

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Executive Summary

As we enter the fifth year of the financial crisis, with growth below trend levels and unemployment high, there are frequent calls for innovation as a way to spur growth and resolve societal problems. Innovation in telecommunications has been strong in the last few decades, and growth in mobile data, apps and similar areas is extremely high, suggesting this is a promising area for the future.

All wireless communications require radio spectrum; this entry and growth barrier is often seen as a block to innovation. A group of experts met at the Aspen Institute in November 2012 to consider whether changes to spectrum policy might stimulate innovation and investment in wireless technologies, networks and solutions.

Innovation can be defined as the successful exploitation of new ideas. The exploitation is often much more difficult than the generation of the idea, particularly where it involves regulatory change—this is an area where spectrum policy makes a difference. Innovations can broadly be characterized as incremental improvements or disruptive changes. Incremental improvements typically happen within the existing framework—for example, these might include carriers deploying small cells to enhance their capacities. Disruptive change often happens outside of the conventional framework and can be facilitated by flexible and innovative spectrum policies. Recent spectrum policy initiatives have tended to concentrate on aiding incremental innovation—for example, by making additional spectrum available on a licensed model such that carriers can expand network capacity and upgrade technology to the latest generation of cellular standard. The work of this group focused on disruptive ideas that could better be served by changes to policy.

Disruptive ideas are often introduced by new players. This phenomenon is sometimes characterized as the "innovator's dilemma"[1] in that the existing players are disincentivized toward changes that reduce their revenues and profitability. Previous successful new entrants include Nextel's nationwide push-to-talk solution and Wi-Fi hotspots. Unsuccessful examples include Northpoint's idea of reusing satellite spectrum; ultra wideband as a new way of sharing licensed spectrum; LightSquared as a new operator; and WiMax as a solution for mobile

broadband. That there are failures should not be surprising. Many innovations fail, and a lack of failure often points to a lack of ambition. These examples all include a mix of new companies, new spectrum access methods and new business models. Understanding the challenges they face can help determine where policy change would most likely reap benefits.

It may be difficult to attract the funding needed for disruptive ideas to compete with established ideas with proven track records, especially where it entails a change in infrastructure. It can be hard for an entrepreneur with a new idea to raise sufficient funding to successfully bid for prime spectrum against the more established players with previously demonstrated business cases. Instead, those with new ideas often seek innovative spectrum access methods that allow them low- to no-cost access to spectrum to reduce the barrier to entry. In some cases, provision of a new spectrum access method can stimulate companies to think up new ways of making use of that spectrum. There is evidence that this is happening with the TV white space spectrum.

Clearly the existing methods of auctioning exclusive spectrum are still needed to support incremental innovation in established markets. But perhaps more can be done at a spectrum policy level to provide a wider range of spectrum products. Those with new ideas could then better match their spectrum access method with their needs and funding constraints. Broadly, the work of the group was to search for gaps in the existing models of spectrum access (such as licensed, unlicensed and experimental) for areas where innovation is not currently well-served.

The recent President's Council of Advisors on Science and Technology (PCAST) report recommended shared access to federal spectrum. The stimulus for the PCAST work was to find methods to liberate additional spectrum in response to calls for 500 megahertz (MHz) to be repurposed to mobile broadband. The PCAST report showed that repurposing federal spectrum is very difficult, but it also found that more rapid access might be possible on a shared basis. The report considers a range of sharing mechanisms and defines a range of new spectrum products. These include unlicensed access to federal bands, secondary-licensed access, database access and the concept of licenses with lifetimes covering a wide time range—from months, to years, to decades.

The PCAST recommendations, when coupled with other policy initiatives including maintaining the clearance and auctioning approach, enable a "staircase" access to spectrum. This allows start-ups with limited resources to initially test their ideas using an experimental license. They can then transition to early commercial service using free unlicensed access, perhaps in TV white space. Next, as business grows, they can move to shared licensed access to federal spectrum for a moderate fee. Finally, as the full potential of the business becomes clear, they can acquire spectrum at auction in a conventional manner.

While many of these concepts have previously been set out, the devil is in the details and similar ideas in the past have often stalled at the implementation phase. Hence, ways to facilitate implementation and practical suggestions as to how to move ahead in complex areas are needed. After all, it is pragmatism rather than idealism that tends to be at the core of the best innovations.

This report proposes the following eleven recommendations to facilitate the staircase function, make the final step of the staircase more flexible, ease the development of new technologies and deployment of networks through governmental initiatives, help commercial and government spectrum users to work more closely and transparently and move towards a better overall spectrum management framework. Specific recommendations appear in the following chart.

Spectrum as a Resource for Enabling Innovation Policy
Recommendations to Guide Future Spectrum Policy Development

1. Review whether more can be done with the current experimental and short-term licenses. The goal is to enable innovative solutions to easily gain access to spectrum for initial testing purposes.
2. Establish predetermined "share-ability" characteristics of bands of federal spectrum that have commercial interest, including predicted time and location availability, any issues in implementation and potential receiver problems. This would help spectrum users readily assess whether any federal sharing might be suitable for them.
3. Continue to seek ways to clear the "undergrowth" of unnecessary restrictions within existing licenses.
4. Increase flexibility in secondary-market transactions by looking at new approaches, such as enabling parties to negotiate some changes to their licenses without the need for recourse to the regulator.
5. Develop and implement a wireless model city framework that can be tailored by city officials and innovators to facilitate initial deployments. Consider whether existing funds can be used to provide some money to assist deployment.
6. Divert a portion of Federal Communications Commission (FCC) fees to a research and development (R&D) innovation fund directed to applied research on the spectrum efficiency of federal systems.
7. Seek a set of practical ways for commercial and government users to work more closely together, sharing data about spectrum use as well as the spectrum itself.
8. Find ways to better align personal and departmental incentives for more efficient spectrum use, especially for government users.
9. Encourage and assist the FCC in implementing a Web-accessible receiver parameters database through their current dashboard (standards as well as actual receiver implementations).
10. Operationalize flexibility and sharing within the FCC and the National Telecommunications and Information Administration (NTIA).
11. Further explore methods that might help achieve an enhanced institutional framework for spectrum management across the commercial and federal spectrum.

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William Webb

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Introduction

As we enter the fifth year of the financial crisis, calls for innovation as a vehicle to engender growth are stronger than ever before. Innovation is perceived as a way to create growth and jobs, both directly through new concepts and companies, and indirectly through improved productivity and other associated benefits.

Telecommunications, and specifically wireless communications, is one of the most promising areas for innovation. This is due to recent technologies: Wi-Fi has changed the way we use computing, smartphones have changed behavior and tablets have delivered new ways of working and playing. Few other areas of the economy can boast such change. Many of our most valuable companies, such as Apple, owe much of their recent successes to the growth in wireless communications. The advent of the wireless "app" has allowed the rapid growth of tens of thousands of start-up companies and benefitted some existing players.

Wireless data is predicted by Cisco[2], and others, to grow by an order of magnitude or more over the coming decade. There have been massive investments in wireless networks to deliver greater speeds and lower latency. These investments yielded the new tablet ("phablet") and other hand-held devices, ever better screens and processors, enhanced operating systems and many other advances that use these networks. There is good reason to predict that wireless communications will continue to deliver innovations that are extremely important to our economy and lifestyle. But no wireless communications can occur without access to radio spectrum. If this is highly costly, it can deter or delay the deployment of new technologies and applications.

In November 2012, a group of experts in wireless communications and spectrum policy met at the Aspen Institute to discuss how the

management of radio spectrum could be modified to facilitate and encourage innovation in commerce and communications. The intent was to consider innovative new approaches to spectrum management that would ensure the continued expansion and migration to new technologies of important existing wireless networks (e.g., CDMA2000 to 4GLTE) while enabling unfettered access for innovative new ideas—a difficult balancing act.

This report provides a record of these discussions and the conclusions that were reached. Not all recommendations were agreed upon by all participants, and there were no votes taken. Thus, attendance at the meeting does not imply assent by any of the participants to any particular point. Rather, the report reflects the rapporteur's general sense of the meeting, noting where appropriate any major differences of opinion.

Background

It has long been recognized that the regulation of telecommunications can have an impact on innovation, both positively and negatively. Many regulators express their desire to promote innovation, while others have had specific duties to encourage innovation added to their mandate. However, innovation can tend to take a backseat to complex issues.

Ofcom's work on innovation[3]

In a sponsored piece of work,[4] the United Kingdom's Office of Communications (Ofcom) considered how it might best fulfill its duty to encourage innovation. It broadly concluded that innovation occurs naturally in an open and competitive economy and that the role of the regulator is to ensure that as few obstacles as possible are put in its way. This generally means minimizing regulation but intervening in any areas where the competitive marketplace is being distorted—for example, by anti-competitive behavior. There might be some useful roles that governments could perform, such as stimulating pre-competitive research and facilitating knowledge transfer so that information is readily available to those considering innovating.

The role of unlicensed spectrum

It has been clear for many years that access to spectrum is needed to deploy new wireless technologies and services. In the mid-2000s, researchers started to consider what spectrum-access regimes might be best for the encouragement of innovation. Ofcom's Spectrum Framework Review[5] noted that unlicensed spectrum, or spectrum commons, appeared to be an area that enabled people to try innovative new ideas; however, access to *licensed* spectrum was needed for the deployment of new networks. The Review noted that some degree of balance was appropriate, although it was unclear precisely how to define that balance. Subsequent work by Richard Thanki[6] and others[7] attempted to place a value on the use of unlicensed spectrum and to identify areas where it led to innovative new services. A report by Plum Consulting showed that unlicensed spectrum appeared to have an economic value greater than licensed spectrum, suggesting that the balance between the two was too heavily biased toward licensed—although this was a contentious view that was far from universally accepted, with other reports indicating the opposite outcome.

By 2012, the use of unlicensed spectrum as one mechanism to allow innovation in wireless was clear. It is equally clear that licensed spectrum has played a significant role in innovation and that additional spectrum is needed to meet growing customer demand for data usage. Finding a way to balance these two needs continues to be a challenge to regulators.

Spectrum crunch, presidential mandate and the FCC response

The often-reported dramatic growth in wireless traffic levels stimulated by data usage on smartphones, tablets and laptops is known as "spectrum crunch" and underlies much of the spectrum management activity since 2008. This growth is well-covered in other reports from Aspen spectrum debates and elsewhere. The pressure this growth placed on wireless networks resulted in a call from the National Broadband Plan and from President Barack Obama[8] for the provision of 500 MHz of additional spectrum by 2020. Similar calls were made in other countries. In finding this spectrum, policies that encourage innovation have not always been at the forefront of regulatory thinking. Simply responding to the needs of previous innovation has been sufficient so far.

Finding and repurposing spectrum is always problematic and becoming ever more so as spectrum is increasingly congested. Achieving the presidential mandate is very challenging for all. In a recent speech,[9] Federal Communications Commission (FCC) Chairman Julius Genachowski described how the FCC met a midterm target to liberate 300 MHz by 2015 through a mix of policies and spectrum bands, including:

1. Auctioning 75 MHz of advanced wireless services (AWS) spectrum in 2013

2. Removing restrictions on use of 70 MHz of spectrum—40 MHz of mobile satellite spectrum and 30 MHz in the wireless communications service band

3. Using incentive auctions to free up more spectrum in the ultra high frequency (UHF) bands, although the amount here is unclear—perhaps 100 MHz

4. Using spectrum sharing—predominantly TV white space—to provide additional spectrum access; the amount is hard to define.

Whether this really does liberate 300 MHz of spectrum is open for debate. Many of the bands discussed are being "modified" rather than "liberated" and outcomes, especially on points three and four above, are far from certain.

While many of the spectrum management policies that achieved this outcome are innovative in their own right, arguably they do little to encourage innovation in wireless. They might enable further 4G deployment by providing the capacity needed for smartphone traffic growth and by allowing innovative new applications and uses. However, it is less clear if the liberated spectrum will lead to the deployment of radically new wireless technologies (as opposed to important enhancements of existing ones). Hence, those interested in new ideas tended to look elsewhere.

White space access and the PCAST report

Since the early 2000s, researchers and others have looked for ways to overcome problems with spectrum availability. One of the solutions is shared spectrum access—whereby users temporarily access spectrum in licensed bands that are not being used by the license-holder. This found its first implementation in TV white space (TVWS), where unlicensed access to spectrum is enabled in the UHF TV band as long as it avoids interference to TV reception and other licensed and preferred usages in the band. In 2012 the FCC published a series of rules culminating in approval of the first TVWS databases and devices. Commercial services are expected to be deployed in TVWS in 2013, with proposed applications to include rural broadband, machine-to-machine (M2M) and enhanced Wi-Fi.

An influential report from the President's Council of Advisors on Science and Technology (PCAST)—published in mid-2012[10]—broadly suggests the extension of white space access techniques into governmental spectrum. It recommends that 1,000 MHz of shared access be immediately identified and made available on a three-tier sharing basis—where the tertiary tier is a lightly licensed use of the spectrum. The report suggests that this is the only practical way of gaining access to spectrum currently used for federal applications, but it also notes that this provides promising ground for innovative wireless technologies and services. While this suggestion was generally welcomed, not all Roundtable participants agreed with its conclusions and some expressed concern that pressure needed to be maintained on clearing spectrum as well as pursuing the alternative approach advocated in the report.

Receiver standards

The experience of spectrum management disputes of recent years—such as LightSquared in the United States and interference to digital TV in the United Kingdom—shows that inadequately performing receivers can be unduly affected by transmissions in neighboring bands. In some cases, this can prevent the repurposing of frequency bands. This is particularly problematic for technologies and services that were not anticipated when receivers in neighboring bands were designed.

At present, receiver performance is generally not mandated. In some cases, relevant standards—such as those for 4G issued by the 3GPP standards body—will set out specifications for receiver performance. Although these specifications are designed to ensure neighboring systems using the same technology can work together, they are rarely sufficiently specified to accommodate *different* technologies in neighboring bands. Because manufacturers often have an incentive to produce equipment at the lowest cost possible, receiver performance can often be compromised—with resulting problems for spectrum management.

This issue has been acknowledged for many years, and there has been much debate and discussion as to how it might best be resolved. However, it is a difficult issue and, to date, no consensus has been achieved. For example, it may be appropriate in some cases to have poorly performing but very low-cost receivers, perhaps in disposable devices. These may not operate satisfactorily in all cases, but because of the low cost it is accepted. Mandating a rigorous receiver performance might limit this market. Even where top performance is required, if the regulator were to set too rigorous a standard, it might result in unnecessarily expensive consumer equipment, thereby inhibiting market success. Suggestions for tightening receiver specifications over time require commensurate advances in radio frequency components and design, which are uncertain.

The previous Aspen Institute AIRS publication and the FCC Technological Advisory Council explored this. Both noted that there are many viable suggestions, including some measure of spectrum usage rights that can guide receiver manufacturers and license terms that make potential interference clear.

Present-day position

By late 2012, the recent wave of innovation in wireless devices, policies that provided additional spectrum and new approaches such as smaller cells and Wi-Fi off-load led many to think it might just be possible to accommodate the rapid growth in wireless usage. Some began thinking about the next wave of innovation, including enhanced personal communications systems, mobile augmented reality and many other ideas. Since much of the spectrum that could conceivably be

repurposed had already been taken, it became clear that enabling further innovation requires a different approach. The work of PCAST and others suggests that additional innovation can be encouraged through unlicensed or lightly licensed spectrum access. Shared spectrum access using authorization database principles appears to be one mechanism to achieve this, although its use remains embryonic and restricted to the United States.

It was against this backdrop that the attendees at the Aspen Institute roundtable considered how spectrum policy could encourage more innovation in wireless communications. The resulting report is laid out in three main sections:

- **Innovation in Telecommunications.** The text begins with a brief discussion of innovation in telecommunications, exploring the differences between incremental and disruptive innovations. Current spectrum policy appears effective in enabling incremental innovations, but more can be done to enable more disruptive ideas.

- **A Range of Spectrum Products.** While it is not possible to predict what disruptions might occur, making available a wide range of different spectrum products is likely to aid those with innovative new ideas. In particular, participants explored new concepts based around sharing.

- **Overcoming Implementation Difficulties.** Ideas are one thing, implementation is another and changes in the area of spectrum policy have often proved difficult to implement. This report explores the problems and sets out some possible solutions to implementation difficulties.

Innovation in Telecommunications

Innovation is sometimes defined as "the successful exploitation of new ideas." Often the exploitation is much harder to accomplish than the idea generation. This is particularly true in wireless systems where access to spectrum is a critical element of the innovation. And, innovative ideas often fail—for example, start-ups typically have a success

probability of about 10 percent. Any policy that encourages innovation should expect to see many failures.

There is a difference between innovation in the underlying wireless bearer and innovation on top of existing bearers. Many of the innovations that consumers would point to in wireless are examples of the latter, including smartphones, apps, mobile versions of Google and so on. These all make use of continuously evolving wireless networks, such as 3G networks and Wi-Fi nodes. Innovations in the wireless bearer happen less often but are continuous (from 2G Global System for Mobile [GSM] to 3G High Speed Packet Access [HSPA] to HSPA+ to 4G Long Term Evolution [LTE], all in the matter of a few years) and often lead to multiple downstream "over the top" innovations. Examples of new wireless technologies, bearers and networks include cellular data, Global Positioning Systems (GPS), Wi-Fi and Bluetooth. To illustrate this point further, the deployment of the GPS satellite system was an innovation in wireless networks that led to myriad "over the top" innovations in satellite navigation products and apps that make use of location.

It is predominantly innovations in wireless bearers that would be enabled through radio spectrum. However, distinguishing among these different types of innovation is not always clear-cut.

Innovation and the market

A market-based framework provides incentives for companies to innovate—it enables them to profit from their ideas. Moving outside such a framework could lead to market distortions, potentially impacting the majority of companies within the framework. Equally, innovation—especially of disruptive ideas—is so difficult that there is an argument for assisting those with innovative ideas. Indeed, this is already often done by governments through vehicles such as tax policy. Making changes to specific areas of spectrum policy to encourage innovation might be appropriate, even if difficult to prove within a conventional economic framework.

Incremental and disruptive innovation

Innovation and investment occur both in larger, established companies and smaller start-ups. This is an important point since direct access to licensed spectrum is generally perceived to be more practicable to large entities that can afford auction fees and associated costs rather than smaller companies.

There is limited evidence as to which type of company innovates most. Anecdotally, recent innovation awards say some 85 percent of entries came from small- and medium-sized enterprises (SMEs). Equally substantive innovation in wireless usage has flowed from the operators investing in 3G and 4G networks. Innovation has also come from large companies like Apple, which provide equipment and app stores that are able to make good use of the new networks. Larger, established players are likely to be the ones that introduce incremental innovations that make small, valuable improvements on the current position. Truly disruptive innovations are likely to come from elsewhere. It is also possible that there is a chicken-and-egg problem in that, if spectrum access were much harder for SMEs, then evidence of innovation would tend to favor larger companies.

While both small and large firms contribute ideas, it may not be the established players who embrace the more radical innovations. Larger incumbents tend to assume that access to piecemeal spectrum for relatively short time periods is of little value. They believe that few equipment providers will invest in and produce consumer equipment available for such bands with an unproven return. However, for example, a private radio solution might be deployed using chipsets, which could be developed in relatively low quantities and turned into modules complete with sensors from a number of boutique electronics companies. So while it might be true that piecemeal spectrum is not well-suited for conventional cellular deployments, it might encourage alternative approaches and ideas for making use of the spectrum. As is often the case in many areas, those with a deep and detailed understanding of the current industry structure, value chain and modus operandi are well able to ensure the continued success of their companies, but they may be less inclined toward concepts outside of their ecosystem or strategic direction.

One example is the potential deployment of a new bespoke network for M2M communications.[11] While existing carriers could deploy the network, it might be seen as disruptive to their current business model (which attempts to use cellular systems for M2M communications) leaving carriers with an "innovator's dilemma." Instead, it might take an entrepreneurial start-up to pioneer this area and to demonstrate how a radical new technology might be superior. However, to do so requires access to spectrum at low cost. TV white space spectrum appears to provide a suitable way ahead in this case and may demonstrate how the provision of spectrum on an alternative basis to licensing is encouraging innovative new models.

The problems with spectrum access for SMEs—for whom mobile-virtual-network-operator-type relationships are not suitable—are: (1) too high a cost to acquire "prime" spectrum at auction in this early stage in their lifecycles; (2) a slow and uncertain regulatory process in which rule changes are needed (SMEs typically only have a few years of funding); and (3) the possibility of license changes or withdrawals if problems are discovered with receivers in neighboring bands, as evidenced by the LightSquared proceedings.

Conclusions

Innovation comes in many shapes and forms. Much innovation is incremental, and the current value chain and spectrum licensing approach appears to support this—as evidenced by myriad innovative new products, services and applications that have emerged using cellular networks in recent years. Occasionally, there is more disruptive innovation in the underlying wireless technology or bearer. This can stimulate many decades of subsequent growth and downstream innovation, as has happened with cellular data.

Disruptive innovations often need, or are based around, different methods of spectrum usage than conventional systems. This can be seen in emerging white space applications and, historically, in approaches such as those used by Nextel to build a national spectrum footprint or even in the failed attempts of companies like Northpoint and the ultra wideband community.[12] Making spectrum available in different forms and in as flexible a manner as possible might be expected in order to

encourage and enable more innovation. Of course, this must be a balanced approach, enabling existing networks and models to continue to develop. Just as most of a country's capital is invested in existing companies rather than in start-ups, most of the spectrum should be in the hands of proven businesses. But there should be some spectrum (and certainly more than exists today) that is available for speculative investment. The next section considers how such spectrum might be packaged to be more useful in supporting wireless innovation.

A Range of Spectrum Products

Until recently, spectrum was broadly available in two forms: licensed and unlicensed. Historically, licensed spectrum was allocated by national regulators (the FCC in the United States). More recently it is often acquired at auction and confers rights on the owner to be the sole user of the band. Unlicensed spectrum is open to all at no cost but with no guarantee of availability or freedom from interference. These two models served the country well, supporting broadcast consumer-oriented communications and public safety communications needs, and more recently, enabling concepts like cellular networks, GPS systems, and home, business and campus-wide Wi-Fi.

Newer approaches are now emerging. For example, TV white space allows unlicensed access to licensed spectrum under entry rules that prevent interference to the licensed user. The PCAST report extends this concept into governmental spectrum and explores variants such as secondary-licensed access and shorter-term licensing.

There are many ways that these new ideas could be harnessed to facilitate innovation by enabling a range of different spectrum access approaches. These are explored below.

Improving existing products

There are many bands with detrimental rules, which are often a legacy from previous years. Clearing through this "undergrowth" might make access to some bands considerably simpler. An example of this includes the AWS bands. Indeed, this is already being done by the FCC (as mentioned in the background section), and the FCC has stressed that it is very open to correcting such issues as soon as it becomes aware of them.

> **Recommendation:** Continue to seek ways to clear the "undergrowth" of unnecessary restrictions within existing licenses to enhance flexibility.

Typically, license-holders notice problematic restrictions and inform the FCC. The FCC then acts to remove them where possible. Making this process simple and fast would be helpful.

The staircase concept

Many (but not all) of the participants believed that the problem that SMEs and innovators sometimes have in acquiring prime spectrum could be resolved by enabling a "staircase" of different spectrum access modes.[13] The first step might be an easily accessible experimental license that allows a small-scale demonstration at no cost.

> **Recommendation:** Review whether more can be done with the current experimental and short-term licenses to enable innovative solutions to easily gain access to spectrum for initial testing purposes.

This recommendation is not made to solve any perceived problem with experimental licensing, which generally works well, but to explore whether more could be done to make it readily available to SMEs.[14] This might be as simple as better publicizing the licenses and simplifying the registration process, or it might mean providing assistance in migration from experimental licenses onward. Having a mix of brainstorming and external research assistance might be a suitable way forward.

The next step in the staircase would be unlicensed access—for example, into TV white space. Beyond this, there could be access into bands that are shared on a restricted basis for a fee that is less than that for sole acquisition of the band. These bands might, per the PCAST Report, be federal bands. Finally, having built a successful business and demonstrated future potential, it might be financially reasonable to acquire prime, auctioned spectrum.

This staircase concept is still very much in its infancy, and a key problem is the lack of liquidity—the limited amount of spectrum available, if any, at each of the steps—making it a high-risk approach for a company. The ideal situation would be like the rental market in a city:

Companies would be sufficiently sure that they would be able to find larger premises and, when they needed them, would not need to overly plan for the transition. Again, there is a chicken-and-egg problem. Entities like band-managers are not putting spectrum on the market at the various steps in this staircase because there is not a proven need for it, but there cannot be a proven need until there is enough spectrum on the market to allow companies to start to follow this path. In such cases, there might be merit in government intervention to kick-start the process.

The PCAST report considers many of these issues and, as a result, makes recommendations for some licenses to be of shorter duration than the typical 10–20 years. Shared access to federal spectrum under PCAST rules might fulfill the criteria for the third step in the staircase, and the band-manager of the federal spectrum might be able to place sufficient spectrum into the market to overcome the chicken-and-egg issue. Hence, shared access to federal spectrum, if set up appropriately, could go some way toward stimulating innovation.

> **Recommendation:** Establish predetermined "shareability" characteristics for bands of federal spectrum that have commercial interest, including predicted time and location availability, any issues in implementation and potential receiver problems. This would help spectrum users readily assess whether any federal sharing might be suitable for them.

This recommendation would, simplistically, lead to a product catalogue of the different types of spectrum available under shared access. Each entry in the catalogue might include the date the spectrum becomes available, the percentage of availability in various regions, the power restrictions, the known sensitivity of receivers in the band and in neighboring bands, the price, the license duration if applicable and so on. This would reduce the time and risk associated with selecting the next step on the staircase.

The final step in the staircase would be licensed spectrum. This could be acquired through market mechanisms such as trading or auction. However, innovative users might need a change to the license terms previously in use.

> **Recommendation:** Increase flexibility in secondary-market transactions by looking at approaches such as enabling parties to negotiate some changes to their licenses without the need for recourse to the regulator.

This relates to occasions when license-holders determine ways to improve their licenses by recommending changes that benefit all affected parties. These changes currently need regulatory approval. This process could be made more efficient with some changes not needing approval, some being approved automatically and the process for more problematic changes being made clear and streamlined.

Possible problems with the staircase

One concern with shared access is what might happen when spectrum access is not available. This could make a system less commercially viable or, in the worst case, result in consumer harm due to overreliance on a solution that is not sufficiently robust. One way to overcome this is band diversity, whereby the device (and perhaps the associated network) is able to operate across multiple bands, thus reducing the probability of none being available. There would be some merit in mandating such band diversity in order to protect consumers and others. On the other hand, requiring unnecessary diversity could increase the cost to consumers of devices and, if needed, of the infrastructure to support it. At this point in time, it is unclear whether such diversity is worthwhile. It might be important to monitor the availability of shared spectrum and the criticality of the applications deployed in order to be able to intervene as needed.

Shorter-term licenses clearly represent a new paradigm—and one that fits well with the staircase idea. However, depending on the method of implementing these licenses, there may be uncertainty as to whether there is a business case for making such an investment and whether consumers might suffer harm when their expectation of a longer lifetime from their equipment does not transpire. Similarly, different types of business models and networks could emerge. For example, a provider of private on-site services could establish a contract with customers setting out the lifetime of the service and the migration approach that would be adopted if there were a move to a different

frequency band. Alternatively, devices with a broad tuning range might be able to adapt automatically to changing bands.

Use of funding in test cities and R&D

Another concept introduced by the PCAST report is that of a test city—that is, a city that provides additional facilities over and above those normally available in order to encourage innovation. Ideally, an innovator with a new idea could deploy in the city of their choosing—often one close to where they are located—without any need for a nominated test city. However, there are many areas of difficulty when deploying wireless systems besides spectrum access, including access to sites, backhaul, power, other city infrastructure and the general issue of permits. A city that promised to ease these problems and perhaps provide funding or a guaranteed market for wireless services would make such a deployment less risky and hence facilitate innovation.

Ideally, these enhanced forms of access would be provided nationwide, but starting in one city might be a more practical way forward. The framework for such model cities could be put together in conjunction with existing bodies, such as the National League of Cities, and then completed in conjunction with the municipal authorities, such as the city's chief technology officer.

Such model cities might require funding to move ahead, and funds may already be available for this purpose. For example, the Universal Service Fund, which is currently underspent, could be partly repurposed toward facilitating innovative deployments of communications systems.

> **Recommendation:** Develop and implement a wireless model city framework that can be tailored by cities and innovators to facilitate initial deployments. Consider whether existing funds can be used to provide some money to assist deployment.

There might be underinvestment in research and development, especially in areas relating to federal spectrum, where the economic incentives are not as strong as for commercial use. Taking a small percentage of the revenue flowing from auction fees or license fees and using this

to fund R&D targeted at improving wireless technology could stimulate innovations. Exactly who would administer the funds and what they would be used for needs further study[15].

> **Recommendation:** Divert a portion of FCC fees to an R&D innovation fund directed to applied research on the spectrum efficiency of federal systems.

This current state reflects the reduction in commercial R&D spending over recent years and the need for early-stage research to stimulate downstream development and innovation. There are many models of funded research that could be used as a basis to take this forward.

After the Aspen Institute event, roundtable participant Dennis Roberson, Vice Provost for Corporate Relations and Strategic Initiatives at the Illinois Institute of Technology, gave further thought to the framework that might be used for a model city and suggested it be based around the following four areas: free and easy physical access for experimental use, permitting support, technical support and general entrepreneurial support.

Free and easy physical access for experimental use would allow for access on fixed passive structures such as light poles, towers, city buildings (both outside—the top and sides—and inside pilot deployments), parks, public spaces in general, city-controlled tunnels (utility and subway), special city-controlled facilities access (e.g., harbors, sports arenas, waste processing facilities) and general right-of-way access. The access would have active capabilities such as unused or lightly used fiber access, access to power sources in venues and potential access or shared access to city-controlled wireless spectrum. It would allow for access on vehicles: buses, subways, light rail, public safety vehicles, city sanitation and maintenance vehicles like street sweepers, etc. Physical access would also guarantee the provision of the power needed to support the wireless infrastructure in the various fixed, active and vehicle environments.

Permitting support would be available at various levels to include:

- Municipal permits: Support would provide expedited permitting for experimental use with a fixed time clock for the above facilities, ombudsman support (hotline) to help smooth the process, the active reduction of the number and the complex-

ity of the permits required and relevant completed sample forms available online. Support could also include assistance in handling any appeals that arise, regularly scheduled group educational forums to provide both needed information about the required permits and the means of accessing the forms and contacts for support and on-demand online education available on an as-needed basis.

- County/state permits: City support as described above to identify necessary county or state permits, to provide education and support for speedy completion of the necessary forms and to expedite the permitting process.

- Federal permits: City continues the processes described above, including education on the relevant federal requirements and support for the completion of needed processes, such as a Special Temporary Authority to handle use of needed spectrum for the company's new application or system. The model city should also have knowledge of the spectrum that is generally available, not available and might be made available under special circumstances.

Technical support could come from municipalities, organizations and individuals. City provided facilities could offer support and testing infrastructure for handling full-scale, real-world testing. This includes equipment, infrastructure and knowledgeable personnel to help set up tests and to make sure that the system/equipment to be tested is ready for the task. This includes general test guidelines to ensure a successful outcome and to ensure that the system does not damage or interfere with existing systems. Technical support could also come pro bono from local research universities, technology corporations (retired wireless technical experts with skills and discretionary time), or even technology corporations. Model cities could also arrange for pro bono use of facilities such as screen rooms and open field-test facilities, equipment (spectrum analyzers, oscilloscopes, antennas, power meters, etc.) for short-term loan or use through an agreement with the city at universities, at government operations, or at commercial enterprises. Expertise could also be available for hire beginning broadly with a city

listing of relevant local facilities and their capabilities and approximate costs (as provided by the group—university, government organization or company—with responsibility for the facility). The list could be further refined to include a city listing of locally available individual and company resources across a range of applicable skill sets (e.g., chip design; embedded, system and application software; antenna design; electromagnetic test resources; system design; quality assurance), also information on university contacts for internships, for co-op and permanent hires, and for faculty advisors/part-time consultants.

General entrepreneurial support could include incubators with their wide range of facilities, educational opportunities, business-plan evaluations, financing support, legal support, public relations and marketing support, even meeting planners to facilitate innovative work in the model city.

Conclusions

In recent years, a number of new approaches to accessing spectrum have emerged or been suggested, including white space and the sharing concepts set out in the PCAST report. Providing a range of spectrum products seems likely to encourage innovation. In particular, facilitating a staircase concept of spectrum products and encouraging a liquid market in such products could be a powerful tool for enabling innovation. However, there are many potential issues with implementing the concepts introduced in this section. Identifying and resolving these issues is the subject of the next section.

Overcoming Implementation Difficulties

Implementing PCAST

The PCAST report is seen as an influential publication, although not all participants agreed with its findings. While the ideas in the report are not all new, and many have been voiced before, the timing of the report appears promising, fitting well with the current issues and possibilities in the spectrum space. However, the ideas in the report will only be implemented if they are institutionalized, such as within the National

Telecommunications and Information Administration (NTIA). For example, during the Aspen Institute workshop, NTIA reported that there has been a test bed for sharing available for three years but that it has made little progress. As a result, calling for another test bed is unlikely to reap benefits unless a different approach is adopted.[16] In the National Broadband Plan,[17] there was a discussion of sharing, but no steps forward had been taken. This is not due to any lack of political will, but instead because there is no single person with the authority to implement ideas of this sort. Instead, decision-making is dispersed with many veto rights, enabling those not in favor to block progress. Having a "Chief Spectrum Officer of the United States" or similar highly placed official would centralize power, but this might be impractical and lead to dangerous decisions around, for example, military issues that might not be well-understood by the chief spectrum officer.

Government and industry working together might overcome some of these problems and result in a more widespread understanding of the issues and data associated with federal systems.

> **Recommendation:** Seek a set of practical ways for commercial and government users to work more closely together, sharing data about spectrum use as well as the spectrum itself.

Successful introduction of these concepts requires incentives for those within government, and specifically within NTIA, to be correctly aligned. At present, there is little incentive for those using spectrum to share it with others. Such sharing adds complexity, cost and delay for little apparent benefit. The classic incentive, used widely in the commercial world, is profit. Commercial users are assumed to have an incentive to share or sell under-used spectrum because of the revenue that might flow to them as a result. It is well-understood that this incentive is weak in government. Typically, if a department does raise revenue, it is appropriated by the Treasury, either directly or as a lower budget settlement in subsequent years. Attempts to apply incentive pricing in the United Kingdom have not been particularly successful.[18] Direct monetary payments are unlikely to be useful. The PCAST report makes some suggestions for other kinds of "artificial currencies" that might be an alternative. But there remains a poor understanding out-

side the government of the pressures and incentives currently facing governmental employees and no clear solution to modify these so that appropriate decisions on spectrum can be made.

> **Recommendation:** Find ways to better align personal and departmental incentives for more efficient spectrum use, especially for government users.

One way to liberate federal spectrum might be for the government to make use of commercial systems where appropriate. This would enable the government to shut down its own systems. However, the evidence shows that this was already done where possible. For other applications, such as military radar, there was rarely an acceptable commercial solution available.

There is an incomplete knowledge of the federal use of spectrum outside of the government. Closer interaction between government and commercial users of spectrum is a way to overcome this knowledge gap. Such interaction would facilitate shared understanding and enable a better provision of key data needed when undertaking shared spectrum activities. This would apply also to discussions between the FCC and NTIA, discussions which are often not open to other commercial players. Making these more open is an important part of the process, fostering a shared understanding of the issues. The database proposed by PCAST could hold much of this information and might be a good starting point for interaction and shared understanding. However, information such as the economic value of spectrum in alternative uses—a key enabler in making informed decisions—is missing from the proposals for this database.

Enhancing PCAST

More flexible licensing could help enable innovative new ideas, especially those that require different spectrum access methods. There has already been much work on enhancing flexibility over many years, and the PCAST team gave serious consideration to this area. For example, in some cases, sensing might be used alongside database access, particularly where updating the database is problematic for operational or security reasons. Sensing might also work alone, or with pre-stored

versions of the database, in remote cases where peer-to-peer communications is needed but there is no ability to connect back to the database. This is an area for research activities in which new ideas and solutions might emerge, and regulations should not prevent this.

Receiver performance

An area of concern among investors and other players is the possibility of unforeseen issues with poor-quality receivers in neighboring bands causing delay and the possible rethinking of usage. Participants highlighted this issue due to the difficulties of LightSquared's proposed service causing the potential degradation of GPS receivers. A solution to the "receiver standard" problem is beyond the scope of this report. However, a practical first step in easing the problem is to create a public database of receiver performance—this was recently proposed by the FCC Technical Advisory Council's Receiver and Spectrum Working Group.[19] This database would allow affected parties to establish early in the process of acquiring spectrum whether there might be a potential problem. The database could be hosted by the FCC. Inputs would come from standards bodies, which would specify receiver performance, and from manufacturers of receivers themselves. One issue is that receiver manufacturers, or network operators, might consider entry into this database as tantamount to a vested right to use the receivers without interference; but in general, the experience of LightSquared showed that such "vested rights" were already assumed in many cases anyway, and there was little to lose.

> **Recommendation:** Encourage and assist the FCC in implementing a Web-accessible receiver parameters database through their current dashboard (standards as well as actual receiver implementations).

Enforcement

In any shared access situation there is a need for enforcement to police any issues that might arise. At present, such enforcement is relatively weak. More detailed and credible ways to rapidly act and resolve interference issues would go a long way toward persuading users to share their spectrum. Enforcement is clearly easier when the secondary

users are licensed in some manner, since their details are then available to those investigating the issue. This might be an argument for a bias toward licensed shared access in some cases. Similarly, sharing is like a marriage in that both sides might need to work to make it successful, rather than resorting to argumentation and the use of a "kill switch" on a sharing database. Mechanisms where shared users could come together to talk through perceived problems are needed—another example of the importance of the commercial and governmental world working much more closely together than has been possible in the past.

Institutional structures

As discussed earlier, institutional structures, arrangements, working practices and culture could act as barriers to the implementation of new methods of spectrum licensing.

> **Recommendation:** Operationalize flexibility and sharing within the FCC and NTIA.

With the recommendation of joint commercial-federal band sharing, there is logic in the idea of a single entity that manages spectrum rather than the current split between the FCC and NTIA. The political difficulties inherent in this are substantial. A long-term objective could be a framework that provides information; reduces gaming by agencies; creates long-term spectrum, technical and operational expertise; and acts as a voice of authority. But there are many obstacles preventing this, including veto power within the Department of Defense, the multiple congressional committees involved, the linkage of existing agencies to political overlays and a political bias against establishing a new agency.

Politics is the art of the possible, and there are examples in related areas of approaches that have been successful. Other potential ideas to operationalize flexibility and sharing include:

- Zero-based spectrum budgeting, where an agency must justify their allocation every few years or lose it. A variant of this might be to set a rule that there is a 5 percent reduction in spectrum usage every few years, and then allow trading so those departments that could not accommodate the loss of spectrum would be able to regain it.

- An annual report that identifies the implicit subsidy for each agency from their holdings of spectrum. The report would highlight the most inefficient uses and the technical solutions available for improvement. It might be possible to allow the private sector to put forward innovative ideas with the incentive that they could be paid some of the subsidy saved as a result.[20]

- Targets could be set based on use—for example, a spectrum occupancy analysis could be conducted on the top 20 cities with the least-used government bands.

- Establish a "Spectrum Office of Information and Regulatory Affairs," which would have involvement with all spectrum-related issues and provide a single point of oversight for spectrum usage and regulation.

- Using a model similar to the Bureau of Land Management, the bureau would develop expertise in matching spectrum supply and demand. This could be a broker for both federal and commercial purposes.

- Mandate that a sophisticated federal buyer must make all purchases of federal radio systems. This would ensure that the technology selected is efficient. It could also provide demand aggregation across agencies/systems.

- Based on the False Claims Act, award anyone who suggests a good idea that saves money and/or improves spectrum efficiency. It was acknowledged that it would be hard to make such an approach work.

Some combination of these ideas could be adopted, and they would not necessarily need to be implemented simultaneously since sequential piece-by-piece change might be simpler to enact.

> **Recommendation:** Further explore methods that might help achieve an enhanced institutional framework for spectrum management across the commercial and federal spectrum.

While flexibility has been widely embraced in principle, there are some areas where it has not been so in practice. For example, when the FCC received a request for an experimental license in a band used by NTIA, the process of gaining approval was often time-consuming.

Next Steps

Based on the work of the group, as reported here, the author makes the following recommendations to guide future spectrum policy development.

Recommendations to facilitate the staircase function

> 1. Review whether more can be done with the current experimental and short-term licenses to enable innovative solutions to easily gain access to spectrum for initial testing purposes.

This first recommendation is not made to solve any perceived problem with experimental licensing, which generally works well, but to explore whether more could be done.[21] This might be as simple as publicizing the licenses better and simplifying the registration process, or it might extend to providing assistance in migration from experimental licenses onward. Having a mix of brainstorming and external research assistance might be a suitable way forward.

> 2. Establish predetermined "share-ability" characteristics of bands of federal spectrum that have commercial interests, including predicted time and location availability, any issues in implementation and potential receiver problems. This would help spectrum users readily assess whether any federal sharing might be suitable for them.

Simplistically, this would lead to a product catalogue of the different types of spectrum available under shared access. Each entry in the catalogue might include, for example, the date the spectrum becomes available, the percentage of availability in various regions, the power restrictions, the known sensitivity of receivers in the band and neigh-

boring bands, the price, the license duration if applicable and so on. This would reduce the time and risk associated with selecting the next step on the staircase.

Recommendations to make the final step of the staircase more flexible

> 3. Continue to seek ways to clear the "undergrowth" of unnecessary restrictions within existing licenses to enhance flexibility.

This would be ongoing. Typically, license-holders notice problematic restrictions and inform the FCC. The FCC then acts to remove them where possible. Making this process simple and fast would be helpful.

> 4. Increase flexibility in secondary-market transactions by looking at approaches such as enabling parties to negotiate some changes to their licenses without the need for recourse to the regulator.

The fourth recommendation relates to occasions when license-holders determine ways to improve their licenses by making changes that benefit all affected parties. These changes currently need regulatory approval, but this process could be streamlined with some changes not needing approval, some being approved automatically and the process for more problematic changes made clear.

Recommendations to fund innovation-friendly initiatives

There are a number of governmental initiatives that could ease the development of new technologies and deployment of networks:

> 5. Develop and implement a wireless model city framework that can be tailored by cities and innovators to facilitate initial deployments. Consider whether existing funds can be used to provide some money to assist deployment.

A model city framework is discussed extensively in this report. Taking this forward has two elements: the first being the development of guidance or a framework that could be used by cities interested in

becoming test beds or showcases; the second being an investigation of the feasibility of using the Universal Service Fund, or another existing fund, to provide the necessary resources.

> 6. Divert a portion of FCC fees to an R&D innovation fund directed to applied research on spectrum efficiency of federal systems.

This recommendation reflects the reduction in wireless R&D spending over recent years despite the need for early-stage research to stimulate downstream development and innovation. There are many models of funded research that could be used as a basis to take this forward, including greater focus on wireless innovation from the National Science Foundation.

Recommendations related to implementing the PCAST report

This will require care and attention to detail, and the following will be essential:

> 7. Find ways to better align personal and departmental incentives for more efficient spectrum use, especially for government users.

Monetary incentives do not generally fit well with the goals and drivers of those in government who make decisions related to spectrum usage. Finding an effective set of incentives that is a better fit and then matching them into the monetary incentives that typically drive commercial use is essential.

> 8. Seek a set of practical ways for commercial and government users to work more closely together, sharing data about spectrum use as well as sharing the spectrum itself.

> 9. Encourage and assist the FCC in implementing a Web-accessible receiver parameters database through their current dashboard (standards as well as actual receiver implementations).

10. Operationalize flexibility and sharing within the FCC and NTIA.

This relates to cultural change such that flexibility and sharing is seen as the norm and pervades the working practices of all relevant staff. This will likely require strong leadership and change management.

Recommendations for a revised spectrum management framework

As a longer-term goal, a better spectrum management framework would be very beneficial:

11. Further explore methods that might help achieve an enhanced institutional framework for spectrum management across the commercial and federal spectrum.

This will likely require careful work by those knowledgeable in the current structures, laws and methods of change.

Some of these next steps are hard to resolve in the abstract and might better be taken forward through a practical case. The forthcoming FCC proceedings on the 3.5–3.6GHz band could be a useful vehicle to do this. In the meantime, roundtable participants clearly see spectrum as a resource for enabling innovation policy. These eleven recommendations offer a practical guide for moving through some of the complexities of spectrum policy, with a vision of achieving the country's next great innovations—its new technological goods and services—and new institutional arrangements to manage these solutions.

Endnotes

1. Clayton Christensen, "The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail," *Harvard Business School Press*, 1997.

2. "Cisco Visual Networking Index: Forecast and Methodology, 2011–2016." Available at: http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360_ns827_Networking_Solutions_White_Paper.html.

3. Ofcom is the UK regulator responsible for telecommunications, including radio spectrum.

4. Matthew Cleevely, "The Role of Ofcom in Encouraging Innovation," January 2006. Available at: http://194.33.160.59/research/technology/innovation/innovation.pdf.

5. "Spectrum Framework Review," Ofcom, November 23, 2004–February 15, 2005. Available at: http://stakeholders.ofcom.org.uk/consultations/sfr/.

6. Richard Thanki, "The economic value generated by current and future allocations of unlicensed spectrum," September 8, 2009. Available at: http://apps.fcc.gov/ecfs/document/view?id=7020039036.; Ibid.

7. Plum Consulting's Phillipa Marks, Ken Pearson, Brian Williamson, et al., "Estimating the commercial trading value of spectrum," a report for Ofcom, July 2, 2009. Available at: http://stakeholders.ofcom.org.uk/binaries/research/technology-research/specestimate.pdf.

8. White House, "Presidential Memorandum: Unleashing the Wireless Broadband Revolution," June 28, 2010. Available at: http://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution.

9. Julius Genachowski, "Winning the global bandwidth race: Opportunities and challenges for mobile broadband," remarks at the University of Pennsylvania, October 4, 2012. Available at: http://www.fcc.gov/document/chairman-genachowski-winning-global-bandwidth-race.

10. President's Council of Advisors on Science and Technology, "Realizing the full potential of government-held spectrum to spur economic growth," July 2012. Available at: http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

11. For more details, see: www.weightless.org.

12. Arguably these failed at least in part due to difficulties in the regulatory process.

13. This would be similar to the approach growing companies adopt in their accommodations: They might initially share space in an Innovation Centre, then acquire some rooms in a shared building, then rent their own building, before finally buying land and building a bespoke headquarters.

14. It was recognized that experimental licensing needed to remain clearly separate from conventional licensing and that experimental licenses could not be seen as a backdoor method of licensing.

15. A similar approach had been followed in the United Kingdom shortly after the 3G auctions of 2000, providing some £5 million (approximately $8 million) a year from 2002 to 2005 for spectrum efficiency. Much of this was spent on research reports that were available to all, highlighting areas where innovative approaches might reap dividends.

16. NTIA is pursuing the idea of a test facility that could be used relatively quickly when interference concerns surface. The facility might include a range of chambers and test ranges as well as flexible equipment allowing rapid real-world testing.

17. FCC, "Connecting America: The National Broadband Plan," March 2010, p. 76. Available at: http://www.broadband.gov/plan/.

18. In 2005, the UK government asked Professor Martin Cave to investigate ways to facilitate commercial access to governmental spectrum. The Cave Audit (available at: http://www.spectrumaudit.org.uk/) recommended that the spectrum pricing regime that was currently in use in the United Kingdom, termed Administrative Incentive Pricing (AIP), be extended to governmental spectrum. AIP rates were calculated based on the predicted value of the spectrum in its highest alternative usage. As a result of this, annual fees of around $150 million were charged on governmental spectrum. This was paid predominantly by the Department of Defense to the Treasury. These fees did result in governmental users taking a more serious look at their spectrum holdings, with departments established and reports produced. But even some seven years later, it has not resulted in any spectrum being returned.

19. FCC, "FCC Actions on TAC Recommendations," 2011. Available at: http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting121012/TAC12-10-12FinalPresentation.pdf.

20. Of course, the subsidy identified here is not real money; so if some payment were to be made, it would need to come from a fund aligned with the subsidy. The fund might be replenished as needed from spectrum fees or similar revenue.

21. It was recognized that experimental licensing needed to remain clearly separate from conventional licensing and that experimental licenses could not be seen as a backdoor method of licensing.

APPENDIX

Spectrum as a Resource for Enabling Innovation Policy

November 14-16, 2012
Aspen Wye River Conference Center
Queenstown, Maryland

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Webb has published 12 books, 100 papers and 18 patents. He is a Visiting Professor at Surrey University, a member of Ofcom's Spectrum Advisory Board (OSAB) and a Fellow of the Royal Academy of Engineering, the IEEE and the IET. His biography is included in multiple "Who's Who" publications around the world. He has been a judge for *The Wall Street Journal's* Annual Innovation Awards for the last decade, has been General Chair of the IEEE's DySpan conference and is a board member of the TPRC conference and of Cambridge Wireless. In his spare time, he is a keen cyclist, having ridden the route of the Tour de France and twice completed the grueling Cent Cols Challenge, climbing over 100 Alpine and Dolomite passes in ten days.

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Select Publications from the Aspen Institute Communications Policy Project

Rethinking Communications Regulation, by Richard Adler

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

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

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

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

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

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

Spectrum for the Next Generation of Wireless, by Mark MacCarthy

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

Rewriting Broadband Regulation, by David Bollier

The report of the 25th Annual Aspen Institute Conference on Communications Policy in Aspen, Colorado, considers how the United States should reform its broadband regulatory system. Participants looked at international models and examples and examined how data and communications should be protected in the international arena. The resulting report explores a range of policies for U.S. broadband

regulation, many of them derivative of the National Broadband Plan adopted by the Federal Communications Commission only a few months before the conference.

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

Scenarios for a National Broadband Policy, by David Bollier

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

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

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

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

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

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

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

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

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

As the converged worlds of telecommunications and information are changing the way most Americans receive and relate to video entertainment and information, the regulatory regimes governing their delivery have not changed in tune with the times. These changes raise several crucial questions: Is there a comprehensive way to consider the next generation of video delivery? What needs to change to bring about a regulatory regime appropriate to the new world of video? The report of the 21st Annual Conference on Communications Policy in Aspen,

Colorado, outlines a series of important issues related to the emergence of a new video marketplace based on the promise of Internet technology and offers recommendations for guiding it into the years ahead. 2006, 70 pages, ISBN Paper: 0-89843-458-0, $12.00

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

The report describes the communications problems facing the safety enterprise community and their potential solutions. The report offers several steps toward a solution, focusing on integrating communications across the safety sector on an Internet-Protocol-based backbone network, which could include existing radio systems and thus make systems more dependable during emergencies and reduce costs by taking advantage of economies of scale. The conference participants stressed that the greatest barriers to these advances were not due to lagging technology but to cultural reluctance in adopting recent advances. Writes Weiser, "The public safety community should migrate away from its traditional reliance on specialized equipment and embrace an integrated broadband infrastructure that will leverage technological innovations routinely being used in commercial sectors and the military." 2006, 55 pages, ISBN Paper: 0-89843-4, $12.00

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