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WIRELESS BROADBAND AND THE FUTURE OF SPECTRUM POLICY

HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED FOURTEENTH CONGRESS

FIRST SESSION

JULY 29, 2015

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED FOURTEENTH CONGRESS

FIRST SESSION

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WIRELESS BROADBAND AND THE FUTURE OF SPECTRUM POLICY

WEDNESDAY, JULY 29, 2015

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met, pursuant to notice, at 10:48 a.m., in room SR–253, Russell Senate Office Building, Hon. John Thune, Chairman of the Committee, presiding.

Present: Senators Thune [presiding], Johnson, Daines, Wicker, Heller, Gardner, Nelson, Markey, Udall, Peters, Schatz, and Booker.

OPENING STATEMENT OF HON. JOHN THUNE, U.S. SENATOR FROM SOUTH DAKOTA

The CHAIRMAN. This hearing will come to order.

My apologies to our panel. We had, as you know, some votes come up, which often times happens around here, and so that pushed us back a little bit. But thanks for your patience, and thank you all for being here today.

We convene today to discuss what Congress and the Federal Government should be doing to ensure that the United States remains at the forefront of the mobile revolution. Today's hearing will be the first in a series to examine the policies related to spectrum and wireless broadband. The Senate has a real opportunity over the next several months to pass meaningful wireless broadband and spectrum reform legislation, and it is my hope that the Committee will use these hearings to inform our work on developing such a bill.

By now, everyone is familiar with the immense power of wireless technologies. From keeping us connected while on the go, to powering the growing Internet of Things, wireless devices and services have become commonplace in the everyday lives of most Americans.

Here in the United States, we also have the benefit of being the global leader in wireless innovation and investment, particularly in 4G mobile broadband. But this committee and Congress as a whole cannot take these developments for granted. Europe and Asia look at our 4G success with envy and are working hard to leapfrog the United States and take the lead in the next generation of wireless, known as 5G. And while the last two decades of wireless policy have largely been a success, we cannot be complacent and think that yesterday's laws are a perfect fit for the future.

After the record-setting AWS–3 auction earlier this year and on the eve of a spectrum auction that may be even more important, now is the perfect time for this committee to start thinking about what is next for American spectrum policy.

Speaking of the upcoming incentive auction, we just saw the FCC this month delay one of its key rulemakings for that auction. It is my hope this doesn't end up being a serious setback, because I would very much like to see the incentive auction happen next year as planned.

While I am sure many of my colleagues would agree, today's hearing is not focused on the near-term actions of the Commission. Instead, we need to be looking further into the future. Our nation's airwaves are only going to get more crowded as the Internet of Things brings tens of billions of wireless devices online. We need more wireless capacity, more wireless efficiency, and more wireless innovation.

To do this, the Government will need to be more conscientious about how it manages and uses its own spectrum, while also proactively breaking down barriers to private-sector deployment.

As I see it, there are three areas where the Committee should focus its legislative attention.

First, we need to improve how the Federal Government, which is the largest spectrum holder in the country, manages and utilizes its own airwaves. Federal agencies already share some of their spectrum with the private sector, but much more needs to be done to encourage them to relinquish or share additional bands.

This does not need to be an antagonistic effort. With a challenging fiscal environment, many agencies may see opportunity in opening up their bands to the public in exchange for new wireless systems that are more efficient and less costly to maintain.

Like the private sector, Federal agencies' wireless needs grow each year. But by aligning incentives and utilizing newer technologies, we may be able to find win-win solutions that benefit everyone.

The second area we need to focus on is identifying specific bands that can be opened up for private use, both licensed and unlicensed. While creating the right spectrum management incentives for the Federal Government will help, history shows that Congress is often the most effective facilitator in bringing more wireless bands to the marketplace.

Additionally, finding spectrum to be auctioned can help bring in revenue for the U.S. Treasury that can then be used to pay down our Nation's fiscal deficit or fund other critical priorities.

Perhaps more important than those revenues is the impact that freeing up more spectrum will have on our economy. More private-sector spectrum has historically led to more jobs and more economic growth. Just yesterday, former Democratic FCC Chairman Julius Genachowski and former Republican FCC Commissioner Rob McDowell wrote a compelling op-ed in *The Wall Street Journal* that suggests 750,000 new jobs could be created by deploying more mobile broadband.

Last, we need to examine ways to reduce the cost of deploying wireless broadband services. Freeing up more spectrum is one way to do that, but there may well be other legal and regulatory bar-

riers that make it more expensive to bring new services to the public. In particular, we ought to look at the rules governing the deployment of private-sector wireless facilities on Federal lands and buildings.

Helping to get government at every level out of the way of wireless deployment will only accelerate how soon Americans will benefit from 5G, from the Internet of Things, and the next exciting wireless development that will enhance people's lives.

I look forward to hearing from today's panel of experts. Among them, they have a wealth of experience in spectrum policy, and I expect they will all have interesting and thought-provoking ideas for the Committee to consider.

I now turn to our Ranking Member. Senator Nelson I think will be here later on, but, Senator Schatz, an opening statement.

STATEMENT OF HON. BRIAN SCHATZ,
U.S. SENATOR FROM HAWAII

Senator SCHATZ. Thank you, Mr. Chairman.

And thank you to the witnesses for being here today.

We spend a lot of time focused in Washington on areas of disagreement, but spectrum policy is one area where there is a real opportunity for bipartisan consensus.

As we will hear from our witnesses today and as we can confirm from our own experience as consumers, wireless and mobile data use is increasing exponentially. That means that the demand for the Nation's finite spectrum resources is greater than ever.

So we have to work together on a spectrum pipeline for the future. We need to develop an aggressive plan to make different types of spectrum available. It is the right thing to do for consumers, the Government, and the private-sector economy.

We share common goals for this pipeline. First, we need to ensure that the Government agencies, like DOD, FAA, and DOT and others, can fulfill their mission. Second, we want to make sure that consumers have access to new competitive services and that our national spectrum policy empowers entrepreneurs to innovate. Finally, we have to provide the right incentives for service providers to deploy state-of-the-art wireless networks.

As part of setting up this spectrum pipeline, Congress will need to grapple with many issues. For one, we have to think about how we properly account for competing commercial and government needs for spectrum and create a path to repurpose Federal spectrum effectively.

I think there is merit in the idea of providing incentives for Federal agencies to make spectrum available for commercial uses—something many of our witnesses will discuss today. We also need to be creative about ways to speed up the process to more spectrum availability.

Most importantly, Congress will need to think about how to balance the need for licensed and unlicensed spectrum. Startups and entrepreneurs are all counting on the availability of licensed and unlicensed spectrum to launch their next innovation. Whether they are working from a coffee shop, a garage, or borrowed space, the next companies need us to get this right.

Ensuring the availability of more licensed spectrum is essential because it provides companies the certainty they need for investment. Unlicensed spectrum, though, is also critical. Not only has unlicensed spectrum become an essential part of the Nation's wireless infrastructure through offloading of traffic from licensed spectrum, but it also provides the foundation for permissionless innovation.

Unlicensed spectrum lets innovators deliver millions of new products, such as hotspots, connected medical equipment or industrial systems, RFID tags, wearables, and more.

In fact, one driver of spectrum-hungry innovations is the growing Internet of Things, a development that Senators Booker, Fischer, Ayotte, and I have been working on. Experts project that within the next decade the Internet of Things will encompass billions of connected devices, nearly all of which will rely on unlicensed spectrum to work. And that is going to put a lot of pressure on the spectrum that we have available today.

Thank you, Chairman Thune and Ranking Member Nelson, for initiating this discussion. And I know we will continue not just today but throughout the fall on these important issues.

The CHAIRMAN. Thank you, Senator Schatz.

We will proceed to our panel. And I want to welcome them all here today.

We have with us Commissioner Jessica Rosenworcel of the Federal Communications Commission. Ms. Meredith Attwell Baker. Ms. Baker is the President and CEO of CTIA—The Wireless Association®. Mr. Blair Levin. Mr. Levin is the former Executive Director of the FCC's National Broadband Plan. Dr. Pierre de Vries. Dr. de Vries is the Co-Director of the Spectrum Policy Initiative with the Silicon Flatirons Center at the University of Colorado School of Law. And Dr. Thomas Lenard. Dr. Lenard is the President and Senior Fellow at the Technology Policy Institute.

Thank you all so much for being here today.

We will proceed, starting on my left and your right, with Commissioner Rosenworcel.

Welcome to the Committee.

STATEMENT OF HON. JESSICA ROSENWORCEL, COMMISSIONER, FEDERAL COMMUNICATIONS COMMISSION

Ms. ROSENWORCEL. Thank you.

Good morning, Senator Thune and members of the Committee. Thank you for having me here.

Few of us go anywhere today without mobile devices in our palms, pockets, or purses, but as commonplace as wireless service feels right now, the truth is we are only getting started. Because, over the next 5 years, worldwide demand for mobile service is expected to grow by 10 times. And as the Internet of Things emerges, wireless functionality will become a part of nearly everything we do.

But the airwaves that are responsible for our modern wireless economy are finite, so we need to use what we have more efficiently. That means we need to rethink how we allocate our airwaves and, in particular, the airwaves used by the Federal Government.

Today, Federal authorities have substantial spectrum assignments, and that makes sense because critical missions throughout the Government depend on wireless service. Federal systems that rely on spectrum help protect us from attack, manage our air traffic, enhance our crop productivity, and monitor our water supplies.

Now, traditionally, when commercial demands on spectrum rise, we go to these Federal authorities and we put on the pressure. We urge, coax, and cajole them, in an effort to free old government airwaves for new private-sector use. If they agree, we clear government users out of a portion of their airwaves, relocate them, and eventually auction the cleared spectrum for new commercial use.

With the tremendous demands on our airwaves today, we could go this route again, just as we have in the past. But it is a creaky system. It is not reliable, and it takes too long. In short, it is not the steady spectrum pipeline the modern mobile economy needs.

So the future of spectrum policy requires incentives. We need a Federal spectrum policy that is based on carrots and not sticks. If we want a robust and reliable spectrum pipeline, we need to make sure that Federal authorities see gain, and not just loss, when their airwaves are reallocated for new mobile broadband use.

We could begin by expanding incentive auctions to Federal spectrum users, modeled on the upcoming incentive auctions in the 600-megahertz band. Now, this is a complex undertaking because agencies do not operate in a market environment, and they are subject to annual budget allocations. But, nonetheless, we should explore it, with discrete spectrum bands or agencies.

We could also update the Spectrum Relocation Fund so that it provides incentives for more government sharing by rewarding Federal users when they share their spectrum with agencies that are being relocated.

While we are at it, we should review laws that create perverse incentives, like the Miscellaneous Receipts Act. If we make changes to this law, we could permit winning auction bidders to negotiate directly with Federal authorities remaining in the band and then help meet their wireless needs. This could speed the repurposing of our airwaves and also help update Federal systems that are past their prime.

Next, the future of spectrum policy requires looking at millimeter wave spectrum. Today, the bulk of our wireless networks are built on spectrum below 3 gigahertz. But, in the future, we need to bust through this ceiling and look high—really high. We need to look at spectrum all the way up to 24 gigahertz and maybe even as high as 90 gigahertz. Because if we combine wide channels from these stratospheric frequencies with dense networks of small cells, we are going to be able to overcome propagation challenges and deliver wireless service at faster speeds than ever before.

This approach is likely to be a major force in the next generation of wireless services, known as 5G. And the time to explore greater use of this spectrum is right now.

Finally, the future of spectrum policy requires not just more licensed spectrum but also more unlicensed spectrum. In short, we need more Wi-Fi. Unlicensed spectrum, like Wi-Fi, democratizes Internet access, it encourages permissionless innovation, and it contributes as much as $140 billion to the U.S. economy annually.

But, historically, the legislative process has overlooked the value of unlicensed spectrum because it gets low marks in the scoring process. But this accounting misses the mark, because the broader benefits of unlicensed spectrum and Wi-Fi to our economy are so great. So in any legislative effort that is upcoming that increases licensed spectrum in our pipeline, we also need a cut for unlicensed. We could call it the Wi-Fi dividend.

Thank you. I look forward to any questions you might have.

[The prepared statement of Ms. Rosenworcel follows:]

PREPARED STATEMENT OF HON. JESSICA ROSENWORCEL, COMMISSIONER, FEDERAL COMMUNICATIONS COMMISSION

Good morning, Chairman Thune, Ranking Member Nelson, and members of the Committee. Thank you for the opportunity to appear before you today and talk about the future of spectrum policy.

Few of us go anywhere today without mobile devices in our palms, pockets, or purses. But as commonplace as wireless service may feel in our lives now, the truth is we are just getting started. Over the next five years, world-wide demand for mobile service is expected to grow by 10 times. As the Internet of Things emerges, wireless functionality will become a part of nearly everything we do.

Back in the here and now, all of this wireless demand has consequences for a scarce resource: spectrum. The airwaves around us that are responsible for our modern wireless economy are finite. The iron laws of physics being what they are, we are simply not making more. So the challenge is to use the spectrum we have more efficiently.

There are many things we can and should do to be more efficient with this scarce resource—from improving network technology to improving network topology. But we also need to rethink how we allocate our airwaves—and in particular the airwaves used by the Federal Government. So that is where I want to begin.

Today, Federal authorities have substantial spectrum assignments. This makes sense because critical missions throughout the government are dependent on wireless services. Federal systems that rely on spectrum help protect us from attack, like early missile warning systems. They help manage our air traffic, enhance our crop productivity, and monitor our water supplies.

Traditionally, when commercial spectrum demands rise, we go to these Federal authorities and put on the pressure. We urge, coax, and cajole them in an effort to free old government airwaves for new private sector use. If they agree, we clear government users out of a portion of their airwaves, relocate them, and eventually auction the cleared spectrum for commercial use.

With the tremendous demands on our airwaves today we could do this again, just as we have in the past. But it's a creaky system. It's not reliable. It's not consistent. It takes too long. In short, it's not the steady spectrum pipeline the modern mobile economy needs.

The future of spectrum policy requires incentives. We need a Federal spectrum policy that is based on carrots, not sticks. If we want a robust and reliable spectrum pipeline, we need to make sure that Federal authorities see gain—and not just loss—when their airwaves are reallocated for new mobile broadband use. To do this, we need to develop a series of incentives to serve as the catalyst for freeing more spectrum for commercial markets.

We could begin by expanding incentive auctions to Federal spectrum users. These auctions would be modeled on the broadcast spectrum incentive auctions that are planned for the 600 MHz band. Participating Federal authorities would receive a cut of the revenue from the commercial auction of the airwaves they clear—and could use these funds to support relocation as well as initiatives lost to sequestration. This is a complex undertaking, because agencies do not operate in a market environment and are subject to annual budget allocations, but we should explore it—with discrete spectrum bands or agencies.

We could also update the Spectrum Relocation Fund. Today the Spectrum Relocation Fund assists Federal authorities with relocating their wireless functions when their spectrum is being repurposed for commercial use. But this fund could also provide incentives for more government sharing by rewarding Federal users when they share their spectrum with agencies that are being relocated.

While we are at it, we should review laws that create perverse incentives. Consider the Miscellaneous Receipts Act. This law can prevent negotiations between

Federal agencies and winning bidders in wireless auctions. But if we make changes, we could auction imperfect rights and permit winning bidders to negotiate directly with Federal authorities remaining in the band to help meet their wireless needs. This could speed repurposing of our airwaves and also provide commercial carriers with incentives to help update Federal systems that are past their prime.

Finally, we should develop a spectrum currency with assistance of the Office of Management and Budget. With a uniform system of valuation for Federal spectrum assignments, we can explore further incentives for efficiency and better understand the opportunity cost of Federal use.

The future of spectrum policy requires looking at millimeter wave spectrum. Today, the bulk of our wireless networks are built on spectrum below 3 GHz. But in the future, we need to bust through this ceiling and look high—really, really high. We need to look at spectrum all the way up to 24 GHz and perhaps as far as 90 GHz. If we combine wide channels from these stratospheric frequencies with dense networks of small cells we can overcome propagation challenges and deliver wireless service at faster speeds than ever before. This approach is likely to be a major force in the next generation of wireless services, known as 5G. The race to 5G is on and our counterparts in Europe and Asia are already making way. We may have led the world in 4G, but laurels are not good resting places. So the time to explore greater use of this spectrum is right now.

The future of spectrum policy requires not just more licensed spectrum—but also more unlicensed spectrum. In short, we need more Wi-Fi. Unlicensed spectrum, like Wi-Fi, democratizes Internet access, encourages permissionless innovation, and contributes $140 billion in economic activity annually. But historically the legislative process has overlooked the value of unlicensed spectrum because it gets low marks in the scoring process at the Congressional Budget Office. But this accounting misses the mark—because the broader benefits of unlicensed spectrum to the economy are so great. So in any legislative effort to increase the licensed spectrum pipeline, we need a cut for unlicensed—call it the Wi-Fi dividend.

In sum, if we combine more incentives to facilitate the repurposing of Federal Government spectrum for new commercial use with more exploration of the possibilities of millimeter wave spectrum and more opportunities for Wi-Fi—we can build a spectrum pipeline that is robust, reliable, and a potent force in our economic future.

Thank you. I look forward to answering any questions you may have.

The CHAIRMAN. Thank you, Commissioner Rosenworcel.

We will move now to Ms. Baker.

STATEMENT OF HON. MEREDITH ATTWELL BAKER, PRESIDENT AND CEO, CTIA—THE WIRELESS ASSOCIATION®

Ms. BAKER. Chairman Thune, Ranking Member Nelson, and members of the Committee, thank you for your leadership in developing a forward-looking spectrum policy, one of the key inputs into our country's economy.

I have worked on spectrum issues at NTIA, as an FCC commissioner, and today I am lucky enough to represent the wireless industry, the most dynamic industry in the nation, at CTIA.

The global stakes for spectrum policy have never been greater. Countries around the world have seen what our wireless leadership has meant for jobs, for economic growth, and for innovation. We need a national recommitment to continue to lead the world in wireless. I am confident we will. I am encouraged by the dynamic thought leaders you have brought this morning here and your bipartisan engagement on this issue. For our part, the wireless industry is dedicated to investing billions more in the wireless future.

We forget now, but we were behind other nations in 3G. Today, the United States is the global leader in 4G. We are home to one-third of the world's 4G devices. Ninety-eight percent of Americans have access to 4G, thanks to $150 billion of industry investment over just the past 5 years.

This 4G foundation supports innovation up and down the mobile ecosystem, licensed and unlicensed. More than 9 out of 10 smartphones across the globe run a U.S. operating system. The same U.S. predominance is true for mobile apps. U.S. companies account for 91 percent of global downloads.

Our wireless leadership has a substantial impact on our economy—over $400 billion annually. The true impact is far larger, because wireless is now more than just a service. Wireless is the platform for innovation in the 21st century. Mobile is no longer just voice and text. It is health, education, and connected everything, from cars to appliances. The Internet of Things will be driven by wireless.

Amazingly, mobile already represents more than half of all Internet traffic. And, as the platform of choice for millennials, that figure will only grow. In the next 5 years, wireless data volumes will increase six-fold.

Mr. Chairman, if South Dakota grew at the same rate, it would be roughly the same size as Minnesota or Colorado by the decade's end.

[Laughter.]

Ms. BAKER. We can meet almost half of that growth through billions in wireless infrastructure and technological improvements. We commit today to do that. But for the rest, we need more licensed spectrum.

Five years ago, under the leadership of my fellow panelist Blair Levin, the FCC formed a 10 year spectrum plan. The FCC identified a 300-megahertz target for licensed spectrum by 2015. They relied on data predictions, and those predictions have proved remarkably accurate, to within one-fifth of 1 percent—remarkable.

Thanks to this committee's leadership, the administration, the FCC, and Commissioner Rosenworcel, we have reallocated 135 megahertz toward that target. The successful AWS–3 auction earlier this year was the key. The remaining deficit underscores just how hard reallocation can be, as well as the critical importance of the upcoming broadcast auction to meet consumers' mobile data needs.

And after the broadcast auction, we don't know what is next. The pipeline will be empty, and we, the United States, do not have a plan. As a nation, we need a new long-term spectrum plan to accommodate future growth. Spectrum reallocations take an average of 13 years. We need to jump-start our efforts today if we are to keep up globally. I believe, working together, we can shrink the timing we need to reallocate.

Using the FCC's own formula, we need to increase our nation's supply of licensed spectrum by 350 megahertz by the end of the decade. We are hard at work identifying potential bands. Reallocating licensed spectrum requires a significant commitment from all stakeholders. But that is why we lead the world in wireless. Time and again, it has been proven to be worth the effort.

As we develop a new pipeline, we also need to ensure our military and government agencies have adequate spectrum and technologies to support mission-critical services. We also need to explore complementary use of spectrum-sharing, unlicensed, as well as high-band spectrum, because the rest of the world is not stand-

ing on the sidelines. Countries around the globe have plans to leapfrog us in 5G—Korea in 2018 and Japan in 2020.

Fortunately, a cross-section of this committee has already taken a leadership role on spectrum. Members have introduced key legislative proposals that would unlock more spectrum, improve Federal agency incentives, and facilitate rural 4G deployment. We now have our new 350-megahertz goal, and we are ready to work with each of you to develop a new 10-year spectrum plan to advance America's wireless future.

Thank you for the opportunity to be part of today's hearing.

[The prepared statement of Ms. Baker follows:]

PREPARED STATEMENT OF MEREDITH ATTWELL BAKER, PRESIDENT AND CEO, CTIA—THE WIRELESS ASSOCIATION®

Chairman Thune, Ranking Member Nelson, and members of the Committee, thank you for inviting me to share CTIA's perspective on the future of spectrum policy. We appreciate your leadership on developing a forward-looking approach to one of the key inputs into America's long-term global competitiveness.

Today's topic is of critical importance to the health of America's wireless industry, and our entire economy. It is something we all have a vested interest in getting right. So as the Committee considers what's next in spectrum policy, I hope CTIA can help inform your work.

The United States is the Global Leader in 4G Mobility

I am proud to report that the United States is the global leader in 4G wireless. This has not always been the case. We were markedly behind Europe and others in the deployment of 3G technologies only a decade ago. But with a combination of sound spectrum policy, a light-touch approach to regulation, and pro-investment tax policy, America now leads.

Today, despite having only 5 percent of all wireless connections in the world, the United States has 33 percent of 4G LTE connections. 98 percent of Americans have access to 4G LTE networks, and, even more impressively, over 93 percent of Americans can choose from three or more mobile broadband options.

Vibrant market competition has driven the widespread adoption of 4G solutions. You likely choose between 4 national carriers—as well as regional operators and resellers—offering you unparalleled choice in wireless solutions. This has led directly to differentiation and new service offerings. It has also supported over $150 billion in private capital in the past five years alone to bring 4G capabilities to American consumers. That investment was greater than that of the truck, rail, and air transportation industries, and it means that every year, wireless networks get faster and better, devices have more capabilities and features, and the Internet of Things around us gets more and more advanced. Speeds are increasing, prices are decreasing, and usage is skyrocketing.

That 4G foundation helps support innovation and investment up and down the mobile ecosystem. Indeed, our global lead is pervasive. Over 9 out of 10 smartphones across the world run an operating system developed by a U.S. company. The same U.S. predominance is true for mobile apps, as 91 percent of mobile app downloads come from U.S. companies. We are also leaders in leveraging unlicensed spectrum to benefit U.S. consumers.

Spectrum Is a Powerful Economic and Social Catalyst

Our global 4G lead has a direct and substantial impact on consumers and our economy. We recently released a Brattle Group study that provides a powerful reminder of what's at stake in spectrum policy, finding that licensed spectrum in the hands of wireless carriers generates over $400 billion in economic activity every year.[1] That's a powerful figure. But it doesn't tell the whole story, which is that for every dollar spent on licensed wireless services, $2.32 is spent throughout the broader economy. When combined with the additional $62 billion that unlicensed spec-

[1] Coleman Bazelon and Guila McHenry, "Mobile Broadband Spectrum: A Vital Resource for the U.S. Economy" (May 2015). See *http://www.brattle.com/system/publications/pdfs/000/005/168/original/Mobile_Broadband_Spectrum_-_A_Valuable_Resource_for_the_American_Economy_Bazelon_McHenry_051115.pdf?1431372403.*

trum contributes,[2] it's clear that wireless services and technologies are an economic powerhouse.

The Brattle Group also found that licensed wireless is a tremendous job creator. In 2013, wireless supported over 1.3 million jobs in this country. With every hundred people employed in the wireless industry, another 650 people find jobs. And wireless jobs are good paying jobs, paying 45 percent higher than the national average.

Just as importantly, licensed spectrum enables network operators to boost speeds and capacity, device manufacturers to develop new products, and app and content creators to craft new offerings. It fuels new investment, innovation and American leadership, reinforcing why spectrum policy is central to our future economic policy.

The wireless industry's full contribution to the economy far eclipses the $400 billion figure. Because wireless is more than just a service. Wireless is the platform, the basic building block, for innovation in the 21st century—in the commercial space as well as the government space.

Mobile is no longer just voice and text, but also video, health, retail, education, energy and connected everything—from cars and appliances to healthcare devices and drones. The Internet of Things is driven by mobility and spectrum. Right now, the connected car market is growing ten times faster than the traditional automobile market. By 2020, an incredible 97 percent of all vehicles shipped in the United States will be able to connect to the Internet. In four years, 1.8 billion connected home devices, smart appliances, home security systems, and energy equipment, will ship, 12 times what shipped just last year. In the same time period, the market for mHealth will nearly top $50 billion, up from $2 billion in 2012. Our connected future and the economic and social benefits that flow from it ride on wireless networks. These networks depend on investment and innovation.

Mobility is also the communications platform of millennials—for 87 percent of millennials, their phone never leaves their side. Over 45 percent of American households do not have a wireline telephone today, and the reliance on mobility is highest among the young, low-income, and minority communities across the Nation. Mobile is the next generation's tool for empowerment and entrepreneurship, and the mobile device is increasingly the gateway to employment, health, and education opportunities.

A Bridge to 5G: Meeting Skyrocketing Consumer Demand for Mobile Broadband

Not surprisingly, mobile broadband continues to grow at record levels as consumers embrace mobility more and more each year. Mobile data traffic grew over 35-fold from 2009 to 2014, and today, more than half of Internet traffic is mobile. The average user consumed 450 megabits a month in 2012. Today, 1.8 gigabits a month. That's just 3G/4G and other licensed data, not unlicensed. Now envision a future where 3G/4G data averages 6, 8, or 10 gigabits a month.

That future is closer than many think and just wait until the remaining third of Americans start using smartphones, and 4G networks and uses become more sophisticated. These growth projections can be a little daunting, just like they were in 2010 when we last had a conversation about the spectrum deficit. In 2014, more than 500 petabytes (that's 500 followed by 15 zeros, the equivalent of 500 million gigabytes) of traffic flowed across wireless networks each month. In 2019, mobile data traffic is projected to be six times that amount. But we won't have six times the spectrum, no matter what we do.

To meet the rapidly evolving needs of U.S. consumers, there is significant amount of work and investment to be done by the mobile industry. Work we stand ready to do.

First, the wireless industry will continue to invest tens of billions of dollars in our Nation's infrastructure, which means more jobs and opportunity across the country as the wireless industry deploys thousands of new cell sites and small cells to densify and extend our networks that already support approximately 300,000 sites.

We also will roll out new 4G LTE functionalities. We tend to speak about wireless generations as singular events like the jump from 3G to 4G or 4G to 5G. The reality is that today's LTE networks are far better than the ones initially deployed just five years ago. And we are committed to continuing to improve those networks year in and year out. We will aggregate spectrum bands into wider channels, introduce the ability to broadcast video content, better leverage unlicensed spectrum, and roll out

[2] "Unlicensed Spectrum and the American Economy: Quantifying the Market Size and Diversity of Unlicensed Devices," (June 2014). See *http://www.ce.org/CorporateSite/media/gla/CEAUnlicensedSpectrumWhitePaper-FINAL–052814.pdf.*

device-to-device solutions. We will see HD Voice, VoLTE, LTE Broadcast, and remarkable new apps and offerings that leverage these new opportunities.

We will use existing spectrum resources more efficiently. Beyond rolling out these substantially more efficient 4G technologies, carriers are re-farming existing mobile bands from voice to data. Verizon is refarming its 1900 MHz PCS spectrum and AT&T is actively refarming Leap's spectrum. T-Mobile has already refarmed MetroPCS' CDMA spectrum for 4G and shut down that legacy network this summer.

And lastly, we need to start a conversation about what the United States needs to support next-generation or 5G networks. We need to work together to identify the use cases, spectrum needs, and economic opportunity presented by 5G, as well as the investment and research needed for us to retain a global lead. In the interim, the most important steps we can take are to solidify our first mover advantage in 4G. Our ability to leverage 5G will be enhanced by making our 4G foundation as strong and dynamic as possible.

A Renewed Focus on Spectrum

While industry can—and will—take steps on its own to address the challenge of a six-fold increase in wireless data, infrastructure investment and engineering enhancements alone cannot meet the future wireless demand. These industry-driven efforts will address approximately 40 percent of the expected growth volumes, but they do not obviate the need for more spectrum.

As smartphone penetration continues and the Internet of Things and our connected life take off, wireless will need hundreds of megahertz of additional licensed spectrum. All of our connected life aspirations will ultimately succeed or fail based on our underlying mobile infrastructure.

In 2010, with no spectrum in the pipeline, the Federal Government called for 300 MHz of new licensed spectrum by 2015, and 500 MHz of total spectrum by 2020. Those targets were established based on projections of mobile data growth that were dismissed at the time as unrealistic. In fact, the FCC and the National Broadband Plan estimates were remarkably accurate. In 2010, the FCC's growth estimates forecast mobile data traffic of 562 petabytes per month in 2014. The actual amount last year? 563 petabytes per month. The FCC was off by one-fifth of one percent.[3]

The Administration has committed significant resources to identifying additional spectrum for mobile broadband, and successfully re-allocated 135 MHz towards the 300 MHz goal. The successful AWS–3 auction earlier this year was the largest step to date, and this remaining deficit underscores the critical importance of the upcoming broadcast incentive auction.

The practical reality is that five years ago, the Administration formed a ten-year spectrum plan. While we're making progress toward the Administration's target, we have much more to do to prepare for the exponential growth that's coming. As a country, we have no plan beyond 2020 to accommodate mobile growth, and the closer we get, the more daunting the timeline looks. Existing systems need to be relocated or retuned, and that alone takes years and billions of dollars. History is our guide: the average time to reallocate spectrum is 13 years.[4] You could raise a teenager in the time it took to bring the 700 MHz band from identification to use. The AWS–3 process seemed to go quickly, but only if you forget that we were talking about access to that band for more than a decade before the 2012 Spectrum Act jumpstarted the process by scheduling the 2155–2180 MHz band for auction. Because spectrum policy is a long game, we need to start planning today to meet future consumer needs.

The backbone of our national spectrum policy should remain licensed and exclusive use spectrum. It is our collective commitment to licensed spectrum that has made the United States the global leader in 4G. Auctions in 2006 and 2008 paved the way to our current winning position. And it is that commitment to licensed spectrum that has given carriers the confidence and certainty necessary to invest billions in spectrum and infrastructure.

We also feel strongly that the military and government agencies need adequate spectrum to support mission critical services, and mobility is just as central to Federal users' future as it is to commercial subscribers. We believe working collabo-

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[3] Thomas Swanabori and Robert Roche, "Mobile Data Demand: Growth Forecasts Met—Significant Growth Projections Continue to Drive the Need for More Spectrum (June 2015). See *http://www.ctia.org/docs/default-source/default-document-library/062115mobile-data-demands-white-paper.pdf.*

[4] Thomas Swanabori and Robert Roche, "From Proposal to Deployment: The History of Spectrum Allocation Timelines," (July 2015). See *http://www.ctia.org/docs/default-source/default-document-library/072015-spectrum-timelines-white-paper.pdf.*

ratively we can find win-win solutions to allow more efficient use of all spectrum and help support important government spectrum initiatives.

CTIA also absolutely supports making additional unlicensed spectrum available. The availability of unlicensed spectrum offers carriers a key tool for off-loading traffic and we know it is imperative to open additional bands to unlicensed use. We also are excited by the promise of incorporating LTE technology into unlicensed bands for a more efficient and robust experience for all users, while co-existing with other unlicensed technologies.

We support experimentation with new spectrum sharing regimes as well. We appreciate that new technologies may allow for more flexible sharing arrangements than the historic geographic and temporal sharing techniques that have long served as staples of spectrum management. And we should, as a country, explore these new tools. To that end, we support the FCC's efforts at 3.5 GHz and hope they will prove successful.

As a country, however, the U.S. cannot settle too quickly into sharing regimes that rely on nascent or untested technologies or on an as yet undefined but likely complex government role. I have yet to meet a carrier CEO or CTO who believes we are ready to make that transition and until these approaches have been tested and scaled at commercially significant volumes, we cannot ask carriers to depend upon undefined or limited access to the spectrum they need to serve millions of users every day.

Refueling the Spectrum Pipeline

America needs a renewed discussion about where the next bands of airwaves will come from to ensure our future connected life is realized. Because after next year's broadcast incentive auction, we don't know what's next. We—the United States—do not have a plan.

Just last month, CTIA released a second Brattle paper, Substantial Licensed Spectrum Deficit (2015–2019): Updating the FCC's Mobile Data Demand Projections (see attachment), to evaluate how much additional spectrum needs to be allocated for commercial use if we are to keep abreast of demand projections. Using the same formula and approach the Commission used to formulate the National Broadband Plan in 2010 and taking into account technical efficiencies and infrastructure investment, Brattle estimates that we need to increase our existing supply of licensed spectrum by over 350 MHz by the end of this decade.

Having seen this process from all sides—as acting head of NTIA, as an FCC commissioner, and now in my capacity at CTIA—I recognize that meeting the goal we have set will not be easy. But our global leadership depends on beginning this process. Countries around the world are looking to the next generation of mobile—5G—not merely as a wireless technology, but as a key input for economic growth. We must do the same or we risk losing what today is a competitive advantage for our economy. Getting this right should be a national economic imperative.

We are committed to working with Congress and the Administration to identify future bands to meet the new 350 MHz target. We disagree that we should abandon the licensed spectrum model because it is too difficult to clear additional bands. We heard many of those same objections in the process that led to the recent AWS–3 auction. Just five years ago, industry was told that the 1755–1780 MHz band supported too many government assets to allow its reallocation any time soon, and even if it could be made available, reallocation would take too long and cost so much as to be impractical. The Congressional Budget Office did not think reallocation of the band was possible. Just two years ago, it was unclear whether the FCC would move forward with an AWS–3 auction. But with Congress' leadership, Administration focus and an unprecedented amount of collaboration, not only did it turn out that the auction was possible, it turned out to be the most financially successful auction the FCC has ever conducted, fully funding FirstNet and providing billions of dollars for deficit reduction. Yes, making additional licensed spectrum available is hard—but it's worth it.

Fortunately, there is already a broad cross-section of this Committee that has taken a leadership role on spectrum. Bills like the Wireless Innovation Act (S. 1618), the Federal Spectrum Incentive Act (S. 887), the Rural Spectrum Accessibility Act (S. 417), and the Wi-Fi Innovation Act (S. 424) demonstrate the broad and bi-partisan interest in advancing America's wireless future. We support these efforts to unlock more licensed and unlicensed spectrum, improve Federal agency incentives, foster greater long-term spectrum planning, and facilitate rural 4G deployment.

We are ready to engage and look forward to working with each of you to help America's wireless industry maintain its position as the world's leader. Thank you for the opportunity to be a part of today's hearing.

ATTACHMENT

Substantial Licensed Spectrum Deficit (2015-2019): Updating the FCC's Mobile Data Demand Projections

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June 23, 2015

THE Brattle GROUP

This report was prepared for the CTIA – The Wireless Association. All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group or its clients.

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I. Introduction

Five years ago the Federal Communications Commission projected a licensed spectrum deficit of almost 300 MHz by 2014.[1] Using the FCC's own formula and approach, we update that forecast and find that by 2019, the U.S. will need more than 350 additional MHz of licensed spectrum to support projected commercial mobile wireless demand. Accordingly, over the next five years the United States (U.S.) must increase its existing supply of licensed broadband spectrum by over 50 percent.[2]

This analysis relies on current projections that demand for wireless broadband capacity, even after accounting for offload to unlicensed services, will increase by six-fold by 2019. Our predictions suggest that just under half of this new demand can be met by increased deployment of cell sites and improved technology, particularly a heavier reliance on 4G and LTE Advanced technologies. In the past six years, wireless operators have invested over $160 billion and, even with additional spectrum, a similar financial commitment will be necessary to enhance and expand networks to help meet significantly higher data volumes.[3]

After accounting for this increased investment by carriers in network technology and infrastructure, we estimate that by 2019 net data demand will increase more than three-fold over 2014 levels. This remaining increase in demand will need to be met by additional licensed spectrum allocations. Importantly, if demand increases faster than expected, if technology deployments lag, or if cell site deployment slows, even more licensed spectrum will be needed. Finally, even if over 350 MHz is repurposed to mobile broadband in the next five years, that spectrum will not address the even greater demand that we expect in 2020 and beyond.

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1 Note, the National Broadband Plan states for 300 MHz of spectrum to be made available by 2015. See FCC, "Connecting America: The National Broadband Plan," Chapter 2, March 2010, at p. 10.

2 There is currently 645.5 MHz of spectrum licensed for broadband. Coleman Bazelon and Giulia McHenry, "Mobile Broadband Spectrum: A Vital Resource for the U.S. Economy," Prepared for CTIA, May 11, 2015, at p. 1 ("Bazelon and McHenry, 2015").

3 CTIA, "2014 Data Survey Results: CTIA Survey Documents Dramatic U.S. Wireless Performance," June 17, 2015, at p. 2.

II. Background

A. Spectrum Demand

As demands for wireless services increase, so do the demands for licensed spectrum to provide those services. Over the past four years, increases in U.S. mobile data traffic demand have met the FCC's data growth expectations.[4] According to Cisco, historic mobile data traffic for North America has increased over 11-fold from 49 petabytes per month in 2010 to 563 petabytes per month by 2014.[5] Applying the FCC's growth expectations for 2010 to 2014 to Cisco's 2009 figure implies a projected 562 petabytes per month by 2014 for North America.[6] This is consistent with Cisco's 2014 reported data demand of 563 petabytes per month.[7]

By current estimates and projections, the total volume of mobile data will increase substantially in the next five years.[8] Cisco estimates that by 2019 U.S. mobile data traffic will reach 3.6

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[4] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," October 2010. In its 2010 analysis, the FCC used a blended projection based on Cisco, Coda, and Yankee Group projections. At the time, Cisco's expectations were the highest, equivalent to 773 petabytes per month by 2014. See "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2009-2014," Cisco, February 9, 2014, Table 7.

[5] For 2010 data, see "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010-2015," Cisco, February 1, 2011, Table 9. For 2014 data, see "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2014-2019," Cisco, February 3, 2015, Table 6.

[6] Calculation: 16 petabytes per month in 2009 x 35x growth from data through 2014 ≈ 562 petabytes per month in 2014. The FCC assumes growth in data by 2014 would be 3506%. See FCC, "Mobile Broadband: The Benefits of Additional Spectrum," October 2010, at p. 23. Cisco projected 16.022 petabytes per month of data for North America in 2009. See "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2009-2014," Cisco, February 9, 2014, Table 7.

[7] "VNI Mobile Forecast Highlights, 2014-2019: North America," Cisco, available at http://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/index.html#~Country (last accessed June 16, 2015). In 2014 the U.S. accounted for 532 petabytes per month of data, or almost 95 percent of all North America traffic. See "VNI Mobile Forecast Highlights, 2014-2019: United States America," Cisco, available at

http://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/index.html#~Country (last accessed June 16, 2015).

[8] For instance, Ericsson also forecasted a rapid growth in data demand. See "Traffic Exploration Data Traffic – Mobile PC/Router/Tablet and Smartphone," available at http://www.ericsson.com/TET/trafficView/loadBasicEditor.ericsson (last accessed June 18, 2015).

exabytes per month, which is a seven-fold increase from 2014.[9] See Figure 1. This increase in traffic will be driven by an increasing number of users (including machine users), more mobile connections per user, and growing demand for faster speeds and more intensive data consuming services, such as mobile video. By 2019, mobile users are expected to increase by 21 million to 290 million, mobile connections will increase by over 600 million to over 1 billion, and mobile video traffic will represent 75 percent of total traffic.[10]

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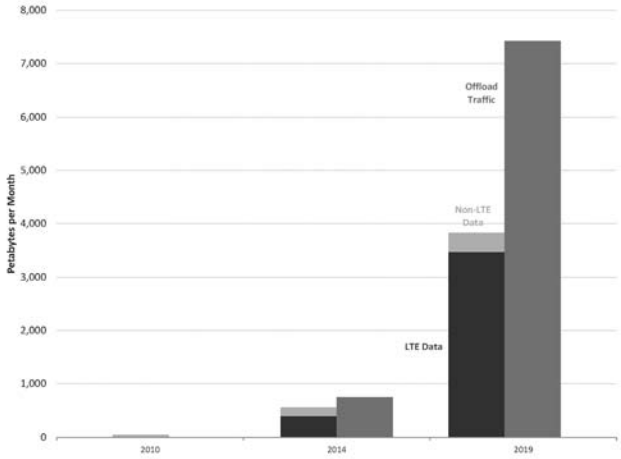
[9] Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slide 5. Cisco's definition of mobile data traffic includes devices such as feature phones, smartphones, laptops, tablets, M2M, and other portable devices. Applications include web/data/VoIP, video, audio streaming, and file sharing. See "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2014-2019," Cisco, February 3, 2015, Table 6. Our analysis suggests that Cisco's 4-year out data projections from 2009 through 2011 were roughly 15 percent higher than realized data demand. We account for this discrepancy in our projections below. See discussion at Section III.B.1 for more details.

[10] Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slide 6.

Figure 1: Wireless Data Demand



Source:

Data based on "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010-2015," Cisco, February 1, 2011, Table 9 and "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2014-2019," Cisco, February 3, 2015, Table 6.

LTE percentage of Offload Traffic based on Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slides 21 and 23.

Although some portion of this increased demand can be met by increasing capital expenditures to deploy new technologies, offload to unlicensed networks, and investment in further network build-out, additional licensed spectrum will also be necessary. Cisco estimates that by 2019, 91

percent of U.S. mobile data traffic will be 4G LTE, up from 72 percent in 2014.[11] These 4G LTE technologies will likely almost double capacity over current 3G technologies.[12]

Moreover, Cisco also estimates that by 2019, twice as much wireless data will be offloaded to unlicensed spectrum as is carried on the macro networks using licensed spectrum.[13] This is up from 2014, when 30 percent more data was offloaded than was carried by macro networks. See Figure 1, above. Accommodating this additional capacity demand will require both additional licensed wireless broadband spectrum and capital expenditures.

B. Adding Capacity: Spectrum versus Infrastructure Complementarity

For wireless broadband networks, there is a necessary balance between the amount of infrastructure and spectrum used. Spectrum-based services require a combination of spectrum and infrastructure to operate. In provisioning a given level of capacity for a network, once the network technology is chosen, up to a point, network operators still face a trade-off between the amount of spectrum and the number of cell sites deployed.[14] At a minimum, a mobile wireless

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[11] As indicated by Figure 1, the magnitude of Cisco's overall projections is largely driven by their projections of LTE growth. See Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slide 21.

[12] See Table 2 below.

[13] Cisco predicts that 66 percent of U.S. mobile data traffic will be offloaded to WiFi networks in 2019. In addition, Cisco estimates that by 2019 63 percent of U.S. mobile device connections will be 4G LTE, up from 41 percent in 2014. See Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slides 15, and 23.

[14] The driving innovation behind mobile wireless networks is cellular architecture. By dividing the geographic footprint of radio base stations into small areas, the same frequencies can be reused in non-adjoining cells. When additional capacity is required, this principle can continually be applied by dividing existing cells into smaller and smaller cells, up to a point.

The data capacity of a wireless cell site is roughly dependent on the amount of spectrum and the network technology deployed, regardless of its geographic coverage area. (With very small cells, total capacity may be smaller. See, Richard Clarke, "Expanding Mobile Wireless Capacity: The Challenges Presented by Technology and Economics," *Telecommunications Policy* (2013), p. 6.) Based on its data capacity, a cell site can only cover a fixed number of subscribers in a given area before the quality of service deteriorates. By varying the power of a cell site, its wireless capacity can be spread over a wide geographic footprint if a cell site covers a large area—as would be the case in rural or suburban deployment—or it could cover a small geographic area—as would be the case in a dense urban deployment.

network requires enough cell sites and related infrastructure[15] to cover its entire service area[16] with adequate capacity and sufficient spectrum to carry projected traffic loads. From that point, carriers must increase capacity by either adding additional spectrum or building more infrastructure.

The process of adding more cells, particularly small cells, is time consuming and expensive, and grows increasingly expensive as networks become more capacity constrained. Operators must obtain leases, permits, and attachment rights; install equipment; obtain backhaul; and integrate new cells with the existing network. This requires capital for the construction and equipment and ongoing expense costs for the lease, backhaul, and maintenance. Moreover, obtaining new cell site locations where needed to relieve traffic growth, and ensuring there is sufficient backhaul to support additional cell sites, becomes increasingly difficult. As network density increases, this is particularly the case in urban areas with strict zoning requirements.

The exact mix of spectrum and infrastructure depends on the relative cost of the two inputs. As the value of spectrum increases, wireless service providers are likely to deploy additional infrastructure to more intensively use the available spectrum. Likewise, as it becomes more difficult and increasingly costly to add capacity through infrastructure, it becomes more efficient to use additional spectrum to increase network capacity. Although some portion of the growing demand for wireless services will be met through increase in capital intensity, more spectrum will also be required given the sheer amount of additional data on the networks.[17]

To keep up with increasing demands, carriers will have to continue investing heavily in their network infrastructure, as they have done in the past. From January 1992 to December 2002, wireless carriers spent just over $193 billion dollars on capital expenditures, or roughly $17.5 billion annually. From January 2003 to December 2013, this figure grew to just under $315

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[15] The physical infrastructure of a network includes transmission equipment for cell sites, network backhaul facilities and routing equipment.

[16] Depending on the propagation characteristics of the spectrum deployed—how the wavelength travels—and the maximum power levels allowed by license, a cell site will have a maximum coverage radius. Within this coverage area, the actual range of a cell is based on design factors such as transmission power levels chosen and various other engineering choices.

[17] Increasing capital intensity is also known as deepening the wireless network. Others have recognized that such deepening will not be sufficient to meet future growing demands. See, for example, Richard Clarke, "Expanding Mobile Wireless Capacity: The Challenges Presented by Technology and Economics," *Telecommunications Policy* (2013).

billion dollars, or roughly $28.6 billion annually. This represents a roughly 60 percent increase.[18] This spending continued at this level as carriers spent over $32 billion in capital investment in 2014.[19] On top of those capital expenditures, carrier investments in purchasing licensed spectrum from FCC auctions total $87.3 billion, which does not include currently licensed spectrum that was originally licensed outside of the auction process or sold on the secondary market.[20] Although continued capital investment in mobile wireless is essential, as shown below, it will not be sufficient to meet the growing demand for wireless capacity.

C. U.S. Spectrum Deficit

In 2010, the FCC in its National Broadband Plan targeted approximately 300 MHz of spectrum to be reallocated to mobile broadband within five years, and a total of 500 MHz of spectrum to be reallocated to wireless by 2020.[21] The President subsequently supported the FCC's call for an additional 500 MHz of spectrum.[22] According to the FCC's analysis, making 300 MHz available by 2014 would create over $100 billion in economic value for the country.[23] While growth in data demand has kept up with the FCC's projections,[24] spectrum reallocations have not.

As we previously estimated, of the 300 MHz of spectrum the FCC identified as needed by this year, only 149 MHz has been reallocated.[25] On net, however, there are only an additional 98.5

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[18] All numbers are reported in 2013 constant dollars. See CTIA, "That Didn't Take Long…" CTIA Blog, March 4, 2015, available at http://blog.ctia.org/2015/03/04/that-didnt-take-long/ (last accessed June 19, 2015).

[19] Figure reported in 2014 dollars. See CTIA, "2014 Data Survey Results: CTIA Survey Documents Dramatic U.S. Wireless Performance," June 17, 2015, at p. 5.

[20] For various auction results, see http://wireless.fcc.gov/auctions/default.htm?job=auctions_home. Figure includes auction results for 700 MHz, AWS-1, PCS, H-Block, and AWS-3. This does not include Auction 5: Broadband PCS C Block, which sold for $10.1 billion.

[21] FCC, "Connecting America: The National Broadband Plan," Chapter 5, March 2010, at p. 10. We describe the FCC's methodology in more detail at Section III.A.

[22] "Presidential Memorandum: Unleashing the Wireless Broadband Revolution," The White House, Office of the Press Secretary, June 28, 2010; and FCC, "Mobile Broadband: The Benefits of Additional Spectrum," FCC Staff Technical Paper, October 2010, at p. 2.

[23] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," October 2010, at p. 2.

[24] As described above, wireless mobile data traffic for North America in 2014 was 563 petabytes per month, whereas using the FCC's 2010 growth factor expectations projected that mobile data traffic would be 562 petabytes per month by 2014 for North America.

[25] Bazelon and McHenry, 2015, at p. 8. The added spectrum includes 10 MHz of PCS H-Block, 65 MHz of AWS-3, 20 MHz of WCS, 14 MHz of SMR, and 40 MHz of AWS-4. The National Broadband Plan

Continued on next page

MHz available in comparison to 2010.[26] This suggests that the U.S. has met roughly 30 percent of the FCC's five-year spectrum target, creating an even larger future spectrum deficit to be made up by 2020.

Up until now, the industry has worked to meet this data demand with less spectrum than suggested by the FCC in 2010. Over the past five years carriers have met the growing demand for mobile wireless data using a combination of the previously licensed and deployed spectrum and larger capital expenditures. Carriers have been able to deploy spectrum, including the original AWS-1 and 700 MHz allocations that were licensed but generally not yet available for deployment by 2010.[27] Moreover, the increase in data demand was not uniform, as the FCC's model implicitly assumed. As consumers increased their usage, peak busy hour usage continued to grow, but not necessarily in the traditional voice busy hour peaks.[28] With the explosive growth of data and video, and the shift to relatively more usage in non-peak times, it will become increasingly difficult for carriers to meet new capacity demands in the future.

Continued from previous page

identified all of this spectrum, except the PCS H-Block and SMR. See FCC, "Connecting America: The National Broadband Plan," Chapter 5, at pp. 76-77.

[26] Bazelon and McHenry, 2015, at pp. 7-9. The FCC estimated 547 MHz of available spectrum in 2010, including 194 MHz of BRS/EBS spectrum and 23 MHz of "other spectrum". The BRS/EBS was reduced to 156.5 MHz when the FCC updated its spectrum screen, reducing the total spectrum inventory by 37.5 MHz (194 MHz – 156.5 MH). We also excluded the 23 MHz of "other spectrum" from our revised inventory, but added 10 MHz of G-Block spectrum that had not been counted for a net reduction of 13 MHz. After this 50.5 MHz (37.5 MHz + 23 MHz – 10 MHz) is netted out, the net added spectrum is 98.5 MHz (149 MHz – 50.5 MHz).

[27] It typically takes at least several years from the time a licensed spectrum band is reallocated and assigned to the point at which the spectrum is ready for a deployment. Among other issues, relocating incumbent users, developing handsets and network equipment, as well as planning and building the network all take substantial time. Moreover, carriers have to carefully plan spectrum deployments in order to have spectrum available for transitions from one technology generation to another.

[28] One analyst has recently compared current wireless networks to mullets, carrying business traffic in the front (during the day) and video and gaming traffic around back (at night). Mitch Wagner, "Networks Are Like Mullets," LightReading, June 15, 2015, available at http://www.lightreading.com/carrier-sdn/sdn-technology/networks-are-like-mullets/d/d-id/716284 (last accessed June 18, 2015). This is a relatively new phenomenon for mobile providers, which has increased the level of traffic during historically off-peak hours. The rise in mobile video demand is also consistent with the rapid, and somewhat unforeseen, shift to tablet devices.

III. Spectrum Forecast

A. FCC's Methodology

This paper updates the FCC's 2010 forecast as reported in the National Broadband Plan. The FCC's analysis started by projecting demand for wireless capacity, using the average forecasts from three different sources: Cisco, Coda Research Consultancy, and Yankee Group.[29] The FCC's analysis projected that demand in 2014 would be 35 times the demand in 2009. As explained above, this projection was very close to reality. According to Cisco, mobile data traffic was 563 petabytes per month by 2014 for North America,[30] as compared to the 562 petabytes per month that would be produced based on the FCC's 2009 growth figure.[31]

The FCC's approach was to calibrate a model of spectrum demand using four inputs:

- Mobile Broadband Data Demand. Using third party estimates, the FCC projected total wireless data demand for mobile networks would grow 35-fold between 2009 and 2014.[32]

- Cell Sites. Based on CTIA projections, the FCC reported 245,912 cell sites in 2009 and projected they would grow by seven percent per year.[33]

- Spectral Efficiency. Recognizing that different generations of wireless technology—2G, 3G, and 4G—had increasing spectral efficiency, the FCC estimated the average efficiency gains based on the mix of subscribers expected to use each technology generation. Their projections included transitioning to 4G, which at that time had not yet been widely deployed. The FCC assumed average spectral efficiency increased from 0.625 Mbps/MHz in 2009 to 1.25 Mbps/MHz in 2014.[34]

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[29] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," FCC Staff Technical Paper, October 2010, at p. 9.

[30] "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2014-2019," Cisco, February 3, 2015, Table 6.

[31] See footnote 6.

[32] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," FCC Staff Technical Paper, October 2010, Exhibit 10.

[33] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," FCC Staff Technical Paper, October 2010, Exhibit 10.

[34] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," FCC Staff Technical Paper, October 2010, Exhibit 10.

- Spectrum In Use. The FCC estimated the amount of spectrum deployed, or in use, as of 2009 to be 170 MHz, including 120 MHz of PCS and 50 MHz of Cellular.[35] Of that, they assumed that two-thirds of this spectrum (113 MHz) was reserved for voice services, implying that 57 MHz was deployed for data in the base year.[36] The total amount of spectrum estimated to be deployed in each subsequent year was the amount required to make capacity meet demand.

Using these inputs, the FCC projected how cell sites and spectral efficiency would grow from that baseline year to meet demand over time. Based on the remaining growth in data demand that was not accommodated by additional cell sites and spectral efficiency improvements, the FCC estimated the amount of additional licensed spectrum that would be required to meet demand.

For the base year of 2009, the total demand was met by the base year number of cell sites, existing spectrum efficiency and deployed spectrum. The projected increases in cell sites and spectrum efficiency met some of the growing demand; the rest was projected to be met by additional spectrum deployed. Specifically, total projected demand increased by 3,506 percent between 2009 and 2014. After accounting for expected cell site growth and spectral efficiency, the remaining increase in demand that had to be met by additional spectrum was 1,250 percent.[37] In total, the FCC projected 802 MHz would be needed to meet this demand, which was 275 MHz more than the 547 MHz allocated as of 2009.[38] This "nearly 300 MHz" spectrum deficit was incorporated into the National Broadband Plan.

B. Updated Inputs

To provide a new five-year forecast and estimate the spectrum deficit through 2019, we use the same basic methodology that the FCC used for its 2009 estimate, updating assumptions to reflect current usage. These updated assumptions are described below.

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[35] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," FCC Staff Technical Paper, October 2010, at p. 16; and FCC, "Connecting America: The National Broadband Plan," Chapter 5, March 2010, at pp. 84-85, which shows 170 MHz of PCS and Cellular currently in use.

[36] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," FCC Staff Technical Paper, October 2010, Exhibit 10. They assumed that the spectrum required for voice remained fixed at 113 MHz, so that only the spectrum required for data would grow.

[37] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," October 2010, at Exhibit 10.

[38] 708 MHz to meet data demand and 113 MHz to meet voice demand.

1. Mobile Broadband Data Demand

Since Coda Research Consultancy and Yankee Group do not have current publicly available estimates, our analysis relies on Cisco's most recent projections of mobile broadband demand. Over the past several years, Cisco has generally published the most robust and detailed estimated projections, and public disclosure of its methods. Consequently, we view their projections as the most appropriate for this context. As discussed in Section II, Cisco estimates that by 2019 U.S. mobile data traffic will reach 3.6 exabytes per month, which is a 7-fold increase from 2014.[39] This demand will come from more users, more mobile connections per user and increased usage. This mobile broadband demand excludes data offloaded to unlicensed networks, which Cisco projects will account for an additional 7 exabytes per month of capacity by 2019.[40] Without this projected growth in unlicensed offloading, the increase from 2014 would be nine-fold.

Nevertheless, Cisco's past U.S. projections have turned out to be somewhat aggressive for certain years; therefore we decided to discount them in order to ensure that our estimates are conservative.[41] We based our discount on the historical accuracy of Cisco's projections four years out.[42] For instance, Cisco's January 2009 projections for 2013 were five percent higher than the

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[39] Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slide 5. Cisco's definition of mobile data traffic includes devices such as feature phones, smartphones, laptops, tablets, M2M, and other portable devices. Applications include web/data/VoIP, video, audio streaming, and file sharing. See "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2014-2019," Cisco, February 3, 2015, Table 6. Cisco's estimates implicitly assume no change in pricing structure of wireless services. If the spectrum deficit is not addressed, it is likely that wireless service pricing would have to change in order to slow demand for wireless mobile data, and new services and offerings may also be curtailed or delayed.

[40] Calculation: (3.6 exabytes per month ÷ (1 – 66 percent)) – 3.6 exabytes per month ≈ 7 exabytes per month. This is based on Cisco's projected 3.6 exabytes per month of U.S. data in 2019, and 66 percent of data offloaded in the U.S. See Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slide 23.

[41] An alternative approach would be to take an average of the two publicly available data projections from Cisco and Ericsson. This alternative would reduce Cisco's original data demand growth by 13 percent in 2019. However, Ericsson does not release their projected growth by technology, so we could not properly estimate the growth in spectral efficiency in this case, nor could we replicate the FCC's formula from 2010 using Ericsson data.

[42] We chose to compare the fourth year to the first year projections (instead of actual realized demand) to add an additional observation of Cisco's performance. If we were to look at the actual year vs. five-year projections, we would only have two observations, instead of three. If we were to take this approach, the discount would have been 20 percent. Using this 20 percent adjustment would also

Continued on next page

2013 projections for 2013;[43] Cisco's 2010 projections for 2014 were 24 percent higher than their 2014 projections for 2014;[44] and their 2011 projections for 2015 were 16 percent higher than their 2015 projection for 2015.[45] The average of these three data points is 15 percent, which we phase in from 2014 forward.[46]

2. Cell Sites

Consistent with the FCC's methodology, we use the CTIA's Annual Wireless Industry Survey to estimate the total cell sites at the beginning of the period and the annual growth in cell sites. The CTIA Survey reports 298,055 cells sites at the end of 2014.[47] Further, the five year rolling average annual cell site growth has decreased from the seven percent in 2009, as used by the FCC,[48] to about four percent in 2014. We assume, therefore, a four percent annual growth in cell sites persists through 2019.[49] These assumptions suggest that the inventory of U.S. cell sites will

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Continued from previous page

require adjusting downward the growth of LTE, somewhat off-setting the impact of the adjustment in our projections by also reducing the spectral efficiency gains. Ultimately, we chose to reduce the Cisco forecast by 15 percent, but without an offsetting reduction in efficiency growth.

43 "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update," Cisco, January 29, 2009, Table 1; and "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012-2017," Cisco, February 6, 2013, Table 6.

44 "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2009-2014," Cisco, February 9, 2010, Table 7; and "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2013-2018," Cisco, February 5, 2014, Table 6.

45 "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010-2015," Cisco, February 1, 2011, Table 9; and "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2014-2019," Cisco, February 3, 2015, Table 6.

46 We apply the 15 percent discount to ensure that we are being conservative. Our understanding is that prior Cisco estimates relied, in part, on assuming the continued proliferation of mobile netbooks and laptops. This turned out to be superseded by the rise of tablets and smartphone devices. Thus, current Cisco estimates based on expected devices may well prove accurate, which would mean our estimate underestimates the actual amount of spectrum required by 2019.

47 CTIA, "2014 Data Survey Results: CTIA Survey Documents Dramatic U.S. Wireless Performance," June 17, 2015, at p. 5. The survey estimates 298,055 cell sites as of December 2014. The FCC estimated 344,904 cell sites by 2014. As discussed in the text, this number is likely inflated due to recent consolidation of networks. See FCC, "Mobile Broadband: The Benefits of Additional Spectrum," October 2010, Exhibit 10, at p. 18.

48 FCC, "Mobile Broadband: The Benefits of Additional Spectrum," October 2010, at Exhibit 10.

49 A four percent growth rate may prove overly optimistic given the sheer number of cell sites now available, the challenge of identifying new sites, and the proliferation of small versus macro cell sites going forward. Overestimating the growth of cell sites, in turn, overestimates the amount of data

Continued on next page

grow about 22 percent over the next five years, from about 298,055 in 2014 to over 362,269 in 2019.[50] See Table 1.

Given that growth in cell sites has decelerated over time, holding the growth rate constant at its recent historical level may be conservative. Cell site growth has been declining in recent years as certain carriers have consolidated networks or retired legacy 2G-only cell sites. In fact, there was a small reduction in total cell sites in 2014.

Table 1: Forecasted U.S. Cell Sites

Year	Change from 2014 [a]	Forecasted Cell Sites [b]
2014	100.00%	298,055
2015	104.00%	309,977
2016	108.16%	322,376
2017	112.49%	335,271
2018	116.99%	348,682
2019	121.67%	362,629

Source & Notes:
[a]: Assume four percent growth each year.
[b]: [a] x 2014[b].

3. Spectral Efficiency

One of the most critical tools for mobile operators to meet the demand growth since 2010 has been the rollout of 4G LTE networks that are dramatically more spectrally efficient than 3G networks. Based on recent technology-specific spectral efficiency estimates published by Peter Rysavy, we assume the current average spectral efficiency by technology. See Table 2. The

Continued from previous page

traffic that can be accommodated by cell site expansion, which then underestimates the potential demand for spectrum. Much like the 15 percent discount to Cisco projections, we seek to apply conservative estimates throughout our analysis so as to not inflate the ultimate spectrum deficit figure.

50 CTIA's survey requests carriers report the number of cell sites in commercial service, including macro-cells, micro-cells, and cell-extending devices such as Distributed Antenna Systems and small cells.

Rysavy estimates reflect optimal efficiency, which we reduce by 20 percent to account for actual efficiency.[51]

Table 2: Summary of Spectral Efficiency by Technology

	Technology	Efficiency *bps / Hz*
[1]	LTE+	1.92
[2]	4G LTE	1.12
[3]	3G	0.72
[4]	2G	0.48

Source & Notes:

Rysavy Research, "Beyond LTE: Enabling the Mobile Broadband Explosion," August 2014. We assume that, on average, LTE+ is consistent with spectral efficiency of LTE (4x4), 4G LTE is consistent with LTE (2x2), 3G is consistent with HSDPA (MRxD), and 2G is consistent with EDGE.

To estimate the average annual spectral efficiency across all speeds, we apply these efficiency rates to Cisco's projections of mobile traffic by technology.[52] Within 4G data traffic, we also account for the expected shift to more spectral efficient solutions, such as 4G+.[53] Our analysis suggests that spectral efficiency will increase by over 40 percent by 2019. See Table 3. The shift to 4G+ includes LTE-Advanced capabilities such as Carrier Aggregation, Coordinated Multipoint, Inter-cell Interference Coordination (ICIC), higher order Multiple Input Multiple Output (MIMO) antennas, improved gain from antenna improvements, and improved small cell operation with existing cells. These gains will not likely be deployed widespread, but will be deployed where peak usage demand occurs. While LTE-Advanced has not been widely deployed at this time, including its anticipated adoption significantly lowers the residual demand that must be met by additional licensed spectrum.

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[51] Based on discussions with Peter Rysavy in April 2015. This reduction is intended to reflect the real-world complications in network deployments that reduce the efficiency of the network equipment.

[52] Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015.

[53] For further discussion of 4G+ technologies, see Richard Clarke, "Expanding Mobile Wireless Capacity: The Challenges Presented by Technology and Economics," *Telecommunications Policy* (2013), Table 3.

Table 3: Forecasted U.S. Mobile Spectral Efficiency

		2G	3G	4G LTE	LTE+	Weighted average efficiency *bps / Hz*
		[a]	[b]	[c]	[d]	[e]
[1]	Spectral Efficiency	0.48	0.72	1.12	1.92	
	Share of Traffic					
[2]	2014	0%	28%	72%	0%	1.01
[3]	2015	0%	24%	59%	17%	1.16
[4]	2016	0%	20%	51%	29%	1.27
[5]	2017	0%	17%	50%	34%	1.32
[6]	2018	0%	13%	46%	42%	1.40
[7]	2019	0%	9%	41%	50%	1.48

Sources & Notes:

[1]: Based on spectral efficiency estimates. See Rysavy Research, "Beyond LTE: Enabling the Mobile Broadband Explosion," August 2014, at p. 71. Data reported in bps/Hz.

[2][a]-[7][c]: Based on traffic share estimates. See Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slide 21 and Richard Clarke, "Expanding Mobile Wireless Capacity: The Challenges Presented by Technology and Economics," *Telecommunications Policy* (2013), Table 3.

[2]-[7][d]: [1][a] x [a] + [1][b] x [b] + [1][c] x [c] + [1][d] x [d].

4. Spectrum in Use

We calculate both the total licensed spectrum allocated for mobile broadband uses and the amount of the total that is deployed in our base year of 2014. As discussed above, since 2010 the FCC has released an additional 149 MHz of mobile broadband spectrum, for a net increase of 98.5 MHz, through a combination of spectrum auctions, rebanding, and other rule changes.[54] This represents about one-third of their own goal of reallocating 300 MHz for mobile broadband in five years. As a result, we estimate that there is 645.5 MHz of spectrum available for mobile broadband.[55]

[54] Bazelon and McHenry, 2015, at pp. 7-10. See footnote 26 for further explanation of this calculation. Not all of these additional frequencies are available immediately. For instance, AWS-3 will be available only as incumbent federal users transition out.

[55] Bazelon and McHenry, 2015, at p. 8.

We estimate that there was a total of 348 MHz of spectrum in use in 2014.[56] As shown in Table 4, this includes the 170 MHz of PCS and Cellular in use as of 2010,[57] as well as 90 MHz of AWS-1, 64 MHz of 700 MHz, and 14 MHz of SMR. Both AWS-1 and 700 MHz have largely been deployed by carriers.[58] Moreover, we understand that Sprint had deployed SMR for its LTE network by December 2014.[59] Lastly, Sprint uses the 10 MHz G block for LTE.[60]

In contrast to the FCC's assumption that total spectrum needed for voice would be held constant, we recognize that with improving technical efficiency, including such technologies as Voice over LTE (VoLTE), and additional cell sites, this demand will be met with fewer MHz. Consequently, we calculate that instead of the 113 MHz used by the FCC, 63 MHz of spectrum is needed to

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[56] As discussed in footnote 27, it typically takes at least several years for bands to be ready for deployment once they allocated and assigned. Since 2014, AT&T has deployed 20 MHz of WCS spectrum. See Phil Goldstein, "AT&T expects to start deploying 2.3 GHz WCS spectrum for LTE this summer," FierceWireless, March 30, 2015, available at http://www.fiercewireless.com/tech/node/69181/print (last accessed May 19, 2015).

[57] FCC, "Mobile Broadband: The Benefits of Additional Spectrum," FCC Staff Technical Paper, October 2010, at p. 16.

[58] For example, Verizon runs an LTE network on its 700 MHz C Block, while AT&T planned to use its 700 MHz Lower D and E Blocks for an LTE Broadcast service. See, Phil Goldstein, "Verizon starts deploying LTE in its AWS spectrum," FierceWireless, October 15, 2013, available at http://www.fiercewireless.com/story/verizon-starts-deploying-lte-its-aws-spectrum/2013-10-15 (last accessed May 19, 2015). At this time, it does not appear Dish has deployed its 700 MHz E Block. See, Mike Dano, "Dish proposal hints at plans to deploy LTE across 700 MHz E Block and AWS-4 holdings," FierceWireless, September 11, 2013, available at http://www.fiercewireless.com/story/dish-proposal-hints-plans-deploy-lte-across-700-mhz-e-block-and-aws-4-holdi/2013-09-11 (last accessed May 19, 2015).

In addition, Verizon started deploying its LTE network on its AWS spectrum. See, Phil Goldstein, "Verizon starts deploying LTE in its AWS spectrum," FierceWireless, October 15, 2013, available at http://www.fiercewireless.com/story/verizon-starts-deploying-lte-its-aws-spectrum/2013-10-15 (last accessed May 19, 2015). T-Mobile also has deployed its LTE network on AWS-1 spectrum. See, Phil Goldstein, "T-Mobile to focus on 1900 MHz LTE deployment to expand network footprint," FierceWireless, September 24, 2014, available http://www.fiercewireless.com/story/t-mobile-focus-1900-mhz-lte-deployment-expand-network-footprint/2014-09-24 (last accessed May 19, 2015).

[59] Todd R. Weiss, "Sprint's LTE Network is 'Substantially Complete,' CFO Says," eWeek, December 5, 2014, available at http://www.eweek.com/networking/sprints-lte-network-is-substantially-complete-cfo-says.html (last accessed May 19, 2015).

[60] Kevin Fitchard, "Sorry, not interested: Sprint bows out of the PCS spectrum auction," Gigaom, November 13, 2013, available at https://gigaom.com/2013/11/13/sorry-not-interested-sprint-bows-out-of-the-pcs-spectrum-auction/ (last accessed May 14, 2015). Although Sprint is planning on using its 2.5 GHz holdings for LTE, it is not generally deployed as of today.

meet voice demand in 2014, falling to 34 MHz by 2019 at which point 97 percent of available spectrum in use will be used to meet data demand.

Table 4: Spectrum in Use as of 2014

	Band Name	Location	Potential Spectrum Supply *MHz*	Currently Deployed *MHz*
	[a]	[b]	[c]	[d]
	700 MHz			
[1]	Paired	700 MHz	58	58
[2]	Unpaired	700 MHz	12	6
[3]	Cellular	800 MHz	50	50
[4]	SMR	800 MHz / 900 MHz	14	14
[5]	AWS-1	1.7 GHz / 2.1 GHz	90	90
[6]	PCS	1.9 GHz	120	120
[7]	G-Block	1.9 GHz	10	10
[8]	H-Block	1.9 GHz /2.0 GHz	10	0
	AWS-3			
[9]	Paired	1.7 GHz / 2.1 GHz	50	0
[10]	Unpaired	1.7 GHz	15	0
[11]	AWS-4	2.0 GHz / 2.2 GHz	40	0
[12]	WCS	2.3 GHz	20	0
[13]	BRS/EBS	2.5 GHz	156.5	0
[14]		**Total:**	**645.5**	**348**

Sources & Notes:

[a]-[c]: Based on Bazelon and McHenry, 2015, at pp. 7-10.

[1]-[7][d]: See discussion above.

[8][d]: The FCC completed its H Block auction on February 27, 2014. See FCC, Public Notice, Auction of H Block Licenses In The 1915-1920 MHz and 1995-2000 MHz Bands Closes (Feb. 28, 2014), https://apps.fcc.gov/edocs_public/attachmatch/DA-14-279A1.pdf.

[9]-[10][d]: The FCC completed its AWS-3 auction on January 29, 2015. See FCC, Public Notice, Auction of Advanced Wireless Services (AWS-3) Licenses Closes (Jan. 30, 2015), https://apps.fcc.gov/edocs_public/attachmatch/DA-15-131A1.pdf.

[11][d]: The FCC adopted flexible use rules for the AWS-4 band on December 11, 2012. See FCC, Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands, Report and Order and Order of Proposed Modification (Dec. 11, 2012), https://apps.fcc.gov/edocs_public/attachmatch/FCC-12-151A1.pdf.

[12][d]: The FCC freed up WCS spectrum for mobile broadband use on October 17, 2012. See FCC, Order on Reconsideration, Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band (Oct. 17, 2012), https://apps.fcc.gov/edocs_public/attachmatch/FCC-12-130A1.pdf.

[13][d]: While the regulatory history of BRS/EBS spectrum is lengthy, the FCC first took a significant step to enabling mobile broadband in the 2.5 GHz band in 2004. See FCC, Report and Order and FNPRM, Amendment of Parts 1, 21, 73, 74, and 101 of the Commission's Rules to Facilitate the Provision of Fixed and Mobile Broadband Access, Educational and Other Advances Services in the 2150-2162 and 2500-2690 MHz Bands (June 10, 2004), https://apps.fcc.gov/edocs_public/attachmatch/FCC-04-135A1.pdf.

C. Estimated Spectrum Requirements

Table 5 below presents our results from updating the FCC's 2010 spectrum forecasts, using 2014 as the base year and projecting spectrum demand to 2019. After adjusting for cell site and spectral efficiency growth, traffic per site is projected to grow by an adjusted 343 percent,[61] all of which must be absorbed by spectrum reallocated to broadband in the next five years. Our analysis estimates that demand for spectrum begins to exceed available supply in 2017 and the deficit grows to 366 MHz by 2019. The upcoming incentive auction will meet some of the demand for more licensed spectrum, but even that reallocation will leave significant demand (best case still than two-thirds of the projected deficit) for more licensed spectrum.[62]

Importantly, these projections only cover demand through 2019. Of course, demand for wireless data is expected to continue to increase beyond that date. Beyond 2020, '5G' technology may offer more technology gains, but that will take time to develop and deploy. The FCC's prior effort in 2010 did not make explicit that its spectrum deficit calculation would need to be updated and recalculated to accommodate future growth. Given continued expected explosive growth through 2020 and beyond, and new more efficient technologies, such as 5G, on the horizon, continued re-assessment of the spectrums needs will be required.

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[61] This is reflected in row [10] of Table 4 below.

[62] This spectrum deficit of 366 MHz must be met by access to spectrum licensed for high power LTE or other deployment, using long term licenses with expectation of renewal. Licensed spectrum in "hybrid" bands with lower power threshold, shorter term licenses would not be sufficient to meet these needs for several reasons. In particular, the technical requirements do not allow for high power 4G LTE deployment. Moreover, the shorter term licenses are likely not sufficient to warrant the investment in such relatively permanent infrastructure. Such hybrid bands may provide opportunities for unlicensed offload, or quasi-offload opportunities, and are part of the FCC's broader spectrum efforts.

Table 5: Spectrum Demand Forecast

	Description	2014	2015	2016	2017	2018	2019
		[a]	[b]	[c]	[d]	[e]	[f]
[1]	Data Growth Relative to 2014 - Cisco	100%	151%	229%	337%	481%	680%
[2]	Adjustment to Cisco Projections	0%	3%	6%	9%	12%	15%
[3]	Updated Data Growth Projections	100%	146%	215%	307%	423%	578%
[4]	Cell Sites	298,055	309,977	322,376	335,271	348,682	362,629
[5]	Absolute Growth	100%	104%	108%	112%	117%	122%
[6]	CAGR	4.00%					
[7]	Traffic per site - Growth	100%	141%	199%	273%	362%	475%
[8]	Avg Spectral Efficiency (Mbps/MHz)	1.01	1.11	1.21	1.25	1.32	1.40
[9]	Absolute Growth	100%	110%	120%	124%	131%	138%
[10]	Tech-Adjusted Traffic per Site - Growth	100%	128%	166%	219%	275%	343%
[11]	Spectrum req'd for data (MHz)	285	364	474	625	784	977
[12]	Percent allocated for data	82%	87%	91%	94%	95%	97%
[13]	Spectrum req'd for voice (MHz)	63	54	47	43	38	34
[14]	Percent allocated for voice	18%	13%	9%	6%	5%	3%
[15]	Spectrum - In Use (MHz)	348	418	521	668	822	1,011
[16]	Spectrum - Currently Allocated (MHz)	645.5					
[17]	Surplus/Deficit (MHz)	298	227	125	-23	-177	-366

Sources & Notes:

[1]: Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slide 21.

[2]: Assumption.

[3]: [1] x (1 – [2]).

[4][a]: CTIA, "2014 Data Survey Results: CTIA Survey Documents Dramatic U.S. Wireless Performance," June 17, 2015, at p. 5.

[4][b]-[g]: Previous Year [4] x [5].

[5][a]: Assumption.

[5][b]-[f]: [5][a] x ((1 + [6][a]) ^ (Current Year - 2014)).

[6]: Based on average cell site growth rate from 2009 to 2013. See CTIA, "CTIA Wireless Industry Survey for Year End 2014," 2015, at p. 2.

[7]: [3] ÷ [5].

[6]: Based on spectral efficiency and traffic share estimates. For spectral efficiency, see Rysavy Research, "Beyond LTE: Enabling the Mobile Broadband Explosion," August 2014, at p. 71. For traffic share, see Robert Pepper, "Cisco Visual Networking Index (VNI) Forecast: Mobile Data Traffic Update, 2014-2019 (Focus on U.S.)," Cisco, February 3, 2015, at slide 21 and Richard Clarke, "Expanding Mobile Wireless Capacity: The Challenges Presented by Technology and Economics," *Telecommunications Policy* (2013), Table 3.

[9]: [8] ÷ [8][a].

[10]: [7] ÷ [9].

[11][a]: [15] - [13].

[11][b]-[f]: [11][a] x [10].

[12]: [11] ÷ [15].

[13]: See discussion at Section III.B.4.

[14]: 1 - [12].

[15][a]: Table 4.

[15][b]-[f]: [11] + [13].

[16]: Table 4.

[15]: [14][a] - [13].

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The CHAIRMAN. Thank you, Ms. Baker.

And we will turn now to Mr. Levin. And I apologize for pronouncing that wrongly the first time.

Mr. LEVIN. Quite alright.

The CHAIRMAN. That is a member mistake, not staff, just so you know.

STATEMENT OF BLAIR LEVIN, FORMER EXECUTIVE DIRECTOR, NATIONAL BROADBAND PLAN

Mr. LEVIN. Thank you very much, Chairman Thune and members of the Committee.

I am a nonresident fellow at the Brookings Institute, but today I am speaking solely in a personal capacity, reflecting on lessons learned directing the National Broadband Plan.

Two lessons are at the heart of this hearing: spectrum demand continues to explode, and it takes a significant time to repurpose spectrum from existing to future uses.

The plan set ambitious goals. Fortunately, I think the Government has been meeting them. But we cannot, however, rest on our laurels, and we must look to the future.

Government faces two critical tasks: allocating and repurposing spectrum. On the allocation question, the Government is on the right track, allocating spectrum to a diversified portfolio of licensed, unlicensed, and shared spectrum, but we do not want a spectrum monoculture.

But we can't allocate what we have not repurposed. So I will focus on repurposing spectrum.

There are four approaches to the task. First, assume the original allocation represents a form of Edenic perfection. Second, allow licensees to freely sell to the highest bidder. Third, have the Government exercise its power to repurpose any band. And, fourth, adopt tools that use market signals and mechanisms to repurpose.

For reasons detailed in my written testimony, the plan focused on the fourth, resulting in, among others, the recommendation that Congress authorize the FCC to conduct incentive auctions.

But the plan was not the originator of the incentive auction. Public policy is not a solo performance; it is a relay race. We took the baton from earlier thought pieces by the FCC staff and others, put them in the context of a plan, handed the baton back to this committee, including my co-panelist, Commissioner Rosenworcel, who was working with you all. You, in turn, handed the baton to the FCC, who, thanks to what I think is great staff work and leadership from Chairman Wheeler, has positioned us for an auction next year.

And herein lies a critical lesson. While repurposing spectrum takes time, the past few years, particularly with AWS–3 and incentive auction, proves we can shrink the time it has taken in the past. The question is whether we take the steps necessary to do so.

But most important involve repurposing government spectrum. I believe embedding more market signals into the decision process for spectrum use is the right place to start.

Some have proposed applying the incentive auction structure to government spectrum. I applaud the spirit and am delighted that the plan's proposal was subject to the sincerest form of flattery.

Nonetheless, I have concerns that differences between private and public actors are such that a government incentive auction may not succeed.

As detailed in my written testimony, these concerns include: government spectrum has multiple users; while all transactions have a potential for a principal agency problem, the problem is much worse in government; the budget process creates a snapback option; government service over-indexes for risk and under-indexes for reward; and it will be difficult to thread the very small needle between providing enough money to incent repurposing spectrum and too much so that either the amount or the use does not cause a political backlash.

I am not saying the option should be taken off the table, but I urge further study of all options. And, again, as detailed in my written testimony, I think more promising options include: administrative pricing; further amendments to the Commercial Spectrum Enhancement Act—and I would note that such amendments would be in the spirit of a letter a number of you signed on August 28 to OMB; third, providing incentives for private-sector bounty hunters; and, fourth, a GSA for spectrum.

None of these ideas are exclusive. Each has trade-offs. Nonetheless, all should be on the menu of options you consider.

In addition, Congress should understand the emerging hybrid relationship of broadband networks. The more robust wireline networks, the more Wi-Fi offload can relieve pressure on scarce spectrum assets. The goal is not spectrum abundance so much as bandwidth capacity abundance. I hope you will hold a hearing exploring, as the House did last week, a wireline deployment agenda.

In closing, I would like to thank the Congress for directing the writing of the National Broadband Plan. It was a rare and wonderful gift to work with a dedicated and talented group of Americans on behalf of all Americans and on a short-term basis with a mandate to think long-term.

I urge you to consider using a similar short-focused analysis that quickly leads to a plan for making sure we have the spectrum we all agree we need for bandwidth abundance and leadership in the 21st-century information economy.

Thank you very much.

[The prepared statement of Mr. Levin follows:]

PREPARED STATEMENT OF BLAIR LEVIN, FORMER EXECUTIVE DIRECTOR, NATIONAL BROADBAND PLAN

Thank you Chairman Thune, Ranking Member Nelson and members of the Committee for the opportunity to speak with you today about issues related to our Nation's long-term spectrum policy.

I am Blair Levin, a non-resident Fellow at the Brookings Institute Metropolitan Policy Program. Today, I am speaking solely in my personal capacity, reflecting on lessons I learned as Chief of Staff for FCC Chairman Reed Hundt (1993–1997), as a Wall Street analyst following the telecommunications and media sectors (2001–2008), and directing the writing of the National Broadband Plan (2009–2010.)

Two lessons from the Plan are at the heart of today's hearings: the growing demand for spectrum and the significant time it takes to repurpose spectrum from existing to future uses. This hearing will reveal different points of view on several topics but I am sure we all agree the failure to adopt policies that repurpose spectrum efficiently will have negative consequences on our economy and society. With the

"Apps Economy" already responsible for over a half million jobs[1] and new markets like the Internet of Things soon to create trillion dollar market opportunities,[2] the Chairman of the Council of Economic Advisors and the Chief Technology Officer were no doubt correct to observe in the Wall Street Journal that avoiding a spectrum crunch by "making more spectrum available (is) one of the most critical infrastructure projects of the 21st century."[3]

Early in the process of developing the Plan, we decided to include a chapter on spectrum. The connection between spectrum and broadband may today seem obvious but at the time this was actually a novel decision. We recognized that broadband use was migrating to mobile. At the same time, there was almost no new spectrum in the pipeline suitable for mobile use. We noted that the process of revisiting or revising spectrum allocations historically had taken 6 to 13 years.[4] The essence of many of our spectrum recommendations was to speed up that process, trying a number of new approaches to align stakeholder incentives and reduce friction to spectrum repurposing.

We established the ambitious (but now-familiar) goal of repurposing 300 megahertz between 225 and 3700 MHz for mobile use in five years and 500 megahertz for broadband use in ten years.[5] In connection with the five-year goal we released a spectrum demand study.[6] Some suggested we were exaggerating the need. It now appears that we were close, but if anything, underestimated the need.[7] Our quantitative goals, and the supporting analysis, helped to clarify the public interest in spectrum repurposing at a time when there, frankly, had not been much interest in planning for the future.

I am pleased to say that the government has been quite successful in tracking the spectrum goals established in the plan. Five years later, we have, according to NTIA, repurposed 245 megahertz.[8] I think it is not unreasonable to expect, given considerable broadcaster interest in the incentive auction, that that repurposing metric may be above 300 megahertz when that auction concludes, about six years after the publication of the Plan.[9]

Nevertheless, we cannot rest on our laurels and must always look to the future. We still have not gotten all the way to 500 megahertz, but I understand work continues on several fronts including the 5 GHz unlicensed band, which may move us toward this benchmark. Looking even farther into the future, I think we need to move beyond simple megahertz targets and focus more on the underlying economic and bureaucratic incentives that will lead to "self-healing" policies where spectrum supply can, over time, evolve to match ever-changing technological demands.

To this end, the government has two critical tasks: allocating spectrum and repurposing spectrum. On the allocation question, I believe the government is on the right track in allocating spectrum to a diversified portfolio of licensed, unlicensed and shared uses.[10] We also need to preserve room for growing numbers of

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[1] *http://files.ctia.org/pdf/The_Geography_of_the_App_Economy.pdf*

[2] *http://www.mckinsey.com/insights/business_technology/the_internet_of_things_the_value_of_digitizing_the_physical_world*

[3] *http://www.wsj.com/articles/jason-furman-and-megan-smith-how-to-avoid-spectrum-crunch-1421970841*

[4] Exhibit 5–C: Time Historically Required To Reallocate Spectrum at *http://www.broadband.gov/plan/5-spectrum/*

[5] Recommendation 5.8: The FCC should make 500 megahertz newly available for broadband use within the next 10 years, of which 300 megahertz between 225 MHz and 3.7 GHz should be made newly available for mobile use within five years. The President, of course, made a similar 10-year commitment. *See https://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution.*

[6] *https://transition.fcc.gov/national-broadband-plan/mobile-broadband-paper.pdf*

[7] *http://www.ctia.org/docs/default-source/default-document-library/bazelon_mchenry_spectrum-deficit_2015-06-23.pdf.* Further, it could well be, given needs that we cannot accurately assess, such as the Internet of Things, connected cars, drones, and business applications for high-resolution two way video, among others, that even today's estimates will be too low.

[8] *http://www.ntia.doc.gov/blog/2015/nearly-halfway-meeting-spectrum-target*

[9] It is, admittedly, a year late. But only one year late, given the history and magnitude of the problem is not too shabby. It demonstrates what is possible when there is a focused effort. See footnote 16, below.

[10] The President's Council of Advisors on Science and Technology made an enormous contribution to our understanding on the opportunities for sharing in its 2012 report, offering insights far beyond what we were able to do with the Plan in 2010. *https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.* Further, the President has also followed up on that report with a second spectrum related executive memorandum. *https://www.whitehouse.gov/the-press-office/2013/06/14/presidential-memorandum-expanding-americas-leadership-wireless-innovatio.*

sensors, radars, RFIDs, beacons, and other technologies—miniaturized to fit inside your phone, car, and other devices—that will come to define the Internet of Things. The last two decades have taught us that we don't want a spectrum monoculture.

I also believe we cannot assume that future network architecture will be the same as today's architecture and the only recourse to future demand is to "pour on more spectrum." Spectrum is too precious a resource not to be used in ever more intensive and creative ways. The generational march of technology (from 3G to 4G and, soon, 5G) is only part of this story. Inevitably, our networks will have to migrate toward greater and greater density (*i.e.,* small cells), more productive re-use (*i.e.,* sharing), and new and different deployment models (*i.e.,* software defined networks).[11] The Commission's recent 3.5 GHz rules provide an important nudge toward this kind of innovation, which could yield capacity gains many times greater than the mere addition of a new spectrum band.

But, we can't allocate what we have not freed up. As we have basically already allocated all spectrum, I will focus my comments on the other principal task going forward—repurposing spectrum.

Approaches to Repurposing. When we arrived to work on the Plan, for the first time since before I served as Chief of Staff nearly two decades earlier, there was no spectrum designated for auction. In light of the evidence in the demand studies, the Plan team focused on repurposing. The team immediately recognized there were four ways to approach the task:

- *Status Quo.* Assume the original allocation represented some form of Edenic perfection. Given changing markets and technology, this was obviously the wrong policy.[12]
- *Liberalization.* Allow all licensees to freely sell any spectrum to the highest bidder. In the case of highly fragmented bands (such as the TV bands), for reasons summarized in what is referred to as the "Letter from 112 Economists," that approach entails enormous risks and costs.[13] In other bands (*e.g.,* AWS–4), this approach could be a viable option.
- *Command-and-Control.* Have the FCC exercise its power as the licensor to repurpose a band anytime it believes reallocation is needed. This approach, which can work in discrete areas, represented the then-current approach. It also has many problems, including the time caused by litigation and other problems inherent in the command-and-control approach.[14]
- *Market-Mechanisms.* Develop tools that use market signals and mechanisms to move spectrum to higher and better uses. This had numerous problems, including lack of legal authority and prior examples. Nonetheless it appeared more promising than the others, so we focused our efforts on that opportunity.

That work ultimately resulted in, among other recommendations, Recommendation 5.4 of the Plan, that Congress should authorize the FCC to conduct incentive auctions. Congress did so in the 2012.[15]

But I want to be clear that the Plan was not the originator of the incentive auction. It came from various ideas developed by Commission Staff, such as Evan Kwerel and John Williams[16], and various papers, particularly one specifically about broadcast spectrum authored for the Brookings Institute by University of Colorado Law School Dean Phillip Weiser,[17] that proposed versions of an incentive auction to repurpose spectrum.

Policy progress is never a solo performance; it's always a relay race. As we focused on market mechanisms, we were fortunate to be able to take the baton from those earlier thought pieces, race through our lap, and then hand the baton off to the Congress and the members and staff of this Committee, including Commissioner

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[11] Chairman Wheeler discussed some of the implications of software defined networking in a recent speech at Brookings. *https://www.fcc.gov/document/remarks-fcc-chairman-tom-wheeler-brookings-institution*

[12] While wrong, the assumption that a past allocation creates permanent rights is at the root of a number of policy arguments.

[13] *http://www.politico.com/static/PPM41_april6_economists_letter_to_obama_regarding_incentive_auctions.html*

[14] Since Ronald Coase's seminal paper in 1959, there has been a general view moving away from command-and-control and towards more flexible use. See, for example, the Federal Communications Commission Spectrum Policy Task Force, Report of the Spectrum Efficiency Working Group, November 15, 2002.

[15] *http://www.gpo.gov/fdsys/pkg/PLAW–112publ96/pdf/PLAW–112publ96.pdf.* See Title VI, Subtitle D.

[16] *http://wireless.fcc.gov/auctions/conferences/combin2003/papers/masterevanjohn.pdf*

[17] *http://www.brookings.edu/~/media/research/files/papers/2008/7/wireless-weiser/07_wireless_weiser.pdf*

Rosenworcel, who was then serving as Staff for then Committee Chair Senator Rockefeller, who led in crafting legislation by which Congress in turn handed the baton back to the FCC who, thanks to great staff work and tremendous leadership of Chairman Tom Wheeler, has put our country in the position being able to hold an auction early next year. It is has been a complicated and difficult task and they are getting a lot right. In particular, I should commend them for keeping to three big priorities: maximizing for the return of licensed spectrum, accommodating unlicensed use on a non-interfering basis, and understanding that we need to hold the auction as soon as possible. Delay imposes large costs on the economy.[18]

Herein lies a critical lesson for this Committee about time. CTIA just released a study about the time it takes to repurpose spectrum. I could quibble with some of the factual assessments[19] in the study, but most important, I agree with its bottom line, there is "reason for optimism that we can work collaboratively to shrink that timeline."

My optimism is based on history, which shows that when government decides to repurpose spectrum, it can do so in a reasonably quick manner. Yes, there are some negative stories but during some of the periods of more than a decade cited in the study, it was the government itself that, frankly, was not moving quickly. On the other hand, as demonstrated with such efforts as AWS–3 and the incentive auction relay team, a focused, targeted effort can repurpose spectrum in a timely manner. After all, it took 35 years from Ronald Coase's proposal[20] for the FCC to hold an auction. In contrast, it will take only 8 to move from Dean Weiser's paper to an actual auction. And it only took two years from the Congressional mandate for an AWS auction to the actual auction.

While on the second anniversary of the Plan, I was pessimistic about our spectrum prospects,[21] I have to say that the last few years has been a good-news story. As discussed above, the government, on a bi-partisan basis, involving the good work of both the executive and legislative branches, has acted to repurpose significant amounts of spectrum. The question is whether the good news continues or it stops.

Repurposing Government Spectrum. For the good news to continue, we have to find ways to more effectively repurpose government spectrum. As discussed above, I start from the premise that embedding more market signals into the decision process for spectrum use is the right place to start.

Potential Concerns with a Government Incentive Auction. One way to do so would be to simply take the incentive auction design and apply it to government spectrum. This has in fact been proposed by a number of parties.[22]

I applaud the spirit and purpose of such proposals. I obviously agree with the principle of incentives and am delighted that the Plan's proposal is subject to the sincerest form of flattery. Nonetheless, I have to note a number of concerns that such a plan will not produce the results we all seek. Briefly, I think such a plan faces the following barriers:

1. *Government spectrum has multiple users.* In the broadcast incentive auction, a single licensee controls the decision of whether or not to participate.[23] With government spectrum, there are generally multiple users, creating additional transaction costs, holdout problems and other difficulties in determining who

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[18] As Doug Brake of the Information Technology and Innovation Foundation has written, "Spectrum is a peculiar resource, if it can even be called a resource at all.25 It is infinitely renewable, divisible in 6 to 8 dimensions, 26 and unused spectrum is wasted opportunity that can never be recaptured." *http://www2.itif.org/2015-coase-wifi.pdf?__ga=1.167425398.95312237.1437826419.* In that light, every day of delay in repurposing spectrum is an economic drag on our economy.

[19] For example, while it is not wrong to write that the AWS–3 spectrum process began in 2002, the focused efforts began after Congress demanded an auction in its 2012 legislation. The 15 years to deployment suggested in the study is, in my book, more accurately described as 5 years of work. Similarly, in AWS–4, the concentrated work began in 2010, not 2002. I also slightly disagree with the assertion in the study that after "the broadcast incentive auction, the traditional licensed pipeline is empty." There are still some proceedings pending through which the FCC can facilitate making more licensed spectrum available to carriers, though admittedly, the number of such proceedings is small.

[20] 1959. The Federal Communications Commission. Journal of Law and Economics 2:1–40.

[21] *http://broadbandandsocialjustice.org/2012/03/when-an-roi-500-times-better-than-goldman-isn%E2%80%99t-enough-reallocating-our-focus-on-reallocating-spectrum/*

[22] *http://www.markey.senate.gov/imo/media/doc/2015–03–26-Federal%20Spectrum%20Incentive%20Act-billtext.pdf*

[23] Of course, the success of the broadcast incentive auction depends on a sufficient amount of broadcasters per market deciding to sell at a price that buyers are willing to pay. But the decision to participate is done at the individual licensee level, which is not analogous to the situation with spectrum used by the Federal Government.

will receive the incentive payment, which also diminishes the motivating power of the incentives.

2. *While all transactions have the potential for a principal-agency problem, the problem is much worse for government actors than private sector actors.* Many decisions throughout the economy involve what is known as the "principal-agent problem", in which the agent, acting on behalf of the principal but with different motives and significantly more information, may not act in the principal's best interest.

   To some extent, I saw this when I first started discussing the incentive auction with broadcasters. Economic theory would have suggested nothing but support for creating option value for the firm owners in an asset that otherwise could not be monetized. Instead I got significant pushback from some who expressed concerns about the impact on their jobs. That opposition has been quieted, to some extent, by the FCC's wise decision to make public the potential economic opportunity for the principals.[24]

   The principal-agent problem is significantly more problematic in a government setting. This is not a criticism of any government employees who I deeply respect. It is simply to acknowledge that the impact of market signals and financial incentives on the decisions of broadcast licensees as to whether to participate in an auction will be substantially greater than on Federal Government employees who will neither see the same signals or benefit financially.[25]

3. The budget process creates a snap back option. In addition to the principal-agent problem, the incentive for government officials to recommend their agencies participate would be diminished further by the understandable fear that any gain in one year with auction proceeds would be offset with congressional budget cuts in subsequent years.

4. The asymmetry of government service risk/reward. I have done two stints in the Federal Government but have spent most of my professional career in the private sector. In every institution in which I have worked, different employees have a different view of their risk/reward ratio for any particular decision. In the aggregate, however, in my experience, government employees are far more concerned about the risk of a wrong decision than the rewards for the right one. This is not surprising and it is also not bad.[26] In the context of this proposed auction however, we should understand that agency decision makers are likely to over-index for the risk of not having the spectrum they need to perform critical functions and under-index the reward for repurposing spectrum.

5. *It will be difficult to thread the needle between providing enough money to incent repurposing of spectrum and too much so that either the amount or the use does not cause a political backlash.* In the broadcast incentive auction, broadcasters will effectively be competing to determine the clearing price and therefore, market forces will set the price for their licenses. For a government incentive auction, proponents have suggested that the price paid to existing agency users will be set as a percentage of the wireless action proceeds. If the percentage is too low, the agencies will not sell.[27] If it is set too high, some agencies will receive what the public perceives as a windfall and both the money and the subsequent use of the money is likely to be heavily scrutinized by the public, dampening any agency's enthusiasm for participating in a future auction. That is, in the wake of the broadcast incentive auction, the public is unlikely to notice or complain how the selling broadcasters use the dividends of their capital asset restructuring. That will not be true for Federal employees using what some will characterize as a windfall outside the normal budget

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[24] *http://wireless.fcc.gov/incentiveauctions/learn-program/docs/ia-opportunities-book.pdf*

[25] For a contrary view, that Federal employees will be appropriately motivated by the opportunity to retain financial assets from the sale of government property, see *http://www.brookings.edu/~/media/research/files/papers/2014/09/23__buildings__bandwidth__spectrum__property/23__buildings__bandwidth__spectrum__property.pdf*

[26] Consider, for example, how many hearings Congress has held to examine allegations of problems caused by the actions of government employees relative to how many hearings it has held to praise government employees. Given the oversight responsibility, the ratio is appropriate. But we have to understand the impact on employees in their decision-making.

[27] The proposed legislation sets the fee at 1 percent, not because an economic analysis determined that was the right price but rather based on budget rules. See. Page 40 of "Making Waves: Alternative Paths to Flexible Spectrum Use. *http://www.aspeninstitute.org/sites/default/files/content/docs/pubs/Making-Waves.pdf.* It strikes me that 1 percent is too low but of course, no one has any idea.

process, so the process of repurposing government spectrum, over time, may not be sustainable.[28]

6. *Creating property rights for individual agencies may create perverse hoarding incentives.* If the Congress were to announce the possibility of different agencies benefitting at some ill-defined time in the future by returning spectrum, that could lead to a spectrum gold rush within Federal agencies who want the option value (either in terms of money or negotiating leverage) of such a benefit. Given the asymmetry of information that leads to difficulty in evaluating the real needs of spectrum for an agency's mission, the law of unintended consequences may kick in and NTIA could find that its job of spectrum manager is more difficult and the process could result in less spectrum repurposed.

To be clear, I am not saying to take the option of a government incentive auction off the table. The experience of the Base Closing Commission is instructive for how to incent Federal employees to support repurposing assets and there is some evidence from that experience that my concerns are overstated.[29] My own experience, however, suggests that Federal employees consider spectrum as a strategic asset in a way that real estate is not, so my skepticism about the ability of a government incentive auction remains. But I urge further study and consideration of all options.

Other Alternatives to Repurposing. In that light, as Congress considers the question of how to accelerate repurposing of government spectrum, it ought to consider the concerns I have noted as well as other options for inserting market signals into government spectrum decisions. These other options include the following:

1. *Administrative pricing.* Administrative pricing is the idea that each government agency that utilizes spectrum is charged in the budget some amount that reflects a broad measure of opportunity costs, thus creating a market signals among government users and others in the government, such as Congress, about the cost of spectrum and encourages agencies that are not using spectrum to move the spectrum off its books. As discussed in the National Broadband Plan, England has been successfully using this technique to more efficiently plan for and use spectrum in government operations.[30] Work on this has already taken place through a Presidential memorandum[31] and an OMB Directive[32] but I believe a clear Congressional directive could strengthen the impact of such a policy.
2. *Further amendments to the Commercial Spectrum Enhancement Act (CSEA).* The CSEA[33] encourages Federal incumbents to clear spectrum not being put to its most productive use by establishing a Spectrum Relocation Fund (SRF) to reimburse Federal agencies operating on certain frequencies that have been reallocated to non-federal use. With certain revisions, CSEA could become an even more effective tool for relocating Federal incumbents from reallocated spectrum and for developing technological advances that will enable future repurposing of Federal spectrum.

   The CSEA funding mechanism was first utilized in connection with the auction of former Federal spectrum in the AWS–1 auction, which concluded in September 2006. The auction proceeds attributable to the former Federal spectrum amounted to $6.85 billion, while, the relocation costs totaled approximately $1 billion, a return on investment the most successful investors on Wall Street would envy. Further, Federal incumbents received modernized systems in other frequency bands, demonstrating that relocation can be a win-win-win: for incumbents, for the U.S. Treasury, and, most importantly, for the American public, which benefits from increased access to the airwaves.

   Congress should improve the CSEA to ensure that the full range of costs is covered to provide Federal agencies incentives and assistance, including upfront planning, technology development and staffing to support the relocation

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[28] This is similar to the issue of setting the right incentives for Designated Entities (DEs) in auctions. If the incentives are not sufficient, no DEs participate. If the incentives are too rich, there is a political backlash. Overtime, the cycle of one followed by the other makes it difficult for the FCC to design a sustainable, successful program.

[29] *http://www.brookings.edu/~/media/research/files/papers/2014/09/23__buildings__bandwidth__spectrum__property/23__buildings__bandwidth__spectrum__property.pdf*

[30] The National Broadband Plan, page 83, Box 5–1.

[31] *https://www.whitehouse.gov/the-press-office/2013/06/14/presidential-memorandum-expanding-americas-leadership-wireless-innovatio*

[32] OMB Circular A–11 Office of Management and Budget (OMB) Circular No. A–11 (OMB 2013)

[33] Title II of H.R. 5419, Pub. L. No. 108–494, 118 Stat. 3986, 3991 (*codified at* 47 U.S.C. §§ 151, 301,302. 303.)

effort. Agencies should be compensated for using commercial services and non-spectrum-based operations, in addition to dedicated spectrum-based system deployments. The SRF should be available to reimburse incumbent Federal users who have to upgrade equipment to accommodate other Federal users moving onto the incumbents' band. Most importantly, Congress should allow funds to be used to "prove out" new deployment concepts that have a high likelihood of resulting in a major auction. Agencies will not commit to major technology transitions unless they believe their mission capability will be significantly upgraded. The law, as currently written, makes it difficult for OMB to authorize the release of SRF money to spectrum repurposing projects unless the agency commits to the auction, presupposing the outcome that the money is needed to test. This creates a Catch-22, boxing in Federal agencies and leading to inaction instead of providing a clear path forward to repurposing when the economics justify the repurposing.

3. *Providing Incentives for private sector bounty hunters.* Taking the CSEA idea one step further, we should incent the private sector to come up with creative solutions for repurposing government spectrum to create the kind of win-win-win options that the CSEA enables. One way to do so, as suggested by my co-panelist Commissioner Rosenworcel, is to create a prize for the first person to use spectrum more efficiently.[34] Another way, more focused on repurposing government spectrum, is to give private sector actors incentives to free up government spectrum by giving the private actors the right to use and sell the spectrum if they can provide the government agency with an equivalent service. This could be accomplished in a number of ways but one would be to auction to private enterprises the right to negotiate with a particular government agency. While such an auction would not likely raise much money, it could give private sector actors incentives to develop creative ways to more efficiently use equipment and other technological developments to free up spectrum.
4. *A GSA for spectrum.* Another approach is to treat spectrum the way the Federal Government treats most of it real estate needs, by centralizing the spectrum management function. Instead of each agency handling its own real estate, the Government Services Administration controls the overall portfolio. Similarly, the Federal Government could put all government-used spectrum under the control of a single administrator. That agency, particularly if it is part of the Office of Management and Budget, will ensure that the spectrum is used efficiently and would be able to balance the needs of the government agencies for spectrum and the possibility of raising revenues by leasing spectrum to private parties.[35] As this idea was first proposed by my co-panelist, Tom Lehnard[36], I will let him explain it, but I think it is an excellent idea[37] and urge its adoption.

None of these ideas are exclusive and each carries their own trade-offs, in terms of time and execution risk. Nonetheless, all should be on the menu of options Congress should consider in addressing the country's long-term spectrum needs.

Wired Broadband Deployment Agenda. In addition, Congress should understand the emerging hybrid relationship of our broadband networks. It is a mistake to think of two distinct broadband networks, fixed and mobile. The different network architectures interact and Wi-Fi, which largely connects over fixed, wireline infrastructure, carries more increasingly carries more of what we think of as "mobile" data traffic.[38] That is relevant to this hearing because the more robust our wireline

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[34] *http://www.mercurynews.com/opinion/ci_26597034/marty-cooper-and-jessica-rosenworcel-heres-how-expand*

[35] Some might believe that NTIA is already authorized to perform this function. Unfortunately, in my view, NTIA is structurally hamstrung. It is a coordinator, rather than a manager, without budget authority, of spectrum resources. I think NTIA in recent years has done an extraordinary job of repurposing spectrum, even more extraordinary when one understands its limited tools. One option Congress should also consider would be to give NTIA the tools to be a strong central manager of Federal spectrum.

[36] *https://www.techpolicyinstitute.org/files/lenard_white_ostp_gsoc.pdf*

[37] I recognize that some have suggested the analogy with GSA has it limits, particularly as spectrum issues go to the core mission of an agency, which is not true of real estate decisions. See *http://fedscoop.com/federal-spectrum-reform.* Still, I believe that having a dedicated team, expert in spectrum and networks, serving the broader Federal needs would go a long way to providing a balance of information about options that is essential for the Federal Government to use spectrum more efficiently.

[38] Juniper recently predicted that Wi-Fi networks will carry almost 60 percent of smartphone and tablet data traffic by 2019. *http://www.juniperresearch.com/press/press-releases/wifi-to-carry-60pc-of-mobile-data-traffic-by-2019?utm_source=gorkanapr&utm_medium=e-mail&utm_campaign=dataoffload15pr2*

network is, the more Wi-Fi off-load can relieve the pressure on our scarce spectrum assets.

Last week the House Communications and Technology Subcommittee held a hearing on "Promoting Broadband Infrastructure Investment"[39] to explore how to incent investments to increase bandwidth abundance on the wireline side. In truth, we are not really looking for a path to spectrum abundance; we are looking for *capacity abundance,* which requires multiple strategies using multiple assets. As was clear from that hearing, there are a number of private,[40] federal,[41] and local[42] developments accelerating next generation wireline network deployments. Just as I hope the House Committee holds hold a hearing on repurposing spectrum,[43] I hope you explore the topic they addressed, as there is an important relationship between developments on both the wireline and wireless sides.

Plan Beats No Plan. In closing, I would like to take this opportunity to thank Congress for directing the writing of the National Broadband Plan, which I was privileged to lead. It was a great and rare gift to work with an incredibly dedicated and talented group of Americans on a short-term basis with a mandate to think long-term. As we look back over five years we can see a number of benefits of that kind of process in terms of accelerating clarity about the long-terms obstacles and opportunities we have. In looking at this critical question of repurposing government spectrum, I urge you to consider using a similar, though appropriately modified, process of a short, focused, analysis that quickly leads to plan for repurposing the government spectrum we need for bandwidth abundance and economic leadership in the 21st Century Information Economy.

The CHAIRMAN. Thank you, Mr. Levin.

Dr. de Vries?

STATEMENT OF J. PIERRE DE VRIES, CO-DIRECTOR OF THE SPECTRUM POLICY INITIATIVE, AND SENIOR ADJUNCT FELLOW, SILICON FLATIRONS CENTER FOR LAW, TECHNOLOGY AND ENTREPRENEURSHIP, UNIVERSITY OF COLORADO AT BOULDER

Mr. DE VRIES. Chairman Thune, members of the Committee, thank you very much for inviting me. It is an honor. It is a pleasure to be here today.

There is no need to rehearse for this committee the boom in wireless services and technologies and the opportunities and the challenges we face. We have just heard some of that. And this very hearing, if nothing else, demonstrates that you fully grasp the scope of the situation.

I have come to believe that the promised spectrum bonanza is at risk if government does not create the tools to respond to the unprecedented diversity and crowding that we are seeing in spectrum. The more we squeeze services together in frequency, in space, and in time, the greater the cost of unwise spectrum allocation, and the greater the risk of service failures due to harmful interference.

The problem is not unlike that of a booming city where you must make room for more and more kinds of traffic—pedestrians, cars, trucks, motorbikes, buses—and, at the same time, real estate values are booming and space is at a premium.

So this growing variety, intensity, and dynamism of spectrum use requires that regulators make initial rules wisely and that we

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[39] *http://energycommerce.house.gov/hearing/promoting-broadband-infrastructure-investment*

[40] *http://docs.house.gov/meetings/IF/IF16/20150722/103745/HHRG–114–IF16-Wstate-SlingerM-20150722.pdf*

[41] The FCC approval of the AT&T/DirecTV deal includes a significant commitment to build-out Fiber to the Premises networks.

[42] *http://www.gig-u.org/cms/assets/uploads/2012/12/Val-NexGen__design__7.9__v2.pdf*

[43] That hearing wisely included testimony on wireless infrastructure but did not focus on spectrum.

find ways to shift routine spectrum management decisions, like rule adjustments and dispute resolution, from regulators to spectrum users.

I have recommended in my written testimony three steps to help deliver on the promise of spectrum, and I think they address the three stages of the spectrum lifecycle.

First, when planning new allocations, the FCC and NTIA should move away from worst-case interference analysis and instead use risk-informed methods that consider not only the consequences but also the likelihood of harmful interference.

Second, when issuing operating rights, regulators should be clearer about operators' interference rights and obligations, and they should use harm claim thresholds to do so. The FCC typically doesn't define rights and obligations very clearly. And this made sense when spectrum rights were not in such great demand, but it is not tenable, given the crowded spectrum bazaar we now face. Harm claim thresholds are good fences, and they will make for good neighbors.

And, third, when in the middle of spectrum disputes, any spectrum user should have the option of taking action against any other, either in front of an FCC judge or in a to-be-created Federal court of spectrum claims.

A Federal court is essential because there is currently no venue where intractable disputes between the FCC and the NTIA can be resolved. And, ultimately, fact-based, transparent, and timely adjudication is going to help make for efficient spectrum management.

Now, while I am convinced that each of these three recommendations on its own brings great benefits, I think there are great synergies between them. To start with, bargaining and contracting, based on harm claim thresholds, is facilitated by a well-functioning system of adjudication. In turn, adjudication is facilitated by clear statements of rights and obligations, as enshrined in harm claim thresholds.

And, finally, a risk-informed rather than a worst-case interference assessment makes for wise rights allocation, and it makes for efficient enforcement. It gives you a quantitative way to balance the rights and interests of interfered-with services and interfering services.

So let me wrap up by saying that I believe Congress, as you know, plays a vital role here, and here are three things you might consider doing.

The first is to take a risk-informed view yourselves when you are presented with questions of harmful interference and avoid the temptation of lapsing into the worst-case analysis.

Second, you can encourage the FCC and the NTIA to use risk-informed interference assessment themselves and to be more explicit about interference rights and obligations.

And, last, you can create a court of spectrum claims as part of the U.S. Court of Federal Claims.

Mr. Chairman, that concludes my testimony. Thank you again for inviting me, and I look forward to your questions.

[The prepared statement of Mr. de Vries follows:]

PREPARED STATEMENT OF J. PIERRE DE VRIES, CO-DIRECTOR OF THE SPECTRUM POLICY INITIATIVE, AND SENIOR ADJUNCT FELLOW, SILICON FLATIRONS CENTER FOR LAW, TECHNOLOGY AND ENTREPRENEURSHIP, UNIVERSITY OF COLORADO AT BOULDER

Chairman Thune, Ranking Member Nelson and members of the Committee, I am very pleased and honored to appear before you today to testify about spectrum policy. My name is Pierre de Vries and I am Co-Director of the Spectrum Policy Initiative at the Silicon Flatirons Center for Law, Technology and Entrepreneurship at the University of Colorado in Boulder.

I am a physicist by training and I have been working on spectrum policy for about fifteen years, first as an executive in a software company and a consultant, and now as a policy researcher. I am currently a member of the FCC Technological Advisory Council.

My testimony today is based on my experience and my current academic research interests. It reflects my views alone, and no opinions or recommendations that I offer should be ascribed to any of the institutions with which I am affiliated. I am testifying today entirely on my own behalf as a private citizen.

My testimony makes the following points:

- Realizing the promise of spectrum—improved public safety and national defense, new services for citizens, profits for companies, and revenue for the government—entails squeezing radio services ever more closely together and shifting as much spectrum management as is prudent from regulators to spectrum users and the marketplace. This in turn requires new approaches to planning, issuing and enforcing spectrum rights. I strongly recommend the following three:
- *First,* when making judgments about the trade-offs between the benefit of a new service and its impact on incumbents, spectrum managers like the FCC and NTIA should move away from worst case interference analysis and use risk-informed interference assessment that considers not only the consequences but also the likelihood of harmful interference. This will improve the analysis of harmful interference, and lead to wiser trade-offs.
- *Second,* when defining allocations, spectrum regulators should provide more clarity about interference rights and obligations, *e.g.,* by providing harm claim thresholds—explicit statements of the interference that systems have to tolerate without being able to claim harmful interference. This will help parties to optimize spectrum boundaries and resolve disputes without relying on the government.
- *Third,* for cases where interference disputes cannot be resolved, parties should have the option of acting against each other directly in front of an FCC judge, and/or in a Federal Court of Spectrum Claims. Fact-based, transparent, and timely adjudication will facilitate decentralized spectrum management.
- Congress can help by itself taking a risk-informed view when presented with questions of harmful interference, and not fixating on the worst case; encouraging the FCC and NTIA to be more explicit about interference rights and obligations; and creating a Court of Spectrum Claims.

1 Squeezing ever more radio services together requires new regulatory tools the planning, issuing and enforcement of rights to use spectrum

There is no need to rehearse for this Committee the explosive growth in wireless services and technologies like cellular data, Wi-Fi, airborne communications, satellite broadcasting, and radar of all sorts; the boom in the wireless economy; and the increasingly tight packing of services in spectrum bands that has resulted. The very fact that you are holding this hearing is testament to your recognition of the value of spectrum to growth and prosperity, and the imperative to rethink the spectrum policy tools we need going forward.

We are in a period of great promise as spectrum-based services offer unprecedented new value to citizens, companies and government. We are inventing new ways to put spectrum to its best use, including—notably—rethinking the division of spectrum between Federal and non-federal uses.

The promise of a spectrum bonanza is at risk, however, if the government does not put in place the appropriate institutional tools to respond to the unprecedented diversity and crowding in spectrum.

The demand for the benefits that radio services can bring to both private and public operators, and to the government through auction revenues, means squeezing together more and more applications and devices—of increasing variety, that require ever more spectrum capacity—into ever-more crowded spectrum. This means ever

closer packing in time, space, and frequency. To give one example along each dimension: a cellular service operating near a NOAA earth station during times when a weather satellite is below the horizon and not visible; geographic exclusion zones that grow or shrink depending on whether a mobile radar is present or absent; and eliminating frequency guard bands between allocations by using receivers that can reject interference from adjacent channels. Even though the accessible frequency range for radios keeps growing, demand is growing too. Greater proximity increases the cost of getting it wrong by flaws in allocation (the spectrum equivalent of land use zoning) or the assignment of spectrum use rights (like auctioned licenses, license exemptions, and Federal frequency assignments), and increases the risk of service breakdowns due to harmful interference.

The problem is not unlike that of a booming city that must make room for more and more traffic of all shapes and sizes—pedestrians, bicycles, motorbikes, cars, trucks, buses, etc.—at the same time that real estate values are exploding and space is at a premium.

The growing variety, intensity and dynamism of spectrum use demands that we find ways to shift the adjustment of rule changes from regulators to operators in more cases. We need to enable private ordering and remove the FCC from a gatekeeping role.

The challenge is particularly acute when it comes to getting the maximum value from Federal spectrum, since these services are vital to that national interest, are competing for access with private uses and, in many cases, jurisdiction over spectrum bands is shared with the Federal Communications Commission (FCC). If we want to reap the full benefits from Federal and other spectrum, we need to create an environment of good governance, and anticipate the problems that success will bring.

These constraints apply regardless of whether one favors spectrum sharing, clearing and reallocation, or some hybrid (like the AWS–3 blocks where cellular licensees have to protect weather satellite earth stations); and regardless of whether one prefers licensed or unlicensed allocation, or some hybrid (such as the 3.5 GHz band where unlicensed devices will be controlled by a Spectrum Access System). These choices are important, but do not change the underlying physics.

The challenges I've described must be addressed at all stages of the spectrum lifecycle: planning new allocations, issuing operating rights, and resolving interference disputes.

The three actions I recommend today correspond to these three stages:

- *When planning new allocations,* spectrum regulators should move away from worst case interference analysis and adopt risk-informed interference assessment that considers not only the consequences but also the likelihood of harmful interference.
- *When issuing operating rights,* regulators should provide more clarity about interference rights and obligations by specifying harm claim thresholds.
- *When resolving interference disputes,* parties should have the option of taking action against each other directly, either in front of an FCC judge or (particularly in the case of disputes between Federal and non-federal entities) in a Court of Spectrum Claims.

2 When making the trade-off between the potential benefit of a new service and its cost to incumbents, spectrum managers like the FCC and NTIA should move away from worst case analysis and adopt risk-informed interference assessment

Should a spectrum manager like the FCC or the National Telecommunications and Information Administration (NTIA) allow a new radio service if it might diminish the value of an existing service by introducing harmful interference? This question is at the heart of spectrum regulation. It has traditionally been answered by engineering analysis focused on the worst case, followed by qualitative rather than quantitative judgments of risk. There is an alternative, however: quantitative risk-informed
interference assessment.

Risk assessment sets out to answer three questions: What can go wrong? How likely is it? What are the consequences? For example, when considering whether to install a burglar alarm system one might consider the various circumstances under which unwanted people might enter your house; how likely each possibility might be; and what harm might befall in each case, from pranks and petty larceny to assault.

The purpose of risk assessment is to provide quantitative evidence to inform decisions on how to avoid and manage risks, and choose between options. In spectrum

management, the risk is that of harmful interference, and the choice is between various possible operating parameter values—such as values for maximum transmit power, the amount of energy leaking into adjacent bands, and antenna directivity—including the option of not allowing a new service at all. Applying quantitative risk assessment to spectrum yields risk-informed interference assessment.

Quantitative risk assessment has been used in other regulated industries for decades but has not yet been applied to spectrum management. A working group of the FCC's Technological Advisory Council (TAC) examined the potential of risk-informed interference assessment last year, and recently published a paper recommending that the FCC begin to use this technique.[1]

2.1 Worst case analysis is inherently conservative, leading to over-protection of existing services and under-provision of new services

A worst case analysis considers the single scenario with the most severe consequence, regardless of its likelihood. However, there are many kinds of radio interference, and their impacts vary; for example, a weak interfering signal leaked into an operating channel may cause more or less harm than a strong signal in an adjacent band, depending on the circumstances. Fixating on a single interference scenario—typically a worst case—does not accurately represent reality and can lead to false confidence that the resulting rules will avert harm. The worst case may be so rare that it can be safely ignored; and a more common but less extreme effect may be more problematic in practice than the worst case.

A worst case approach is inherently conservative and usually inappropriate. For example, when deciding on the amount of domestic protection to buy, most consumers do not plan for a worst case like home invasion. Rather, they take a view—based on the particular threats in their neighborhood, their need for security, and costs—of various options like deadbolts, burglar bars, intrusion alarms and steel doors.

In the case of spectrum, worst case analysis all too easily leads to rules that severely limit the benefits of new services while giving incumbents more protection than they need. This approach arguably made sense when spectrum rights were not in such great demand. It is not tenable when high value services have to be squeezed ever-more tightly together.[2]

In engineering practice, risk is typically evaluated by considering the combination of likelihood and consequence for multiple hazards. By contrast, a worst case analysis focuses on a single scenario with very severe consequences, regardless of its likelihood.

2.2 Quantitative risk assessment is used in many regulated industries

For decades, quantitative risk assessment has been used in regulated industries from finance to food safety, including cases where safety of life is paramount:

- The U.S. Nuclear Regulatory Commission adopted quantitative risk assessment in the Seventies. Its 1995 policy statement on probabilistic risk assessment (PRA) encouraged greater use of this technique to improve safety decision-making and regulatory efficiency. In 2009 it published guidance on the use of PRA to support licensee requests for changes to plant licenses.
- The U.S. Environmental Protection Agency (EPA) uses risk assessment to characterize the nature and magnitude of health risks from chemical contaminants and other environmental stressors. The EPA first issued a cancer risk assessment in 1976. A series of guidelines followed, based on a 1983 risk assessment paradigm developed by the U.S. National Academy of Sciences. Risk assessment practices are now well established at the agency and are widely used for public and environmental health protection.
- The U.S. Food and Drug Administration uses risk analysis to ensure that regulatory decisions about foods are science-based and transparent. It has developed FDA-iRisk, a publicly accessible online tool to estimate the health burden of microbial and chemical hazards in food.

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[1] The Spectrum and Receiver Performance Working Group of the FCC Technological Advisory Council, A Quick Introduction to Risk-Informed Interference Assessment (April 1, 2015), *http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting4115/Intro-to-RIA-v100.pdf.* For a summary, see J. Pierre de Vries, Risk Informed Interference Assessment (May 12, 2015), *http://www.ntia.doc.gov/files/ntia/publications/15-05-12_csmac_risk_hand-out.pdf.*

[2] There are exceptions where a conservative approach remains appropriate, such as services where interruption is absolutely unacceptable and spectrum protection is the only way to guarantee it. Even when doing a worst case analysis in such cases, however, one still needs put various hazards in context by comparing interference risks with non-spectrum risks like operator error, power outages, device misconfiguration, intentional jamming, etc.

Risk assessment methods are also used by other U.S. Government agencies and departments including the Office of Science and Technology Policy and the Office of Management and Budget; the Departments of Homeland Security, Health and Human Services, and Transport; and the Federal Aviation Administration, NASA, and Occupational Safety & Health Administration.

2.3 Using risk assessment in spectrum policy

The FCC TAC has proposed a three step method for analyzing radio interference hazards: (1) make an inventory of all significant harmful interference hazard modes; (2) define a consequence metric to characterize the severity of hazards; (3) assess the likelihood and consequence of each hazard mode, and aggregate them to inform decision making.[3]

Continuing the home safety analogy, householders would first to consider all the hazards they are exposed to, like fire, theft, windstorms and earthquake. Second, they would put them all on same footing with a common consequence metric such as dollars: how much it would cost to recover from a particular eventuality. Third, they would consider the likelihood and severity of each of these hazards, which would depend among other things on where they lived and their desire for personal security. Householders assess the likelihoods and consequences intuitively when deciding whether to buy a smoke alarm or install burglar bars; insurance companies do a quantitative analysis to calculate the insurance premiums for various risks. In the final aggregation step, the householder considers all these risks together when deciding how to allocate their limited resources on insurance policies and protective measures.

The benefits of risk-informed interference assessment include:

- Providing quantitative information to policy decision-makers who are balancing the benefits of a new service against its adverse technical impact on incumbents, including services that are essential to life safety and national security;
- Providing a single framework for comparing different interference scenarios and assessments, in other words, enabling apples-to-apples comparisons of different kinds of interference; and
- Enhancing the completeness of analysis and increasing the chances of identifying unexpected harmful interference mechanisms.

Achieving widespread use of risk-informed interference analysis will take time, not only to work through spectrum-specific technical issues but also to shift the management culture from a worst case to a risk-informed worldview. However, the sooner we start applying these methods, the sooner citizens, industry, and the Treasury will reap the benefits of squeezing services more tightly together. In other words: *Start small, but start soon.*

Congress should encourage spectrum managers like the FCC and NTIA to start using quantitative risk assessment in their own work; to publish the analyses and results so that others can learn from them; and to pilot risk-informed interference assessment in limited-impact cases. There is no need to start with headline-grabbing initiatives; an incremental approach will build expertise and confidence. Congress can also set a good example by itself taking a risk-informed view when faced with arguments about harmful interference, and not fixating on the worst case.

3 When defining operating rules, spectrum managers should provide harm claim thresholds—explicit limits on the interference that systems have to tolerate without being able to claim harmful interference

Users operate their radios within the constraints set by regulators. These constraints are codified in operating rules—maximum transmit power, allowed out-of-band emissions, antenna directivity, and so on—made by the FCC and NTIA. These arrangements aim to strike a balance between the interests of incumbents, whose operations should be protected against harmful interference, and entering services that could deliver significant new value such as wireless broadband, home healthcare, and the much-vaunted Internet of Things.

Given the imperfect information available to the regulators, the balance they strike is likely to be sub-optimal, that is, it is unlikely to minimize costs and maximize benefits. Even if it is perfect, the chosen balance is likely to become obsolete as technologies, businesses and missions evolve. For example, there might be a net social gain if the benefit of faster data services, enabled by increased transmit power, outweighed the cost of increased interference to an adjacent service or the

[3] Spectrum and Receiver Performance Working Group, *supra* note 1.

cost of improving receivers to be more impervious to such interference. Adjustments to the rules are therefore inevitable and desirable.

At the moment, adjusting the rules requires action by the regulators in almost all cases. This is slow and inefficient, since regulators have limited resources and imperfect knowledge, and the variety, intensity and dynamism of spectrum use keeps increasing. We need to enable as much spectrum management as possible by spectrum users themselves, individually and collectively, and minimize the FCC's gatekeeping role.

There are a few cases where parties do successfully renegotiate spectrum boundaries—that is, the operating parameter values such as license area boundaries, frequency band edges, time of operation, or limits on transmitted power that demarcate spectrum rights—typically in situations where there is a small number of parties, ideally all in the same business; the adjustment of cellular service boundaries is an oft-cited example.

Sufficient clarity helps parties to an interference negotiation or dispute to know what their rights and obligations actually are. This is essential when parties have limited information about each other's technology and business, as is usually the case at spectrum boundaries or in bands shared among very different services, and/or when they do not negotiate repeatedly.[4] Harm claim thresholds—the explicit statement in the operating rules that govern a service of the interfering signal levels that it needs to tolerate without being able to bring a harmful interference claim—provide the required clarity.[5] They are good fences that will make for good neighbors.

Harm claim thresholds give manufacturers and operators the information they need to determine the best way to tolerate potentially interfering signals in adjacent bands without the government placing requirements on their designs. For example, vulnerable operators can invest in high performance receivers that tolerate interference in adjacent bands even when their own desired signals are weak; or they can deploy more basic receivers and invest in increasing the desired signal level by deploying more transmitters. Conversely, harm claim thresholds allow potentially interfering operators to plan their transmissions so that they are not vulnerable to claims of harmful interference.

In cases where the initially assigned harm claim threshold is not (or is no longer) economically optimal, it can be adjusted by negotiation among affected neighbors. If a service can generate additional value by operating above a set threshold, it will have to share some of that value with the affected service—which is entitled to protection against interference above the threshold—to be allowed to breach the threshold. This is like a utility paying a property owner for an easement that allows their pipeline or cables to cross a piece of land; the land owner is willing to allow some encroachment on their rights in return for a payment.

Making analogies between spectrum and property is a tricky business since all metaphors have their limits.[6] However, it is worth recalling that real estate transactions depend on clear definitions of property boundaries, and the associated rights and obligations. Transactions will only flourish if purchasers know what they are buying, whether it's an easement or the property itself. It is also essential that they can be confident that their rights will be enforced—a topic tackled later in the recommendations on adjudication.

Setting a harm claim threshold thus has a variety of benefits:

- It reduces uncertainty about the rights and obligations regarding interference for both interfering and affected parties, allowing them to plan and invest with more confidence.
- It shifts decisions about system design, including receiver performance, away from government to where it belongs: with manufacturers and operators.
- It allows parties to adjust operating rights and spectrum boundaries among themselves, which reduces rent seeking and the load on regulators; it facilitates such negotiations by providing an unequivocal starting point, unlike the current obligation not to cause harmful interference—which lacks a quantitative definition.

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[4] These constraints usually do not apply to negotiations between cellular operators—perhaps the reason why they can bargain successfully about adjusting spectrum boundaries.

[5] J. Pierre de Vries, Optimizing Receiver Performance Using Harm Claim Thresholds, 37 Telecomm. Pol'y (2013), *http://dx.doi.org/10.1016/j.telpol.2013.04.008.*

[6] J. Pierre de Vries, *De-Situating spectrum: Rethinking radio policy using non-spatial metaphors,* 3rd IEEE Symposium on New Frontiers in Dynamic Spectrum Access Networks (2008), *http://dx.doi.org/10.1109/dyspan.2008.63.*

The implementation details of a harm claim threshold approach have been discussed elsewhere.[7] I will note just a few key points here.

- Different allocations can have different thresholds; the approach is not one-size-fits-all. An allocation's harm claim threshold can be customized—for example, lower interference thresholds to provide more protection for life-safety services. It can also be used to allocate costs in ways that best serve the public interest, for example by imposing interference mitigation requirements on the party that can most easily meet them.
- A harm claim threshold is not a receiver performance specification. It merely describes the interference conditions an affected system needs to tolerate without claiming harm. It does not prescribe how a receiver should perform in the presence of such signal levels, but relies on the marketplace to find the best solution.
- Harm claim thresholds may not be sufficient in cases where receivers are not controlled by a license holder (such as television or GPS), for life-safety systems like aviation, or for unlicensed devices. Additional measures may be required to ensure that receivers operate adequately.

The use of harm claim thresholds will also facilitate the enforcement of spectrum rights, the subject of the next recommendation.

4 More adjudication options are required for cases when interference disputes cannot be resolved, including the option for parties to act against each other directly in front of an FCC judge, and/or in a Court of Spectrum Claims

The current regime for resolving interference disputes limits the value of spectrum use because it is too often not fact-based, transparent, or timely. The problem is particularly pressing where Federal and private systems are squeezed tightly together because it is not clear where intractable disputes between the parties will be resolved.[8]

Conflict between neighbors about spectrum use is inevitable, and will become more prevalent as more users and uses are squeezed together. While increasing numbers of disputes will be resolved by negotiation—especially so if my first two recommendations are adopted—adjudication is a necessary backstop; it provides a framework and incentive for negotiation, and a means of resolving intractable disagreements. As is often the case in civil disputes, the mere threat of litigation and opportunity for document discovery can aid the parties in moving to a settlement.

The FCC's adjudication process is ad hoc and unpredictable. Many interference disputes—since records are generally not public, I do not know how many—are resolved by field agents of the Enforcement Bureau. However, the agency's capabilities, both in terms of personnel and equipment, are limited. When a conflict cannot be resolved in the field, FCC enforcement is often delayed or addressed through notice-and-comment rulemaking when adjudication would have been more appropriate and efficient.

The shared jurisdiction between the FCC and NTIA means that there is currently no venue where intractable disputes between them can be resolved; the FCC is responsible for managing non-federal, including commercial licensees, and the NTIA is responsible for managing Federal authorizations.[9] Since a substantial collection of frequency bands is already shared between Federal and civil users, jurisdictional disagreements occasionally arise between FCC and NTIA.[10] It is an open question how intractable disputes between Federal and non-federal users will be resolved. Coordination between the NTIA and FCC is the only currently available mechanism; this will fail when they themselves disagree.

In collaboration with Dean Weiser of the University of Colorado Law School, I have proposed an adjudication regime that moves from the current ad hoc, politi-

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[7] Receiver & Spectrum Working Group, FCC Tech. Advisory Couns., Inference Limits Policy: The use of Harm Claim Thresholds to improve the interface tolerance of wireless systems (2013), *http://transition.fcc.gov/bureaus/oet/tac/tacdocs/WhitePaperTACInterferenceLimitsv1.0.pdf.*

[8] Close coexistence will not just occur in so-called shared bands, but also as a result of clearing and reallocating Federal bands. Given the universal need to squeeze services more tightly together, the result in both cases will be narrow frequency guard bands and small exclusion zones.

[9] The NTIA is part of the Executive branch, while the FCC is an independent regulatory authority whose mandate and authority derives from Congress and the Communications Act of 1934.

[10] Executive Office of the President, President's Counsel of Advisors on Science and Technology, Report to the President Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth (July 2012), *http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf2.*

cally charged, and notice-and-comment driven process to a more-fact-based process of hearings before specialized judges.[11] I will now describe the two components: more intensive use of judges by the FCC, and the establishment of a Federal Court of Spectrum Claims. The measures we recommend address non-urgent harmful interference cases, and not those that pose an immediate threat to the safety of life or property.

4.1 Using FCC judges to resolve disputes between parties under FCC jurisdiction

First, regarding the FCC, the development of a specialized interference adjudication function would involve building or co-opting a capacity it does not currently have. One solution would be to second technical advisers to the existing Office of Administrative Law Judges (ALJs) from other parts of the agency; another is to appoint Administrative Judges.[12]

In order to advance this proposal, the Samuelson-Glushko Technology Law & Policy Clinic at the University of Colorado Law School and I requested that the Commission initiate a rulemaking to provide a fact-based, transparent, and timely adjudication process for spectrum interference disputes.[13] We proposed that the Commission should:

- Permit a private party to file a spectrum interference complaint against another private party directly with the Office of Administrative Law Judges, thereby providing operators with fact-based, transparent, and timely process to resolve harmful interference disputes;
- Modify existing rules to add deadlines to the adjudication process; and
- Make resources available as and where needed to ensure the adjudication process is fact-based and timely; for example, by providing support staff, hiring or loaning additional ALJs, and obtaining spectrum engineering advice from inside or outside the agency.

FCC adjudication would not be appropriate in all cases. Cases that fall within its scope are those where appropriate FCC rules already exist; where both parties are under the FCC's jurisdiction; and where one private party claims that another private party is causing harmful interference. The ALJ option would be ideal for small bilateral disputes, while rulemaking by the Commission would be more appropriate for multi-party disputes, and single-party cases that highlight broader problems.

The ALJ option would not be appropriate for disputes between the government and private parties—the situation I turn to next.

4.2 Creating a Court of Spectrum Claims to resolve disputes between Federal and non-federal users

Even with the FCC acting as an expert adjudicator, Dean Weiser and I proposed that Congress establish a Court of Spectrum Claims that could hear cases in this field. Such a body would be housed within the existing United States Court of Federal Claims, the court that hears cases involving claims against the U.S. Government. It would consist of specialized decision makers who could hear cases regarding spectrum matters.

Such a venue is essential if Congress wants to see more delegated, dynamic negotiation and reassignment of spectrum rights between Federal and private users. Federal and non-federal users will be operating in ever-closer proximity regardless of the spectrum management regime: both band sharing and band reallocation will lead to ever-tighter packing of radio services in time, space and frequency. Con-

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[11] J. Pierre de Vries & Phillip J. Weiser, The Hamilton Project, Unlocking Spectrum Value through Improved Allocation, Assignment, and Adjudication of Spectrum Rights, (March 2014), *http://www.hamiltonproject.org/files/downloads_and_links/THP_DeVries-WeiserDiscPaper.pdf.* For a full set of related resources see, Hamilton Project, *http://www.hamiltonproject.org/papers/unlocking_spectrum_value_through_improved_allocation_assignment/* (last visited July 20, 2015).

[12] The key difference is that Administrative Judges are not a formal part of the Federal Government-wide system for selecting such officials. Since the FCC does not have many ALJs on staff (only one, at present) and those in place may lack the specialized knowledge that would enable more effective adjudication in this area, using Administrative Judges may be an appealing alternative.

[13] Petition: Samuelson-Glushko Tech. Law & Pol'y Clinic and J. Pierre de Vries, Petition for Rulemaking: Spectrum Interference Dispute Resolution (May 8, 2015), *http://apps.fcc.gov/ecfs/comment/view;ECFSSESSION=qTgSVtcPYBypk93Q6ryZQXghc2sKTVJ5NQnRLzGHLQV216sFnT8Q!-1954627099!-774309124?id=60001031161.* Notice: Fed. Commc'n Comm'n, Consumer and Gov't Aff. Bureau Reference Info. Center Petition for Rulemaking Filed, Proceeding RM–11750, Report No. 3023 (June 11, 2015), *http://apps.fcc.gov/ecfs/comment/view;ECFSSESSION=qTgSVtcPYBypk93Q6ryZQXghc2sKTVJ5NQnRLzGHLQV216sFnT8Q!-1954627099!-774309124?id=60001060847.*

sequently, spectrum disputes between Federal on non-federal users become ever more likely.

Mutually beneficial arrangements between parties are most likely if both sides know their rights and are confident claims will be enforced. A government agency or department would be loath to give up control and allow sharing if it cannot depend on reliable enforcement—and that might be doubly true of a company buying spectrum access from the government in an auction, or by contract with a Federal entity. Most contract disputes do not go to court, but the backstop of judicial recourse gives parties the confidence they need to enter into a contract. The Court of Federal Claims provides this backstop for entities contracting with the Federal Government; a division for spectrum claims would fulfill that function in the specialized case of federal/non-federal spectrum cooperation.

The CSMAC Enforcement Subcommittee addressed the question of how spectrum sharing arrangements between Federal and non-federal operators could be enforced, and by whom.[14] Even if implemented, this industry recommendation—that the NTIA and FCC enact parallel dispute resolution tools, and that a joint NTIA/FCC coordination committee would oversee federal/non-federal sharing—is not sufficient.[15] It promises to be a good mechanism for avoiding disputes and facilitating their resolution, assuming good will on all sides. However, it is not clear that the NTIA has the ability to order a recalcitrant agency or department to turn off an interfering device or system, and the CSMAC recommendation does not address how a disagreement between the NTIA and FCC themselves would be resolved.[16] For this, a backstop adjudicator with authority over both Federal and non-federal operation—such as a Court of Spectrum Claims—is required.

Thus, even if the FCC were operating effectively as an adjudicator (and the establishment of such a Federal body would greatly enhance that likelihood), the FCC is not set up to handle disputes involving the Federal Government as a party. The establishment of a specialized court outside of the FCC would enable the U.S. Government to sue or be sued when appropriate.

Dean Weiser and I also recommend that the Court of Spectrum Claims be allowed to hear disputes between two private parties, ending the FCC's monopoly on hearing such claims and providing a choice of forum. This Court would provide an alternative and a check against the FCC's possible failure to operate effectively in this area. In all events, appeals from either the FCC or the Court of Spectrum Claims would proceed to the Court of Appeals for the District of Columbia to promote uniformity of decisions in both forums.

In summary, courts with expertise in spectrum policy, either in the FCC and/or in a newly created Court of Spectrum Claims, can transform adjudication from the current ad hoc and sometimes politically charged process to a more fact-based, transparent, and timely procedure that could resolve spectrum-related disputes more expeditiously.

5 The three initiatives complement each other

While each of the three proposals outlined here—using risk-informed interference assessment, defining harm claim thresholds, and allowing parties to resolve interference disputes before a judge—will bring noteworthy benefits on their own, there are significant synergies between them.

Harm claim thresholds realize their full promise when parties can use them to (re)negotiate spectrum boundaries that are closer to the optimum without the cost and delay associated with relying upon spectrum regulators.

Such bargaining and contracting is facilitated by a well-functioning system of dispute resolution that includes the backstop of adjudication. If a dispute arose—for example, about whether and how entitlements were breached—the parties could resolve the matter through negotiation, mediation, or formal adjudication either at the FCC or in the Court of Spectrum Claims.

In its turn, adjudication will be facilitated by objective criteria for establishing whether harmful interference has occurred. This will be aided by clear statements of the rights and obligations regarding interference protection, *e.g.,* through harm claim thresholds.

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[14] Commerce Spectrum Management Advisory Committee, NTIA, Enforcement Subcommittee Report (May 12, 2015), *http://www.ntia.doc.gov/files/ntia/publications/csmac-enforcement_sc_responses_050415.pdf.*

[15] The parallel dispute resolution approach contemplates that Federal users could rely on the FCC's authority over non-federal spectrum users to enforce sharing arrangements, and non-federal entities could rely on the NTIA to take necessary actions against Federal users.

[16] Neither the CSMAC recommendation nor this proposal addresses interference events that are immediate threat to life and property.

For its part, risk-informed interference assessment supports both efficient allocation (including the setting of harm claim thresholds) and efficient rights enforcement (including inter-party adjudication) by providing an objective, flexible tool for balancing the interests of interfering and affected services.

6 Action by Congress can lay the foundation for continued growth in spectrum use

If the Nation is to reap the full value of Federal and other spectrum, Congress needs to create the tools of good governance and anticipate the problems that success will bring.

Action by Congress can unlock the potential of Federal and non-federal spectrum and lay the groundwork for continued growth in all three stages of the spectrum lifecycle: planning new allocations, issuing operating rights, and resolving interference disputes.

- *Regarding the planning of new allocations,* Congress should avoid the temptation of worst case analysis and nightmare scenarios, and instead itself make—and encourage the FCC and NTIA to use—risk-informed interference assessments that consider both the likelihood and consequences of interference harms.
- *Regarding the issuing of operating rights,* Congress should support and encourage the FCC and NTIA to bring greater clarity to interference rights and obligations, such as through the use of harm claim thresholds.
- *Regarding the resolution of interference disputes,* Congress should put in place any instruments that are needed to allow parties, both Federal and non-federal, to take action against each other directly in front of a judge, including by the creation of a Court of Spectrum Claims within the existing United States Court of Federal Claims.

Mr. Chairman that concludes my testimony. Once again, I want to express my appreciation for being invited to testify here today on this important topic. I would be happy to respond to any questions that you might have.

The CHAIRMAN. Thank you, Dr. de Vries.

Mr. Lenard—Dr. Lenard, I should say.

STATEMENT OF THOMAS M. LENARD, PH.D., PRESIDENT AND SENIOR FELLOW, TECHNOLOGY POLICY INSTITUTE

Mr. LENARD. Thank you, Chairman Thune, Ranking Member Nelson, and members of the Committee. I appreciate the opportunity to testify before you today.

I would like to stress two points today in my testimony. First, while the broadcast auction is of course extremely important, I think attention should also be paid to another category of spectrum: the mobile satellite service, or MSS, spectrum. And, second, the all-important long-run task of freeing up more government spectrum should be addressed with a combination of administrative, budgetary, and market mechanisms.

The MSS spectrum, because it is already licensed and doesn't need to be auctioned, could be deployed for mobile broadband more quickly than other spectrum blocks. The inability to efficiently utilize the MSS spectrum results from a history of regulatory failures, mostly recently involving the LightSquared spectrum. Not approving the LightSquared spectrum for mobile broadband would effectively transfer a large block of spectrum from the commercial sector back to the Government—exactly the opposite of what we are trying to achieve.

The issue of government spectrum has been a challenging one for policymakers for some time now. Most inputs used by government agencies are subject to annual budgetary allocations and must be purchased in a market. In contrast, spectrum was awarded by the Department of Commerce and now is effectively owned by those

agencies. From the agencies' perspective, the spectrum is free. Moreover, even if government agencies could sell their spectrum, any benefit might be offset by budget reallocations that would net out the agencies' gain.

From an agency's perspective, a better strategy might well be to make some use of the spectrum even if that use is of low value or even to let the resource lie idle and wait for some future use, since doing so is costless.

A TPI study I co-authored with Professor Lawrence White of the NYU Stern School of Business recommends a combination of administrative, budgetary, and market mechanisms to free up government spectrum.

On the administrative/budgetary side, the NTIA should prepare an annual report that reports data on the government spectrum inventory, the opportunity costs of the various bands, and the likely sources of surplus spectrum.

Most importantly, OMB should become a skeptical auditor of government-held spectrum—its use and its opportunity costs. As part of its annual budget process, OMB should require government agencies to provide an accounting of their spectrum.

OMB should have a heightened awareness of spectrum as a scarce resource. The NTIA estimates of opportunity costs would be helpful in this regard and should routinely search for underutilized spectrum that could be auctioned by the FCC.

Over the long run, the Federal Government should pursue incentive pricing mechanisms that force government agencies to internalize the costs of the spectrum they use. We recommend considering a model based on the GSA, which leases office space to government agencies at market-based rents. These rental payments provide an incentive for government agencies to economize on space.

Following the GSA model, the Federal Government should create what we call a government spectrum ownership corporation, or GSOC. The GSOC would lease spectrum to user agencies at rental rates based on estimates of the relevant opportunity costs, with the net proceeds going to the Treasury.

In the first year, OMB would add to each agency's budget a sum just equal to the rental payment, so the first year's financial transactions would be a wash for all agencies as well as for the Treasury. In subsequent years, spectrum would be treated the same as any other budget item. Thus, the normal budgetary negotiation process would recognize the opportunity costs of spectrum in the same ways that the opportunity costs of an agency's use of other resources are recognized.

The goal would be that such a system would, like the GSA framework, provide sensible incentives for agencies to economize on spectrum use. The GSOC might then have a surplus of spectrum that could be sold or leased to the private sector. The GSOC could also accumulate a fund, again, similar to the GSA, that could be used to purchase additional spectrum if needed for leasing to government agencies.

Thank you again for the opportunity to present my views, and I look forward to answering your questions.

[The prepared statement of Mr. Lenard follows:]

PREPARED STATEMENT OF THOMAS M. LENARD, PH.D., PRESIDENT AND SENIOR FELLOW, TECHNOLOGY POLICY INSTITUTE

Chairman Thune, Ranking Member Nelson and Members of the Committee. My name is Thomas Lenard, and I am President and Senior Fellow at the Technology Policy Institute, a non-profit, non-partisan think tank that focuses on the economics of innovation, technological change, and related regulation in the United States and around the world. I appreciate the opportunity to testify before you today on wireless broadband and the future of spectrum policy.

The growth of wireless broadband is a bright spot in the U.S. economy, but it depends on the availability of spectrum and in particular flexibly licensed spectrum rights. Freeing up spectrum from other uses would allow greater expansion of wireless broadband, bringing substantial gains for U.S. consumers, businesses, and the Federal treasury. A recent study by the Brattle Group, using the Federal Communications Commission's methodology, estimates that by 2019 the U.S. will need more than 350 additional MHz of licensed spectrum to support projected commercial mobile wireless demand—50 percent more than is currently available.[1]

Despite significant progress toward a more market-based approach to the allocation of spectrum, much of the most valuable spectrum remains unavailable to the private sector or locked into inefficient uses under FCC license terms. The latter group includes allocations to broadcast TV and mobile satellite services (MSS). Even more spectrum is unavailable to the market because it is occupied by the Federal Government.

In the short run, the largest block of available spectrum—indeed, the only significant block of spectrum that is already licensed but not deployed—is the Mobile Satellite Service (MSS) spectrum. Beginning in 1986, the FCC allocated over 150 MHz of prime spectrum to MSS—mobile "satellite phone" service—for which demand has been extremely limited. Because it is already licensed and doesn't need to be auctioned, the MSS spectrum could be deployed for mobile broadband more quickly than other spectrum blocks. The National Broadband Plan initially counted 90 MHz of MSS spectrum, mostly controlled by Dish and LightSquared, toward its 2015 goal of an additional 300 MHz for wireless broadband; but this estimate has been cut by more than half due to exclusion of the LightSquared spectrum. The failure to utilize the LightSquared spectrum represents a costly regulatory failure. Interference disputes between LightSquared and users of adjacent spectrum are a complex issue, but ultimately the inability to resolve them stems from the absence of a flexibly licensed regime—in essence, the lack of clearly defined quasi-property rights and the absence of a market mechanism for buying and selling those rights. This has made it difficult for the occupants of adjacent bands to strike a mutually beneficial deal that would have enhanced the value of the spectrum and benefited consumers. The FCC should do what is needed to rapidly return as much as possible of the LightSquared spectrum to the spectrum pipeline.[2]

The broadcast TV spectrum is the other major private-sector category that under current FCC license terms can't be used for wireless broadband. At the conclusion of the DTV transition in 2009, 294 MHz of prime spectrum remained allocated to broadcast TV. The FCC projects the upcoming incentive auction will release 120 MHz of this broadcast spectrum for mobile broadband uses, but many consider this projection optimistic. Moreover, U.S. experience indicates that large-scale reallocations of spectrum such as the proposed incentive auction have taken 6–13 years to complete. Indeed, it has already been five years since the National Broadband Plan proposed the incentive auction and three years since Congress authorized the FCC to do it.

Potentially the largest source of additional spectrum is the Federal Government, which has "sole or primary use of between 60–70 percent of the spectrum suitable for wireless broadband."[3] My testimony recommends both administrative/budgetary and market mechanisms for freeing spectrum from these bands based on a TPI

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[1] Coleman Bazelon and Giula McHenry, "Substantial Licensed Spectrum Deficit (2015–2019): Updating the FCC's Data Demand Projections," the Brattle Group, prepared for CTIA—the Wireless Association, June 23, 2015.

[2] For a discussion of this issue, see Thomas M. Lenard and Lawrence J. White, " The Spectrum Crunch, MSS Spectrum and LightSquared," Technology Policy Institute, April 2013; and Thomas Lenard and Lawrence White, "Broadcast Spectrum is not the only Spectrum Available, *The Hill,* July 23, 2013.

[3] CTIA, "From Proposal to Deployment: The History of Spectrum Allocation Timelines," p. 3, available at *http://www.ctia.org/docs/default-source/default-document-library/072015-spectrum-timelines-white-paper.pdf.*

study I co-authored with Professor Lawrence White of the NYU Stern School of Business.[4]

Government Spectrum Use and Opportunity Costs

There is a widespread consensus that spectrum in government hands is likely not being used efficiently and that some—perhaps a significant amount—could be reallocated to more efficient private uses.[5] However, efforts to determine the extent of this "surplus" and then to devise a method of freeing it from government hands confront a dilemma: the absence of a market mechanism, or even a budgetary mechanism, that could encourage this reallocation.

First, government agencies do not operate in a market context, and their goal is not to maximize profits. Consequently, the "opportunity cost" paradigm that naturally applies in a market-oriented context is often neglected within government agencies.

Second, unlike most of the inputs that are used by a government agency—e.g., personnel, materials, vehicles and equipment, real estate—which are subject to annual budgetary allocations and must be purchased in a market, spectrum under a government agency's control was awarded by the Department of Commerce and now is effectively "owned" by those agencies. From a government agency's perspective (*i.e.,* the perspective of the agency's senior management), the spectrum is a free resource, for which it pays no rent or upkeep costs. The perceived opportunity costs of spectrum are small at best, since there is no market for this spectrum because the agencies are not allowed to sell it.

Further, even if there were an active market for government-held spectrum (and hence readily apparent opportunity costs), and even if a government agency were interested in exchanging spectrum for revenues that could be used to achieve agency objectives, the agency could nevertheless be largely indifferent to those opportunity costs for the following reason: If an agency were to sell its spectrum, the agency's net gain might be far smaller than the selling price—or even zero. That result could occur due to budget reallocations that would net out the agency's gain. From an agency's perspective, a better strategy might well be to make some use of the spectrum under its control (even if that use is of low value, as judged by opportunity costs), or even to let the resource lie idle and wait for some future use, since doing so is costless.

As an analogy, one might think of real estate that, at some time in the past, had come under a government agency's ownership and control. If that real estate has little or no upkeep costs, then from the agency's perspective it is a free resource. The opportunity costs of the real estate may be of little interest to the agency, for the budgetary recoupment reasons mentioned above. The agency may put the real estate to low-value uses, or even keep it idle. When challenged by higher governmental authority, an agency's narrow interests will be best served by claiming that the real estate is vital to the agency's current and future functions.

There are limits, of course, to the real estate analogy. As compared with spectrum, the opportunity costs of an agency's real estate holdings are likely to be much clearer. Physical inspection of the property to determine whether the agency is making reasonable use of it (in light of its opportunity costs) is surely easier as well.

Accordingly, the task of determining the extent of surplus spectrum in government hands and reallocating it to wireless broadband use is more difficult than if the resource were real estate. Further, implicit in this discussion is the inability to bring the power of markets as a force for assisting in the reallocation. As a consequence, the effectiveness of market or quasi-market mechanisms in identifying and freeing up government spectrum might be limited—at least in the short run.

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[4] Much of this testimony is drawn from Thomas M. Lenard, Lawrence J. White, and James L. Riso, "Increasing Spectrum for Broadband: What Are the Options?" Technology Policy Institute, February 2010.

[5] This is implied by the broadly popular Radio Spectrum Inventory Act, which is premised on the ability to "promote the efficient use" of spectrum. In 1996 former Senator Larry Pressler recommended that the Federal Government reallocate 25 percent of its holdings below 5 GHz (see *https://www.policyarchive.org/bitstream/handle/10207/8335/bg-1085.pdf,* p. 8). For additional references on why government users might be expected to use spectrum inefficiently see Mark M. Bykowsky and Michael J. Marcus, "Facilitating Spectrum Management Reform via Callable/Interruptible Spectrum," presented at TPRC 2002, available at *http://intel.si.umich.edu/tprc/papers/2002/147/SpectrumMgmtReform.pdf;* Kenneth R. Carter and J. Scott Marcus, "Improving the Effectiveness and Efficiency of Spectrum Use by the Public Sector: Lessons from Europe," presented at TPRC 2009, available at *http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1488852*; and Martin Cave and Adele Morris, "Getting the Best out of Public Sector Spectrum," presented at TPRC 2005, available at *http://web.si.umich.edu/tprc/papers/2005/497/Morris%20Cave%20public%20sector%20spectrum%209%209%202005.pdf*

Spectrum Sharing

Spectrum sharing has become the preferred means of freeing up government spectrum. The 2012 report by the President's Council of Advisors on Science and Technology (PCAST) concluded that "the traditional practice of clearing government-held spectrum of Federal users and auctioning it for commercial use is not sustainable" and recommended a policy of "share[ing] underutilized spectrum to the maximum extent consistent with the Federal mission."[6] But this task is also hindered by the lack of market forces.

Establishing a system in which Federal agencies face the opportunity costs of the spectrum they use would greatly facilitate efficient sharing of government spectrum. When faced with the opportunity costs, the government user may decide to make investments or otherwise alter the way it uses the spectrum so as to increase spectrum availability and/or permit less restrictive conditions for private-sector users. This increases the combined social value (to government and private users) of the spectrum. Thus, it is important that Federal users internalize the costs of their spectrum use.

For government agencies that have only an occasional need for spectrum—e.g., for emergencies—consideration should be given to purchasing an "option" to over-ride/displace some private spectrum users at such times (rather than owning the spectrum and letting it sit idle or severely underused most of the time). This would be an innovative way of "sharing" spectrum. The government agency could hold a procurement auction. Potential sellers of this (call) option for "when needed" spectrum would presumably be those who could economize or dispense with their spectrum usage during such emergency periods (rather than, for example, wireless broadband providers whose networks likely would also be severely stressed during such emergencies).

Administrative/Budgetary Mechanisms

Strengthening administrative and budgetary mechanisms holds the greatest promise for freeing up government-held spectrum for the short run and would complement the market mechanism discussed subsequently. I recommend the following:

1. The National Telecommunications and Information Administration (NTIA) should prepare an annual report that presents data on the government's spectrum inventory, the opportunity costs of the various bands, and the likely sources of surplus spectrum. The data on surplus positions should take into account changes in usage and technology.
2. The Office of Management and Budget (OMB), as part of its annual budget process, should require any U.S. Government agency that has a spectrum allocation to provide an annual accounting of that agency's use of that spectrum.[7] OMB should have a heightened awareness of spectrum as a scarce resource (the NTIA estimations of opportunity costs would help in this awareness) and should routinely search for under-utilized spectrum that could be auctioned by the FCC.[8] In essence, OMB should become a skeptical auditor of government-held spectrum, its use, and its opportunity costs.
3. OMB should encourage (and provide the funding for) agencies to create employee incentive plans that would provide rewards (including cash awards) to agency employees for devising ways for their agency to economize on its use of spectrum. The spirit of these awards would be consistent with other government awards that encourage employees to take special efforts to utilize resources efficiently and to provide outstanding performance.

Market Mechanisms: A Government Spectrum Ownership Corporation (GSOC)

Over the longer run, the Federal Government should pursue incentive pricing mechanisms that force government agencies to internalize the costs of the spectrum they use.

One model to consider is based on the market-oriented rental rates that agencies are charged when they lease space in buildings that are owned (or leased) by the

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[6] "Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth," President's Council of Advisors on Science and Technology, July 2012.

[7] A partial step in this direction is included in OMB Circular A–11, which provides guidance on the preparation of the budget. Section 31.12 instructs agencies to consider the value of radio spectrum required for telecommunications, radars, and related systems, to the extent practical, in economic analyses of alternative systems/solutions. *https://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/s31.pdf*

[8] OMB should also be encouraging agencies to share the use of under-utilized spectrum, again encouraging greater efficiency.

General Services Administration (GSA). The GSA's Federal Buildings Fund (FBF) provides recognition of the opportunity costs of those buildings.[9] The government agencies make rental payments to GSA, which can use the money to acquire additional property if necessary. These rental payments provide an incentive for government agencies to economize on space.

Suppose, then, that all U.S. Government-used spectrum was "owned" by a central government agency and leased to government users. In this case, the idea that the spectrum-using agencies should pay rental fees to the central agency—and that those rental fees should represent something approximating the opportunity costs of the spectrum holdings—would not be much different from the practice that government agencies pay rent for their use of the GSA's buildings.

Accordingly, the Federal Government should create a "Government Spectrum Ownership Corporation," or GSOC. The GSOC would take possession of all government-held spectrum, with the existing user agencies granted annual leases (that are perpetually renewable at the option of the agency) at annual rental rates that are determined by the GSOC, based on its estimates of the relevant opportunity costs. The GSOC would forward its net proceeds to the Treasury. In the first year OMB would add to each using agency's budget a sum that is just equal to the rental payment, so the first year's financial transactions would be a "wash" for all agencies (and for the Treasury).

In subsequent years the agencies' budgets would start from the base that included the initial assignments and rental charges; but the GSOC would change the rental rates in light of updated information about opportunity costs. The agencies and OMB would then negotiate (as they do now) over resource usage and budget allocations; but, although the agency's budget would take into account its spectrum rental costs, there need not (and should not) be a one-to-one adjustment in an agency's budget allocation in relation to any changes in its spectrum rental costs. Instead, the agency's budget allocation should reflect its overall resource needs in light of its overall mission and operations. Thus, this "normal" budgetary negotiation process would recognize the opportunity costs of spectrum in the same ways that the opportunity costs of an agency's use of other resources are recognized.

The goal would be that such a system would (like the GSA framework) provide sensible incentives for agencies to economize on spectrum use. The GSOC might then have a surplus of spectrum that it could sell or lease to the private sector (or turn over to the FCC for auctions). The GSOC could also accumulate a fund (again, similar to GSA) that could be used to purchase additional spectrum if needed for leasing to government agencies.

Conclusion

There is a significant opportunity for large economic gains for the U.S. economy from expanding wireless broadband by freeing up under-used government spectrum and reallocating broadcast and MSS spectrum. Public policy should take advantage of that opportunity.

Thank you for the opportunity to present my views and I look forward to answering your questions.

The CHAIRMAN. Thank you, Dr. Lenard.

And we now have been joined by the Ranking Member, the Senator from Florida, Senator Nelson. I want to recognize him for a statement, and then we will get into some questions.

STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM FLORIDA

Senator NELSON. Mr. Chairman, before I make the statement, I want you to know and the members of the Committee how much I appreciate the well wishes and support in the course of the last couple of weeks. For that kind of outpouring, indeed it is humbling to me.

And I want to thank you for having this hearing on this important topic of spectrum.

[9] As another analogy, government agencies pay postal rates to the U.S. Postal Service (USPS) when the agencies make hard-copy mailings through the USPS.

It is true there are more wireless devices in this country than there are people, and the number is going to continue to grow. And as this demand for these wireless devices continues to increase, so, too, is going to be the necessity of dedicating more spectrum to help power this technology. And, while businesses are clamoring for more and more spectrum, of course we have our government reliance on a certain amount of spectrum, and that is going to become even greater.

So, as we begin looking to the future of spectrum policy, I believe that we have to approach this from a balanced position between licensed spectrum—the frequencies used to transmit radio, TV, and broadband signals—and the unlicensed spectrum, which supports technologies such as Wi-Fi.

And since spectrum is a finite public resource, we must also ask the commercial and government spectrum holders to become more efficient users. We should reallocate spectrum when we can, and we should fully embrace spectrum-sharing when we cannot allocate the spectrum.

We have the ability to meet future spectrum demands for both private-sector and government users. However, it is critical that the Department of Defense, NASA, the FAA, and other agencies have access to the necessary spectrum and updated technologies to meet their future critical mission needs.

And so, as we look to the future, it is important to recognize that spectrum legislation is not only necessary but it has traditionally been bipartisan. And there is no better evidence of that than the 2012 Act, which was generated in this committee with the leadership of Senator Rockefellers and Hutchison. And this committee should exert that same degree of leadership and consensus in addressing this future spectrum policy.

And I want to say how pleased I am that FCC Commissioner Rosenworcel is here today. And I want to thank her for her leadership on spectrum policy.

And we are the beneficiaries of your thoughtful approach to this.

Mr. Chairman, I know that the Commissioner's re-nomination is before this committee, and I would simply request that we consider it without any significant delay.

And thank you for the opportunity.

The CHAIRMAN. Thank you, Senator Nelson. And welcome back. We are delighted to have you back, even fitter and better-looking than before, and appreciate the progress you have made. When you are not here, we have a significant deficit in the knowledge of oceans and space, the things that this committee covers that we don't have a lot of in South Dakota. So we need your good Florida representation and voice. Great to have you back.

As we get into questions here, I want to just mention one thing. The FCC is currently considering a large number of wireless and spectrum-related items, several of which are on its open meeting agenda for next week. And so I want to ask my colleagues to please keep that in mind, as Commissioner Rosenworcel will have limited ability to comment on active items that are on circulation currently at the commission.

I am going to start. Mr. Levin, in your recent filing with the Broadband Opportunity Council, you discussed a number of ways

to lower the cost of deploying broadband networks. And I want to know, are there any specific proposals regarding wireless infrastructure that you recommend Congress should consider?

Mr. LEVIN. Certainly. Thank you. There were a number which were discussed at the hearing at the House, and I think you mentioned some of them, in terms of greater access to Federal property. This has been an ongoing thing. When I was Chief of Staff at the FCC in the early 1990s, we dealt with those issues. But I think that there is an increasing focus on them because we need to create bandwidth abundance. So I would certainly encourage you to take a look at the broad range of things that a number of government agencies can do.

And, by the way, I think the Broadband Opportunity Council is a terrific initiative and very much look forward to their report later this month. Hopefully they will adopt a number of recommendations that I and others made that will facilitate the lowering of the costs of deployment on Federal property.

The CHAIRMAN. Good.

Ms. Baker, you have voiced concern in the past that the U.S. risks falling behind other countries in deployment of fifth-generation mobile technologies, or what we refer to as 5G, without access to more wireless spectrum. Some companies have begun considering whether they can feasibly deploy mobile services in high-band spectrum, including what is referred to as millimeter wave bands.

What steps can we as policymakers take to encourage the continued deployment of 5G technologies?

Ms. BAKER. So I appreciate the question, and I think that we need to look at everything. I think Commissioner Rosenworcel is quite right in looking up, but we need to look—for now, it took 6 years to roll out from when it was proposed to when it was deployed. And so I think we were not the leaders in 3G; we were the leaders in the 4G. And how did we get there?

We got there through conversations like this, forward-thinking. We got there through aggressive auctions. So I think we really need to look at the base of 350 more megahertz of licensed spectrum by 2020 for our industry, for the wireless industry. We got there through a light-touch regulatory environment. And we got there through sound tax policy.

So if that got us to where we were winning in 4G, I think that will get us to where we are winning in 5G.

If you look at Europe, for instance, during the same period of time when we started to win in 4G, we deployed 73 percent more cap-ex than they did. I think that is largely due to their regulatory environment. Our speeds are now 30 times faster than they are in Europe, and we have three times more LTE subscribers.

So I think we have the winning equation right now, and we need to keep it up and start with 350 megahertz more for licensed spectrum.

The CHAIRMAN. OK.

Commissioner Rosenworcel, how do we move beyond the current adversarial process, whereby the private sector identifies a desirable band of spectrum, the Government users resist, and then both sides spend significant time and resources fighting over the costs of relocation?

Commissioner ROSENWORCEL. Thank you for the question, Senator.

This is a movie we have seen before. We tend to do this over and over again, where we knock on the door of Federal authorities like the Department of Defense and the Federal Aviation Administration, and we beg and plead for some spectrum, and, over time, we secure some scraps and slowly, slowly relocate them and then auction off those airwaves.

That system is just too slow for the modern wireless economy. It is absolutely essential that Federal authorities, which control as much as 60 percent of our vital airwaves, that those Federal authorities start seeing some incentives to be efficient with those airwaves so that when reallocation comes they see gain and not just loss.

The CHAIRMAN. Does anybody else want to address that question?

Ms. Baker?

Ms. BAKER. Thanks. I would love to.

I think that this committee is really on to—I appreciate all the hard work this committee has done. And there are a number of bills out there and there are a number of ideas that I think have merit. I think for our spectrum need, we need to look at all of them, but I would say you, Senator, were completely right when you said it can't be antagonistic; it has to be a win-win situation for everyone.

The top three items, to my mind, that will make a material difference in the short term, as well as many of these ideas that are going to make a difference in the long term, are updating the Spectrum Relocation Fund—and I think what I mean by that is there needs to be money for the agencies to do technical deployment.

If we are going to move them into another band, we ought to let them study whether they can share, whether they can use a different technology. There is not money for that right now, as well as for long-term spectrum. We don't want to move somebody into a band and then move them again.

So I think updating the Relocation Fund so that it will fund those projects would be great help.

I also think that incentive auctions for Federal agencies is a very good idea—that is the Markey-Fischer bill—making sure that they get some money out of giving up their spectrum.

And, last, I think as Commissioner Rosenworcel has talked about, more commercial-government partnerships, the Miscellaneous Receipts Act in particular.

When I was actually at NTIA during AWS–1 and we were relocating, there was a wireless company that wanted to move the Department of Justice faster than the Department of Justice had money to and was planning to move. That wireless company wanted to pay for updated equipment for the Department of Justice, but they couldn't. Every way we looked at it, it was going to be a gift to the Department of Justice that would have been illegal from a private company.

So I think that just makes sense, that is just good government, to try and have a commercial entity pay to move faster. Things like that that we consider all make good sense.

The CHAIRMAN. Good. Thank you.

Senator Nelson?

Senator NELSON. Mr. Chairman, Senator Booker has another commitment. I want to defer my time to him.

The CHAIRMAN. Senator Booker?

STATEMENT OF HON. CORY BOOKER, U.S. SENATOR FROM NEW JERSEY

Senator BOOKER. I appreciate the graciousness of the chair. I only really have one question. But I do want to thank both the Chairman and the Ranking Member for working so closely with Senator Rubio and I on legislation.

And I really want to direct my one question to Commissioner Rosenworcel.

You know that Senator Rubio and I have this legislation that is directing the FCC to just take a look, just to examine the spectrum in the 5-gigahertz band to see whether or not spectrum-sharing is possible.

This bill clearly, plainly states in it, that this is not a taking of spectrum at all. I have had conversations with folks in the auto industry. It is just asking you to examine it, to see if spectrum-sharing is possible. I have never seen such an overreaction and a reaction that has nothing to do with what the text of the bill says. It is just asking for you to examine it.

And so you have spoken and written at length about this, the importance of using this spectrum in the upper 5-gigahertz band effectively and efficiently in order to reap the vast benefits that may exist if—and, again, our bill says "if"—we find the spectrum-sharing is safe, first and foremost, and possible.

The longer we wait to examine it just to know the facts, this important and valuable real estate could possibly risk losing out on new innovations and capabilities that could be unleashed.

So my simple question is, can you just describe for the Committee the importance of this examination and why this is such an important band as a bastion for future innovation? And what is your response to this common sense legislation that is just asking to examine that band? And what do you see as some of the greatest challenges in moving forward?

Commissioner ROSENWORCEL. Thank you, Senator.

I very much like your legislation, as you know, and I am optimistic we can find a way forward that both brings us more Wi-Fi and continues to allow the auto industry to proceed with its safety efforts associated with dedicated short-range communications systems.

As you probably know, it was 1999 when we assigned this spectrum to the auto industry, and, since that time, they have been working on roadside safety and vehicle-to-vehicle safety efforts. But back in 1999, I had a phone that was the size of a brick, and I paid a princely sum to use it. And since that time, we now have lots of new wireless technologies that help with automatic braking and lane changes and other safety measures.

So I feel like what we need to do is figure out how to take all those advances in technology, what we know now about inter-

ference, and test to see if we can combine Wi-Fi use with auto safety efforts in this band. I am optimistic we can do that.

I appreciate that the auto industry is, in fact, testing with one manufacturer a listen-before-talk system. I think there are other kinds of tests we can run, because I think there is a way forward here that both delivers vehicle safety and more Wi-Fi.

Senator BOOKER. And the bill does not in any way threaten safety at all.

Commissioner ROSENWORCEL. It encourages testing, and I think that is a smart and prudent course.

Senator BOOKER. Mr. Chairman, thank you very much.

The CHAIRMAN. All right. Thank you, Senator Booker.

Senator Schatz?

Senator SCHATZ. Should you go to the other side?

The CHAIRMAN. Well, we do it in order of appearance, and you were actually here first. But if you would like to defer, I am sure my colleagues on this side would be happy.

[Laughter.]

Senator SCHATZ. Well, having said that, I would be pleased to defer, and then I will go next.

The CHAIRMAN. All right. We will then recognize Senator Daines.

STATEMENT OF HON. STEVE DAINES, U.S. SENATOR FROM MONTANA

Senator DAINES. Thank you, Mr. Chairman.

I want to talk a little bit about rural America. You have several members here who represent rural states. The question is for Ms. Baker and Ms. Rosenworcel regarding spectrum warehousing.

Industry and regulators continue to talk about the shortage of spectrum and the need to make more spectrum available for commercial use, but really this is only half the problem.

I am concerned, in a state like Montana—for example, there are two nationwide wireless carriers, providers, and they collectively own over 100 megahertz of spectrum in some of my counties but provide zero coverage. There are many places in Montana that we still don't get any coverage, particularly in tribal areas of my state.

So my question to Ms. Baker and Ms. Rosenworcel is, what can industry and government do, working together, to make sure that spectrum held in rural communities is actually put to use?

Ms. ROSENWORCEL. All right. Good question. We have got to find ways to make sure that rural America is not left behind in the wireless revolution. And I take your point that we have spectrum and it does not always get deployed in our most remote communities. So here are some things that we can do.

First, we can make sure that when we auction off spectrum we auction off licenses that are small enough that small rural providers can easily purchase those licenses and participate. Because those small providers are more likely to deploy in their rural communities.

We have also set up a new designated entity program that helps small rural providers by giving them bidding credits in our auction, so they can buy spectrum and get a slight discount because we know it is harder and more expensive to deploy in rural America.

We also have a tribal bidding credit to help with deployment on tribal lands.

And, going forward, we are going to enhance our Mobility Fund to make sure we support small wireless providers serving in rural areas.

That is a lot of different things. I think together they can be effective over time. And I think it is important that we actually pick up the pace and make all of them happen as soon as possible.

Senator DAINES. OK.

Ms. Baker?

Ms. BAKER. Thanks for the question. And I think there were actually two questions within there. And the first one, I think that there are two answers as to how do we incite—well, there are obviously more than that, but you have two good available options right now. The, how do we get more citing to more rural areas—and I do want to compliment the Fischer-Klobuchar bill, the Rural Spectrum Availability Act. I think that that will bring about more citing in rural lands.

As former Senator Burns used to say, Montana is so beautiful, but there is a lot of dirt between streetlamps.

Senator DAINES. There is.

Ms. BAKER. So I think that that is a pretty important act. I think that that is going to allow rural areas to pick off the licenses of the larger spectrum——

Senator DAINES. Yes. And, importantly, because of the beauty of a state like Montana, with the trout streams, the backpacking, the camping, the hunting and so forth, we are now attracting a workforce, that they want to be right next to the stream as well as being able to access their wireless device and be part of this global economy. We are seeing some amazing things going on in the technology business in places like Montana, building world-class companies.

Ms. BAKER. So the FCC also has promised a Mobility Fund, and the Mobility Fund was I guess promised 5 years ago. And that will—we have LTE built out to 98 percent of the people in this country, but the 2 percent that aren't part of that 98 percent cover a large bit of territory. And so where it is not economically feasible for the carriers to deploy, this Mobility Fund really needs to get enacted so that they can——

Senator DAINES. Yes, and I think that is something to look at in terms of where we are going to be in the next 10 or 20 years. Millennials, they want to be able to have a fly rod in one hand and their mobile device in the other, and they don't want to trade off quality of life for quality of career. And this is why it is going to be so important in some of these areas that aren't—they don't want to be sitting in traffic jams, having to worry about an hour back and forth to work, when they could be in a trout stream within 5 minutes from where they work.

That is literally happening right now in Montana. It is very exciting. So we appreciate your help on that.

I want to just finish up with a question regarding some of the concerns we are hearing from the broadcasters as it relates to translators.

I am a strong proponent of innovation technology. I was part of a cloud-computing company for 12 years in Montana. We took the company public, a global company based in Montana. So I am a strong advocate for technology.

But one idea being discussed in next year's incentive auction plan would be to take channels that our local Montana broadcasters use in these places where we have high mountains and valleys and set them aside for unlicensed uses. Because of our topography, translators is how the signals reach the far ends of a state like Montana.

I am a huge proponent of Wi-Fi, the Internet of Things, and other potential unlicensed apps. But I also want to ensure that Montanans can continue to receive our local news, our local programs over the air.

So it is my last question; I am out of time. But has the FCC done any modeling or studies relating to the translators and potential impact?

Commissioner ROSENWORCEL. Thank you.

I definitely understand that translators are particularly important for broadcasting out west in states like Montana. That is how people get their television signals. And I know, as we try to crowd more devices into our airwaves and in the 600-megahertz band, they are going to be competing for space.

Now, in a state as rural as Montana, I don't think that competition will be quite the same as it is in New York City. So I have some confidence they are going to continue to be able to remain on the air.

But with respect to modeling, I would like to get back to you. I am sure our auction team has done some, but I am not familiar with it, and I would be happy to provide that for you.

Senator DAINES. I would appreciate that, to look at it exactly, make sure I understand what is going on there in the details of this competition. I appreciate it.

Commissioner ROSENWORCEL. Absolutely.

Senator DAINES. OK. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Daines.

Senator Schatz?

Senator SCHATZ. Thank you.

Ms. Baker, you mentioned in your testimony that it can take as much as 13 years to reallocate spectrum for wireless broadband use from start to finish. Can you just very briefly tell me, what do you think are the key things we can do to improve that?

Because, you know, we are making policy here, but even if we make the most brilliant policy in the world, 13 years is not going to cut it in order to make our broadband infrastructure work. So give me your thoughts on that, please.

Ms. BAKER. Great question. And I think some of the ideas that you have seen on this panel are important.

I think the shortest time it has been has been 6 years; the longest has been 13. It is getting better, and I would say that is because of the cooperative stance and the win-win that we are starting, the rapport that we have developed with the agencies.

But I think improving the incentives for agencies to move, such as, you know, in the Relocation Fund; improving citing on Federal lands—all of that is going to help shorten the period of time.

And so I think that we, working together, can shrink it to more of 6 years than 13.

Senator SCHATZ. So it seems to me that the things you are talking about, in terms of the Relocation Fund and the other kind of mechanical fixes, have to do with shrinking it, say, from 13 years to the 5-to-7-year range.

But there is this other question about the kind of misalignment of incentives that the commissioner talked about, which is that DOD doesn't get anything for having given up their spectrum. And to make it easier for them to give up their spectrum through the Relocation Fund is probably not enough of a pot-sweetener to get them to actually let go of this.

And if we are going to get this to happen, we are going to be contending with the Armed Services Committee, Defense Appropriations, and others. And so, to me, you know, we are going to have to go beyond just improving the execution side. Because, in the end, that will compress the 13 years to 6, but we may still get a "no" unless they know, look, that billions of dollars in revenue are on the table, and it is not unreasonable for them to say, if this is our spectrum, maybe it should be substantially our revenue.

Commissioner, do you want to comment on that?

Ms. ROSENWORCEL. Yes. Thank you, Senator. I think those are terrific points.

The bottom line is we need our Federal authorities to internalize the cost of the spectrum they use. They don't do that right now. It is just a resource they have. So when we try to take it away, we are trying to take something from them.

If we can come up with incentives so that they see gain when we do that, we can both make them more efficient and have more spectrum for the pipeline that we are talking about here today.

Senator SCHATZ. Right.

And I will just—by way of a comment, and then, Mr. Levin, I would be anxious to hear your thoughts on this.

There are kind of two paths here. One would be to sort of adjust the next budget and adjust the way CBO scores it and all that, and I understand that that is one path. But that will also take a very long time. And so it may be that the legislative branch actually has to orchestrate an agreement in the short run to kind of make sure that this happens in a reasonable timeframe.

Because if we decide that we are going to change the way that CBO scores it, then we need language in the budget, so that we are, again, talking about 5 to 10 years, in my opinion.

I think we all understand the misalignment of incentives is the basic problem, and we can solve that, you know, appropriators and authorizers. It won't be uncomplicated, but it won't be any more complicated than if we tried to do it sort of through the regular order. And given our looming sequestration problem, there is some urgency and some incentive for us to just get after this.

Mr. Levin?

Ms. LEVIN. Yes. A couple of comments.

First of all, when Congress passed the 1996 Act, it put deadlines on every one of the proceedings. As Chief of Staff at the FCC at the time, I hated those, but they were great. They basically enabled me to be able to manage the process, obviously with the Chairman, in a way where there were no excuses for not meeting the deadlines. We met the deadlines. So I certainly urge you to create deadlines, even if, fortunately, other people will have to implement them.

Second, I think we have to understand the asymmetry-of-information problem. And Dr. Lenard, I think, has done a good job articulating this. But part of the problem that I saw at the FCC in both of my stints there was that there are always experts in spectrum at the agencies who have greater knowledge—and this is not NTIA's fault; they don't have the resources, they are hamstrung—or at OMB. I think there needs to be, as Dr. Lenard said, some kind of information.

Because the principal-agency problem is where the agent has both different incentives than the principal—and the principal here is the American public—as well as greater information, asymmetric information. So I think we need to address that problem, as well, and I think there are a number of different things.

Finally, I agree with the Commissioner's comment about incentivizing or internalizing the costs. I think there are a number of different ways, but, again, administrative pricing and also amendments to the Commercial Spectrum Enhancement Act I think go a long way to doing that, can be done more quickly, and I think, actually, the last few years, have proven—for example, when Congress said in the 2012 legislation we want AWS–3 quick, that gave the political mandate to the forces in the Executive Branch to be able to do that.

Senator SCHATZ. Thank you very much.

The CHAIRMAN. Thank you, Senator Schatz.

Senator Peters?

STATEMENT OF HON. GARY PETERS, U.S. SENATOR FROM MICHIGAN

Senator PETERS. Thank you, Mr. Chairman.

And thank you to the panelists here today to talk about this important issue.

And I just want to take a moment to kind of piggyback on comments made by my colleague Senator Booker regarding opening up the 5.9-gigahertz spectrum. And I certainly appreciate his desire to open up that band, but I also want to thank the Committee for slowing down that process.

We have some significant interests that are very concerned about what that means, particularly in the area of safety. There are and will be incredible advances in safety, as vehicle-to-vehicle communications, vehicle-to-infrastructure communications advance.

In fact, I had the opportunity just a couple weeks ago to be at the ribbon-cutting for a new test track at the University of Michigan for advanced vehicle technology, a 35-acre track that will test these incredible technologies. And I have to say, it is an incredible public-private partnership with a wide range of companies, from auto suppliers to insurance companies to telecommunications com-

panies, everybody coming together because of the exciting potential that this technology has to save lives.

I mean, we can talk about new apps and new creative ways to communicate. This is about saving lives. It has been estimated that up to 80 percent of all auto crashes could be eliminated. And at a time when 30,000-plus people die on our highways every year, that is a big deal. As a father to young daughters who are driving, it is a really big deal to me, as I am sure every mom and dad in the audience, as well, as to how important it is.

And so we have to get this right. And I think that is the concern with folks, is just to make sure that before we open it up we are getting it right and we are not interfering with this potential.

So, on that note, Ms. Baker, you said in your written testimony that the wireless industry supports experimentation with new spectrum-sharing regimes. But you also warned in that testimony against settling into shared regimes that may rely on some untested technologies. And I certainly share that concern, and I think that is where most of the intelligent transportation community is right now, just concerned about whether or not these are tested.

And I know the parties who are eager to open up this spectrum to unlicensed use make the argument that these advanced vehicle technologies won't be interfered with because there are untested technologies that will protect them. But for groups who have invested millions and millions of dollars into these technologies over the last decade and are on the very verge of starting to see the return of those investments in unprecedented ways, that is not real comforting, that there may be untested technologies out there that will protect them, don't worry. We need to have more than that.

So I wanted to ask you, what sort of testing of these shared technologies and what scale would wireless carriers need to see completed in order to be convinced of their viability?

Ms. BAKER. So I think this is one of those questions—and thank you for the question. But I think this is one of those issues where we in Washington see it as a policy issue and our companies see it as a business issue. The verticals for the wireless industry are the most important part of the future growth, and certainly in the automobile and the automobile industry is at the very top of that list.

So I think that we have the policy questions and the jurisdictional questions, which—we at CTIA have joined in partnership with the automobile industry to form the Intelligent Car Coalition to really address some of these policy issues. But the technical issues are real, and these really shouldn't be policy questions; they should be technical issues. And I think we now have a new CTO so that we can actually look at these questions.

We are all for sharing. With the Internet of Things that is coming our way, we have to be for everything. We are for sharing, we are for unlicensed, we are for licensed. But it has to work. And so I think that you raise very important points, that we are for unlicensed, we are for experimentation, but it can't interfere with the underlying critical use.

Senator PETERS. So what is the role for private industry? How do you see private industry dealing with that?

Ms. BAKER. Well, every single one of our major carriers has deals with the automobile industries, and they are all—it is in their future use to work together. And I see AT&T has Drive Lab in Atlanta, as well as you have, you know, in Michigan. So I think that these are working together probably outside of our Washington space faster than we are working together here.

Senator PETERS. Yes. And so we have to let that process move forward as it is happening now. We don't need additional legislation at this point; we just need to let things continue to move forward.

Ms. BAKER. I think the commercial world is working really well.

Senator PETERS. Great. Thank you so much.

The CHAIRMAN. Thank you, Senator Peters.

Senator Heller?

STATEMENT OF HON. DEAN HELLER, U.S. SENATOR FROM NEVADA

Senator HELLER. Mr. Chairman, thank you, and thanks for holding this hearing as we continue to work in this committee and try to bring more spectrum to the market.

I was lobbied out in the hallway on my way in, and I was requested to ask one of our witnesses if any of them know where Tom Brady's cell phone is.

[Laughter.]

Senator HELLER. But I think I will—maybe that is a hearing for another day.

But, anyway, thanks for holding this hearing.

Senator MARKEY. Mr. Chairman, when you have a hearing on that, could I have equal——

[Laughter.]

Senator HELLER. Controversy. Controversy.

But, anyway, we all know that spectrum provides Internet access in places that wireless won't reach and provide Internet competition where it does reach. This is about innovation and ensuring competition in the marketplace so that it exists to empower consumers in dictating price, speed, and efficiency in the data plants.

As we continue our work, it is my opinion that these are the beacons we should continue to reach for. I know it is not easy, and that is why I appreciate the chairman staying focused on clearing more spectrum and holding this hearing today. And I believe that after the scheduled 2016 broadcast incentive auction is up, we probably will not have anything in the pipeline to follow.

Now, we cannot close the digital divide and provide an environment in which services will get better and prices lower if we don't have more spectrum coming to the market. The digital divide is something that severely impacts my home state of Nevada.

As *Politico* wrote extensively on this this week and many of us have known for a long time, the money provided to RUS through the stimulus has been an unmitigated disaster. I was adamantly opposed to the stimulus, and I am not about to go into all that, but we have to admit that the inability of RUS to get these projects going should not be a surprise.

It is the same argument that was raised, of course, in 2008. It is not realistic to expect any company to lay wireless across rugged

terrains like Nevada to bring broadband to rural areas. Instead, we need to think critically on how we bring faster Internet to these areas. And I know the discussion today can provide and has provided some answers to that.

And while today is about the long-term need for spectrum, a lot of questions remain about how spectrum auctions are conducted and how to enhance the benefit of these auctions. So I hope that we have the opportunity, as a follow up hearing, to learn more about that and how to address some concerns that will remain.

I want to give a couple of examples—and, Ms. Baker, I am going to direct them toward you, if I may—just a couple of examples of the problems that exist. And this is in line with what Mr. Daines had to say earlier about a rural state.

People don't realize, when you think of Nevada, you probably think of Las Vegas or Lake Tahoe, but it is a vast state—110,000 square miles. Las Vegas is in about 5,000 square miles of it; Reno, a couple thousand square miles. But 110,000 square miles is a lot of space.

Recently—and I say "recently"—a few years ago, I was in a motor home, with four children in the motor home, and it broke down. Now, I am a pretty good mechanic, but that day I wasn't good enough. Fortunately, we were pulling a vehicle behind it. Got in the vehicle, drove down the road for 2 hours before we could get a signal on the cell phone. I would suggest that if someone were to do that today and break down in the same spot, they would still have to drive 2 hours to find a cell phone signal in order to get the help that they need.

Another example is I have a son and his wife who have 1.5 million followers on Vine. Now, if I was driving through Nevada, I probably couldn't get the weather, I probably couldn't get the news, and I probably couldn't see their latest Vine, because there just isn't the access to that information.

So I think the key to it, is what I am trying to say, is that we can talk about spectrum, we can talk about all these issues, but the problem, foremost, is the ability to actually have the access to it. And so I guess in line with what Mr. Daines said, we have 85 percent of the property in the state of Nevada is Federal lands. And that is the problem.

What can we do, Ms. Baker, what can we do, with the vast holdings that the Federal Government has, in the ability to get wireless service to rural portions of the state?

Ms. BAKER. That is a great question.

And I do know that Nevada is disproportionate, at 85 percent of Federal lands. I think the country average is 30 percent, so you are greatly over there. So I think you should turn to your colleague Senator Johnson and thank him, because he did question the GSA nominee on Federal lands.

I understand you got an answer back from her last night about making citing on Federal lands a priority.

Senator HELLER. I will stick around for his questions.

Ms. BAKER. This committee did a great job in directing the FCC in the Spectrum Act to expedite citing on non-Federal land. And we need to finish the job and get GSA to actually enact their promise.

I know that Klobuchar and McCaskill have a bill. Senator Johnson, you have been on this.

Expediting the citing on Federal lands, so it should take months instead of years, would be a great big help, I think, to states like Nevada.

Senator HELLER. OK.

You had a comment?

Ms. ROSENWORCEL. I agree. How about that?

Federal lands are about 30 percent of the lands in this country, obviously a lot more in Nevada. And if we want to get deployment there, we are going to have to bring the cost equation to a new place. Because if you don't have a lot of people, it is really hard to spend the money to deploy because there aren't a lot of people who are going to be able to use that service.

So one of the things we can and should do is make sure that the Federal Government manages those lands in a way that accelerates deployment and doesn't impede it.

Senator HELLER. Commissioner, thank you for understanding the problem.

Ms. BAKER. Can I just say that this has been a problem since I was at CTIA 17 years ago.

And I think, Senator Markey, you are going to remember trying to get citing in Rock Creek Park.

So, while we have some commitments from the GSA, this is something that I think we should probably stay on.

Senator HELLER. Ms. Baker, thank you.

Mr. Chairman.

The CHAIRMAN. Thank you, Senator Heller.

Senator Markey?

STATEMENT OF HON. EDWARD MARKEY, U.S. SENATOR FROM MASSACHUSETTS

Senator MARKEY. Thank you very much.

And Ms. Baker is correct. It was driving me crazy. We had deployed all this spectrum, and every day I was riding in through Rock Creek Park, and every day I was losing the connection at the same place. And 1 year went by, 2 years went by, 3 years went by. It is kind of a National Park kind of a thing, but it is not in the middle of Nevada. How come we can't figure it out here in the middle of Washington, D.C.? So we had to act in a bipartisan fashion to kind of work with the telephone companies to try to figure—let's solve this problem.

And I agree with you, Senator Heller, that it is critical, because I have heard your family sing, and there is a good reason why they have 1.5 million followers on Vine.

Senator HELLER. They don't get it from me.

Senator MARKEY. It is not a genetically transmitted skill?

Senator HELLER. It is from their mother. From their mother.

Senator MARKEY. From their mother.

So it is very, very important that we have them listened to everywhere in America.

And so that is why, ultimately, spectrum is the oxygen of the wireless world, and we have to make sure that we continue to accelerate the pace at which we accomplish these goals.

And, again, back in 1993, I worked with Mike Oxley and others, and we moved over 200 megahertz of spectrum to create the third, fourth, fifth, and sixth cell phone companies. The first two companies were analog and 50 cents a minute, but once we moved over that spectrum, we had a revolution by 1996. And everyone all of a sudden had a cell phone in their pocket because it was under 10 cents a minute and it was digital.

And that was bipartisan. And the revenues went to the Federal Government. It was great. It was an auction. We did a good job.

But the Government didn't really want to give up the spectrum at the time. They were very much—generals sat here and said, you don't know what you are going to do to our national security and you can't move over that spectrum. But we did it.

So that is why, you know, Senator Fischer and I have introduced our legislation. We say, OK, we are going to work with you to move over the spectrum, but you will be incentivized because a certain percentage of the auction will go back into the Government, into these agencies.

Can you talk a little bit about that, Ms. Baker and Ms. Rosenworcel? If you could, both of you, make brief comments on that.

Ms. BAKER. I think we both have praised that bill. We both think it is a very good idea. I think an agency is going to be much more incentivized if they are able to keep some of the profits when they are moved. And it creates not only a win-win but a win-win-win, because they get profit from the auction, they get updated, more efficient equipment and newer equipment, and then, of course, we have the mobile industry can move in and innovate in that spectrum.

Senator MARKEY. Commissioner Rosenworcel?

Ms. ROSENWORCEL. Yes. Thank you.

I think your bill with Senator Fischer is a terrific idea. Again, we need to internalize the cost of spectrum that our Federal agencies use. They need to be rewarded when they are efficient and help us get more spectrum into the mobile economy, because right now all they see is loss.

Senator MARKEY. Mr. Levin, you were there back in prehistoric telecommunications time.

Mr. LEVIN. Yes.

Senator MARKEY. Can you give us your perspective on it?

Mr. LEVIN. Yes. Two things I would just say.

First, as to your history, it is exactly right, though I would note that one of the things we did pursuant to the 1996 Act was to equalize the terminating access charges between wireless and wired. And I think that is an important lesson about certain bottlenecks and barriers. And it was really, once we did that, then AT&T Wireless created the one plan, and that really turned mobile from being a luxury product to being a mass market product.

Senator MARKEY. Thank you.

Mr. LEVIN. Can I just say real quickly, on the incentive auction, I am a big believer in incentive auctions, and I am delighted that you wrote the bill. I do have some concerns, as I have indicated in the written testimony, simply about whether it will work. My experience in the Federal Government—and I have had two stints

there—suggests a number of concerns that I would have. And so I think whenever the Congress considers a number of paths, you have to consider, you know, the likely outcome. And reasonable people can estimate things differently——

Senator MARKEY. And you know what I think? I think we are going to work it out. Once you say "work it out," that is what happened back then, and——

Mr. LEVIN. No, I agree with that.

Senator MARKEY.—all of a sudden, the Defense Department was working it out. And they got benefits, and the public got benefits, and I think the same thing is going to happen here.

And, Ms. Rosenworcel, could you talk a little bit about this constant understating by the Federal Government of the value of unlicensed spectrum? Can you talk a little bit about that, how historically that has always happened and it has almost invariably been wrong?

Ms. ROSENWORCEL. Oh, do you mean when the Congressional Budget Office estimates just how much our airwaves are going to bring in?

Senator MARKEY. Can you talk about that?

Ms. ROSENWORCEL. I can. I can talk not just as a Commissioner but as a former congressional staffer.

It is——

Senator MARKEY. On this committee.

Ms. ROSENWORCEL. On this committee, on these issues.

So here just for starters. We recently held an auction of spectrum we call AWS–3. It raised over $40 billion. That is an extraordinary sum by any measure, and it is a testament to how valuable our airwaves are.

The Congressional Budget Office, when reviewing the auction of 65 megahertz of AWS spectrum, suggested that as a result of the cost of relocation that auction would net out to zero dollars.

Now, there is a pretty big delta between 40-plus billion and zero dollars, and I think it is instructive. Our airwaves are extraordinarily valuable, but our accounting systems for measuring them in the legislative process don't appear to be fully up to date.

Senator MARKEY. And I agree with you 100 percent. And it is just something that I think we have to continue to monitor, because there are tremendous benefits, even reducing the Federal deficit, of having the proper accounting standard. And sometimes the agencies get behind in terms of what these technologies can produce in terms of general benefits for the economy.

And I thank all of you for all your work.

Thank you, Mr. Chairman.

The CHAIRMAN. Yes, sir. Thank you, Senator Markey. And it wouldn't be the first time they missed an estimate or two.

Senator Johnson?

Senator JOHNSON. Mr. Chairman, Senator Gardner asked for 10 seconds, so I will yield him 10 seconds.

STATEMENT OF HON. CORY GARDNER,
U.S. SENATOR FROM COLORADO

Senator GARDNER. Thank you, Senator Johnson.

Every committee that could meet now is meeting now, and so I apologize for not being able to attend.

But, Dr. de Vries, before I have to go vote in the Energy Committee, I wanted to welcome you to the Committee. I owe my law degree and my student loan to the University of Colorado, so welcome to the Committee.

Thank you.

STATEMENT OF HON. RON JOHNSON, U.S. SENATOR FROM WISCONSIN

Senator JOHNSON. That actually was 10 seconds.

[Laughter.]

Senator JOHNSON. I thought it was going to be Senate time.

The CHAIRMAN. He hasn't figured the Senate out yet, has he?

[Laughter.]

Senator JOHNSON. Thanks, Senator Gardner.

Ms. Baker, I just want to go back to what Senator Heller and Senator Markey were talking about, the challenges that your members have faced trying to, you know, locate broadband infrastructure on not only Federal land but also Federal buildings.

Can you give us some even better examples or just talk about how significant a challenge this really is?

Ms. BAKER. Well, I mean, as we mentioned, across the board, the Government owns 30 percent of the land in the United States. That is a third, so that is a lot. And in a place like Nevada, that is even—you know, as we talked, that is 85 percent.

It literally takes years. You know, there are some stories of 5 years. And, shockingly, some of the Department of Defense bases are some of the worst. And historic buildings are bad. These places where people are now expecting broadband to be ubiquitous and to be in contact constantly are now taking years, with multiple different reviews of environmental and animal—all sorts of different studies that have to be done.

So it is extremely costly; it takes years. Anything that would be streamlined, whether it be the forms, whether it be the reviews, whether it be the timelines, all of that would be helpful to us in deploying on those Federal lands.

Senator JOHNSON. And who pays for that, that time delay and that cost?

Ms. BAKER. Well, ultimately, consumers, but obviously the companies pay for all of the studies that go into the citing on Federal lands.

Senator JOHNSON. But, bottom line, it is consumers. You know, we drop calls, we can't get access to the data, and, in the end, it is our bills that really reflect those costs.

Can you just speak—obviously, we have been encouraging the GSA to actually complete its mandate under the Spectrum Act of 2012. Can you just talk—first of all, I would like your evaluation. If you are in contact with GSA, are they moving forward? Are they going to meet their commitment to complete their work by the end of this fiscal year?

Ms. BAKER. Well, I mean, we were making light of the citing on Rock Creek Park, but when I worked for CTIA 17 years ago this was a priority, of trying to get citing on Federal lands. So then I

actually went into the Government and thought, well, I will fix this.

And so we were at NTIA and we had a Federal working task group to cite on Federal lands and create a portal and make it easier for industry to be able to cite on Federal lands. And here I am 17 years later, and it is one of the top priorities of CTIA, to be able to cite on Federal lands in a more streamlined process.

So I think that, you know, "trust but verify" is probably a good warning here.

Senator JOHNSON. Any suggestions you can provide GSA in terms of actually completing its mandate and, you know, again, information you can offer them to encourage their activity?

Ms. BAKER. I think having Senate oversight is a really important—it obviously worked for the FCC for non-Federal lands.

Senator JOHNSON. OK. Well, thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Johnson.

Senator Wicker?

STATEMENT OF HON. ROGER F. WICKER, U.S. SENATOR FROM MISSISSIPPI

Senator WICKER. Thank you very much.

Ms. Baker, Ms. Rosenworcel and Senator Markey have learned one lesson from the AWS–3 auction, and that is that it could be scored incorrectly by billions of dollars. I think we will acknowledge that that auction was a huge success. What other lessons learned are there, other than this scoring snafu that was talked about?

Ms. Baker?

Ms. BAKER. So, you know, it is interesting, because I guess I have been at this for so long, but every time we have one of these auctions the lessons learned really are lessons learned. And so I think AWS–3 was tremendously easier in the relocation and the lead-up to the auction and in the actual auction than AWS–1 was.

We learned that cooperation really works. So if you can be not antagonistic and work together to cooperate beforehand as well as once the auction happens, you can actually relocate faster.

I really think that there needs to be funding for technological research for the agencies so that they can figure out how they can make better plans and they can have longer-term plans. I think that is a really important priority going forward for the Relocation Fund to apply to.

Senator WICKER. That wouldn't need to come out of the appropriations, would it?

Ms. BAKER. It could come out of the $45 billion proceeds of the last auction.

Senator WICKER. Ms. Rosenworcel, what other lessons learned, other than the obvious accounting snafu?

Ms. ROSENWORCEL. First lesson: Spectrum is incredibly valuable. That goes without saying, but I think that that dollar figure makes it really apparent.

The second lesson is we were able to clear some of the airwaves of our Federal authorities a lot faster because of the kind of cooperation that Ms. Baker just described. Developing cooperative re-

lationships with our Federal spectrum users is important because it will speed the process.

And then, finally, I don't want to talk too much about it, but it has also become clear that we have to update our designated entity process to make sure that big companies do not abuse bidding credits designed for very small businesses.

Senator WICKER. What do you mean by that?

Ms. ROSENWORCEL. We have a situation before us right now where a very large company was able to avail itself of some bidding credits that were designed for small businesses, and we are making active efforts to make sure that that situation is remedied and doesn't happen again.

Senator WICKER. Ms. Baker, do you agree with that?

Ms. BAKER. Designated entities are pretty much completely in the FCC's jurisdiction to decide how to—we at CTIA really work for more spectrum so that the industry—as mentioned, 350 megahertz is what we need to continue our global lead in wireless. How it gets divided up is really Commissioner Rosenworcel's job.

[Laughter.]

Senator WICKER. Well, thank you for that punt. And it went very, very high.

[Laughter.]

Senator WICKER. Just to end up, Mr. Chairman——

Mr. LEVIN. If I——

Senator WICKER. Yes. Please.

Mr. LEVIN.—might just interrupt. I apologize.

But in terms of scoring, I do want to just note—I was Chief of Staff when we did the first auctions, and I followed on Wall Street pretty much every auction after that—the private sector also gets it wrong. And the reason is, you don't know until you hold the auction; that is why you hold the auction.

And I think that part of the challenge for policy is when there is—and, by the way, these things go up and they go down. There are certain auctions that—a lot depends on market conditions and new uses. So it actually is a difficult challenge.

I think that particular one—again, I agree with Commissioner Rosenworcel—it shows the incredible value of the spectrum. And that is only going to increase, in my view.

But I do think that we have to try to find mechanisms and tactics that are not dependent on being 100 percent right and that kind of over time send signals so that we kind of create that pipeline. And that is what I think the real challenge for this committee and the Congress is.

Senator WICKER. Thank you very much.

And let me just ask this final line of questioning. I am very interested in telehealth, and I think members of this committee are. We are trying to be innovators and actually lead the transformation in my home state of Mississippi.

As we begin to benefit from the intersection of wireless and health care, do we have adequate and available spectrum we need to foster growth and innovation in this industry and to fully enable members to deliver more patient-centric treatment solutions using wireless?

Ms. BAKER. I will take it first.

No, we don't. We have just really finished a very thoughtful series of papers to look at what our need is going to be. And as we move forward, as wireless is the platform for connected life, for the Internet of Things, we need more spectrum. We need more licensed spectrum. We need 350 more megahertz by 2020.

I agree with you that telehealth is an incredible platform that is going to affect all Americans. And for us to get it right and for us to be able to continue to innovate, we are going to need more spectrum.

Ms. ROSENWORCEL. I agree.

Senator WICKER. Wonderful.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Wicker.

Senator Udall?

STATEMENT OF HON. TOM UDALL,
U.S. SENATOR FROM NEW MEXICO

Senator UDALL. Thank you very much, Mr. Chairman. Really appreciate this hearing today.

Commissioner Rosenworcel, let me direct my first question to you.

With so many wireless devices connecting to the Internet, we are facing what I would call a spectrum crunch that could hinder the next Internet revolution. And I am exploring some spectrum policy ideas in a bipartisan way with Senator Moran. But I think American ingenuity could solve this. We just need to get more innovators and researchers to focus on it.

And that is why I really like the idea that you and your cell phone pioneer, Marty Cooper, proposed. And, in fact, I plan to push for a Spectrum Challenge prize. This contest would provide a significant monetary award to the first person who finds a way to make spectrum use vastly more efficient.

Could you share your thoughts on how a Spectrum Challenge prize could spur American innovation and competitiveness?

Ms. ROSENWORCEL. Sure. Thank you so much for the question.

There are really three things we can do to make sure that we clear space in our skies for all of these wireless uses that are coming into our economy. We can clear more spectrum; we are talking about that here. We can deploy more towers, and we have been talking about that, particularly with respect to Federal lands. But, finally, we can get more innovative with technology.

And so I worked with Marty Cooper, who is widely known as the "father of the cell phone," to come up with the idea of "Race to the Top, a Spectrum Challenge." We need to create a prize that incentivizes the development of new technologies that are cost-effective that could increase the capacity of existing airwaves by, say, 100 times.

If we did that and we were able to tap into American ingenuity and create those kind of new technologies, we would find all the spectrum that we have today would be able to perform better and carry more traffic.

So Marty Cooper and I have proposed that the winner of that type of prize should perhaps just get some spectrum license themselves in order to keep this internally consistent. That would be

valuable for them, but the greater value for all of us in the wireless economy who would benefit from those new efficiencies.

Senator UDALL. Yes. Thank you very much for that response.

And I would note we had an earlier hearing where we talked about prizes, Chairman Thune. And it was very interesting to hear the witnesses talk about the innovative capability and developing that and that there is huge potential.

Ms. Baker, Senator Moran and I recently wrote a letter, signed by Chairman Thune and Ranking Member Nelson and other members, to the Office of Management and Budget about the Spectrum Relocation Fund.

This multimillion-dollar fund pays the costs of relocating Federal users when a particular spectrum band is auctioned for commercial use. But my understanding is that the rules governing this fund seem to limit the ability to meet President Obama's goal of freeing up more spectrum for commercial use.

Could you expand on your earlier comments on making better use of this Spectrum Relocation Fund?

Ms. BAKER. Well, first of all, thank you for your letter, and thank you for your efforts. We think it is really important and critical, and we think it can make a significant difference in the way that agencies do their planning.

I think that it is very important for them to be able to do technology research to see if they can share, to see what sort of technologies are out there that they can move to if they are going to be moved but not when they are under the gun of moving. So I think that that research is important.

And I also think that long-term spectrum planning is critical to our future. You don't want to move someone to a band that you are then going to move them again. That is just a waste of everyone's time and money.

So I think giving the financial support for these agencies to do long-term planning—it is tough, because a place like the Department of Defense has people who are spectrum experts. Some of the smaller agencies who are using, you know, spectrum do not.

But providing them more money to be able to look into this is going to be really critical to our future and to be able to get the 350 megahertz that the wireless industry sees that we need by 2020. So we appreciate your efforts.

Senator UDALL. Yes. Thank you.

Do any other panelists have comments on that?

Mr. LEVIN. Two things.

First, on prizes, I completely agree with Commissioner Rosenworcel. I just might note, consistent with Dr. Lenard's testimony, a version of that is providing greater flexibility in the uses of the MSS spectrum. We pushed for that in the plan; the Commissioner has done that. And I think you are going to see private incentives drive new innovation and technological change.

Second, I completely agree with the spirit of the letter. And, indeed, Recommendation 5.5 in the plan talked about amendments to the CSEA and, I think, are consistent with that letter. And I look forward to OMB's response and hope that there is follow-up to that.

Senator UDALL. Thank you. Thank you very much.

Thank you, Chairman Thune.

The CHAIRMAN. Thank you, Senator Udall.

I think we have kind of started to wind it down here. I do want to ask one last question. I want to direct this to Dr. de Vries.

You have raised concerns about that inability of private spectrum licensees to negotiate agreements related to interference. Do you believe interference disputes are likely to increase as license holders live closer and closer together? And what obstacles exist for parties to enter into arrangements that would enhance efficiency?

Mr. DE VRIES. Yes, thank you, Chairman Thune. That is a very good question, and I think it is inevitable, as we squeeze all these services closer and closer together.

I mean, we have heard from Senators from rural states, but I think, in terms of spectrum, we are facing a transition from a rural spectrum society to an urban spectrum society, where, you know, in the past, if you think about, you know, you have a large land holding, if you have a feedlot, it is really not going to bother your neighbor, who is, you know, 40, 80 acres away, and even if it does bother them, they have one too. Now, in spectrum, we are building a situation where we have feedlots right next to residential neighborhoods. So the likelihood of interference disputes grows.

There are a couple of things we can do to deal with that. The first is we need to make sure that there are expedited ways to deal with those disputes. Many options.

Right now, if private parties have an issue, they have to ask the FCC to resolve it. They should be able to deal with each other directly. If there is a dispute between the FCC and the NTIA, as far as I know—and I am a physicist, and I apologize—but, as far as I know, there is no way you can go to resolve a dispute between the FCC and the NTIA.

We should also allow parties to find the optimum arrangements themselves. Right now, because rights to spectrum are vague, it is OK if everybody is in the same business. If everybody is a farmer, you can make the arrangements, but if you are actually talking between farmers and householders and factories, it is much harder because of the ambiguity in the rules.

And that is why I suggest things like harm claim thresholds that actually make it clear what interference protection one is entitled to and what you are not entitled it. That will make it easier for people to negotiate, because they will know what the starting point is for the negotiation.

The CHAIRMAN. Thank you.

Well, I think we have covered a lot of ground today. I appreciate very much all our panelists, your responses, your testimony. We will take it to heart and encourage you as we move forward, and we will have, hopefully, a plan moving forward.

We encourage you to work with us and share suggestions, thoughts, advice, recommendations with us. Because, obviously, this is an issue that is not going to go away; demand is only going to increase. And we need to make sure we are doing everything to ensure that there is an available supply of spectrum for the future needs in our economy.

Thank you all very much.

The hearing record will remain open for 2 weeks, during which time senators are asked to submit any questions for the record.

Upon receipt, the witnesses are requested to submit their written answers to the Committee as soon as possible.

Thanks again.

This hearing is adjourned.

[Whereupon, at 12:24 p.m., the hearing was adjourned.]

A P P E N D I X

AEROSPACE INDUSTRIES ASSOCIATION
Arlington, VA, July 28, 2015

Hon. JOHN THUNE,
Chairman,
Committee on Commerce, Science, and Transportation,
United States Senate,
Washington, D.C.

Hon. BILL NELSON,
Ranking Member,
Committee on Commerce, Science, and Transportation,
United States Senate,
Washington, DC.

Dear Chairman Thune and Ranking Member Nelson:

The Aerospace Industries Association (AIA) represents an industry that employs more than one million direct workers across all 50 states and adds $240 billion in sales to our national economy. Our industry leads the manufacturing sector in net exports, adding over $60 billion each year to a positive balance of trade. Equally important, our members design, develop and manufacture the cutting-edge aircraft, satellites, radars, and weapon systems that keep our Nation safe and protect U.S. national interests around the globe.

As you know, many of these technologies are spectrum-dependent. Without continued and reliable access to spectrum, Federal agencies and military service members may not be able to accomplish their missions effectively. Consequently, our industry is a critical stakeholder in the debate about spectrum policy and the management and use of spectrum by the Federal Government. We understand that the civilian economy demands increased access to additional spectrum, while government demands for bandwidth increase as well. However, changes in spectrum policy must take care to ensure that any such transition not be conducted to the detriment of our national security, intelligence capabilities, or new entrants to our economy such as the integration of unmanned aircraft into our national airspace. We urge you to consider the need for future sharing among Federal and commercial users of spectrum.

The systems built by our members are primarily developed and manufactured in the United States. All of AIA's members are U.S. manufacturers. We have an established industrial base and supply chain that makes enormous contributions not only to our economy, but also to our Nation's safety and well being. Our ability to maintain this resource relies on the continued availability of spectrum to support our systems and solutions.

I respectfully request your approval, if appropriate; to place a copy of this letter in the hearing record of your March 26, 2015 hearing titled "Next Steps for Spectrum Policy". We greatly appreciate your expertise and leadership on spectrum issues, and as you pursue changes in spectrum policy in the current Congress, I hope you will consider the needs of our industry and consider us a resource in future stakeholder discussions.

Sincerely,

DAVID F. MELCHER,
President and CEO,
Aerospace Industries Association.

ATTACHMENT

ISSUE PAPER

Spectrum Policy: Critical Need to Weigh Concerns of U.S. Aerospace Industry in Repurposing of U.S. Government Spectrum

AIA RECOMMENDATIONS

- Government should carefully examine spectrum repurposing proposals such as those in the National Broadband Plan ("the Plan"), paying particular attention to the impact, total costs and risks to the nation's aerospace manufacturing industry and critical federal functions.
- The aerospace industry cautions against spectrum repurposing that would result in interference to or loss of critical space, air traffic control, navigation, weather forecasting, aircraft certification, and national security capabilities.
- Decision makers must include the aerospace industry in all discussions concerning spectrum repurposing efforts and develop a long range spectrum vision to provide appropriate certainty for public and private investments.

BACKGROUND

The Aerospace Industries Association (AIA) closely monitors spectrum-related provisions in federal legislation. Such legislation impacts government users, the private sector, and the general public. The aerospace industry is one of many that depend upon spectrum resources to serve the public, and to maintain and create jobs.

For decades the Congress has made wise and important investments to develop capable national infrastructure supporting civil aviation, law enforcement, weather and climate monitoring, and national security space functions. This infrastructure depends upon radio frequency spectrum to operate.

- The civil aviation industry, which requires radio frequency spectrum for aircraft certification, aeronautical communications, navigation, and sense and avoid capabilities, contributed $1.3 trillion to the U.S. economy in 2009. More recent statistics show the U.S. with 737 million enplanements in 2011, with each passenger benefiting from our industry's stake in spectrum resources.
- Our space infrastructure, consisting of systems built by U.S. industry over decades, helps us lead the world in scientific advances and provides unique capabilities – such as the Global Positioning System (GPS) (122 million receiver units sold in 2010 alone), earth observation, missile launch

Please address questions to Rich Efford, Assistant Vice President, Legislative Affairs at: (703) 358-1000

warning, space–based weather forecasting, secure global communications, and ISR – that are absolutely critical to the nation's economy and our national security.

AIA represents more than 300 companies in these industries and engages the National Telecommunications and Information Administration (NTIA), the Federal Communications Commission (FCC), congressional leaders, and other relevant decision makers and over the course of this year will impress upon you the importance of America's investment.

The aerospace industry supports the President's National Broadband Plan. AIA members are some of the largest users of wireless cellular and broadband communications. We use spectrum on our factory floors, and in our products. We provide broadband to aircraft and passengers flying thousands of feet above the ground, and to our over 1.05 million employees. However, it is critical that decision makers recognize the breadth of spectrum use by the public, and show balance in allocating spectrum resources when interests overlap. As the voice of the nation's leading aerospace and defense manufacturers, AIA strongly believes that repurposing federal spectrum should not adversely impact U.S. national security or the safety and integrity of our nation's civil aviation, communication, and navigation systems. As repurposing federal spectrum is also costly and can take decades, every effort should be made to ensure that existing commercial spectrum is used efficiently.

We support a long range spectrum vision that will provide certainty for commercial wireless broadband investments and federal agencies alike.

KEY POINTS

Major federal spectrum repurposing effort underway: A 2010 Presidential memorandum directed NTIA in collaboration with the FCC, to make available 500 MHz over 10 years suitable for wireless broadband on an exclusive or shared basis. The February 2012 Middle Class Tax Relief and Job Creation Act of 2012 [Public Law 112-96] requires NTIA to identify 15 MHz of spectrum in 1675-1710 MHz within 1 year (by Feb. 2013) and the FCC to auction this and additional bands within 3 years.

U.S. aerospace industry designs and builds the U.S. government systems faced with repurposing: AIA is proud to advocate on behalf of an industry that includes more than 800,000 workers nationally, with more than 30,000 suppliers across all 50 states. Our industry accounts for over $324 billion in revenue, with exports totaling over $89.6 billion and fueling a positive trade balance of over $42.2 billion – the highest of any U.S. manufacturing sector.

Spectrum is critical to U.S. national security and may be costly to repurpose: The Deputy Assistant Secretary of the Navy stated that "further erosion (of spectrum) will reduce operational capability and will possibly endanger military personnel." Additionally, the Commander, Air Force Space Command has stated that, "we are very concerned that vacating that part of the spectrum would be both long term and expensive." National security space and aerospace systems represent major taxpayer investments and require 20 to 40 year planning horizons.

AIA looks forward to weighing-in on the National Broadband Plan: The repurposing of the 1755-1850 MHz band as well as other efforts related to the Plan are a significant concern for the aerospace industry. AIA's members are eager and able to provide you the relevant expertise to inform any decision germane to the spectrum discussion. Please do not hesitate to call upon us as you reach out to the spectrum stakeholder community.

COMPETITIVE CARRIERS ASSOCIATION
Washington, DC, July 29, 2015

Hon. JOHN THUNE,
Chairman,
U.S. Senate Committee on Commerce, Science, and Transportation,
Washington, DC.

Hon. BILL NELSON,
Ranking Member,
U.S. Senate Committee on Commerce, Science, and Transportation,
Washington, DC.

Dear Chairman Thune and Ranking Member Nelson:

Competitive Carriers Association (CCA) respectfully submits this letter for the record regarding today's hearing on "Wireless Broadband and the Future of Spectrum Policy." CCA commends the Committee for beginning a bipartisan process to consider ways to meet future demand for wireless services through a long-term legislative solution.

Mobile broadband is a critical component of modern life, and spectrum is the lifeblood of mobile services. CCA represents over 100 competitive wireless providers ranging from small, rural carriers to regional and nationwide providers, as well as approximately 200 associate members consisting of small businesses, vendors, and suppliers that service carriers of all sizes. All CCA members depend on procompetitive policies that support their ability to access critical spectrum resources and continued growth of mobile broadband to meet their customer's needs.

In addition, mobile broadband powers advanced telemedicine, limitless education, employment prospects, public safety, precision farming, and other innovative new services and opportunities, both in urban population centers and in rural America. Indeed, nearly half of all United States households are now "wireless only" and PEW Research recently found that "nearly two-thirds of Americans are now smartphone owners, and for many these devices are a key entry point to the online world." While carriers continue to make impressive progress to provide innovative services, there is still work to be done. CCA supports the Committee's focus on fueling broadband investment and growth with additional access to spectrum and by promoting policies that remove barriers to competition and facilitate the next disruptive innovation.

Ensure Competitive Spectrum Policies

Building on the Spectrum Act and the progress made implementing it, Congress has a key role to play in creating durable, enduring processes to meet our wireless nation's spectrum needs. Looking over the horizon, rather than focusing on a particular spectrum band or technology, policymakers should foster efficient spectrum management that maximizes utilization of this finite, taxpayer-owned resource.

While we all must cooperatively work to identify additional spectrum resources for mobile broadband use, competitive principles currently in place should guide future spectrum policy. For example, spectrum must be interoperable to support open ecosystems that allow carriers of all sizes and technologies to maximize use of spectrum to unleash new services. Interoperability was required for the original Cellular spectrum band, and policies requiring or restoring interoperability in other spectrum bands provide carriers with the certainty that scarce spectrum resources can be used to enhance competition and service offerings. Future spectrum allocations must be interoperable to support a competitive mobile ecosystem.

Additionally, the FCC should continue to allocate spectrum in smaller geographic license sizes. CCA applauds efforts to reinforce this principle, and commends Chairman Thune's repeated support in previous hearings for using smaller geographic license sizes to encourage interest in rural areas. Smaller geographic license sizes, like Cellular Market Areas or Partial Economic Areas, are necessary for smaller carriers to be able to compete for spectrum at auction and support utilization nationwide, particularly in rural areas. Furthermore, policymakers should consider appropriate build-out requirements and, as required by the Communications Act, policies that help to avoid excessive spectrum aggregation that impedes competition.

The Next Band: A Broad Range of Solutions Should Be Considered

There is no one-size-fits-all solution to making more spectrum available for mobile carriers, and each additional spectrum band will have unique utilization challenges and opportunities. Congress should consider a broad range of ideas that collectively add up to new and enhanced opportunities for access to additional spectrum resources. Market-based proposals, like those contemplated in the Rural Spectrum Accessibility Act (S. 417), provide incentives for wireless carriers to enter into business agreements to partition or disaggregate a spectrum license to make unused spec-

trum available to small carriers or for carriers to serve rural areas, particularly when this spectrum may otherwise go unused.

Despite recent efforts to repurpose the AWS–3 band, the Federal Government remains the holder of the largest amount of spectrum. While Federal users must retain access to resources necessary to complete their missions, Congress should consider policies to support reallocation where appropriate. A good example is the Wireless Innovation Act (S. 1618), which supports identifying Federal spectrum that can be reallocated for mobile broadband use and encourages deployment on Federal buildings and lands. Another example, the Federal Incentive Auction Act (S. 887) provides monetary incentives for Federal users to reallocate spectrum for commercial use in exchange for a percentage of the auction proceeds. These legislative efforts provide opportunistic uses of spectrum which encourage more efficient use. As FCC Commissioner Rosenworcel has articulated, carrots to incentivize spectral efficiency among Federal users allow the mobile broadband industry and the Federal Government to cooperate to identify opportunities to maximize use of otherwise under-utilized spectrum.

Increasing demand for spectrum, and the limited amount of new spectrum resources available for license, requires policies that consider opportunities that unlicensed spectrum offer for innovators, entrepreneurs and existing mobile operators to maximize spectral resources. Unlicensed spectrum, as a compliment to licensed spectrum, helps to support enhanced services and competition. In identifying future spectrum bands for potential reallocation for commercial use, higher frequency spectrum can support on-the-spot capacity solutions, while continued work to identify lower frequency spectrum to support wide area coverage, particularly in rural areas. Progress in identifying spectrum for unlicensed use in the 3.5 GHz and 5 GHz bands provides a good example of ways to support new technologies while enhancing licensed carrier services. Stakeholders prefer exclusive use of licensed spectrum, yet facing today's realities all options should be on the table. Access to new frequencies and technologies, with open ecosystems that support the availability of devices in all spectrum bands, for all carriers, should be encouraged.

Role of Technology

Spectrum availability, as vital as it is, requires sound standards-setting to support both competition and meet growing wireless demands. Policymakers should continue to play a role as standards are developed to ensure all Americans benefit from new innovations and technology advancements. Establishing core competitive principles for emerging technology while avoiding unnecessary regulation will help bridge the digital divide between urban and rural areas. New technologies like LAA, LTE–U, smart antennas, dynamic spectrum access and cognitive radio may help alleviate network congestion and provide carriers with new avenues to offer faster, more efficient service to otherwise unserved areas. This is a particular focus of CCA members that do not have the same spectrum portfolios of their largest rivals. Ensuring the capabilities of future networks now will help us to meet the needs of urban and rural consumers alike and in turn will spur development of 5G services. The United States has led the world in 4G deployment. The same should be true of 5G deployment, and these policies will foster that leadership. Policymakers should keenly emphasize that new technologies and services are available nationwide to maximize spectrum utilization and make sure that rural areas are not left behind as new services evolve.

Infrastructure

While spectrum is the invisible infrastructure over which mobile services ride, carriers also depend on towers and other physical network components. Wireless broadband is necessarily dependent on costly infrastructure to provide services. Competitive carriers depend on reasonable facilities siting policies to deploy critical wireless services. Many competitive carriers serve the most rural areas of the United States and often face challenges obtaining prompt collocation or tower construction permits or rights of way for siting on Federal lands. Efforts to streamline the siting process and remove unnecessary red tape encourage faster deployment of mobile broadband infrastructure and services to consumers.

The Bureau of Land Management (BLM), National Parks Service (NPS), United States Forest Service (USFS) Fish and Wildlife Service (FWS) and other Federal agencies own, manage, or administer significant portions of land, particularly in western and rural states. Competitive carriers seeking to deploy mobile broadband in these areas face unreasonable delays and other impediments to constructing and siting on these lands. Barriers to deployment often raise a carrier's cost through onerous administrative, legal and regulatory requirements. Consolidating Federal requirements, and trimming excessive or duplicative rules when multiple Federal

agencies are involved in approving the same infrastructure project would help to streamline an otherwise laborious process. For example, creating an application clearing house to coordinate all Federal permitting required for a project would reduce delays and utilize limited resources more efficiently.

Similarly, carriers depend on timely responses from state and local governments on siting applications. Shot clocks and other defined timeframes and parameters allow for efficient application consideration without creating unnecessary delays or obstacles for carriers to expand their facilities. The Supreme Court's ruling in *T-Mobile South LLC* v *City of Roswell,* which requires local and state governments to act expeditiously and clearly state their objections to a tower siting application, is a step in the right direction. Should further disputes regarding state and local authority continue to arise, we encourage Congress and the FCC to provide additional guidance to provide clear rules of the road for tower siting.

Certainty Regarding Other Inputs to Wireless Broadband Supports Continued Investment

While today's hearing is focused on spectral inputs for continued growth of mobile broadband services, CCA would be remiss not to mention the need for certainty regarding access to other inputs and incentives. For example, carriers, non-nationwide carriers in particular, require access to reasonable data roaming, access to devices, and certainty regarding the Universal Service Fund (USF) to continue to invest to meet growing demands. Congress created USF to provide reasonably comparable services to urban and rural consumer alike, requiring that support be predictable and sufficient. These policies have enabled years of expansion of mobile wireless services in rural America. USF injects a healthy dose of funding to supplement and compliment competitive carriers' private sector investments to expand mobile broadband service in rural and high cost areas that are otherwise uneconomical to serve. Any uncertainty regarding existing and future support has the potential to delay or prevent deployment of broadband infrastructure.

Uncertainty regarding existing and future support has the chilling effect of stalling deployments and forcing carriers to make difficult decisions regarding existing and planned mobile broadband services. In addition, this uncertainty has the potential to strand existing investments, leaving behind a legacy of rusty towers and reduced services. Congress must continue its oversight to ensure that USF support is sufficient and predictable to support wireless service throughout rural America.

Similarly, uncertainty regarding the availability of devices to utilize new spectrum allocations or access to backhaul and roaming to provide services limits smaller carriers' ability to invest and provide services in rural and underserved areas. As the legislative process continues, CCA encourages the Committee to focus on providing carriers of all sizes with access to all inputs necessary to meet continually growing demands.

In conclusion, CCA applauds and supports committee efforts to provide additional spectrum resources for mobile broadband and welcomes the opportunity to help craft a proactive approach to potential solutions. Enacting policies that provide competitive carriers with certainty while eliminating or streamlining burdensome procedures and creating innovative solutions to access finite spectrum resources will encourage investment and expansion in mobile broadband infrastructure and foster continued innovation and economic growth. Consumers across the United States, especially in rural areas, will benefit from Congress's continued focus on policies that support competition and investment in mobile broadband. CCA appreciates the opportunity to contribute to the record for today's hearing, and looks forward to continued work with the Committee, its Members, and the FCC on these important issues to increase mobile broadband services and support competition in the industry. Please do not hesitate to contact me with any questions.

Sincerely,

STEVEN K. BERRY,
President and CEO.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN THUNE TO HON. JESSICA ROSENWORCEL

Question 1. Commissioner Rosenworcel, you have emphasized the importance of small-scale policy experiments to examine the impacts of new policies and laws before they are put in place on the large scale. How can policymakers use small-scale experiments to develop innovative approaches to spectrum policy?

Answer. Our economy now depends on a potent mix of mobility, increased broadband capacity, and the decreased cost of cloud computing, allowing us to send

information anytime and anywhere. Up ahead lies the Internet of Things, where billions of machines with sensors seamlessly communicate with one another, turning today's steady stream of data into a torrential flow.

While this new digital landscape is dynamic, the traditional regulatory process is not. It can often be risk averse to new ideas. But we can overcome this risk aversion if we experiment on a smaller scale, with "sandbox" projects, before implementing ideas on a national scale.

The Commission has already begun to embrace this kind of sandbox thinking. We have tested broadcast channel sharing on towers serving television stations in Los Angeles. We have towns in Alabama and Florida that are our test cases for migration to all IP networks. We also have created an experimental spectrum licensing process to help researchers and developers tinker with our airwaves—a process that has already led to systems that support rocket launches, patient-monitoring equipment, and robotic technology for the armed forces.

I believe we also can use this approach for developing innovative ideas in spectrum policy, including ideas that facilitate the reallocation of airwaves from Federal to commercial use. To do this, we could identify specific spectrum bands used by Federal authorities that are ripe for repurposing through auction. We could test different ways of expediting reallocation with these bands—by providing financial incentives for speedy Federal relocation, by encouraging other Federal authorities with spectrum to make space for those being relocated through benefits in the Spectrum Relocation Fund, or by exempting some Federal users from the Miscellaneous Receipts Act and allowing the auction of spectrum not yet fully cleared for commercial use.

Question 2. Commissioner Rosenworcel, you have proposed auctioning to commercial entities the right to negotiate with a particular Federal agency for access to its spectrum assignment. Please explain how your proposal would operate as a practical matter. Would a reasonable alternative be to allow agencies to directly lease their excess spectrum to the private sector?

Answer. We need a Federal spectrum policy that is based on carrots, not sticks. In other words, we need to develop a system of incentives to help free more Federal spectrum for commercial use. If we do this right, we can reward Federal authorities for efficient use of spectrum in a manner where they see gain in commercial reallocation, rather than just loss.

We can do this by designing auctions of imperfect spectrum rights. These auctions would involve spectrum bands that have not fully been cleared of Federal users. However, we would provide the winning bidder in such auctions with the right to negotiate directly with remaining Federal users to help meet their wireless needs. This option would require adjusting the Miscellaneous Receipts Act. This law presently prevents negotiations between Federal agencies and winning bidders. It also prevents provision of service or equipment from winning bidders to remaining Federal users. But if we made changes to this law, we would be able to speed repurposing of our Nation's airwaves and provide commercial carriers with incentives to help update Federal systems that are past their prime. To do this right, however, we would have to have sufficient information about remaining Federal uses at the time of auction. This information would be necessary for bidders to assess the viability of their participation in the auction, including the likelihood that they would be able to address existing Federal needs and also make commercial use out of the band.

To some extent, the same kind of repurposing could be accomplished with allowing agencies to directly lease their excess spectrum to the private sector. However, the leasing approach has some problems that need to be considered. Arguably, this approach would deepen the property right of Federal users in spectrum they presently hold. It also would create challenging incentives, encouraging Federal authorities to hold onto their excess airwaves for leasing instead of working to help clear them for auction. In addition, commercial entities may be better positioned to develop new efficient solutions for Federal users through an exemption in the Miscellaneous Receipts Act, than Federal authorities themselves, who may have an institutional bias toward providing service through more limited changes to existing systems.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. ROGER F. WICKER TO HON. JESSICA ROSENWORCEL

Question. During your testimony, you noted the need to make sure that rural America is not left behind in the wireless revolution and that smaller carriers are more likely to deploy in rural communities. The Universal Service Fund (USF) plays

a critical role in supporting existing and planned wireless services in these areas. To this point, you stated that "we are going to enhance the Mobility Fund to ensure we support small wireless providers serving in rural areas." Congress created USF to provide reasonably comparable services to urban and rural consumers alike, and required that support be predictable and sufficient. Uncertainty regarding existing and future support can have the chilling effect of stalling deployments and potential reductions in wireless service.

What steps is the Commission taking to "enhance" the Mobility Fund, and will ongoing support through Phase II of the Mobility Fund be sufficient to support existing services in rural areas as well as continue to expand mobile broadband in rural and high-cost areas?

Answer. The Commission first developed the Mobility Fund in the Universal Service Fund and Intercarrier Compensation Transformation Order, which was adopted in 2011. In doing so, the agency sought to support "the universal availability of mobile networks capable of delivering mobile broadband and voice service in areas where Americans live, work, or travel." The development of this fund has proceeded in phases—in an effort to ensure that the limited dollars available are deployed in rural areas that truly lack service and are most at risk of falling behind.

The Mobility Fund kicked off with Phase I, which offered roughly $300 million in a one-time reverse auction to providers serving rural areas where updated wireless service was not available. This auction concluded three years ago, in September 2012.

It was followed in February 2014 by another reverse auction specifically designed to provide support for updated wireless service on tribal lands. This Tribal Mobility Phase I auction awarded approximately $50 million in support for mobile voice and broadband service offered by providers serving tribal communities.

These efforts were followed by a rulemaking in June of 2014 seeking comment on Phase II of the Mobility Fund. This rulemaking made clear that our purpose was to "target. . .Mobility Fund Phase II on preserving and extending service in" rural areas "that will not be served by the market without governmental support." In particular, the rulemaking sought comment on how to ensure that our Mobility Fund Phase II is devoted to "preserving service that otherwise would not exist and expanding access to 4G LTE in those areas that the market will not serve." I think this approach is a good one. With this next step in our Mobility Fund efforts, we should apply laser-like focus on areas that lack service and areas where updated service requires additional support. I believe the funds we have available will be sufficient to make this happen and the Commission should move forward to complete Phase II of our Mobility Fund efforts.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. STEVE DAINES TO HON. JESSICA ROSENWORCEL

Question 1. Given that all of the spectrum that is best suited for mobility is occupied, much of it by Federal users, what can we do to ensure that agencies are using spectrum efficiently and/or reallocate some of the Federal spectrum for mobile broadband use?

Answer. Federal authorities have substantial spectrum assignments. They use their airwaves for everything from protecting our borders to keeping planes in the skies to fighting forest fires. These are critical tasks that we should support. But if we want to continue to grow our wireless economy, we need to reassess just how much of our airwaves are dedicated to these tasks and consider if there are ways to accomplish the same objectives using scarce spectrum resources more efficiently.

I believe the best way to do this is to develop a Federal spectrum policy based on carrots, not sticks. In other words, we need to find ways to reward Federal authorities for efficient use of their spectrum so that they see benefit in commercial reallocation—rather than just loss.

To do this, we need a series of incentives to serve as the catalyst for freeing more spectrum for commercial markets. We could begin with a valuation of all spectrum used by Federal authorities, ideally developed by the Office of Management and Budget. This effort would help us develop consistent ways to reward efficiency, identify incentives for reallocation for commercial use, and better understand the opportunity cost of continued Federal use.

We also could adopt a system of incentives that are straightforward and financial—under which a certain portion of the revenue from commercial auction of spectrum previously held by Federal authorities would be reserved for the Federal entity releasing this spectrum. This is a complex undertaking, because agencies do not operate in a market environment and are subject to an annual budget allocation.

Nonetheless, we could explore such incentives with discrete spectrum bands or agencies.

In addition, we should consider auctions of imperfect spectrum rights, which could provide the winning bidder with the opportunity to negotiate directly with the existing Federal authority calling those airwaves home. This option would require adjusting some laws, like the Miscellaneous Receipts Act. This law prevents negotiations between Federal agencies and winning bidders in wireless auctions. But if changes are made, the Federal Government could auction spectrum that is not fully cleared and allow winning bidders to negotiate directly with Federal authorities remaining in the band to help meet their wireless needs. This could speed repurposing of our Nation's airwaves and also help provide commercial carriers with incentives to help update Federal systems that are past their prime.

Finally, we should look at the Spectrum Relocation Fund, which was created in the Commercial Spectrum Enhancement Act. Today this fund assists Federal authorities with relocating their wireless functions when their spectrum is being repurposed for commercial use. But this fund also could provide incentives for more government spectrum sharing, if changes were made to reward Federal users when they share their airwaves with agencies that are being relocated.

Question 2. While many parts of the country are gearing up for 5G, there are still parts of the U.S. where it is not possible to make a phone call wirelessly. Are there things we can do to encourage build-out and streamline infrastructure deployment in rural areas, and particularly tribal areas?

Answer. Yes. We can and should take steps to encourage infrastructure deployment in rural areas, including on tribal lands. This is not only the right thing to do—it is consistent with our duty to promote universal service under the law.

To encourage wireless deployment in rural areas, the Commission has taken a number of steps. These include recently revising our auction policies to include a bidding credit for rural service providers so that they can compete more effectively for spectrum in the remote communities where they serve. The Commission also has a Tribal Land Bidding Credit program to facilitate service on underserved tribal lands. In addition, for the upcoming 600 MHz auction, the Commission will offer licenses in Partial Economic Areas, which are smaller than traditional Economic Areas, and facilitate broader participation by small and rural service providers.

To encourage infrastructure deployment in rural areas, on October 17, 2014, the Commission adopted a Report and Order updating its infrastructure policies. Among other things, the Commission exempted certain wireless deployments on utility structures from review under the National Historic Preservation Act. This approach will reduce bureaucratic hurdles that can slow infrastructure deployment, especially in rural areas with limited population.

Going forward, there are additional actions we should consider. For instance, I think we should explore incentives for wireless carriers to lease unused spectrum to rural or smaller carriers in order to expand wireless coverage in rural communities. I know this approach is under consideration in the proposed Rural Spectrum Accessibility Act. I also believe the Commission should work closely with the Advisory Council on Historic Preservation, tribes, and other stakeholders to develop a "program alternative" which could expedite deployment of small cell infrastructure under the National Historic Preservation Act. This would help facilitate the deployment of this infrastructure nationwide, but could be especially helpful in rural areas.

Question 3. What steps is the FCC taking to encourage wireless deployment on tribal lands?

Answer. Wireless deployment on tribal lands lags behind deployment elsewhere and puts residents at a clear disadvantage in an economy that is increasingly dependent on mobile connections. As a result, a variety of Commission polices have been put in place to help expedite deployment and improve wireless service in tribal communities.

For nearly a decade and a half, the Commission has had a Tribal Land Bidding Credit program, which provides incentives for wireless carriers participating in spectrum auctions to offer service on tribal lands. Today, this credit is available to any entity that secures a license at auction and deploys service to federally-recognized tribal areas where the wireline penetration rate is 85 percent or less. In order to ensure that tribal lands receive timely service, deployment covering 75 percent of the qualified tribal lands is required within three years.

More recently, in February 2014, the Commission concluded its Tribal Mobility Fund Phase I reverse auction, known as Auction 902. This auction for universal service support offered up to $50 million in one-time funding to accelerate service on tribal lands and enhance broadband availability. To encourage tribal participa-

tion, the Commission offered a 25 percent bidding credit for tribally-owned entities participating in the reverse auction. It is my understanding that two of the winning bidders from this auction plan to provide service on tribal lands in Montana. As the agency continues to update its universal service support policies, we will need to study the impact of this auction—in Montana and elsewhere—and identify what further efforts are necessary to facilitate greater deployment on tribal lands.

In addition, the Commission has an outstanding Notice of Proposed Rulemaking seeking comment on how to promote greater use of spectrum over tribal lands—in order to improve the availability of wireless service to unserved and underserved tribal communities.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. AMY KLOBUCHAR TO HON. JESSICA ROSENWORCEL

Question. The recent AWS–3 spectrum auction raised a record $45 billion. However, some of the big winners were the largest wireless carriers. Last Congress I held a hearing in the Antitrust Subcommittee about competition in the wireless market and I believe it is important to make sure that auction rules do not create barriers to entry for other wireless carriers. Additionally, I have worked with Senator Fischer on making sure that rural carriers can also get access to already licensed spectrum in the secondary markets by introducing the Rural Wireless Spectrum Act to incentivize companies with spectrum licenses to partner with small rural carriers to provide service in rural America.

Commissioner Rosenworcel, do you agree that we need to protect competition in auctions as well as use additional tools to boost wireless coverage in rural areas through the secondary market?

Answer. Yes. I agree that our spectrum auctions must remain competitive and that we must take steps to improve wireless coverage in rural areas.

I believe that fostering competition in our spectrum auctions is not just a good idea—it's required under the law. In Section 309 of the Communications Act, Congress charged the Commission with "promoting economic opportunity and competition" when developing the bidding methodologies that govern the auctions of our airwaves. To this end, the Commission recently revised its competitive bidding rules in order to provide more opportunities to participate in our auctions and win spectrum licenses. As part of this effort, for the first time ever, the Commission adopted a bidding credit for rural service providers so that they can better compete for spectrum in the remote communities that they serve. In addition, for the upcoming 600 MHz auction, the Commission has established a market-based spectrum reserve that will provide competitive carriers and rural service providers with greater access to valuable low-band spectrum.

I am optimistic that these recent revisions to our competitive bidding rules will both enhance competition and expand coverage in rural areas. But I recognize that more can be done, especially with respect to deployment in rural areas through use of the secondary market. That is why I believe we should explore developing incentives for wireless carriers to lease unused spectrum to rural or smaller carriers in order to expand wireless coverage in rural communities. This is the fundamental idea behind the Rural Spectrum Accessibility Act—and a concept I support.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BRIAN SCHATZ TO HON. JESSICA ROSENWORCEL

Question 1. Commissioner Rosenworcel, as you may recall, Hawaii transitioned to digital television a month earlier than the rest of the United States to accommodate the unique nature of the state and to ensure a smooth transition. As we prepare for the upcoming incentive auction, likewise, we want to be certain that the needs and economic realities of non-contiguous states are taken into account to make sure this transition is successful as the digital television transition.

The law specifically created a $1.75 billion fund to compensate any broadcasters for expenses associated with repacking. Do you expect that this fund will be sufficient for the affected broadcasters to repack?

Answer. Yes. At this point in the auction process, I believe that the $1.75 billion fund established by Congress will be sufficient to cover the reasonable costs and expenses associated with the relocation of stations following the incentive auction. I recognize, however, that there are estimates from the broadcasting community that suggest that the cost of relocation may be slightly greater than the amount in existing law. If in the future the current fund proves insufficient, Congress may wish to take steps to provide additional support.

Question 2. The law also provides a 39 month window for the transition. Is the FCC confident that the equipment and personnel required to repack the affected stations will be available within the specified timeframe?

Answer. Yes. At this point in the auction process, I believe that the 39-month period for the transition will be adequate for the repacking process. The Commission has already adopted policies designed to facilitate a smooth transition for broadcasters and their viewers during this period. For instance, in the *Incentive Auction Report and Order,* the Commission determined that stations required to repack following the auction will receive a construction period tailored to their specific circumstances. Stations also will have the opportunity to request a one-time, six-month extension of construction permits if they experience delays or unexpected challenges. In addition, the Commission will work with stations to help mitigate any service disruptions if construction of post-auction facilities is not completed prior to the 39-month deadline for all stations to cease operating on their pre-auction channels. I believe these policies will support an orderly transition during the 39-month period. But I also recognize that unexpected difficulties may arise, including pressures on the capacities of tower and transmission companies as well as regional weather events. I believe that the Commission must work with Congress to ensure that such difficulties do not jeopardize a smooth transition or harm viewer access to free, over-the-air television.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN THUNE TO HON. MEREDITH ATTWELL BAKER

Question 1. Ms. Baker, the Spectrum Act created the Technical Panel to review agency spectrum relocation plans. What has been the experience of the wireless industry with the Technical Panel? In what ways might the panel be improved to address our Nation's spectrum needs going forward?

Answer. Industry's experience with the Technical Panel, which is comprised of three agencies, the FCC, NTIA and OMB, has been positive and, in general, we believe anything that enhances communication and collaboration between the government and industry is a positive. In the AWS–3 process, carriers and vendors alike participated in the CSMAC working groups to collaborate with agency stakeholders on ways to gain spectrum access on a system-by-system basis and this interaction proved to be very helpful in understanding each side's operational requirements and ultimately paved the way to developing each agency's transition plan.

As far as improving upon this concept, it likely would be worthwhile to have a Technical Panel post-auction so that it can review each agency's transition plan throughout the implementation process. This oversight could include measuring agency progress toward certain milestones, which in turn could be tied to payment to agencies as a way to incentivize quicker transitioning of the spectrum for commercial use.

Question 2. Ms. Baker, you have previously argued that continued growth of wireless broadband is based on availability of exclusive use licensed spectrum. Please share your views on whether exclusive use is a viable model for the future and the appropriate role for sharing arrangements and technologies.

Answer. Exclusive use spectrum has played a central role in the U.S.'s global lead in 4G technologies. Exclusive use auctions in 2006 and 2008 provided spectrum that is the backbone of much of our national 4G deployment. As I noted in my written testimony, the backbone of our national spectrum policy should remain licensed and exclusive use spectrum for the foreseeable future. Exclusive use spectrum is critical to carriers' planning; without it, they would be unwilling to make the enormous capital investments to build network capacity—investments that drive technology, create jobs and provide services to businesses and consumers. Of course, as the wireless industry evaluates spectrum that may be made available for exclusive licensed use in the future, we recognize that temporal and geographic sharing may be required, particularly as incumbent licensees relocate to other bands, or otherwise vacate their spectrum. The AWS–3 band provides a good example of how commercial users will work with Federal licensees to share spectrum while the relocation process occurs. This type of sharing, which always has been part of our national approach, can be an effective bridge to exclusive licensed use. Other types of database-based sharing may be appropriate in the future. For example, the FCC continues to refine the rules that will govern shared access to the 3.5 GHz band for government users, licensed entities and unlicensed operations. However, these forms of flexible sharing, driven by database access and other technologies that have not been fully tested, cannot currently satisfy our spectrum needs and consumer demand. While we continue to support the FCC's efforts to evaluate potential sharing

arrangements and technologies, they are not yet mature enough to meet our Nation's critical spectrum requirements.

Question 3. Ms. Baker, are reforms needed to the Spectrum Relocation Fund to meet Federal agencies needs and facilitate reallocation of Federal spectrum? Please provide specific examples of changes that you believe are required.

Answer. The Spectrum Relocation Fund has been an important and positive development, and further enhancements to the Fund could facilitate more efficient and effective spectrum use. CTIA strongly supports changes to how auction proceeds that are deposited into the Spectrum Relocation Fund are distributed, to provide Federal entities with incentives to use spectrum more efficiently and potentially make additional spectrum available for auction to commercial users. Today, money from the Spectrum Relocation Fund only compensates Federal users whose spectrum is being immediately auctioned. A portion of auction proceeds should be available to Federal agencies that wish to conduct research and development activities, even if their spectrum has not been designated for auction. Of course, distribution of those research and development funds cannot be unchecked; Federal agencies should be required to show specific plans and how they may lead to the re-allocation and auction of some or all of the spectrum they currently use. Another way the Spectrum Relocation Fund can be reformed is to provide an incentive to Federal entities that vacate their current spectrum when it is auctioned, instead of being relocated to alternative spectrum. Today, Spectrum Relocation Fund money is only available to cover relocation costs. However, if a Federal agency vacates the spectrum completely—and uses a commercial system or shares a system with other Federal users—it should recognize a benefit for doing so. Finally, because the Spectrum Relocation Fund only covers spectrum that is auctioned, there is no path to compensate Federal entities whose spectrum becomes available for unlicensed operations. While CTIA believes that exclusive use licensed spectrum should continue to be the focus of U.S. spectrum policy, if Federal spectrum becomes available for unlicensed use, those incumbent users must also be compensated.

Question 4. Ms. Baker, what actions can Congress or the Federal Communications Commission take to promote United States leadership in 5G?

Answer. As I noted in my testimony, a combination of sound spectrum policy, a light-touch approach to regulation, and pro-investment tax policy, have propelled the U.S. to its current status as the world's leader in 4G services. And it is a continued commitment to that course that will help us retain our lead as we move toward 5G. That requires filling the spectrum pipeline to ensure that America's wireless providers can meet user demand for mobile bandwidth with a mix of low-band, mid-band, and high-band spectrum. It also requires the FCC to exercise regulatory restraint and avoid the imposition of regulations that raise cost and slow innovation and infrastructure investment. And finally, it requires the adoption of both regulatory and tax policies that facilitate the deployment of advanced wireless infrastructure. Each of these elements is important and collectively they can work to help us maintain America's competitive edge.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. KELLY AYOTTE TO HON. MEREDITH ATTWELL BAKER

Question. In your testimony, you noted that the FCC's 2010 spectrum demand study was quite accurate in estimating the incredible growth of mobile data traffic. The technological advancements of the Internet of Things has no doubt assisted this skyrocketing usage. Earlier this year, I coauthored a resolution with my colleagues—Senators Fischer, Schatz, and Booker—regarding the significance of the Internet of Things, which unanimously passed the Senate.

The Internet of Things incorporates innovative devices, services, and applications that already are and will continue to influence all of our lives. However, none of this is possible without a robust mobile network. For our role in creating sound spectrum policy, what is the most important action Congress can take to ensure the mobile network has the capacity to support the full potential of the Internet of Things?

Answer. CTIA is pleased that the Senate has recognized the significance of the developing Internet of Things (IoT), which is a means to wirelessly connect everyday objects to the Internet and to each other, allowing them to send and receive data. This exciting advance depends on a robust mobile infrastructure. And, the technological advancements brought about by the increasing popularity and continued growth of IoT has contributed to the skyrocketing demand for innovation and faster speeds. Support for IoT will require greater amounts of spectrum; ideally a continual mix of licensed and unlicensed, depending on the intended use cases. For in-

stance, given the need for heightened security and reliability, health information, medical monitoring, financial records and connected vehicles, for instance, would be best suited to a licensed spectrum platform. When it comes to connected home devices and beacons, an unlicensed platform may be appropriate.

To best ensure that American consumers may fully benefit from the myriad benefits of IoT, I would encourage the Senate to undertake comprehensive action to ensure an ongoing, plentiful supply of licensed and unlicensed spectrum. CTIA supports the broad availability of free, unlicensed spectrum as long as uses of such spectrum do not interfere with licensed users or reduce the availability and usability of licensed spectrum.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. RON JOHNSON TO HON. MEREDITH ATTWELL BAKER

Question 1. The AWS 3 auction was a huge success for taxpayers, government, and industry. What can Congress do to ensure that future auctions are as successful, if not more successful?

Answer. Consumer appreciation for the convenience and ease brought by the mobile connected life has led to skyrocketing demand for ever more substantial services at ever faster speeds. By 2019, wireless networks will face an estimated six-fold increase in data traffic over record 2014 levels. While carriers continue to upgrade their networks and deploy advanced services to more areas, infrastructure and technology alone cannot satisfy consumer demand. To keep up, our Nation will need more than 350 megahertz of new licensed spectrum by the end of the decade.

Congress can help ensure that future spectrum auctions are successful in several ways. First, Congress should prioritize freeing up clear, unencumbered licensed spectrum for commercial mobile uses. Unhindered access to clear spectrum is the best way to provide the reliable and robust services that consumers have come to expect.

Next, Congress should emphasize the importance of freeing up uniform spectrum bands across the globe rather than in individual countries, known as "internationally harmonized" spectrum bands. Allocating harmonized spectrum minimizes radio interference and facilitates international roaming. Further, harmonization reduces the cost of mobile devices for consumers because the economies of scale encourage manufacture and delivery of more products and services to more people and allows them to use their mobile devices for less cost and with greater ease when travelling.

In addition, Congress should take steps to ensure that auction winning bidders have access to their spectrum as quickly as possible post-auction. Condoning or appearing to condone delay in the post-auction transition process would impede broad auction participation, hinder competition and delay investment. On the other hand, improving the speed at which new licensees may access their spectrum would incentivize more rapid deployment and foster greater broadband adoption.

Finally, Congress should require the FCC to develop and implement straightforward auction procedures, as well as understandable and predictable licensing rules for new spectrum bands. Regulations must be minimal and interference rules must be clear up front. The FCC should not condition or suggest technologies or uses. The benefits of flexible use have become even more apparent over time and thus must remain the default approach. Similarly, the AWS–3 auction illustrated that paired spectrum blocks are preferable to unpaired given that bidders in that auction won unpaired blocks for a fraction of the cost of paired blocks.

Question 2. What can Congress do to ensure that the necessary infrastructure is in place to handle the ever-expanding mobile broadband service offerings and increased data traffic?

Answer. The FCC's 2009 "shot-clock" order, which was upheld by the U.S. Supreme Court in *City of Arlington, Texas, Et Al.,* v. *Federal Communications Commission, Et Al.* (2013), has significantly improved the process for siting wireless infrastructure on properties governed by the municipal zoning process. Similarly, the FCC's 2011 decision facilitating access to utility poles has improved the process for deploying small cell and distributed antenna system technologies. Unfortunately, the process does not work as well when a provider is attempting to site on property controlled by the Federal Government, which accounts for 28 percent of the landmass of the United States. This property is often adjacent to population centers or transportation corridors and is attractive for siting if approvals could be gained in a reasonable expeditious manner. While Congress made a good-faith effort to address this in Section 6409 of P.L. 112–96, and the President did so as well in Executive Order 13604—Improving Performance of Federal Permitting and Review of Infrastructure Projects, and Executive Order 13616—Accelerating Broadband Infra-

structure Deployment, siting on Federal properties continues to take significantly longer than siting on properties governed by the municipal zoning process. To remedy this disparity, Congress should act to impose streamlined timeframes for review and approval of wireless infrastructure deployments on Federal property. Industry does not seek free access to these locations, and CTIA recognizes that there may be instances in which siting requests may not be granted, but enactment of procedural reforms should generally have the effect of promoting investment and wider access to services.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. DEAN HELLER TO HON. MEREDITH ATTWELL BAKER

Question. Ms. Baker, while it is clear that additional spectrum is necessary moving forward, I am also interested in another aspect of mobile broadband—infrastructure deployment, particularly on Federal lands considering Nevada is 85 percent Federal lands. What are some of the challenges industry faces in deploying wireless infrastructure on Federal lands? Do you have any recommendations for streamlining the process?

Answer. Compared to the process for siting infrastructure in a location governed by the municipal zoning process, which generally works well, the process for siting on Federal property is cumbersome and time consuming. While the municipal zoning process takes months, Federal processes often are measured in years. This is true across many agencies, and it is certainly the case at the Bureau of Land Management and the National Park Service, two of the largest landholders in Nevada. Leases to place new sites on lands regulated by BLM and NPS can take two or three years to negotiate and even simple lease renewals can take 12–18 months. In addition, even though BLM generally requires applicants to collocate antennas at existing sites (reducing the impact on subject lands), its processing of applications for "joint use of facilities" is time consuming. Both agencies should take steps to ensure that applications necessary for the deployment of wireless broadband service are processed without delay. As a first step in this process, BLM and NPS should consider adopting more standardized and streamlined procedures for processing wireless broadband siting applications.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. CORY GARDNER TO HON. MEREDITH ATTWELL BAKER

Question. Ms. Baker, I recently introduced the Wireless Innovation Act with Senator Rubio and others. Our legislation would create a spectrum pipeline as well as lead to more transparency and efficiency among Federal spectrum users. Moving forward, is this the right kind of spectrum policy to enable industry to keep up with consumer demand and maintain its global leadership?

Answer. It is, and CTIA greatly appreciates the work you and the other sponsors of S. 1618 have invested in crafting a blueprint to ensure that our wireless future is as bright as our present. The bill's comprehensive acknowledgement of and plan to address the need for both licensed and unlicensed spectrum, improved spectrum management, and a streamlined process for infrastructure deployment offers an outstanding starting point for the Committee's work to address the critical question of what comes after the broadcast incentive auction. Collectively with other bills pending before the Committee, such as the Federal Spectrum Incentive Act (S. 887), the Rural Spectrum Accessibility Act (S. 417), and the Wi-Fi Innovation Act (S. 424), there is clear bi-partisan interest in advancing America's wireless future. CTIA stands ready to work with you and all members of the Committee to advance comprehensive spectrum legislation at the earliest possible date.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. STEVE DAINES TO HON. MEREDITH ATTWELL BAKER

Question 1. Ms. Baker: what steps is industry taking to increase deployment on tribal lands?

Answer. By making available licensed spectrum on Tribal lands for commercial use, wireless carriers can provide the Tribes with access to a valuable resource that gives rise to a number of economic, social, and public safety benefits. But while broadband—and wireless broadband in particular—can be a boon for economic development, this is only true if broadband can be and is actually deployed. Steps can and should therefore be taken to streamline the siting process, while protecting

Tribal interests and cultural resources. There are several steps the Bureau of Indian Affairs ("BIA") should take to facilitate wireless broadband deployment on Tribal lands.

First, BIA should conclude its pending proceeding to streamline the right of way approval process. On June 17, 2014, BIA sought comments on new rules that would streamline the process of obtaining BIA grants of rights-of-way on Indian lands. BIA recognized that the rules, which were last updated in 1980, were burdensome and outdated. CTIA supports the proposed changes to the extent they would expedite broadband deployment on Tribal lands. Parties filed comments in November 2014 and BIA held Tribal consultations during August 2014. Thus, this item is ripe for action and BIA should act expeditiously to conclude its proceeding.

Second, BIA should consider ways to implement or encourage uniformity in the Tribal consultation process. For example, Tribes generally do not follow uniform timetables for responding to Tower Construction Notification System ("TCNS") notifications. Tribes often enter the process late and then seek additional information regarding a project, which merely delays action. CTIA recommends that Tribes have a standardized window not only to respond to the initial TCNS notifications of a proposed facility, but also for responding to information subsequently provided by the applicant to the Tribe at the Tribe's request. The Tribal application process should also be standardized to the extent possible. That way, applicants are better able to provide necessary materials and information to Tribes at the outset. A more simplified application process also could simplify and streamline review. In addition, BIA should encourage use of a uniform fee schedule by federally recognized Tribes for reviewing and processing wireless applications. The fees should be cost-based and used to ensure that Tribes are not penalized for protecting their cultural rights.

Finally, BIA should make clear that Tribal monitoring should be limited to situations of particular concern where the proposed site and excavation indicates that a potential impact on items or areas of Tribal significance is likely, based on clearly articulated factors. Monitoring can be an expensive process. In some cases, negotiation of these monitoring agreements, or the actions of monitors themselves, has delayed projects. For example, Tribal monitors have effectively shut down projects by refusing to oversee work until the financial terms of their employment are re-negotiated. BIA should work with Tribes to narrow the scope of antenna siting actions that require Tribal monitoring, subject at all times to the applicant's obligation to cease excavation and construction immediately upon the discovery of any items of cultural significance. In this way, the relevant Tribe(s) can be consulted during the most sensitive siting projects without impeding the deployment of valuable broadband services in areas where extensive Tribal monitoring is not needed.

Question 2. Ms. Baker: In your testimony, you mention that other countries are working to leapfrog the U.S. in the race to 5G. Can you talk a bit more about what our European and Asian trading partners are doing in this area?

Answer. From Western Europe to South Korea and Japan, our trading partners are taking steps to enhance their competitiveness and overtake the U.S. in wireless innovation. While the steps they are taking vary by country, these initiatives include the allocation of additional spectrum and investment in or support for research into 5G technologies. South Korea has pledged to facilitate the deployment of 5G trials for the 2018 Winter Olympics, with full deployment anticipated by 2020. South Korea's initiative, which includes 1.6 trillion Won in government support, is intended to include ultra-HD and hologram transmission. Japan has undertaken a similar initiative, aimed at delivering 5G by the time Japan hosts the 2020 Summer Olympics in Tokyo. While the U.S. is widely acknowledged as the world's current leader in wireless, these and other countries are working to claim that mantle, which is exactly why the United States needs a comprehensive plan to maintain our advantage in this key sector. That plan starts with a meaningful spectrum pipeline.

Question 3. Ms. Baker, I think we can all agree that more spectrum is needed to keep up with consumer demand and maintain our lead globally. But once spectrum is made available, the industry then invests billions more to deploy wireless infrastructure. As you know, in a state like Montana we have unique challenges but I want all of Montanans to be able to enjoy all of the benefits that access to mobile broadband provides. Are there things we can do to streamline infrastructure deployment in rural areas, and particularly tribal areas?

Answer. Deploying infrastructure in rural, less dense areas is a challenge for any networked industry, and wireless is no exception to that. While the substantial fixed costs associated with infrastructure deployment make such investments difficult, there certainly are things policymakers can do to help strengthen the business case for rural investment.

First, Congress and the Executive Branch should take steps to streamline the process for deploying telecommunications infrastructure—wireless and wireline alike—on Federal properties. The Federal Government controls more than a quarter of the lands that make up the United States. In many cases, those Federal land holdings are adjacent to, or even surround, rural communities. Streamlining the process for deploying infrastructure on or across these parcels may improve access for all those who live or work near, or traverse, these areas. Such relief also should be afforded to energy providers, as communications networks rely on access to commercial power.

Second, Congress should enact legislation to extend bonus depreciation, a proven tool to encourage businesses to make additional capital investments. High fixed-cost industries like wireless are very sensitive to tax policies and a failure to extend this provision, which lapsed at the end of 2014, would raise the cost of infrastructure deployment, the exact opposite of what is needed to encourage investment in hard-to-serve areas. Senator Roberts has proposed a bill, S. 1660, to extend bonus depreciation permanently and CTIA urges support for his legislation.

And third, it is imperative that a meaningful Universal Service Mobility Fund component be available to facilitate wireless deployment. Universal Service Fund support should be disbursed in a technologically neutral manner to support services that consumers—including those who live in rural areas—actually want and need. Increasingly, those services include mobile broadband. While 4G LTE service is available to 97 percent of the American public, there is more to be done. As industry works to fill in gaps in coverage, there are many providers that view the current Mobility Fund as inadequate to support the sort of ubiquitous deployment you seek for all Montanans.

Individually and collectively, these policy initiatives would improve the case for continued, or new, investment in rural America.

Finally, with specific respect to tribal areas, please see my answer to question 1.

Question 4. Ms. Baker, in a Wall Street Journal opinion piece that ran the day before the hearing, two former FCC officials noted that U.S. investment in mobile infrastructure—nearly $32 billion last year—is more than 50 percent higher than in Europe. I'm sure that delta has a lot to do with why you say we lead in this space. Can you talk a bit about what conditions have led U.S. companies to invest at such a significantly faster rate than their counterparts in other parts of the world?

Answer. There are a number of factors that have helped drive the disparity in investment that divides the U.S. from Europe. First, the U.S. was "first to market" with the spectrum that provides the foundation for 4G services, and the first to deploy LTE technologies. Second, until the FCC's recent Open Internet Order, the U.S. market had benefitted from a twenty-year, bi-partisan consensus that "light touch" regulation was the right approach to enabling both competition and investment. The Open Internet Order marks a departure from this course toward a European-style of regulation that has been proven to result in reduced investment. Third, the U.S. market has more competition than is the case in Europe. This vibrant competition among networks necessitates investment by providers hoping to attract and retain subscribers. Providers that fail to invest lose out in the marketplace. And finally, a decade-long, bi-partisan commitment to incenting investment through enactment and extension of bonus depreciation initiatives has helped fuel investment in U.S. network. In a high fixed-cost industry like wireless, the right tax policies matter. As I noted in response to question 1, Congress should extend this policy.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. AMY KLOBUCHAR TO HON. MEREDITH ATWELL BAKER

Question 1. Earlier this month I was in rural Minnesota and heard some heartbreaking stories from families, communities and students about how they needed better broadband access. Many of them are looking to wireless broadband as an answer. One student wrote an essay to his local carrier about how he would hold his phone up by the window in order to try and download information he needed to do his homework. Another family talked about how when they got Wi-Fi they suddenly had young kids in their front yard using it. I've also heard from farmers who are looking to use new technology in their equipment but are limited based on coverage in the fields. This is one of the reasons I have introduced the Rural Spectrum Accessibility Act with Senator Fischer, to incentivize more rural spectrum deployment.

Ms. Baker, right now population density drives where spectrum is built-out. What more can we do at a national level to reframe spectrum policy so that rural communities, businesses, and students are not left behind?

Answer. Deploying infrastructure in rural, less dense areas is a challenge for any networked industry, and wireless is no exception to that. While the substantial fixed costs associated with infrastructure deployment make such investments difficult, there are things policymakers can do to help strengthen the business case for rural investment.

First, Congress and the Executive Branch should take steps to streamline the process for deploying telecommunications infrastructure—wireless and wireline alike—on Federal properties. The Federal Government controls more than a quarter of the lands that make up the United States. In many cases, those Federal land holdings are adjacent to, or even surround, rural communities. Streamlining the process for deploying infrastructure on or across these parcels may improve access for all those who live or work near, or traverse, these areas. Such relief also should be afforded to energy providers, as communications networks rely on access to commercial power. With this in mind, CTIA greatly appreciates the support you expressed for these efforts in your July 2015 letter to the co-chairs of the Broadband Deployment on Federal Property Working Group.

Second, Congress should consider initiatives such as the Rural Spectrum Accessibility Act (S. 417) you have sponsored with Senator Fischer. By providing an incentive for licensees to partition or disaggregate licenses to make unused spectrum available to small carriers or carriers serving rural areas, your bill could help bring increased investment to those communities. S. 417 could provide an important supplement to industry efforts such as Verizon's LTE in Rural America program, which has assisted smaller carriers in bringing the benefits of 4G LTE service to more than 2.4 million people.

Third, Congress should enact legislation to extend bonus depreciation, a proven tool to encourage businesses to make additional capital investments. High fixed-cost industries like wireless are very sensitive to tax policies and a failure to extend this provision, which lapsed at the end of 2014, would raise the cost of infrastructure deployment, the exact opposite of what is needed to encourage investment in hard-to-serve areas. Senator Stabenow has proposed a bill, S. 1666, to extend bonus depreciation through 2016 and CTIA urges you to support her legislation.

And finally, it is imperative that a meaningful Universal Service Mobility Fund component be available to facilitate wireless deployment. Universal Service Fund support should be disbursed in a technologically neutral manner to support services that consumers—including those who live in rural areas—actually want and need. Increasingly, those services include mobile broadband. While 4G LTE service is available to 97 percent of the American public, there is more to be done. As we work to fill in gaps in coverage, there are many providers that view the current Mobility Fund as inadequate to support the sort of ubiquitous deployment you seek and your constituents deserve.

Individually and collectively, these policy initiatives would improve the case for continued, or new, investment in rural America.

Question 2. I've continued to work on issues to promote broadband investment and deployment. Consumers are demanding increasing speeds and service levels from both wireline and wireless providers. However, deployment can often be hampered by slow and redundant permitting processes, particularly when it comes to placing infrastructure on Federal lands. That is why I worked with the Administration to advance the concept of "Dig Once" at the Department of Transportation. Additionally, I sent a letter with Senator McCaskill calling on the Broadband Deployment on Federal Property Working Group to take action and streamline permitting and siting processes as well as improve consistency across Federal agencies.

Ms. Baker, how does the lack of consistency and the resulting uncertainty affect your member companies' ability to deploy wireless broadband to more rural areas? What else needs to be done to improve infrastructure deployment across the country?

Answer. CTIA provided extensive input on this very subject when we responded to the Broadband Opportunity Council's Request for Comment. See *http://www.ntia.doc.gov/files/ntia/ctia-the_wireless_association_boc.pdf.* In particular, substantial effort should be undertaken by the Executive Branch, or, failing that, by Congress, to streamline and expedite antenna siting decisions. The process for deployments governed by the municipal zoning process generally works well, with approvals usually issued within the 150 days contemplated by the Federal Communications Commission's rules. By contrast, siting on Federal properties can take years, with wide variance between the processes employed by various agencies and departments. Initiatives that would move toward the use of common forms and fee schedules, master contracts, and uniform schedules and processes for deploying broadband facilities on Federal lands, buildings, rights-of-way, federally assisted

highways, and Tribal lands would assist the industry in expanding broadband access.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. JOHN THUNE TO J. PIERRE DE VRIES

Question. Mr. de Vries, you have recommend creating a Court of Spectrum Claims to deal with spectrum disputes. In what way would your proposal help alleviate conflicts in the marketplace that are likely to occur as spectrum utilization increases?

Answer. A Court of Spectrum Claims would provide a forum and a process where conflicts in the marketplace—especially between Federal and commercial users, but also others—could be resolved.

It could help prevent conflict, or nip it in the bud, by providing parties with the reassurance that any disputes that might arise could be resolved in a neutral forum with expertise in spectrum matters. The Court would be independent of the FCC and NTIA whose interests, or perceived interests, might cause concern to some or all of the parties to a dispute.

The Court's most important contribution would be in fostering cooperation—the flip-side of conflict. Successfully freeing up and sharing government spectrum for others to use productively—and likewise, for government users to gain access to non-federal spectrum—requires a back-stop to ensure that the promised access rights and interference protections in such a bi-lateral market will be delivered.

Since Federal and commercial spectrum users are under the mutually exclusive jurisdictions of the Department of Commerce and the FCC, there is a need for a new entity—a Court of Spectrum Claims, for example—that can oversee both types of users (federal ones and private ones), adjudicate potential disputes, and spur cooperation in advance of any judicial claim.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN THUNE TO THOMAS M. LENARD, PH.D.

Question 1. Dr. Lenard, in your testimony, you argue that government agencies do not operate in a market context, and therefore their goal is not to maximize profits. Please explain incentives that can be provided to agencies to maximize efficient use of agency spectrum while allowing agencies to fulfill their statutory obligations.

Answer. The key is to have a mechanism that requires government agencies to internalize the costs of the spectrum they use. My testimony suggests a mechanism based on the General Services Administration (GSA) model—a Government Spectrum Ownership Corporation (GSOC) that would take possession of all government-held spectrum and lease it to agencies at rental rates based on estimates of the relevant opportunity costs. In this way, agencies would have appropriate incentives to economize on the spectrum they use. Surplus spectrum could then be sold or leased to the private sector.

Question 2. Dr. Lenard, do you support permitting agencies to lease their excess spectrum to the private sector? What considerations might there be if this idea is pursued by Congress?

Answer. Yes, this would be one way of inducing agencies to internalize the costs of the spectrum they use and incentivizing them to release more spectrum into the private sector. For this to be successful, agencies should be able to keep the lease payments and Congress (and the executive) should refrain from instituting offsetting budget cuts.

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