

THE ROLE OF RECEIVERS IN A SPECTRUM SCARCE WORLD

HEARING BEFORE THE SUBCOMMITTEE ON COMMUNICATIONS AND TECHNOLOGY OF THE COMMITTEE ON ENERGY AND COMMERCE HOUSE OF REPRESENTATIVES

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THE ROLE OF RECEIVERS IN A SPECTRUM SCARCE WORLD

THURSDAY, NOVEMBER 29, 2012

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON COMMUNICATIONS AND TECHNOLOGY,
COMMITTEE ON ENERGY AND COMMERCE,
Washington, DC.

The subcommittee met, pursuant to call, at 11:58 a.m., in room 2322 of the Rayburn House Office Building, Hon. Greg Walden (chairman of the subcommittee) presiding.

Members present: Representatives Walden, Terry, Stearns, Blackburn, Gingrey, Latta, Guthrie, Eshoo, Markey, Barrow, and Christensen.

Staff present: Ray Baum, Senior Policy Advisor/Director of Coalitions; Andy Duberstein, Deputy Press Secretary; Neil Fried, Chief Counsel, Communications and Technology; Debbie Keller, Press Secretary; Andrew Powaleny, Deputy Press Secretary; David Redl, Counsel, Communications and Technology; Charlotte Savercool, Executive Assistant; Roger Sherman, Democratic Chief Counsel; Shawn Chang, Democratic Senior Counsel; David Strickland, Democratic FCC Detailee; Margaret McCarthy, Democratic Professional Staff Member; and Kara Van Stralen, Democratic Special Assistant.

Mr. WALDEN. We will call to order the Subcommittee on Communications and Technology and our hearing on “The Role of Receivers in a Spectrum Scarce World.” First of all, I want to thank our witnesses not only for your extraordinary testimony—we appreciate it; I have read through it—but also for your patience and that of our visitors here today as well.

As you know, we are all in our organizational phases in the Congress and we are giving courtesy to my colleagues on the other side because they were having an organizational meeting today. And we appreciate their breaking loose so we could get this going even though we are a little delayed. So it is what it is. Thank you. I will start with some opening comments and then recognize my friend and colleague from California.

OPENING STATEMENT OF HON. GREG WALDEN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF OREGON

Good fences make good neighbors. Where I come from in Oregon, we know that is the case whether it is crowded city blocks or sprawling ranches. In many places in my district, the ranches stretch for miles, and running out of space isn’t a problem. But in our digital world—in Oregon and around the country—we are run-

ning out of room. Demand for spectrum is far outpacing supply, and we need to figure out how to use this room we have as efficiently as possible. In short, how do we create good, strong fences to make sure everyone stays within their spectrum bands so spectrum can be used as efficiently as possible?

Now, why is this important? Simple. Spectrum equals jobs. Telecommunications is the most vibrant and innovative sector in America. Spectrum is the fuel that it runs on, but there is a limit to our supply. As our subcommittee continues its work to free up more spectrum, we are also focused on maximizing the use of the existing spectrum. We have taken a forward-looking approach—authorizing first-of-its-kind incentive auctions and taking a look at making government spectrum use more efficient and more available.

This hearing focuses on receivers and how interference issues can impact our ability to roll out new broadband services. While the controversy surrounding LightSquared and GPS is one example, we have seen similar debates involving a would-be broadband provider called M2Z networks. We have seen it in satellite radio; we have seen it in unlicensed and white-space devices. So that this issue is starting to recur more frequently raises an important question: What engineering techniques and smart strategies are available to fit more mobile services in a crowded spectrum environment without having to carve out larger and larger guard bands—big, inefficient moats—to avoid interference? And how can we do so without unreasonably increasing the costs of services and devices?

Now, the Federal Communications Commission has traditionally tried to combat interference by regulating wireless transmitters and placing wireless services of a similar type in neighboring bands—like a city planner placing schools next to other schools and factories next to other factories. While that has generally been successful in the past, fitting additional users into existing spectrum is becoming more difficult with the accelerating rise of the new wireless technologies and services.

Recently, both the FCC and the President’s Council of Advisors on Science and Technology have taken a fresh look at the way we manage interference and suggested that we need to begin examining receiver performance to maximize our spectrum resources. This is in part because receivers are developed to meet current technological needs, not to anticipate a changing spectrum environment. They are built for the technology world of today or even a few years ago, which, as we know, will look very different in just a few more years. Again, we need to be prepared.

As a result, the FCC is increasingly either rejecting new users to protect existing ones or turning to guard bands—bands of restricted-use spectrum to physically separate the two licensed uses. Sometimes these guard bands are like digging a big, wide moat between neighbors when a simple fence will do. Neither rejecting new users, nor ordering large guard bands, is ideal if we intend to remain the world’s most innovative wireless community and economy.

Today’s witnesses include electrical engineers and a physicist with expertise in radio engineering. So I look forward to your guidance on how receiver performance strategies in devices as different as televisions, Smartphones, and GPS systems impact our ability

to put spectrum to its best use. I am also looking forward to your thoughts on how to strike a balance so we can accommodate new innovations in wireless technology without forcing manufacturers to waste time and money over-engineering receivers for unworkable future uses. Remember: spectrum equals jobs, and we must make sure it continues to remain a job-creation engine into the future. We must ensure that our policies promote continued growth and innovation in this sector without endangering our Nation's communications, commerce, and security.

We are also looking forward to the full report from the Government Accountability Office as we requested in our spectrum legislation, which is now law, as they look at this issue as well.

So, gentlemen, thank you for being here. I now would recognize the gentlelady from California.

[The prepared statement of Mr. Walden follows:]

Opening Statement of the Honorable Greg Walden
Subcommittee on Communications and Technology
Hearing on “The Role of Receivers in a Spectrum Scarce World”
November 29, 2012
(As Prepared for Delivery)

Good fences make good neighbors. Where I come from in Oregon, we know that's the case for crowded city blocks and sprawling ranches alike. In many places in my beautiful district, the land stretches for miles and running out of space isn't a problem. But in our digital world—in Oregon and around the country—we're running out of room. Demand for spectrum is far outpacing supply, and we need to figure out how to use the room we have as effectively as possible. In short, how do we create good, strong fences to make sure everyone stays within their spectrum bands so spectrum can be used as efficiently as possible?

Why is this important? Simple—spectrum equals jobs. Telecommunications is the most vibrant and innovative sector in America. Spectrum is the fuel that it runs on, but there's a limit to our supply. As our subcommittee continues to work to free up more spectrum, we are also focused on maximizing use of existing spectrum. We've taken a forward-looking approach—authorizing first-of-its-kind incentive auctions and taking a look at making government spectrum use more efficient.

This hearing focuses on receivers, and how interference issues can impact our ability to roll out new broadband services. While the controversy surrounding LightSquared and GPS is one example, we have seen similar debates involving a would-be broadband provider called M2Z networks, satellite radio, and unlicensed white-space devices. That this issue is starting to recur more frequently raises an important question: What engineering techniques and smart strategies are available to fit more mobile services in a crowded spectrum environment without having to carve out larger and larger guard bands—big, inefficient moats—to avoid interference? And how can we do so without unreasonably increasing the costs of services and devices?

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Recently, both the FCC and the President's Council of Advisors on Science and Technology have taken a fresh look at the way we manage interference and suggested that we need to begin examining receiver performance to maximize our spectrum resources. This is in part because receivers are developed to meet current technological needs, not to anticipate a changing spectrum environment. They are built for the technology world of today or even a few years ago, which, as we know, will look very different in just a few more years. Again, be prepared.

As a result, the FCC is increasingly either rejecting new users to protect existing ones or turning to guard bands—bands of restricted-use spectrum to physically separate the two licensed uses. Sometimes these guard bands are like digging a big, wide moat between neighbors when a simple fence will do. Neither rejecting new users, nor ordering large guard bands, is ideal if we intend to remain the world's most innovative wireless economy.

Today's witnesses include electrical engineers and a physicist with expertise in radio engineering. I look forward to their guidance on how receiver performance strategies in devices as different as televisions, smartphones, and GPS systems impact our ability to put spectrum to its best use. I am also looking forward to their thoughts on how to strike a balance, so we can accommodate new innovations in wireless technology without forcing manufacturers to waste time and money over-engineering receivers for unknowable future uses. Remember: spectrum equals jobs, and we must make sure it continues to remain a job-creation engine in the future. We must ensure that our policies promote continued growth and innovation in this sector without endangering or nation's communications, commerce and security.

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OPENING STATEMENT OF HON. ANNA G. ESHOO, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Ms. ESHOO. Thank you, Mr. Chairman. And my thanks to all of my Republican colleagues for your patience, as well as that of the witnesses and everyone that has come to this hearing today as the Democrats held their reorganizational caucus. And I had no idea that it would take the amount of time that it did, especially with unanimous nominations, but the speeches went on and on. So thank you again for your patience.

Mr. Chairman, harmful interference between adjacent spectrum bands is becoming the new spectrum crisis. As time in which demand for mobile broadband continues to skyrocket, ensuring that every megahertz of spectrum is used efficiently is as important as our ongoing effort to free up new spectrum bands. And our subcommittee I think has worked very, very hard on this certainly with the instruction of witnesses, our terrific staffs, and others as well.

What happened to LightSquared, a promising company with plans to inject new competition into the wireless broadband market, is disappointing. But unfortunately, that ship has sailed. What is just as unfortunate is that this isn't the first time in which an incumbent has raised the problem of receiver overload. Similar interference issues arose between cellular and public safety radio systems, as well as between satellite digital radio systems and proposed terrestrial data services.

These are tough issues. Consumers want their Smartphones and tablets to provide fast, reliable broadband service, but no one wants more expensive devices, a potential outcome of setting standards on receiver performance. If we successfully reconcile these competing goals, I believe consumers win, new entrants will have greater certainty before investing billions of dollars, and a thriving consumer electronics industry will not be unduly burdened.

Like most members of this subcommittee, I am not an engineer and I don't have the technical expertise to answer questions such as how much interference is tolerable, what the cost of imposing standards are on receiver performance, and if such standards were imposed, how many megahertz of unused guard bands could be repurposed for mobile broadband? Recognizing the importance of spectrum efficiency, we included a GAO study of receiver performance in the bipartisan spectrum bill, which was signed into law earlier this year. The results of this study, the work of the FCC's Technological Advisory Council (the TAC) along with the experts testifying before our committee today will guide us as we tackle these challenging questions and determine whether new legislation and FCC rulemaking or advancement in technology or a blend of these things—I don't know—are the appropriate path forward.

So thank you again, the patience of our witnesses. You got to stay longer in Washington. Oh, joy, is right. But we really appreciate your being here to be instructive to us. We thank you for your important work that you have done and what you will continue to do to promote spectrum efficiency.

And with that, I yield back, Mr. Chairman.

Mr. WALDEN. I thank the gentlelady for her opening statement and comments and now I turn to the vice chair of the subcommittee, Mr. Terry.

OPENING STATEMENT OF HON. LEE TERRY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEBRASKA

Mr. TERRY. Thank you, Mr. Chairman, for holding this important hearing on receivers. I can tell you that many in Nebraska are very upset that wide receiver Kenny Bell was not named All-Big Ten and have demanded a hearing for which I appreciate you calling.

Seriously, though, we have before us a policy that is especially difficult to solve. As recent disputes over interference clearly illustrate that the center of these conflicts is the question of who bears the cost of mitigating interference, the incumbent or the newcomer? This transaction cost is a big obstacle to efficient spectrum use. And the efficiency of spectrum use is so vital because spectrum is the lifeblood of the wide variety of wireless services that see ever-increasing demand. Spectrum, like valuable land, cannot lie fallow or else our economy really bears the cost.

The problem before us requires us to look closely at the costs involved with mitigating interference. I am very interested in hearing our witnesses' ideas about how best to handle these costs. If the FCC has a role here, what should it be? Whatever the answer is, I understand that our task is to ensure that the licensees are able to utilize their inputs effectively, but we must also avoid the trap of imposing inordinate costs on a single type of licensee or hampering innovative uses of spectrum.

I look forward to working with all of my colleagues and look forward to hearing from our witnesses.

Yield to the gentleman from Florida.

OPENING STATEMENT OF HON. CLIFF STEARNS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF FLORIDA

Mr. STEARNS. I thank my distinguished colleague from Nebraska and I welcome this hearing.

And this hearing is an important follow-up from the hearing of my Oversight and Investigations Subcommittee that I chair that was held in September and that examined the FCC's role in the LightSquared network. As we discussed during that hearing, LightSquared's billion-dollar investment has simply been put in jeopardy due to an overload interference issue that is caused by faulty receivers and GPS devices. I warned then that we must not let poor receiver standards result in more interference issues down the road. Therefore, I am very pleased that this subcommittee is closely examining the issue and beginning an important discussion in how we can address receivers going forward. It is extremely important.

I agree with the witnesses today that we should be wary of government mandates that would govern receiver designs. However, I do believe that more must be done to ensure maximum use of our spectrum.

So I look forward to their approaches and I yield back, Mr. Chairman. Thank you.

Mr. WALDEN. The gentleman yields back.

Mr. Latta or Mr. Guthrie, any comments before we go on? Seeing none, the time is yielded back.

Is there a request for time on your side, Dr. Christensen?

It doesn't appear we have any other Members seeking recognition at this time. So now we will move right—

Mr. TERRY. Note this date in history.

Mr. WALDEN. They have waited long enough. So let's start with Mr. Repasi. Thank you for being here from the Federal Communications Commission. We appreciate your testimony and look forward to your comments. And just kind of pull that mike close, make sure it is on, and then we will avoid any receiver or transmitter interference with your comments.

STATEMENTS OF RONALD T. REPASI, DEPUTY CHIEF, OFFICE OF ENGINEERING AND TECHNOLOGY, FEDERAL COMMUNICATIONS COMMISSION; PIERRE DE VRIES, SENIOR ADJUNCT FELLOW, SILICON FLATIRONS CENTER FOR LAW, TECHNOLOGY, AND ENTREPRENEURSHIP, UNIVERSITY OF COLORADO AT BOULDER; AND BRIAN MARKWALTER, SENIOR VICE PRESIDENT, RESEARCH AND STANDARDS, CONSUMER ELECTRONICS ASSOCIATION

STATEMENT OF RONALD T. REPASI

Mr. REPASI. Good afternoon, Chairman Walden, Ranking Member Eshoo, and members of the Communications and Technology Subcommittee.

My name is Ron Repasi and I am deputy chief of the FCC's Office of Engineering and Technology. OET is the Commission's primary resource for engineering expertise and provides technical support to the chairman, commissioners, and the FCC's Bureaus and Offices.

I appreciate your bipartisan interest in receiver standards and for this opportunity to testify concerning the role of receivers in enabling spectrum to be used for new and innovative communication services. I am pleased to report that the FCC's efforts to explore the issue in a comprehensive way that includes stakeholders and technical experts in both the Federal and private sectors.

There is no question that, without concerted action, the demand for mobile broadband spectrum would quickly outpace the available supply. The Commission has and continues to take numerous steps to meet this demand, including reallocating spectrum, fostering advanced spectrum sharing techniques, and promoting improvement in efficient spectrum use.

The Commission's spectrum management efforts have focused primarily on transmitters by establishing limitations on power and noise that they may generate outside their designated frequency bands while the performance of receivers has generally been left to the marketplace. Receivers are expected to operate within the same parameters as their associated transmitters. That is not always the case because sometimes receivers pick up energy outside of the spectrum provided for their service.

Receiver performance is becoming increasingly important as a limiting factor as we move to repurpose spectrum and pack more services closer together. The continuing challenge for the Commis-

sion will be to maximize the amount of usable spectrum for cost-effective deployment of new communication services while sufficiently protecting incumbent receivers. If receiver technology remains static or is unable to keep pace with the rapid evolution of transmission technologies, the challenges before the Commission will increase dramatically.

In 2003, the Commission initiated a Notice of Inquiry to consider incorporating receiver interference protection standards into spectrum policy on a broader basis. The proceeding was terminated in 2007 but the Commission found that nothing precludes it from evaluating the issues raised by parties in the context of other proceedings that are frequency band or service specific.

Over the past several years, receiver performance issues have arisen in certain band-specific instances as a conflict between legacy stakeholders and new entrants. The Commission is proactively addressing the issue of receiver performance and its impact on spectrum access for new services. Earlier this year, Chairman Genachowski initiated a review of spectrum efficiency and receiver standards with a two-day workshop at FCC headquarters, featuring a broad range of experts and stakeholders, including licensees, equipment manufacturers and consumers. Chairman Genachowski has also tasked the Commission's Technological Advisory Council to study the issue of receiver performance, and OET Chief Julius Knapp has been working with the TAC as it develops its recommendations. The TAC plans to finalize its recommendations at this upcoming December 10 meeting and then submit to the Commission those recommendations for consideration.

Commission staff participated as well in various technical groups organized by private sector entities and to discuss ideas about how to address receiver spectrum issues. Staff also met with filter and electronic component suppliers to discuss technology developments that hold promise for improving the interference rejection capabilities of receivers. These efforts by the Commission to gain a broader perspective on receiver performance have been conducted in tandem with OET's cooperation with GAO as it carries out the Job Creation Act requirements to the study receiver performance and spectrum efficiency. We look forward to the GAO report and consulting with Congress as we consider what next steps may be appropriate following release of the report.

Again, thank you for this opportunity to testify here today. We look forward to working with you and your staff to forge solutions to future engineering challenges. And I would be happy to answer any questions you may have.

[The prepared statement of Mr. Repasi follows:]

**Statement of
Ronald T. Repasi
Deputy Chief, Office of Engineering and Technology
Federal Communications Commission
Before the House Communications and Technology Subcommittee
Energy and Commerce Committee
U.S. House of Representatives**

“The Role of Receivers in a Spectrum Scarce World”

November 29, 2012

Good morning Chairman Walden, Ranking Member Eshoo, and Members of the Communications and Technology Subcommittee.

My name is Ron Repasi and I am the Deputy Chief of the Federal Communications Commission’s Office of Engineering and Technology (OET). OET is the Commission’s primary resource for engineering expertise and it provides technical support to the Chairman, Commissioners, and the FCC’s Bureaus and Offices. I have served as an engineer at the Commission in several capacities over the past 20 years. Prior to joining OET, I spent more than a decade in the Commission’s International Bureau where I helped secure global spectrum allocations for fixed and mobile satellite services at two ITU World Radiocommunications Conferences. I also supported the development of service rules for satellite operations, including provisions for shared

satellite and terrestrial spectrum use. In OET, I have served as the agency's representative to the Interdepartmental Radio Advisory Committee (IRAC), dealing with competing spectrum demands among federal and non-federal operators. I also work with our federal partners in other forums to develop new and innovative ways to deal with the need for more spectrum.

I appreciate your bipartisan interest in receiver standards, and for this opportunity to testify concerning the role of receivers in enabling spectrum to be used for new and innovative communications services. I'm pleased to report on the FCC's efforts to explore this issue in a comprehensive way that includes stakeholders and technical experts in both the federal and private sectors.

There is no question that, without concerted action, the demand for mobile broadband spectrum would quickly outpace the available supply. The Commission has, and continues, to take numerous steps to meet this demand, including reallocating spectrum, fostering advanced spectrum sharing techniques, and facilitating improvements in efficient use of the spectrum. The National Broadband Plan set an ambitious goal of freeing up 300 MHz of additional spectrum for reallocation or shared use for mobile broadband services by 2015. Indeed, the FCC has focused its efforts on several fronts to develop and create spectrum-use opportunities and is on track to exceed the 300-MHz-by-2015 goal.

The Commission has generally managed spectrum by focusing on transmitters as opposed to receivers. The Commission has traditionally identified the frequency bands in which various types of transmitters may operate and established limitations on their

power and the radio noise they may generate outside their designated frequency bands. The goal here is to prevent interference outside of the designated band by transmitters.

The performance of receivers has generally been left to the marketplace. Receivers are expected to operate within the same parameters as their associated transmitters. That is not always the case because receivers can sometimes pick up energy outside the spectrum provided for the service in which they operate. In establishing provisions for new services, the Commission often invites comment about any receiver issues that should be taken into account, particularly relative to legacy equipment. Where such issues arise, the Commission has addressed them in a variety of ways, such as establishing guard bands between the existing and new radio services, placing technical or operational restrictions on the new service, or requiring the new service to correct any interference that may occur.

Receiver performance is becoming increasingly important as a limiting factor as we move to repurpose spectrum and pack more services closer together on the spectrum chart. The continuing challenge for the Commission will be to maximize the amount of usable spectrum for cost effective deployment of new communication services while sufficiently protecting incumbent receivers. If receiver technology remains static or is unable to keep pace with the rapid evolution of transmitter networks, the challenges before the Commission will increase dramatically.

In 2003, the Commission initiated a Notice of Inquiry to consider incorporating receiver interference protection standards into its spectrum policy on a broader basis. The proceeding was terminated without prejudice in 2007 but the Commission concluded

that nothing precludes it from evaluating these issues raised by parties in the context of other proceedings that are frequency band or service specific. The comments during that process provided an important first step in focusing on the relationship between receiver performance and spectrum efficiency.

Over the past several years, receiver performance issues have arisen in some instances as a conflict between legacy stakeholders and new entrants where deployment of new technologies and services threatens to adversely impact an incumbent or place restrictions on the new entrant. Examples include interference issues between new cellular radio systems and public safety radio systems, proposed terrestrial mobile data services and satellite digital radio systems, new terrestrial wireless services and fixed satellite services, and ancillary terrestrial service in the mobile satellite service and GPS.

More recently, the Commission acted to address the issue of receiver performance and its impact on access to spectrum for new services. Earlier this year, Chairman Genachowski initiated a review of spectrum efficiency and receiver standards with a two-day workshop at FCC headquarters, featuring a broad range of experts and stakeholders, including licensees, equipment manufacturers and consumers. The workshop addressed the characteristics of receivers and how their performance affects the efficient use of spectrum and the development of new services. Key topics included current practices for receiver design, case studies involving interference due to receiver performance, and new approaches for promoting interference avoidance and efficient use of spectrum, given the current receiver base and potential future deployments.

Chairman Genachowski has also tasked the Commission's Technological Advisory Council (TAC) to study the issue of receiver performance, and OET Chief Julius Knapp has been working with the TAC as it develops its recommendations. The role of receivers in enabling access to spectrum for new services affects a broad range of stakeholders, from the federal as well as the private sector. An approach that is being discussed within the TAC is based on developing interference protection limits that would define what signal levels services would be expected to tolerate from adjacent services. A licensee would need to demonstrate that it is experiencing signal levels above the limit in order to make a claim of harmful interference. The TAC is considering whether the interference protection limits might be established through a multi-stakeholder process and whether rules would be appropriate.

What has been revealed in the TAC discussions is that the private sector has published receiver standards for many services, but such standards often are not developed in coordination with adjacent services, are not well known, or the basis for the standards is not well understood. Better awareness and coordination could improve this situation, perhaps championed by the private sector and with the FCC in the role of facilitator. The TAC plans to finalize its recommendations at its December 10, 2012 meeting and then submit them to the Commission for consideration.

Commission staff has also participated in workshops organized by the private sector to discuss ideas about how to address receiver spectrum issues. Staff has met with filter and electronic component suppliers as well to discuss technology developments that hold promise for improving the interference rejection capabilities of receivers.

These efforts by the Commission to gain a broader perspective on receiver performance have been conducted in tandem with OET's cooperation with the Government Accountability Office (GAO), providing support as GAO carries out the requirements of Section 6408 of the Middle Class Tax Relief and Job Creation Act of 2012 related to the study of receiver performance and spectrum efficiency. We look forward to the GAO report and consulting with the Congress as we consider what next steps may be appropriate following its release.

Conclusion

Again, thank you for this opportunity to testify here today. The Commission looks forward to working with you and your staff to forge solutions to future engineering challenges. I would be happy to answer any questions you may have.

Mr. WALDEN. Thank you very much, Mr. Repasi. We appreciate the good work of you and your staff and Julius Knapp down at the FCC. We have called upon you or Julius before for your engineering answers, and we appreciate all that you do down there.

We are going to go now to Mr. Pierre de Vries, Senior Adjunct Fellow, Silicon Flatirons Center, University of Colorado, Boulder. Mr. de Vries, thank you for being here. I appreciate your testimony and look forward to you offering it orally.

STATEMENT OF PIERRE DE VRIES

Mr. DE VRIES. Thank you, Chairman Walden, Ranking Member Eshoo, and members of the subcommittee. It is a pleasure and an honor to be here today.

Yes, I am the physicist. My name is Pierre de Vries. I have been involved in spectrum issues for about a decade and spent the last 4 years focusing on the issue that is the subject of this hearing today.

I laid out my testimony under four headings, and I would like to just summarize the key points: first, the “spectrum crunch.” The spectrum crunch that matters is the need to squeeze in evermore services into increasingly crowded spectrum, and that requires the ability to improve receivers and radio systems in general to tolerate interference in adjacent bands if they are in a given band. In this regard, I would like to compliment and commend you, Mr. Chairman and the committee, for your hard work on the incentive auction legislation. That was a vital step in extracting maximum value from this very scarce spectrum.

The FCC can also play its part, I believe, by drawing boundary lines more clearly. That is by clarifying both the rights that radio services have to be protected from harm and their responsibilities to tolerate reasonable interference.

Second, yes, receiver performance is key. Receivers in one band or in fact more accurately the receivers and the transmitters together as a system in that band—receivers that cannot tolerate reasonable levels of interference in an adjacent band unfairly impose costs on others and they reap the benefits themselves—for example, cheaper equipment. So far, as we have heard, the FCC has handled such interference almost entirely by placing the burden on the neighbor—for example, by reducing their transmit power sometimes to zero, effectively precluding the introduction of valuable new services. However, the receiving system operator also needs to bear some responsibility, but it needs to know what that responsibility is.

So third, I believe we can go a long way towards solving this problem by using harm claim thresholds, also known as interference protection limits or interference limits, and that is the proposal I am putting to you today. Harm claim thresholds state the interference levels in adjacent frequencies that a service needs to tolerate without being able to bring a harmful interference claim. No FCC-mandated receiver specifications or standards are required. Harm claim thresholds let manufacturers and operators figure out the best way to deal with interference—for example, by deploying suitable receivers.

Now, there may well be a few cases where harm claim thresholds won't be sufficient and additional measures, perhaps even mandated standards, may be unavoidable in a few cases, but they should be a last resort.

Finally, Congress and this committee in particular can play a decisive role by continuing to focus attention on this issue as you are doing by making clear that the FCC can use approaches that don't mandate receiver standards like the one I have mentioned and by funding the FCC to commission the engineering studies that are necessary to inform smart regulatory frameworks.

So Mr. Chairman, that concludes my testimony. Thank you again for inviting me today. I would be very happy to respond to any questions.

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

Testimony of
Pierre de Vries

Senior Adjunct Fellow, Silicon Flatirons Center for Law, Technology and Entrepreneurship
University of Colorado at Boulder

before the

House Committee on Energy and Commerce
Subcommittee on Communications and Technology

hearing on

“The Role of Receivers in a Spectrum Scarce World”

November 29, 2012

Chairman Walden, Ranking Member Eshoo and members of the Subcommittee on Communications and Technology, I am very pleased and honored to appear before you today to testify about the role of receivers in a spectrum scarce world. My name is Pierre de Vries and I am a Senior Adjunct Fellow 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 involved in spectrum issues for about a decade, first managing technology incubations and technology policy projects at Microsoft and then as a policy researcher. As co-director the Silicon Flatirons Center’s Spectrum Policy Initiative, I have organized, and participated in, a series of public conferences and expert working groups over the last four years that have brought together industry, policy makers, academics and civil society to develop solutions for the increasingly costly radio interference problems that we face, and that are the focus of today’s hearing.

While my testimony today is based on my experience and my current academic research interests, it reflects solely my own views. I am testifying today entirely on my own behalf as a private citizen.

This testimony makes the following points:

- *First*, the “spectrum crunch” that really matters is the need to squeeze ever more services into increasingly crowded spectrum, and that requires improving the ability of radio systems to tolerate reasonable signals in adjacent frequency bands.
- *Second*, receivers are key. However, it’s not just a matter of “better receivers,” but rather of creating the right incentives so that receiving systems, the combination of transmitters and receivers, can better tolerate interference.
- *Third*, setting harm claim thresholds, i.e. explicit limits on the interference that systems have to tolerate without being able to claim harmful interference, would allow the FCC to incentivize improved system performance without mandating receiver performance standards.
- *Fourth*, Congress can help by continuing to focus on this issue; by making clear that the FCC can use approaches that do not mandate receiver standards, like the one outlined here; and by allocating funding to the FCC for engineering studies.

1. The “spectrum crunch” that really matters is the need to squeeze ever more services into increasingly crowded spectrum, and that requires improving the ability of radio systems to tolerate reasonable signals in adjacent frequency bands

Radio services are recognized, more than ever before, as vital to creating jobs and building a better society. The key challenge is to squeeze more and more services, of increasing variety, into ever more crowded spectrum. However, greater proximity increases the risk of service breakdowns due to harmful interference, caused both by poor interference tolerance in receivers and by inappropriate signals radiated by transmitters. Inadequate receiving systems can impose costs on neighboring transmitters, just as much as transmitters can harm receivers.

Two wireless systems can operate simultaneously at the same time and place by using different frequencies. Each transmitter broadcasts on its designated frequencies, and their respective receivers tune to those frequencies by filtering out signals on other frequencies. If the filtering does not reject signals on other frequencies sufficiently well, the receiver will admit a mixture of desired and undesired signals and be unable to extract its own desired signal from the mix.

Interference is defined as “unwanted energy” in 47 CFR § 2.1(c); however, *harmful* interference only occurs when an unwanted signal “seriously degrades, obstructs, or repeatedly interrupts” a service. The amount of service degradation a receiver experiences is thus a combination of the strength of the unwanted signals delivered by the adjacent service, and the receiver’s ability to pick out its desired signal from the surrounding unwanted signals. The responsibility for harmful interference is therefore shared between transmitters and receivers.

The ability of receivers to tune out unwanted signals improves the further those signals are away from the desired frequency. Filtering out close-by signals adds cost. In the past, when more

spectrum was available and filtering was expensive, the preferred solution was to spread services out widely in frequency, and so economize on receiver cost. Now that spectrum is more crowded, this solution seems questionable in an increasing number of cases.

The policy challenge is to ensure that services that are affected by each other's signals have the appropriate information and incentives to find the appropriate levels of interference and mitigation. The old strategy, which was to avoid any possibility of interference, is increasingly problematic as we need to crunch ever more services ever more closely together. A better approach is to maximize the value of wireless services, taking into account the costs and benefits of interference, rather than simply minimizing interference as an end in itself.

It has therefore become increasingly important to incentive receivers to tolerate reasonable signals outside their authorized bands. I believe the most effective way the FCC can do this is by drawing boundary lines more clearly, that is, by clarifying radio services' rights to be protected from harm, and their responsibilities to tolerate interference.

While this is a key ingredient, it is of course not the whole story; we also need to make economically efficient assignments that facilitate the adjustment of rights where necessary, and we need more effective enforcement of rights disputes. However, I will focus only on rights definitions today.

2. **Receivers are key. However, it's not just a matter of "better receivers," but rather of creating the right incentives so that receiving systems, the combination of transmitters and receivers, can better tolerate interference.**

Poor receiver performance has limited the introduction of valuable new services, and has led to costly instances of avoidable harmful interference. Many examples come to mind, including the dispute over M2Z's proposed operation in the AWS-3 band adjacent to existing AWS-1 cellular service, the recent GPS/LightSquared matter, and the unexpected interference from AWS-1 cell towers into broadcasters' electronic newsgathering receive stations.

This problem has been well understood for quite some time. For example, in its comments on the 2003 Receivers NOI ("Interference Immunity Performance Specifications for Radio Receivers" ET Docket No. 03-65) the NTIA enumerated examples of "a number of instances of reported interference that could have been avoided if appropriate receiver standards had been applied." Similarly, the Spectrum Working Group of the FCC Technological Advisory Council summarized in its December 2011 white paper "a number of examples of situations where receiver performance was a significant issue affecting access to the spectrum for new services."

Wireless systems in one band that cannot tolerate reasonable signal levels in an adjacent band unfairly impose costs on others, notably the operators in those adjacent bands, while reaping the benefits themselves, for example by using cheaper receivers. This is not only unfair, but prevents the addition new wireless services that could foster innovation, improve public safety, and create jobs. Government has a legitimate role in seeking to limit such an unfair economic externality where one service stands to gain while their neighbor bears the cost.

So far, the FCC has handled such interference to a receiver due to signals from inside an adjacent band almost entirely by placing the burden on the neighbor, e.g. by reducing their transmit power, moving neighbors away from the band boundary, or requiring transmitters to provide additional filters for receivers.

However, it takes two to tango: both the receiving system and the transmitting system play a role. The receiving system that is being protected also needs to bear some responsibility. While this is often framed as a matter of “better receivers,” it is actually a system issue: in addition to using more robust receivers, an operator might also improve interference tolerance by increasing the strength of the desired signal at the receiver, and/or by moving their service away from the frequency boundary (aka internal guard bands).

An analogy can illustrate some of the issues. Imagine the property line between a two adjacent lots. (In the radio case, it would be a boundary between two frequency bands, not two geographic areas.) Everyone has to take some responsibility for tolerating sounds that come from their neighbors. If I live in a tent, I’m going to be very sensitive to noise from next door. One response, and a typical one in spectrum policy, is to make the neighbors keep their voices down, i.e. limit the allowed transmit power in the adjacent band or perhaps even prohibit transmission altogether. However, it seems unreasonable for me to demand that my neighbors always whisper when they’re in their own garden. I could also take some responsibility myself, for example by moving indoors; in radio terms, that’s analogous to adding receiver filters to exclude signals in the adjacent band. I could ask the person I’m talking with to speak more loudly or come into the same room so that I can hear them better, or I could go to a room on the other side of the house. The radio analogy would be to increase the desired radio signal level by increasing transmitter power or deploying more transmitters, or to move an operating channel away from the band boundary, respectively.

This example is a riff on the case of the doctor and the confectioner (*Sturges v. Bridgman* 1897) cited by Ronald Coase in his 1959 paper “The Federal Communications Commission.” In both cases, harm is reciprocal: avoiding disturbance to me by silencing my neighbors causes harm to them, and allowing them to make noise disturbs me. Receiving systems with inadequate interference tolerance can harm the interests of neighboring transmitters – the converse of the conventional assumption that it is always transmitters that harm receivers. As Coase suggested, the ideal solution is to give the parties well-defined rights so that they can find the optimal balance among themselves.

3. **Setting harm claim thresholds, a statement in the service rules that defines the signal levels a service needs to tolerate without being able to bring a harmful interference claim, would allow the FCC to incentivize improved system performance without mandating receiver performance standards.**

There are a variety of ways one can include the receiving systems into the interference trade-off. In addition to industry acting in its own interest, government agencies can, for example: improve designers’ knowledge of the interfering systems on the other side of a band boundary by making information about the standards used in adjacent bands readily available; encourage manufacturers to use more advanced technology through information dissemination, procurement rules, and stating the interference they need to tolerate; make interference claims contingent on meeting certain receiver performance standards; and mandate receiver performance levels in FCC rules and government procurement contracts.

A key tool, I believe, is for the FCC to state the interfering signal levels in adjacent frequencies that a service needs to tolerate without being able to bring a harmful interference claim; the NTIA

could use the same approach when managing federal spectrum assignments. This is the key to the proposal I am putting forward today.

It is useful to define terms when discussing receiver performance, since the expression “receiver standard” is used with many different meanings. I will use the term *receiver specification* to refer to any description of receiver performance requirements. Receiver specifications can be developed by any party, including individual manufacturers, customers, standard-setting organizations or government. The term *receiver standard* will refer to a receiver specification developed by a standard-setting organization, and the term *receiver mandate* will refer to refer to a receiver specification (which may or may not be a receiver standard, i.e. a specification developed by a standard-setting organization) that is required by rule or statute.

Mandating “better” receivers may be unavoidable in a few cases, such as where receivers are not controlled by a license holder, for life-safety systems, or for unlicensed devices, but should be a last resort. Receiver performance specifications are just one of many requirements needed to define a wireless system; others include specifications of transmitter performance, and the power, height and spacing of transmit antennas. These specifications result from trade-offs between many design requirements, including the nature of the service to be delivered, cost constraints, quality of service requirements, and the radio interference environment. Imposing receiver performance mandates requires the FCC to take a position on these trade-offs for every product and every allocation where they are required. A mandate necessarily embeds these design trade-offs in regulation; but while industry-defined receiver standards can evolve quite rapidly as technology changes, regulation changes more slowly. Last but not least, there are questions about whether the FCC currently has sufficient statutory authority to impose receiver mandates.

A better base-line solution is to set harm claim thresholds in service rules:

A harm claim threshold defines the interfering signal levels that must be exceeded before a service can bring a harmful interference claim.

This gives manufacturers and operators the information they need to figure out the best way to tolerate potentially interfering signals in adjacent bands, including by improving the performance of their receivers. For example, they can invest in high performance receivers that tolerate high levels of adjacent band noise even when their own received signals are weak; or they can deploy more basic receivers, but invest in increasing the level of their own received signals by deploying more transmitters.

In other words: Setting harm claim thresholds allows the FCC to incentivize improved system performance without imposing receiver performance mandates. A judicious choice of thresholds will incentivize better receivers without mandating them.

Setting harm claim thresholds has many benefits:

First, citizens benefit because more clarity about interference rights and better receivers will lead to valuable new commercial services being deployed in limited spectrum while protecting public safety and enhancing national security by improving resistance to both “friendly” interference and hostile jamming.

Second, setting harm claim thresholds delegates decisions about system design, including receiver performance, to manufacturers and operators. This gives them more flexibility, and reduces the need for the FCC to adjudicate interference disputes.

Third, explicit thresholds enable better planning and thus encourage investment in new services by more clearly stating the rights and responsibilities of services to tolerate interference from each other.

The implementation details of a harm claim threshold approach have been discussed elsewhere, e.g. in my paper “Optimizing Receiver Performance Using Interference Limits” delivered at the TPRC conference this year (<http://ssrn.com/abstract=2018080>). I note a few key points here:

First, a harm claim threshold is not a receiver performance mandate since it does not specify how a receiver should perform in the presence of interference. It merely defines the interfering signal levels that must be exceeded before a service can bring a harmful interference claim.

Second, the approach is not one-size-fits-all. An assignment’s harm claim threshold can be customized to reflect the current and expected performance of systems in this assignment, and those next to it.

Third, multi-stakeholder groups that include engineers from all affected parties at a band boundary can play an important role in developing the technical parameters and enforcement protocols for harm claim thresholds. The FCC’s role may be limited to encouraging the creation of such a group, and protecting the interests of future licensees and other absent stakeholders. The work of a multi-stakeholder group can be the basis for a rulemaking, should that be required.

Fourth, there may be cases where the initially assigned harm claim threshold is not economically efficient. For example, there might be net social gain if the threshold were increased, allowing increased transmit power and thus better service in the adjacent band. The FCC should allow parties to adjust the limit by negotiation among affected neighbors. If the Commission deems that there is no prospect of such negotiations being concluded successfully, it could put incumbents on notice that the harm claim threshold level will be increased step-wise over time.

Fifth, harm claim thresholds may not be sufficient in cases where receivers are not controlled by a license holder, for life-safety systems like aviation, or for unlicensed devices. Additional measures may be required to ensure that such receivers operate adequately in the presence of interference. One possible solution is to require that manufacturers *self-certify* that a receiver is fit for purpose in its envisaged use, e.g. that it will operate successfully given the prescribed harm claim thresholds. This could be done by individual companies, or collectively through an industry-certified “Seal of Approval.” Alternatively, the FCC may *condition* full interference protection on receivers meeting certain performance criteria, as it did in the 800 MHz Public Safety proceeding (2004 Report and Order in WT Docket 02-55). Finally, it may choose to *mandate* receiver performance levels in the same way that the Federal Aviation Administration requires that aviation radio receivers meet certain industry standards.

In conclusion: setting harm claim thresholds is a minimally intrusive way to incentivize better receiver system performance. If expectations about the interference tolerance of receiving systems had been set more clearly in the past, the lost opportunities and economic harms I cited above could have been reduced or avoided.

4. **Congress can help by continuing to focus on this issue; by making clear that the FCC can use approaches that do not mandate receiver standards, like the one outlined here; and by allocating funding to the FCC for engineering studies.**

Congress plays an important role in ensuring that government creates the right incentives for the public and private sectors to make the most of our limited resources. Smart regulation will maintain and advance American leadership in spectrum innovation. It can do so in at least three ways:

First, this Committee can keep attention focused on the problem through oversight hearings like these. Spectrum players face many concurrent challenges. It is always tempting to defer difficult strategic problems such as improving the interference tolerance of radio systems. Congressional oversight provides essential reminders that we cannot realize the full potential of wireless services without dealing with this problem now.

Second, it can make clear that the FCC can use the harm claim threshold approach, or others like it, without new statutory authority. Some doubt exists whether the FCC has the authority to regulate receivers under current rules. Setting harm claim thresholds avoids this difficulty by simply clarifying the definition of harmful interference definition already on the books (47 CFR § 2.1(c)), and leaving it up to industry players, individually or collectively, to decide on the receiver performance level that would meet these needs. Since harm claim thresholds do not regulate receivers, no additional authority is needed.

Third, Congress can provide the FCC with the resources to fund the engineering studies that can accelerate the development of such smart regulation. It is vital that the FCC develop its own expertise on such a key topic, and not rely entirely on partial, tendentious submissions by warring

parties. With additional funding, the FCC could commission technical consultants to develop harm claim thresholds for critical cases, such as terrestrial cellular next to satellite service, or adjacent services in the shared 3.5 GHz band. It could also address fundamental issues that underpin wise regulation: for example, how much more spectrum value can be achieved, at what cost, given various kinds and degrees of improvement in system design?

Mr. Chairman that concludes my testimony and 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.

Mr. WALDEN. Thank you, Mr. de Vries. We appreciate that. I was hoping you would give us your neighbor/tent analogy. I thought that really put it in perfectly understandable terms.

We will go now to Mr. Markwalter, who is the senior vice president, Research and Standards, at the Consumer Electronics Association. Mr. Markwalter, we appreciate your testimony and look forward to your comments.

STATEMENT OF BRIAN MARKWALTER

Mr. MARKWALTER. Thank you. Subcommittee Chairman Walden, Ranking Member Eshoo, and members of the subcommittee, on behalf of the Consumer Electronics Association, thank you for the opportunity to testify at today's hearing on "The Role of Receivers in a Spectrum Scarce World." My name is Brian Markwalter and I am senior vice president of Research and Standards at CEA.

CEA's more than 2,000 member companies include almost all the world's leading consumer electronics manufacturers and hundreds of small business. CEA and its members have a vital interest and an important role to play in ensuring the most effective and efficient use of spectrum.

As we continue to examine how to make the most efficient use of our Nation's spectrum, CEA believes that spectrum management must include an approach that examines the interaction between transmitters and receivers. This approach need not cause a shift from command-and-control spectrum management to command-and-control device regulation. The pillars of spectrum policy in a world of overcrowded airwaves must include better information about receivers in the field and their ability to tolerate interference, certainty on possible new allocations so that businesses and Federal spectrum users may make informed design and investment decisions, and primary reliance on stakeholders to find the cost and performance boundary between adjacent systems.

Equipment manufacturers and wireless service providers have a strong self-interest in developing and deploying devices that are resistant to forms of interference and to create as little interference as possible. Service providers require that their receivers meet very stringent design specifications to ensure non-interference.

Licensed mobile devices must meet applicable standards bodies' requirements prior to use by wireless providers. The two primary examples are the standards created by the Third Generation Partnership Projects. Industry has developed these standards to ensure the items such as reference sensitivity levels, receiver input levels, adjacent channel selectivity, and blocking characteristics are standardized and controlled.

Digital TV receivers provide another example of effective response by industry stakeholders to document the RF environment and the associated tradeoffs made by receivers to operate in the wide range of expected signal levels. The standard in this case ATSC Recommended Practice A/74. CEA believes that A/74 serves as a good starting point for the industry-to-industry dialogue as needed to complete incentive auctions and introduce new mobile broadband services as the upper adjacent neighbor to the TV band.

The debate over efficient use of spectrum has moved beyond knee-jerk reactions and entered a thoughtful, solutions-oriented

discussion in venues like the FCC's Technological Advisory Council. The early calls for government mandates on device design have faded as stakeholders have come to understand that such approaches are not the best solution we have to spectrum crowding. We look forward to a broader review of the soon-to-be-released TAC report.

As we work to mitigate interference between the services and receivers in adjacent bands, CEA offers the following principles to guide policymakers and industry:

First, reduce uncertainty. The ultimate goal of spectrum management should be to make the interference environment more transparent so that designers have all the information needed to deliver cost-effective products that allow more efficient use of adjacent bands.

Second, use voluntary performance principles and industry standards, not device mandates. Instead of adopting static regulations governing receiver design, we believe the FCC should allow industry to develop standards responsive to planned allocations.

Third, collect information. The FCC should continue to carefully inventory what services are operating in each band and work with industry and government users to understand the types of receivers deployed and their interference immunity characteristics.

Fourth, case-by-case analysis. Any regulatory action regarding spectrum allocations and receiver performance should be narrowly tailored to allow technological advancement. These principles are explained in more detail in my written testimony.

To conclude, CEA is encouraged by the numerous fresh ideas on spectrum policy and the concerted effort to free up spectrum for much-needed commercial use. We believe that the right regulatory approach to spectrum management leverages stakeholders' deep understanding of their system capabilities and price points in response to any government-articulated plans for future allocations.

I would be happy to answer any questions.

[The prepared statement of Mr. Markwalter follows:]

Before the
House Committee on Energy and Commerce
Subcommittee on Communications and Technology
U.S. House of Representatives

Hearing on “The Role of Receivers in a Spectrum Scarce World”

Testimony of
Brian Markwalter, Senior Vice President, Research and Standards
Consumer Electronics Association (CEA)

November 29, 2012

Subcommittee Chairman Walden, Ranking Member Eshoo and members of the committee, on behalf of the Consumer Electronics Association (CEA), thank you for the opportunity to testify at today’s hearing on “The Role of Receivers in a Spectrum Scarce World.”

CEA’s more than 2,000 member companies include almost all of the world’s leading consumer electronics manufacturers and hundreds of small businesses. CEA’s members design, manufacture, distribute, and sell a wide range of consumer products including televisions, smartphones, tablets, computers, digital video recorders (“DVRs”), game consoles, navigation devices, music players, cordless telephones, radios, and products that combine a variety of these features and pair them with services. CEA and its members have a vital interest and an important role to play in ensuring the most effective and efficient use of spectrum.

As we continue to examine how to make the most efficient use our nation’s spectrum, CEA believes that spectrum management must include an approach that examines the interaction between transmitters and receivers. We refer to this as a “systems approach.” This view, which is aligned with the most recent thinking among the many experts working on the subject, need not cause a shift from “command and control” spectrum management to “command and control” device regulation. The pillars of spectrum policy in a world of over-crowded airwaves must include: (1) better information about receivers in the field and their ability to tolerate

interference; (2) certainty on possible new allocations so that businesses and federal spectrum users may make informed design and investment decisions; and (3) primary reliance on stakeholders to find the cost and performance boundary between adjacent systems.

When one considers the vast number of receivers that are operating in a myriad of bands, there has been a remarkably low incidence of reported harmful interference. As spectrum resources become crowded, however, industry is incentivized to design and deploy highly robust transmitters and receivers. To do so, and to reduce the risks of interference, government and industry must also work to more carefully define the environment in which these systems operate. Some adjustments to spectrum policy must be made to facilitate repurposing spectrum going forward.

To be clear, equipment manufacturers and mobile providers have a strong self-interest in developing and deploying devices that are resistant to forms of interference and devices that create as little interference as possible. The limited amount of available spectrum combined with the high cost of spectrum and the dynamic interference environment faced by the industry incentivizes the development of efficient and robust receivers.

For an example of this market and technical reality, commercial mobile service providers require that their mobile receivers meet very stringent design specifications to ensure non-interference and efficient use of spectrum. Similarly, manufacturers of devices using unlicensed spectrum must ensure their receivers are not susceptible to interference, while still efficiently using the available spectrum. The technology used by licensed and unlicensed mobile devices is state-of-the-art and extraordinarily robust. Indeed, the interference and operational environment faced by mobile devices requires highly advanced receivers to ensure proper operations and, in the case of unlicensed devices, to operate on a secondary, non-interference basis.

Licensed mobile devices must initially meet applicable wireless standards bodies' requirements prior to use by wireless providers. The two primary examples are the standards created by the *Third Generation Partnership Projects* known as 3GPP and 3GPP2. Industry has developed these standards to ensure that items such as: (1) reference sensitivity levels; (2) receiver input levels; (3) adjacent channel selectivity; and (4) blocking characteristics are standardized and controlled. Moreover, these requirements are extremely stringent to protect licensed providers from harmful self-interference as well as adjacent band interference from other operations. However, just designing and building equipment to meet internationally recognized industry requirements is not the final step for licensed mobile devices. Next, an industry-driven certification process must certify them. Finally, licensed mobile devices are put through rigorous interoperability tests by the individual wireless providers to make certain that the device, including the receiver, is operating as intended, in an effective and robust manner.

Digital TV receivers provide another example of effective response by industry stakeholders to document the RF environment and the associated tradeoffs made by receivers to operate in the wide range of expected signal levels. The standard in this case is *ATSC Recommended Practice: Receiver Performance Guidelines*, known as ATSC A/74. Broadcasters, TV manufacturers, tuner designers and chip suppliers all contributed to the development of A/74. Manufacturers inform us that A/74 is an important part of the design input as they develop and test TV receivers. A/74 captures an understanding of the broadcast reception environment in which received signal strength varies tremendously and the desired TV channel may be considerably weaker than adjacent channels. CEA believes that A/74 serves as a good starting point for the necessary industry-to-industry dialog that is needed to complete incentive auctions and to introduce new mobile broadband services as the upper adjacent neighbor to the TV band.

As evidenced by this hearing, the debate over efficient use of spectrum has moved beyond knee-jerk reactions and entered a thoughtful, solutions-oriented discussion in venues like the FCC's Technological Advisory Council (TAC). The early calls for government mandates on device design have faded as stakeholders have come together to understand that such approaches are not the best solution we have to spectrum crowding. Instead, we should allow innovation to deliver remarkable efficiency gains. Experts are now actively working on policy tools that leverage demonstrated successes, like industry-developed standards, and developing new approaches such as interference limits that add receivers to the spectrum management equation. These approaches still need to be captured in greater detail and circulated to industry and government users of spectrum beyond the FCC TAC, but they are a welcome work in progress.

As we work to mitigate interference between the services and receivers in adjacent bands, CEA offers the following principles to guide policymakers and industry:

1. **Reduce Uncertainty.** The ultimate goal of spectrum management should be to make the interference environment more transparent, so that designers have all the information needed to deliver cost-effective products that allow more efficient use of adjacent bands.
2. **Voluntary Performance Practices and Industry Standards, Not Device Mandates.** Instead of adopting static regulations governing receiver design, we believe the Federal Communications Commission (FCC) should outline the environment in which it expects receivers to operate. Inappropriate regulations reduce flexibility for innovation in an area that is inherently vibrant. The FCC should encourage industry, through voluntary standards-setting organizations, to lead efforts to create voluntary receiver performance guidelines based on projected spectrum environments. Technical experts from the

affected parties involved in new band allocations need to be at the table working to balance system requirements before final rules are in place.

3. **Information Collection.** The FCC should continue to carefully inventory what services are operating in each band and identify bands that are likely to be the target of tighter allocation. Further, whenever the FCC takes action to reallocate spectrum, it should take an inventory of what services and receivers are operating in adjacent bands. When reviewing merger and license applications, the FCC should seek public comment regarding existing services and receiver use. Industry and government users have a role to play in helping to understand the types of receivers deployed and their interference immunity characteristics. Better information on fielded equipment is one of the pillars of spectrum policy that needs more attention.
4. **Case-by-Case Analysis.** Any regulatory action regarding spectrum allocations and receiver performance should be narrowly tailored. Further, any such action must be technology neutral and flexible; allowing for technological advancement and a robust marketplace for receivers. Receivers which fully resist interference maybe be technically possible, but they also maybe unaffordable. As much as we would all like a simple, new policy approach to forever preclude incidences of interference, history says that the interactions are too complex to prevent with a single approach.

To conclude, CEA is encouraged by the numerous fresh ideas on spectrum policy and the concerted effort to free up spectrum for much needed commercial use. Every new use of spectrum and re-allocation has some degree of uncertainty as to its future impact. We believe that the right regulatory approach to spectrum management leverages stakeholders' deep understanding of their system capabilities and price points in response to any government-

articulated plans for future allocations. We look forward to reviewing the results of this year's FCC TAC efforts on spectrum efficiency and to actively participating in all regulatory processes.

Mr. WALDEN. Mr. Markwalter, thank you for your very thoughtful testimony. We appreciate your being here today as well.

I will lead off with the questions and I will start with you just as you were giving your testimony and certainly, Mr. de Vries. What did you think of Mr. de Vries' proposal for our consideration regarding the harm claim threshold notion of how you might—I won't say regulate in this space—but provide guidance in this space? Is that something CEA would be interested in? Is that something you see as workable?

Mr. MARKWALTER. Yes, well, we are definitely interested. And we should confess we are both on the TAC and so we are both working this issue very carefully, the interference limits approach. There are a lot of details to be worked out yet.

Mr. WALDEN. Um-hum.

Mr. MARKWALTER. What is very appealing about the approach is it allows the problem to be stated and doesn't go directly to the solution. So as Pierre, described, it sets up the environment and allows—

Mr. WALDEN. A framework.

Mr. MARKWALTER. A framework.

Mr. WALDEN. Yes.

Mr. MARKWALTER. And, you know, leaves in the hand of the users to build equipment to meet those needs rather than going directly to solutions by dictating specific device performance. There are some complicated issues yet to be worked out about how you would, you know, establish the limits—

Mr. WALDEN. Um-hum.

Mr. MARKWALTER [continuing]. To begin with in different use cases but—

Mr. WALDEN. I appreciate that and I want to encourage the TAC and its work and you two, since you are here in public and not back in your TAC world, to continue because while trying to break loose spectrum is one of the most enjoyable tasks we have here on the subcommittee. It is simple and easy and there is never any—well, there is a limit what we can do. And so we are going to be looking at all these efficiencies.

Mr. de Vries, the growing need to place varied wireless services in neighboring spectrum bands has prompted the FCC to increasingly rely on guard bands, and that is something that I really want to drill in a bit here. How efficient a solution is that? One of my underlying questions I guess is how much guard band, how much spectrum lies fallow because we have this problem between transmitter and receiver? Can you kind of address that piece of this? And does anybody know how much that is? That is not calculated, I assume.

Mr. DE VRIES. Mr. Chairman, I think the answer to it is how long is an elastic band? It depends on how hard you pull it. To go back to the levels analogy, so let's say I have got a receiver in this band—

Mr. WALDEN. Um-hum.

Mr. DE VRIES. If I set the level of the maximum interference that it can tolerate very low, that is effectively a guard band.

Mr. WALDEN. Right.

Mr. DE VRIES. Right? If I set it very high, it is not. And choosing exactly where—

Mr. WALDEN. Right.

Mr. DE VRIES [continuing]. One chooses that level influences how much you free up.

Mr. WALDEN. Got it.

Mr. DE VRIES. And so that decision, which the way we are thinking on the TAC probably—the discussion starts amongst engineers in a multi-stakeholder space—may end up at the FCC. But where that number is set influences how much more we can squeeze in.

Mr. WALDEN. Right. OK. Well, you know, in my background I was in the radio broadcast business 22 years and a licensed amateur radio operator and so I played a little in this. And you know, we had to limit our transmission, can have this exposure and, you know, we all argued about how sloppy the front ends are on AM receivers, you know, and all the interference you get from power lines and everything else. And so it just has always struck me that there is ability to improve in that side of the equation. So I appreciate that.

Let me go to Mr. de Vries. In the license context there is a licensee on the hook at the FCC that has an ongoing relationship with both the subscriber and the manufacturer.

Mr. DE VRIES. Um-hum.

Mr. WALDEN. The licensee can try to get a solution deployed in the marketplace, but when there is no licensee, as was the case with the GPS device problems in the LightSquared case, it is a lot harder to identify and help the individually impacted customers. So what do you think the remedy is in such cases short of prohibiting or limited the proposed new service? Do we need to treat these situations differently from the licensed ones? Do we need to be particularly careful where and how we deploy such devices?

Mr. DE VRIES. I think one definitely needs to pay additional care to these cases for exactly the reasons that you state. I think that there are a variety of possible solutions on offer, and the ones that are chosen depends on one's assessment of the risk. So the simplest solution is to say we will set the harm claim thresholds and we will assume that it is a well run industry with a lot of consensus and they will come up with industry standards and they will sort it out.

On the other hand, if one has less appetite for risk, you could say we are going to require manufacturers to self-certify, not have the government tell them how to build their devices, but say it is going to work. And then thirdly, and that is the last resort that may be necessary for there to be mandated standards for particular kind of devices.

Mr. WALDEN. OK. My time has expired. Before I turn over to my ranking member and friend from California I just want to say publicly that the chairman of the FCC was very helpful to me during the LightSquared GPS issue by making Julius available for a closed-door meeting of engineers from both sides. The poor legal folks and lobbyists were, you know, apoplectic on the sidelines but we tried to drill down in this space: is there an engineering solution here? Are there notch filers? Are there other things you can do in this space? So I appreciated his willingness to let us do that.

I turn now to my friend from California.

Ms. ESHOO. Thank you very much, Mr. Chairman.

And thank you again to the witnesses not only again for your patience but your excellent testimony, too. It is on a very important subject.

Before I begin with the questions, I would just like to ask—and you don't have to do it now—but in the majority's memo for today's hearing it states that the PCAST report recommended the establishment of minimum technical standards for receivers, and I would just like to know where in the report it says that? We don't find it, and as we are talking about whether there should be or shouldn't be and how much, I think that it is important to have that clear. So it is in the memo but we don't find it in the PCAST report. But you can get that to us?

Mr. WALDEN. Yes, I didn't—

Ms. ESHOO. Yes, afterward. All right?

Mr. WALDEN. We will be happy to find it.

Ms. ESHOO. But I think it is a semi-important point.

To Mr. de Vries, you have been an advisor, you know, to PCAST, to the President's Council of Advisors in Science and Technology. Can you describe how government users would benefit from establishing objective criteria for harmful interference conditions? And just be as brief as you can because I want to get through the panel.

Mr. DE VRIES. Um-hum. I think government users would benefit by there being clearer criteria for what counts as harm, which means they would be able to engineer their systems to be more interference-tolerant, jamming-tolerant.

Ms. ESHOO. And by putting in place what you just described, does this require technological advances? Are there costs to it? And how open would the defense community be to it do you think, I mean in your estimation, because that is really the largest nut to crack I think.

Mr. DE VRIES. The setting of the threshold is just a number. And the engineering that is required is left to industry.

Ms. ESHOO. Um-hum.

Mr. DE VRIES. I can't speak for the DOD. I would observe I think that one of the benefits of having clearer fences is that it makes sharing or coexistence more feasible, which means that it is less necessary perhaps to relocate and clear.

Ms. ESHOO. Um-hum.

Mr. DE VRIES. They may find that attractive.

Ms. ESHOO. Um-hum. Thank you.

Mr. Repasi, thank you again for your fine work and for being here. We have heard today that in reallocating spectrum, the FCC should consider an inventory of services and receivers that are operating in adjacent bands. Does the FCC do this today? And if not, from an engineering perspective, would this information help you to better anticipate potential concerns with harmful interference?

Mr. REPASI. Thank you. Currently, the FCC does not collect an inventory of receives that are in adjacent bands. We rely on—

Ms. ESHOO. How do you know?

Mr. REPASI. We rely on the information that is supplied in the course of our rulemakings. Manufacturers who have concerns about interference, whether it is on a band or overload interference, will

supply technical information to support their arguments on what their threshold—

Ms. ESHOO. I mean, wouldn't it be in the interest of whomever is the applicant to bring forward what is advantageous to their case and then you rely on that?

Mr. REPASI. That is correct. The earliest possible opportunity, of course, would be when the Commission issues a proposal for a new rule, whether it—

Ms. ESHOO. I think that is a little squishy, don't you?

Mr. REPASI. Well, that is the first opportunity.

Ms. ESHOO. Well, I mean you may not want to say yes to that, squishy, but I mean, you know, in this town people obviously are going to advance and I think it is human nature to advance the best case possible, to advance your case. But if the information you are using is just that, it could be biased and that is what I am concerned about. But maybe I am off on the wrong track on this.

Mr. REPASI. But that information would go into what proposals we present and we seek comment on those. And if there were assumptions that we made that are challenged by the public, we take that information into account. And usually, supporting technical material is supplied in our record to support the challenge to our assumptions.

Ms. ESHOO. Thank you very much.

Mr. Markwalter, thank you again for what you do. You suggested in your testimony that equipment manufacturers have a strong self-interest in developing and deploying products that create as little interference as possible. I agree, but is this a problem that has been many years in the making? I mean to help expedite a long-term solution, would you support the FCC reopening the formal proceeding on the matter? Does it need that?

Mr. MARKWALTER. So I think given the time that has passed and the amount of work that is even currently underway—

Ms. ESHOO. Um-hum.

Mr. MARKWALTER. I would recommend we wait for the TAC report to come out and see—

Ms. ESHOO. Um-hum.

Mr. MARKWALTER [continuing]. What work is teed up for the TAC next year, because I think the interference limits, this notion of clarifying rights and expectations is being addressed pretty thoroughly.

Ms. ESHOO. Um-hum.

Mr. MARKWALTER. So I would leave it at that. I think there is plenty of work—

Ms. ESHOO. Um-hum.

Mr. MARKWALTER [continuing]. For the industry yet to do in that environment.

Ms. ESHOO. Thank you. That is most helpful. Thank you to each witness.

And thank you, Mr. Chairman.

Mr. WALDEN. You are welcome.

The Chair now recognizes the gentleman from Nebraska, the very able vice chair of the Subcommittee on Communications and Technology, Mr. Terry.

Mr. TERRY. Well stated, just like I wrote it.

Thank you, Mr. Walden, for your able leadership over the last 2 years. And certainly the receiver issue is one that you have mentioned many, many times and I am glad we have this hearing.

I am intrigued, Mr. de Vries, about this harm claim threshold standard. It is almost a libertarian type of view in how to resolve this issue. I have to work in examples, so the first issue that I have is how do we resolve the incumbent receiver? And so using the GPS versus LightSquared issue, using the harm claim threshold, tell me how that would require or force GPS receivers to upgrade to be able to better filter out the delete over interference?

Mr. DE VRIES. The way I anticipate this might work is when you start, you are going to have a lot of devices out there. We are beginning a transition. So the thresholds would be set very low. So I am the GPS receiver, very low interference threshold so that all the existing receivers are protected. That may be so low that no service can be deployed. The FCC might then say or industry might agree that 10 years from now it goes up to here at which point these receivers have 10 years to build filters to accommodate this increased signal.

Mr. TERRY. All right. That is interesting. How would they know how to predict what type of interference or level of interference could occur in 10 years? So in a sense would the FCC have to come back and say, hey, there is this new standard? So now we are getting back to the standards issue. So is that the way it would work? Because right now, these GPS folks can just say we don't have any reason to move.

Mr. DE VRIES. I am so glad you asked that question, sir, because I wasn't clear. So the harm claim threshold doesn't attempt to describe the actual interference environment.

Mr. TERRY. All right.

Mr. DE VRIES. It simply says if the interference is below this number, you cannot claim harm.

Mr. TERRY. OK.

Mr. DE VRIES. If it is above the number, then you can. So the FCC does not get into the business of trying to predict what the environment will be.

Mr. TERRY. But just where the threshold would be, the harm threshold—

Mr. DE VRIES. Yes.

Mr. TERRY [continuing]. Would still be set by the FCC?

Now, Mr. Repasi, add a layer then on the involvement in this plan of the FCC. How long would it take for the FCC to establish a harm claim threshold and what would be the processes to get there?

Mr. REPASI. Thank you. Well, as we know, currently, the TAC is debating on how to flesh out this approach and provide formal recommendations to the Commission. We also have the GAO that is reviewing spectrum efficiency standards, and that report is due by February of next year. We, of course, would have to take the recommendations from the TAC and then the recommendations—

Mr. TERRY. Well, for further questions let's just assume that TAC recommended an approach like the harm claim threshold.

Mr. REPASI. Right. It would come down to where we would apply it first. If it is applied in a specific case, we would have to deter-

mine who the neighbors are before we could adjudicate whether the harm claim threshold is sufficient to protect the existing services, let alone services that are—

Mr. TERRY. So it would still have to be done on a per-device level?

Mr. REPASI. I think it would still have to be on a case-specific, band-specific basis, yes.

Mr. TERRY. OK.

Mr. REPASI. Because the interference to a receiver that is looking into space for example, may be a much lower threshold than for a receiver that is communicating with a broadband advanced wireless system.

Mr. TERRY. Some of the earlier discussions amongst us is that the FCC preferred more of a standards-based. I would assume the thinking would be that on a standards-based, then it is clear; everyone knows what they have to manufacture to or engineer up to. Any thoughts that you could share with us? Is that where the FCC is? Are they waiting for the report to come out?

Mr. REPASI. I think we are waiting for the report to come out. We want to make sure we have all the facts in line before we come out with a specific proposal on how to implement some of the recommendations, including from the GAO. So I think we are a little bit of a wait mode. But nonetheless, we want to be sure that we don't curb innovation. We did have that 2003 NOI that we released. We got a lot of good comments from the industry. Some of the comments still remain today. The sentiment still remains the same. And there was concern expressed in the record there that standards could equate to curbing innovation, and we want to be careful not to be in a position to stop innovation.

Mr. TERRY. All right. Thank you.

Mr. WALDEN. The gentleman's time is expired.

Turn to our friend from the Virgin Islands, Dr. Christensen.

Mrs. CHRISTENSEN. Thank you, Mr. Chairman.

And again thank you for your patience with us today.

I guess I would ask this question to the panel but beginning with Mr. Repasi because I know you are familiar with NTIA's work in the role of receivers in managing spectrum for Federal users. Do you or any of the other panelists think that there are lessons that we can learn from NTIA's approach to setting Federal receiver standards?

Mr. REPASI. Thank you. Yes, I believe you are referring to the NTIA study document that was produced in the 2003 time frame as well, and they listed several types of standards for the fixed and mobile systems that were operating through a range of spectrum. That of course is helpful to know where things are on the Federal side as far as where they operate and what their thresholds are for interference so that when we do get into looking at new uses of spectrum that involve Federal users, we at least know what the starting point is.

Mrs. CHRISTENSEN. Any other comments from anyone else? So I will just go on to another question.

Mr. DE VRIES. The one thing that I learned from that report was how complicated receiver specifications become and how service-specific they are and that they intend to imbed assumptions about

how things work today into requirements that then live on perhaps for life.

Mrs. CHRISTENSEN. And as things change and new innovation. Just if you wanted to comment.

Mr. MARKWALTER. Thank you. And I agree with that. It is a good reference point but a Federal user is both user and procurer, you know, manages everything about it. In a commercial case, the allocations are done by the FCC but equipment may be purchased by a licensee or may be done independently. So there are a lot of parts at work that doesn't map over from Federal use to commercial use.

Mrs. CHRISTENSEN. And Mr. Markwalter, what tools do you think are currently available to the FCC to incentivize and improve receiver standards?

Mr. MARKWALTER. Yes, so I know we are all kind of falling back on the TAC report. I think there are some good things that will be documented in the TAC report. The FCC right now, you know, clearly can articulate the emissions side. It is less clear what the authority is on regulating receivers. And, you know, as we have said, we probably need to see what the exact tools are being proposed before we decide whether that is the right amount of authority or not. And then as the previous cases show, they have the ability to go in and work with users in adjacent bands and figure things out, but the evidence I see is that the best case is when the adjacent users, even if they are in conflict because the problems are typically so technical and so case-specific, if they can bring a solution to the FCC, that seems to be the best outcome.

Mrs. CHRISTENSEN. OK. So that was my next question which I was going to pose to Mr. de Vries. What role do you think manufacturers of receiver devices should play in setting performance levels or defining a reasonable level of interference?

Mr. DE VRIES. I think manufacturers do that as part of their business. The discussion about what a good receiver is is a negotiation between the provider and their customer and that that is what happens when industry sets standards or when purchasers like the Federal Government do it.

Mrs. CHRISTENSEN. OK. Thank you, Mr. Chairman. I will yield back the balance of my time.

Mr. WALDEN. I thank the gentlelady for yielding back.

I think we have each got a few other questions to ask.

I am going to throw one out that is just slightly outside of what we came here to talk about but it plays into it a bit, and that has to do with the notion of efficient use of spectrum as opposed to just interference use. But do you all look at things like how much spectrum there might be or more usage capability if you have, for example, interoperable devices in the cell phone world? Does LTE and that sort of thing, does that begin to merge all that in when you are looking at total number of users versus total amount of spectrum? I mean do you all get into those discussions?

Mr. de Vries?

Mr. DE VRIES. Chairman, I grin because I have great difficulty with the concept efficient use of spectrum.

Mr. WALDEN. OK.

Mr. DE VRIES. I don't know what it means. To me maybe because I am a geek, efficiency is a ratio. It is what you get out for what you put in.

Mr. WALDEN. Um-hum.

Mr. DE VRIES. The number of frequencies that you put in is not the only input.

Mr. WALDEN. Um-hum.

Mr. DE VRIES. There are things like investment costs—

Mr. WALDEN. Um-hum.

Mr. DE VRIES [continuing]. Infrastructure costs, deployment costs, and I think what I try to focus on is how do we maximize the value of radio services.

Mr. WALDEN. OK.

Mr. DE VRIES. And in fact that is somewhat of a change from what we have traditionally done, which is how do we minimize interference if we need to maximize value?

Mr. WALDEN. All right. Now, bring that down from your physicist level. You know, we work better with pictures—

Mr. DE VRIES. Yes.

Mr. WALDEN [continuing]. And small words. So tell me what that means for us as policymakers. I mean, from your perch, from your big-brained perspective, what is it we can do in this space? I mean we all talk about crisis and spectrum. There is spectrum out there right now. I think this is a down-the-road spectrum crisis and hopefully technology eclipses that. But what is it that we should be looking at that we are not?

Mr. DE VRIES. I think the first thing I would say is that you have to keep all our noses to the grindstone.

Mr. WALDEN. That is what we are here for.

Mr. DE VRIES. As you have said, it is a long-term problem and everybody's tendency is to punt and not deal with the long-term ones because there are lots of short-term hard problems.

Mr. WALDEN. Um-hum.

Mr. MARKEY. It is not just us, sorry, that likes to punt things.

Mr. WALDEN. So what should we be looking at specifically?

Mr. DE VRIES. What I, of course, would be saying is two things: one, to focus on encouraging the FCC to set these clear boundaries—

Mr. WALDEN. Um-hum.

Mr. DE VRIES [continuing]. Because I have ended up thinking about interference limits as the minimal effective step that we need to take to make progress on this problem.

Mr. WALDEN. Um-hum.

Mr. DE VRIES. And I think part of that is to, if you can, remove any uncertainty that the FCC has the ability to do that because there have been doubts about FCC authority regarding receiver standards. These are not receiver standards; therefore, they should be able to move ahead.

Mr. WALDEN. OK. Mr. Markwalter, do you have some comments along these lines?

Mr. MARKWALTER. I don't think I have much to add. There are some people who are looking at the question of the complexity of band plans, especially for cell phones—

Mr. WALDEN. Um-hum.

Mr. MARKWALTER [continuing]. Which is sort of related to what you are talking about. One of the things that inhibits phones that can be used across a lot of different carriers and a lot of different bands is the fact that, you know, as we find more spectrum, it is not all together—

Mr. WALDEN. Right.

Mr. MARKWALTER [continuing]. Anymore. It is scattered around. And so there is a separate part of the TAC working on that issue as—

Mr. WALDEN. Sort of—

Mr. MARKWALTER [continuing]. It is sort of an unrelated problem.

Mr. WALDEN. Right.

Mr. MARKWALTER. You know, we conjecture that, you know, there is a time in the future where technology gets better and better where receivers can be more agile so—

Mr. WALDEN. Um-hum. So you can skip across the bands and still—

Mr. MARKWALTER. Correct. And we are clearly not there yet—

Mr. WALDEN. Um-hum.

Mr. MARKWALTER [continuing]. And we are having some discussion about how accurately we could project when that would happen. And really what you would like to do is have receivers that are cost-effective that can be agile in the future; then, you have got a shot at changing allocations.

Mr. WALDEN. All right. Thank you.

Once again, I am going to turn to Ms. Eshoo.

Ms. ESHOO. Thank you, Mr. Chairman. I will be as brief as possible. I just have three quick questions to ask Mr. Repasi and yes or no will do.

I would like to ask you to address the question that has been raised about the need for guard bands if receiver filters can dramatically improve spectral efficiency. Do you think based on today's filter technology that guard bands can be eliminated as an interference mitigating solution? Yes or no? No.

Mr. WALDEN. Turn on your mike.

Mr. REPASI. I am sorry. No, I don't think they can be eliminated in all cases when you have two adjacent services.

Ms. ESHOO. Are you seeing any leaps in improvement of filter technology for public broadband services?

Mr. REPASI. Seeing leaps, no; seeing improvements, yes. Filter technology is improving. As I mentioned in my testimony, we have met several times with equipment manufacturers and component designers, and at the component level, there are improvements being made mainly because of the demand for more broadband services. The demands are being placed on the component designers to come up with better filters that are sharper and able to better deal with interference issues because they have got the spectrum congestion issues.

Ms. ESHOO. So in the foreseeable future we still need guard bands to separate mobile broadband services from adjacent services like over-the-air broadcast television?

Mr. REPASI. Yes. With current technology, even in the PCS world where they are going to 4G deployments with LTE—

Ms. ESHOO. Um-hum.

Mr. REPASI [continuing]. Remember, you have downlinks in one band and uplinks in another—

Ms. ESHOO. Uplinks in the others, um-hum.

Mr. REPASI [continuing]. With frequency division duplex technology—

Ms. ESHOO. Um-hum.

Mr. REPASI [continuing]. Where there is a duplexer spacing in between the two out of necessity because the up- or downlink channel could interfere with the lower uplink channel if there is not sufficient—

Ms. ESHOO. Um-hum.

Mr. REPASI [continuing]. Separation between the two. That is the equivalent of a guard band.

Ms. ESHOO. Um-hum.

Mr. REPASI. And this is with the state-of-the-art technology as it is now.

Ms. ESHOO. Thank you.

I yield back, Mr. Chairman.

Mr. WALDEN. Thank you.

Gentleman from Nebraska?

Mr. TERRY. Thank you. Mine is to the consumer electronic, Mr. Markwalter. So let's take the again GPS/LightSquared interference issue. And now the FCC is threatening or developing their harm threshold saying that now GPS devices have to have a higher level of being able to filter out the interference. What does that mean to the consumer electronics manufacturers who are making the GPS? What would be the burdens on them and what would be the potential cost to them to now develop the filters to meet this harm threshold?

Mr. MARKWALTER. Sure. I think the industry and one of the things we have talked about a lot and I have included in my testimony is how important it is to have the industry directly involved in that. And in my mind, ideally, you want the industry to try to develop those numbers, to recognize the problem and try to develop those numbers because it is very hard as an outsider to understand the cost and performance impact.

GPS in particular isn't a communication system as everybody has talked about. You know, it is a positioning system so it has different behaviors in how it is trying to pick up signals, so I won't even hazard to guess what the cost impact would be. And the truth is it depends on where you set the level. And so that is going to take some dialogue about, you know, how much impact do you want to have on this type of positioning system to in the future be able to get new use of the adjacent band.

Mr. TERRY. All right. And it still comes back to that. It is almost a device and some specific for the FCC would have different thresholds particularly on different devices, Mr. de Vries?

Mr. DE VRIES. I don't think that would be appropriate. That actually to me would be a receiver specification. So if you build this device, you have got to do this. I believe that it is appropriate to set the harm claim threshold for a service. And so, for example, in a service like GPS, you could have a certain level for terrestrial operations. You might have another level, a different value, for aviation. But many more permutations like that and we get too—

Mr. TERRY. Right. That makes more sense to me. All right. Still, it means that incumbents would have a new standard put on them or threshold of harm that was different than perhaps when the manufacturers put the product out, whatever it would be. So they would have to redevelop technology for the next generation of device. All right. I wish I can come up with more questions but that did add some context and clarification. So thank you.

Mr. WALDEN. The interesting thing in that is it is kind of what we all go through with updating computers and software.

Ms. ESHOO. Absolutely.

Mr. WALDEN. You know, I tried to download a little app on my older iPhone and the new app won't load on the old iPhone.

Ms. ESHOO. Right. Right.

Mr. WALDEN. I mean it just is the march of technology.

Mr. TERRY. That is a discussion some of us lay people were having in our office. What does it take? Is this simply writing new code or is the device going to have to have physical filter device chips in it? What does it take?

Mr. WALDEN. I will let the engineer—

Mr. TERRY. Do we have an engineer here?

Mr. MARKWALTER. So this also relates kind of to the other questions to me. I think most of what we are talking about here is a hardware question, what the engineers would call the RF front end, the radio part of the equipment. And so we are talking about things like filters for the most part. This other group that, you know, we are looking at these potential for future agile radios. What we hope to get to is where there is less of that sort of fixed, you know, these components that can't move; they are highly specifically designed to more of this, you know, digitally with processors and algorithms, you know, software as you talked about, but we are not there yet for very many things. Most of it is still much more cost-effective, performance is a lot higher, and the battery life is a lot better to separate out the RF front end.

Mr. WALDEN. OK.

Mr. MARKWALTER. So for now it is hardware.

Mr. WALDEN. Mr. Gingrey, do you have any questions for our witnesses or comments you would like to make? We have a transmitter issue here.

Mr. GINGREY. Yes, I—

Mr. WALDEN. You might want to slip to the other microphone.

Mr. GINGREY. Is it working?

Mr. WALDEN. No.

Ms. ESHOO. No.

Mr. GINGREY. All right. I will move.

Mr. WALDEN. I think you may have to move up to this level, which you have sought to do for some time.

Ms. ESHOO. He can sit next to me.

Mr. GINGREY. I am making progress.

Mr. WALDEN. Watch the seniority grow, right there, before our very eyes.

Mr. GINGREY. Mr. Chairman? All right. We are live. Mr. Chairman, thank you for calling today's hearing on another issue within the realm of spectrum, and of course, that is the receivers.

And I also want to thank the panel, these technical experts in providing the subcommittee with their perspective on this important issue. In my brief time this morning I will get right to my questions. And let me start with you, Mr. Markwalter.

Based on your testimony, you voiced support for industry standards as opposed to FCC mandates when it comes to the interfering subordinates. Would FCC standards undermine what is already in place, and if so, how?

Mr. MARKWALTER. Well, in some cases we already have very good industry standards in place, so I guess if the FCC did something on top of that, I would argue that it would undermine it because it would in effect overrule what maybe industry has already done. So when I talked about the cell phone industry has very robust standards and, you know, a very strong test regime to make sure products meet it. So overlaying mandates on top of that probably would have a bad effect. And, you know, what we would like to see is industry working on these voluntary standards because we think they understand their use cases better and what can be tolerated in terms of cost and efficiency and then figure out where there is regulation necessary or not from that point.

Mr. GINGREY. Mr. de Vries, do you have a comment on that?

Mr. DE VRIES. So I would actually echo that because the standards that industry set reflect what their best practices are. Very often—and Mr. Repasi can correct me—but the FCC does sometimes incorporate reference to industry standards in its rules deferring to industry. The difficult issue that the harm claim threshold and interference limit approach is trying to address is not one industry trying to referee interference from Verizon to AT&T to T-Mobile but from cellular to broadcast things, say, or vice versa. And typically, what we have seen is that broadcasters don't often read the cellular standards and the cellular guys don't read the broadcasting standards. That is an outstanding problem.

Mr. GINGREY. Well, let me then move to Mr. Repasi and shift a few questions for you in your important position as part of FCC. Can you clarify for us whether the FCC currently has the authority to impose receiver standards?

Mr. REPASI. Thank you. I am here to offer engineering and technical expertise. I am not in a position to offer a legal opinion on the Commission's authority but I can say that the approaches that are being considered within the TAC are certainly within our ability from a technical perspective to implement the approaches that are being highlighted in that process.

Mr. GINGREY. Yes, I was going to ask. I think maybe you just answered the question. I was going to ask you if this was a situation where we in Congress would need to act to grant FCC the necessary authority but you have kind of taken a pass on that in regard to your level of expertise. Personally, I think that it is unclear as to what authority the FCC has in this arena. Hypothetically speaking, and not to indicate support for further regulation, but does the Commission currently even have the resources to set technical standards for this wide variety of receivers out there? And would Congress need to authorize and appropriate new funding for this purpose under the FCC?

Mr. REPASI. Thank you. Yes, we do have the technical expertise to deal with the recommendations that come out of the TAC. Again, I think we have the expertise to implement those. As far as funding goes, we are in a position now where we would have to factor in any budgeting into the next fiscal year budget and we would have to address it when we deal with our budget issues for the following year as far funding new programs at the agency.

Mr. GINGREY. Yes, well, of course as I am sure you all have talked about in your testimony, there are untold number of receiver devices out there for hundreds of different purposes, and we see them all parts of society. So therefore, how would you anticipate receiver regulations even being implemented? I mean is this something that can be done and how costly would it be? How much more funding would be necessary for the FCC to take on this challenge?

Mr. REPASI. I don't have a specific cost estimate or even a ballpark that I could offer up, but as far as the approach, I would imagine if we apply the approach in several frequency bands, it could be voluminous at first trying to manage the different type of receiver specifications. As Mr. de Vries had mentioned, broadcasters are not participating in 3GPP. 3GPP participants aren't participating in the broadcast standard development. So it is going to be new, I think, across different industry sectors on understanding the underpinnings of each of the standards. So I think there is a hurdle there and it will take some time to get that level of understanding among the different industry sectors.

And then as far as incorporation by reference to some of the standards, we are very familiar with 802.11 from IEEE. We are very familiar with the 3GPP standards. So again within the Commission we have the expertise. We know the underpinnings of those standards, so maybe it is less of a hurdle for us to deal with it.

Mr. GINGREY. Well, thank you very much. I thank all three of you.

And Mr. Chairman, I yield back.

Mr. WALDEN. I thank the gentleman for yielding back.

I recognize the gentleman from Massachusetts, Mr. Markey.

Mr. MARKEY. Thank you, Mr. Chairman, very much.

We are about to enter a brave new world where tens of thousands of domestic drones consume an increasing share of spectrum and crowd into already congested bands. The FAA Modernization and Reform Act passed in February requires the Federal Government to fully integrate government commercial and recreational drones into U.S. airspace by October of 2015. There could be as many as 30,000 drones in the sky above the United States by 2020. Drones can carry surveillance equipment including video cameras, infrared thermal imagers, radar, and wireless network detectors. Drones may gather information, take measurements, snap photos, use GPS and communicate all this information back to its operators. All this requires spectrum and raises a number of questions about whether this dramatically expanded use of drones will cause interference problems.

But we must also ensure that as drones take flight in domestic airspace, they don't take off without privacy protections for those along their flight path. Drones shouldn't interfere with our privacy

and they also shouldn't interfere with other devices using neighboring spectrum.

Mr. Repasi, what steps is the FCC taking to ensure potential interference problems are addressed as thousands of drones will soon fill our skies? Has the FCC staff met with FAA staff to address what receivers are necessary on drones to ensure interference is minimized? And what are you doing to protect privacy?

Mr. REPASI. Thank you. As far as interference concerns with respect to drones, it is a case of interference scenario just like any other where you have radio communications equipment, whether it is used for video or whether it is used for controlling the aircraft. We have tradeoffs that we have to make with respect to the allocation, whether it is in an aeronautical band and who the neighbors are so we can deal with power levels and emissions to make sure that interference is not caused to those drones.

As far as working with the FAA, we stand ready to work with the FAA to discuss these issues. In fact we have a team of folks who deal with the FAA regularly on the Interdepartment Radio Advisory Committee where not just the FAA but other Federal agencies who are interested in the use of drones participate and discuss technical issues that we deal with from an interagency perspective.

And I must say from a privacy perspective, I haven't been involved in privacy issues with respect to the Commission's work, but I would be more than happy to go back to the appropriate bureau and have somebody contact you directly to answer your questions.

Mr. MARKEY. Well, today, Mr. Barton and I are releasing the FAA's response to our inquiry asking how the agency plans to ensure that the privacy of Americans will be protected as the agency permits the large expansion and use of drones in domestic airspace. What is clear from the FAA's response is that they have little interest in establishing privacy protections, public transparency into its current and future licensing process. The FAA is wrong. The FAA is dead wrong on this issue in terms of ensuring that privacy is protected.

These 21st century eyes in the sky shouldn't become spies in the skies preying on the private lives of Americans all across our country, 30,000 drones without insurance that the information gathered is not compromised.

All three of you, hopefully, would support legislation that establishes privacy rules of the sky that ensure private information on Americans is protected before drones are licensed. So the question that I have for each of you is do you think drone operators should have to disclose what data they collect, how long data is retained, and whether information is provided or sold to third parties? Does the public have a right to know where and when these drones will be flying over their backyards gathering information about their families? Mr. de Vries?

Mr. DE VRIES. Sir, I am afraid I have no expertise.

Mr. MARKEY. That is fine. Mr. Markwalter?

Mr. MARKWALTER. The same. I am not familiar with the issue.

Mr. MARKEY. OK. Well, I will tell you who the experts are—your ordinary families. And as new technologies take off, they have to be accompanied by the human values which have animated civilization for 5,000 years and the protection of the sanctity of a family

its privacy. What it does, where it goes is still central to the identity of us as a species. And I think it is important for this committee to play a role in ensuring it is built into this new technology.

I thank you, Mr. Chairman.

Mr. WALDEN. The gentleman's time is expired.

I turn now to the gentleman from Florida, Mr. Stearns.

Mr. STEARNS. Yes, thank you, Mr. Chairman.

Mr. Markwalter, you stated in your testimony that an inventory of what services and receivers are operating in each band as an area of spectrum policy that needs more attention. And so I agree with you and have long called for various spectrum inventories to be conducted. Do you think there is a role for Congress here that there should be legislation that would apply to help bring this spectrum inventory to fruition?

Mr. MARKWALTER. I think at this point we should see what the TAC tees up for next year because I think this question of the dearth of information on what is out there is going to become critical, and so we may see some work in that area. So I think we can wait for a couple more reports to come out and then address the issue of whether legislation is needed to push it.

Mr. STEARNS. And what time next year will this be?

Mr. MARKWALTER. So presumably the TAC would lay out its work agenda early in the year. We have had quarterly meetings in the past. I would think within the first quarter of next year we would have both the GAO report and know what the TAC plans on working on.

Mr. STEARNS. Mr. de Vries, as you explained your testimony, "wireless systems in one band that cannot tolerate reasonable signal levels in an adjacent band unfairly imposed cost on others, notably the operators in those adjacent bands, while reaping the benefits themselves, for example, by using cheaper receivers." You know, I think this is what exactly happened in LightSquared or the GPS case. As you stated, not only is this unfair, but it also prevents the addition of new wireless services that could foster innovation, improve public safety, and obviously create jobs. What do you believe either Congress or possibly the FCC, their role to prevent this situation from occurring again?

Mr. DE VRIES. I believe the important role that the FCC can play is to foster the definition of these harm claim thresholds.

Mr. STEARNS. OK.

Mr. DE VRIES. And they can do that by fostering a multi-stakeholder process, bring parties from different industries, different services together, and then if necessary, to take steps to actually put those values into the rules.

Mr. STEARNS. Anyone else have a suggestion here? Mr. Markwalter?

Mr. MARKWALTER. Yes, well, I agree. And as I mentioned earlier, we work on the TAC so you will probably get more alignment on our views than misalignment. I think we are sort of behind in the curve in all aspects. So none of our tools are in place to help us get in front of the problem and that is what we are trying to get to, a point where we can establish what we are trying to do with spectrum rather than build and then figure out we got a problem

after the fact. So we really need to get some of these tools in place and unwind the problem a little bit. It is just not going to be solved overnight.

Mr. STEARNS. Mr. Repasi, you stated in your testimony that better awareness and coordination between entities in adjacent bands would go far in solving some of the receiver problems we have seen occur recently. What do you think the FCC's role is? Could they facilitate this process?

Mr. REPASI. Yes, I think our rulemaking processes are open and transparent. We again make proposals based on assumptions. We expect that the folks who have an equity or stake in the use of that spectrum will come into our rulemaking process and challenge our assumptions, if there are concerns about interference, it would be brought up as early as possible in the process so that we could deal with those interference concerns before we go to final rule.

Mr. STEARNS. Any other folks on the panel have any other suggestions in how the FCC could facilitate this process? No?

All right, Mr. Chairman, I yield back the balance of my time.

Mr. WALDEN. The gentleman yields back the balance of time.

The Chair recognizes the future vice chair of the full committee, Mrs. Blackburn.

Mrs. BLACKBURN. Thank you, Mr. Chairman.

And thank you all for being here and for the hearing.

I have just got a couple of questions and I know you all are ready to depart this room. And we are going to have votes in a couple of minutes.

Mr. Repasi, if I could come to you first. And I want to thank you all for submitting your written testimony in a timely manner. That is always helpful.

You suggested in your testimony that the FCC clarify what a license-holder's rights are in a band of spectrum, incentivize receiver manufacturers to respect those rights, and enforce those rights when one licensee in an adjacent band doesn't play by the rules. So this policy framework if you will really strikes me as looking at three goals. And I want to see if you agree with this: number one is recognition of a licensee's rights in a given band of spectrum with clear rules of the road to ensure that licensees respect other licensees' valuable property rights; and number two, promotion of new entrance to the wireless marketplace because they would have regulatory clarity from the onset; and number three, accomplishment of the aforementioned goals without stifling innovation in the wireless marketplace by imposing potentially crippling device or guard band mandates. So recognizing that the Commission's Technical Advisory Committee plans to give us a report on December 10 that could address these issues, I would like to ask what your professional and technical opinion is on how you would instruct the Commission to structure the rules of the road and to provide the clarity and the guidance on respecting property rights.

It is to you, sir.

Mr. REPASI. Thank you. We are, as you are aware, awaiting the recommendations for the TAC but are also awaiting the recommendations of the GAO. They are mandated by the Job Act to have their report by February of next year. We would need to take that information, those facts into account in a general process

where we have input from the public who could be affected by whatever rules we would propose to set up to give them clarity, to identify what the environment would look like.

Mrs. BLACKBURN. Yes, sir. But I am asking what your advice to them would be. What would your professional advice be?

Mr. REPASI. I am sorry. To the Commission or to the public?

Mrs. BLACKBURN. Yes. Yes.

Mr. REPASI. To the Commission? Well, clarity is good. Clarity allows certainty. Certainty leads to investment. Investment leads to competition and innovation, which is important for this mobile wireless economy. So certainly in any technical tradeoffs that would weigh into the policies that would be presented before the Commission, the technical issues are one of several things. You have got the legal and economic issues as well, but certainly the technical issues are very important from that perspective.

Mrs. BLACKBURN. Yes, specificity and clarity in a timely manner is a good thing. So I appreciated your testimony.

Mr. Markwalter?

Mr. MARKWALTER. Yes?

Mrs. BLACKBURN. In your testimony you wrote, "the early calls for government mandates on device design have faded as stakeholders have come together to understand that such approaches are not the best solution we have to spectrum crowding." Now, I was pleased to read that because as anybody who has sat through these hearings has heard from me, I like seeing industry set best practices and guidelines and standards and come up with those rules of the road if you will. So in your view, what is the current status of the various private industry stakeholder proposals to address receiver standards? And do you think they are making progress in a voluntary self-regulation working framework? And is there anything out there, any kind of uncertainty or lack of clarity that is preventing the industry from making progress toward meeting the balance between flexible use and greater efficiency?

Mr. MARKWALTER. OK. Thank you. So I think industry—and I don't know if you are aware or not—CEA is one of those standard-setting organizations. In fact, our standards are incorporated by reference for closed-captioning for example. So because I am close to it, I guess I see the industry is always working on it. Where it might not be sufficient is the enter-industry relationships as we have mentioned a couple of times here today where we are trying to put two users next to each other like cell phones and broadcasters and to get those industries talking. That level of dialogue needs to be increased. I think to the extent we have a shortcoming it is in that area.

Mrs. BLACKBURN. OK.

Mr. WALDEN. OK.

Mrs. BLACKBURN. Anybody want to add anything further to that on the progress or lack thereof? OK.

Yield back.

Mr. WALDEN. Gentlelady yields back her time.

I want to thank our witnesses for your testimony, your guidance, your counsel, your good work at TAC. I want to thank the FCC for your work in this area. Know that we care a lot about it and we are going to continue to be involved in it. And we will look forward

to the report from TAC. We will look forward to the GAO report in February as well.

The record will stay open for 10 days for further comments and questions or maybe some back to all of you, which would help us in our work.

So again, thank you for your patience this morning as we got going and thank you for your comments and your testimony.

With that, the subcommittee is adjourned.

[Whereupon, at 1:22 p.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

**Questions for the Record
Ron Repasi
Deputy Director of the FCC's Office of Engineering and Technology**

**"The Role of Receivers in a Spectrum Scarce World"
November 29, 2012**

**Questions of Representative Greg Walden
Chair, Communications and Technology Subcommittee
House Energy and Commerce Committee**

Question 1

What steps does the FCC take when creating new licenses in a new band to try and prevent interference problems with adjacent services?

Answer

The Commission runs data-driven, transparent proceedings to solicit public comment on potential changes in the use of spectrum. These proceedings typically identify the provisions for avoiding harmful interference to adjacent services. Commission licensees, manufacturers, federal operators and any other entities with concerns about interference have the opportunity to raise interference concerns and supply technical information to support their arguments. The Commission reviews supporting technical material that is supplied in its record to assess the impact on other services before finalizing technical rules or conditions for a new service.

Question 2

Should all types of wireless receivers be subjected to these types of requirements? Would exempting some classes of devices create additional challenges?

Answer

The Commission considers receiver performance issues if it appears to be a potential issue when changing the use of adjacent spectrum. The Commission generally has not established requirements for receivers, nor has it sought to protect all receivers from interference irrespective of their performance. Instead, the Commission balances receiver performance against the need to make efficient use of the spectrum. Special consideration may be given to safety services, yet it may be inappropriate to completely exempt all types of receivers used for safety or other services from any expectation of reasonable performance.

Question 3

The U.S. GPS Industry Council asked the Commission to adopt heightened GPS-specific interference protections (in the form of a mandatory license condition) as part of its AWS-4 proceeding, despite the fact that GPS operations are located nearly 400 MHz away from the nearest point of the proposed AWS-4 band. Did the Commission engage in a technical analysis of the potential for interference into GPS operations if the Commission had adopted its originally proposed protections (similar to the protections that already exist for other commercial CMRS bands located closer to GPS operations)?

Answer

The previous 2GHz MSS licensees had agreed that their ancillary terrestrial services would meet more restrictive out-of-band emission levels in the GPS band and the Commission conditioned their operating authority accordingly. The prospective licensees of AWS-4 operating authority had voluntarily reached a private agreement with the United States GPS Industry Council representing GPS interests to meet those same levels. The Commission concluded that the most appropriate approach was to require, as a license condition, AWS-4 licensees to comply with the voluntary agreement and the specific out-of-band levels. The Commission did not make an independent determination as to whether the levels contained in the private agreement were necessary. Other terrestrial services, particularly the personal communications service, operate closer in the spectrum to the GPS band. The more stringent limits do not apply and I have found no evidence of any reports of harmful interference.

Sub-question (a)

Should the Commission adopt mandatory interference protections without engaging in a technical analysis?

Answer

The Commission generally performs a technical analysis prior to adopting rules or conditions to protect against harmful interference. In the AWS-4 rulemaking, the Commission did not reach the issue of whether and, if so, at what level, to establish an out-of-band limit rule for protection of GPS from AWS-4 operations because the current and prospective licensees voluntarily agreed to meet more restrictive out-of-band emission levels in the GPS band than required of other commercial wireless carriers.

Sub-question (b)

(b) Do federal spectrum users who are located in comparable or more adjacent frequencies comply with the heightened interference protections that the GPS industry has sought to impose on commercial operators?

Answer

Information on federal spectrum systems' ability to comply with the more restrictive GPS interference protections has not been provided in the record of the AWS-4 proceeding or other spectrum proceedings. Though NTIA regulations do require agencies proposing a new system to measure the emission levels into the GPS bands, and to submit the data to NTIA prior to receiving spectrum certification, there is no requirement on federal systems to limit their emissions inside the GPS bands to any specific levels. The measurement and reporting requirement applies to federal systems operating in two ranges of spectrum, one of which is the 960-1710 MHz band that overlaps the GPS L1 band.

Record Correction

On page 18 of the transcript, Representative Blackburn addressed me as follows in the section quoted below. Although I answered this question, I wish to clarify for the record that the testimony that Representative Blackburn quoted was that of another witness. I did not suggest in my testimony that the FCC take the actions noted.

Quotation from Record

BLACKBURN:

Thank you, Mr. Chairman.

And thank you all for being here and for the hearing.

I've just got a couple of questions, and I know you all are ready to depart this room and we are going to have votes in a couple of minutes.

Mr. Repasi, if I could come to you first, in your testimony -- and I want to thank you all for submitting your written testimony in a timely manner. That's always helpful. You suggested in your testimony that the FCC clarify what a license-holders rights are in a band of spectrum, incentivize receiver manufacturers to respect those rights, and enforce those rights when one licensee in an adjacent band doesn't play by the rules.

So this policy framework, if you will, really strikes me in -- as looking at three goals, and I want to see if you agree with this. Number one is recognition of a licensee's rights in a given band of spectrum with clear rules of the road to ensure that licensees respect other licensees' valuable property rights.

And number two, promotion of new entrants to the wireless marketplace because they would have regulatory clarity from the onset. And number three, accomplishment of the aforementioned goals without stifling innovation in the wireless marketplace by imposing potentially crippling device or guard band mandates.

So, recognizing that the commission's Technical Advisory Committee plans to give us a report on December 10th that could address these issues, I'd like to ask what your professional and technical opinion is on how you would instruct the commission to structure the rules of the road and to provide the clarity and the guidance on respecting property rights.